SESSIONAL PAPERS

VOLUME XXXVI.—PART II.

SECOND SESSION OF TENTH LEGISLATURE

OF THE

PROVINCE OF ONTARIO.

SESSION 1904.

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1904.

LIST OF SESSIONAL PAPERS.

ARRANGED ALPHABETICALLY.

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Accounts, Public	1	*Printed.*
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Algoma Central and Hudson Bay Railway. Papers *in re* guarantee	85	*Printed.*
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Archives, Report	48	"
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Fruit Experimental Stations, Report	17	*Printed.*
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No. 2 . . . Estimates for the service of the Province until the Estimates of the year are finally passed. Presented to the Legislature 28th January, 1904. *Not Printed.* Estimates for the year 1904. Presented to the Legislature, 5th February, 1904. *Printed.* Estimates for the service of the Province until the Estimates of the year are finally passed. Presented to the Legislature, 29th March, 1904. *Not Printed.* Estimates (Supplementary) for the year 1904. Presented to the Legislature, 23rd April, 1904. *Printed.*

No. 3 . . . Report of the Commissioner of Crown Lands for the year 1903 Presented to the Legislature, 14th March, 1904. *Printed.*

No. 4 . . . Report of the Clerk of Forestry for the year 1903. Presented to the Legislature, 7th April, 1904. *Printed.*

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No. 7 . . . Report of the Commissioner of Public Works for the year 1903. Presented to the Legislature, 22nd February, 1904. *Printed.*

No. 8 . . . Report of the Inspectors of Factories for the year 1903. Presented to the Legislature, 15th April, 1904. *Printed.*

No. 9 . . . Report relating to the registration of Births. Marriages and Deaths for the year 1902. Presented to the Legislature, 4th February, 1904. *Printed.*

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No. 11 . . Loan Corporations. Statements by Building Societies, Loan and other Companies, for the year 1903. Presented to the Legislature, 7th April, 1904. *Printed.*

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No. 13 . . Auditors' Report to the Board of Trustees, University of Toronto, on Capital and Income Accounts, for the year ending 30th June, 1903. Presented to the Legislature, 4th February, 1904. *Printed.*

No. 14 . . Report of the Ontario Agricultural College and Experimental Farm, for the year 1903. Presented to the Legislature, 30th March, 1904. *Printed.*

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No. 15 . . Report of the Ontario Agricultural and Experimental Union of the Province, for the year 1903. Presented to the Legislature, 15th April, 1904. *Printed.*

No. 16 . . Report of the Fruit Growers' Association of the Province, for the year 1903. Presented to the Legislature, 15th April, 1903. *Printed.*

No. 17 . . Report of the Fruit Experiment Stations of the Province, for the year 1903. Presented to the Legislature, 15th April, 1904. *Printed*

No. 18 . . Report of the Inspector of Fumigation Appliances of the Province, for the year 1903. Presented to the Legislature, 15th April, 1904. *Printed.*

No. 19 . . Report of the Entomological Society, for the year 1903. Presented to the Legislature, 14th March, 1904. *Printed.*

No. 20 . . Report of the Bee-Keepers' Associations of the Province, for the year 1903 Presented to the Legislature, 15th April, 1904. *Printed.*

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No. 21 . . Hand-book for the use of Women's Institutes in Ontario. Presented to the Legislature, 10th February, 1904. *Printed for distribution only.*

No. 22 . . Reports of the Dairymen's Associations of the Province, for the year 1903. Presented to the Legislature, 15th April, 1904. *Printed.*

No. 23 . . Reports of the Live Stock Associations of the Province, for the year 1903. Presented to the Legislature, 15th April, 1904. *Printed.*

No. 24 . . Report of the Registrar of Live Stock of the Province, for the year 1903. Presented to the Legislature, 15th April, 1904. *Printed.*

No. 25 . . Report of the Farmers' Institutes of the Province, for the year 1903. Presented to the Legislature, 10th February, 1904. *Printed.*

No. 26 . . Report of Ontario Fairs and Exhibitions of the Province, for the year 1903. Presented to the Legislature, 10th February, 1904. *Printed.*

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No. 27 . . Report of the Bureau of Industries of the Province, for the year 1903. Presented to the Legislature, 15th April, 1904. *Printed.*

No. 28 . . Report of the Commissioner of Highways, for the year 1903. Presented to the Legislature, 7th March, 1904. *Printed.*

No. 29 . . Report of the Bureau of Labour, for the year 1903. Presented to the Legislature, 24th March, 1904. *Printed.*

No. 30 . . Report of the Ontario Game Commission, for the year 1903. Presented to the Legislature, 26th February, 1904. *Printed.*

No. 31 . . Report of the Department of Fisheries, for the year 1903. Presented to the Legislature, 5th April, 1904. *Printed.*

No. 32 . . Report of the Temiskaming and Northern Ontario Railway Commission, for the year 1903. Presented to the Legislature, 10th February, 1904. *Printed.*

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No. 33 . . Report of the Inspector of Division Courts, for the year 1903. Presented to the Legislature, 11th February, 1904. *Printed.*

No. 34 . . Report of the Inspector of Legal Offices, for the year 1903. Presented to the Legislature, 14th April, 1904. *Printed.*

No. 35 . . Report of the Inspector of Registry Offices, for the year 1903. Presented to the Legislature, 15th April, 1904. *Printed.*

No. 36 . . Report of the Provincial Board of Health, for the year 1903. Presented to the Legislature, 15th February, 1904. *Printed.*

No. 37 . . Report of the Secretary and Registrar of the Province, for the year 1903. Presented to the Legislature, 14th March, 1904. *Printed.*

No. 38 .. Report upon the Lunatic and Idiot Asylums of the Province, for the year ending 30th September, 1903. Presented to the Legislature, 26th February, 1904. *Printed.*

No. 39 .. Report upon the Prisons and Reformatories of the Province, for the year ending 30th September, 1903. Presented to the Legislature, 24th March, 1904. *Printed.*

No. 40 .. Report upon the Hospitals and Charities of the Province, for the year ending 30th September, 1903. Presented to the Legislature, 30th March, 1904. *Printed.*

No. 41 .. Report upon the Institution for the Education of the Blind, Brantford, for the year ending 30th September, 1903. Presented to the Legislature, 8th February, 1904. *Printed.*

No. 42 .. Report upon the Institution for the Education of the Deaf and Dumb, Belleville, for the year ending 30th September, 1903. Presented to the Legislature, 8th February, 1904. *Printed.*

No. 43 .. Report of Superintendent. Neglected and Dependent Children of Ontario, for the year 1903. Presented to the Legislature, 22nd February, 1904. *Printed.*

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No. 44 .. Report upon the Inspection of Liquor Licenses, for the year 1903. Presented to the Legislature, 11th March, 1904. *Printed.*

No. 45 .. Report of the Provincial Municipal Auditor for the year 1903. Presented to the Legislature, 4th February, 1904. *Printed.*

No. 46 .. Return from the Records of the several Elections in the Electoral Divisions of Muskoka, Sault Ste. Marie and North Renfrew since the General Elections of May 29th, 1902, shewing: (1) The number of Votes polled for each candidate in the Electoral District in which there was a contest; (2) The majority whereby each successful Candidate was returned; (3) The total number of Votes polled in each District; (4) The number of Votes remaining unpolled; (5) The number of names on the Voters' Lists in each District; (6) The population of each District as shewn by the last census. Presented to the Legislature, 21st January, 1904. *Printed.*

No. 47 .. Report upon the state of the Library. Presented to the Legislature 14th January, 1904. *Not printed.*

No. 48 .. Report of the Archivist, Ontario, for the year 1903. Presented to the Legislature, 14th April, 1904. *Printed.*

No. 49 .. Copy of an Order in Council advising that the tender of the Riordon Paper Mills, Limited, for the supply of Paper to the Province, for the ensuing five years, be accepted. Presented to the Legislature, 4th February, 1904. *Printed.*

No. 50 . . Copy of an Order in Council in accordance with the provisions of section 9 of the Act, respecting the Education Department. Presented to the Legislature, 4th February, 1904. *Not printed.*

No. 51 . . Copy of an Order in Council, advising that the Agreement for renewal of Contract between Warwick Brothers and Rutter, with reference to the Printing and Binding for the Province, be approved. Presented to the Legislature, 4th February, 1904. *Printed.*

No. 52 . . Copy of an Order in Council, respecting the commutation of the Surrogate Court Fees of the County of Huron. Presented to the Legislature, 8th February, 1904. *Not printed.*

No. 53 . . Copy of an Order in Council, respecting the commutation of Surrogate Court Fees of the County of Bruce. Presented to the Legislature 4th February, 1904. *Not printed.*

No. 54 . . Copy of an Order in Council, respecting the commutation of the Surrogate Court Fees of the Counties of York and Wentworth,. Presented to the Legislature, 4th February, 1904. *Not printed.*

No. 55 . . Return to an Order of the House of the tenth day of June, 1903, for a Return of copies of all correspondence between the Government, or any member or department thereof, and any other person or persons, respecting the establishment of a Reformatory in the County of Oxford. Presented to the Legislature, 4th February. 1904. Mr. *Sutherland*. *Not printed.*

No. 56 . . Return to an Order of the House of the fourth day of June, 1903, for a Return of copies of all correspondence, papers, documents, decisions and memoranda in any way relating to the Mining Locations H.W.696, H.W.697, H.W.698 and H.W. 705, and particularly as to the southerly part of H.W. 697, containing thirteen acres, granted to one Gideon Larivière, which locations, are situate on, or near the North Pay of Sturgeon Lake in the District of Thunder Bay. Presented to the Legislature, 4th February, 1904. Mr. *St. John*. *Not printed.*

No. 57 . . Return to an Order of the House, of the twelfth day of June, 1903, for a Return,—similar to that ordered by the British House of Commons on the 25th day of June, 1902, of reproductive undertakings operated by Municipal Boroughs in Great Britain—respecting waterworks, electric lighting plants, gas works and other public utilities operated by Municipalities in the Province of Ontario, also the rates charged the consumers in the various Municipalities of the Province for water, gas and electric lighting. Presented to the Legislature, 4th February, 1904. Mr. *Preston* (*Brant*). *Printed.*

No. 58 . . Return to an Order of the House, of the fourth day of June, 1903, for a Return of copies of all correspondence between the Minister, or Commissioner of Public Works, or Fisheries, or other officer, or *employe*, of or under them, or either the Departments of Public Works, or Fisheries, and any other person or persons, and also any order or directions, or papers, or entries respecting the granting of licenses for pound net fishing, east of a line running from Cape Hurd to the mouth of the Spanish River, during the years 1899, 1900, 1901 and 1902, or either or any of them. Also, copies of all such licenses granted during the above years, or either, or any of them. Presented to the Legislature, 4th February, 1904. Mr. *Smyth.* *Not printed.*

No. 59 . . Return to an Order of the House, of the 8th day of June, 1903, for a Return of all copies of all forms of application or subscription for terminating stock and of all forms of certificates of such stock used by Loan Corporations doing business in the Province. Presented to the Legislature, 4th February, 1904. Mr. *Downey.* *Not printed.*

No. 60 . . Return to an Order of the House, of the fourth day of June, 1903, for a Return of copies of all correspondence, between the Metropolitan Power Company, or their Solicitors, and the Government for a grant of land under the waters of the Ottawa River, and all papers in connection therewith. Presented to the Legislature, 4th February, 1904. Mr. *Matheson.* *Not printed.*

No. 61 . . Copy of an Order in Council and Report of Registrar of Loan Corporations in the matter of the Canadian Co-operative Alliance. Presented to the Legislature, 5th February, 1904. *Not printed.*

No. 62 . . Copy of an Order in Council respecting Surrogate Court Fees to be paid to His Honour Judge Holt. Presented to the Legislature, 10th February, 1904. *Not printed.*

No. 63 . . Copy of an Order in Council respecting Surrogate Court Fees to be paid to His Honour Judge Jamieson. Presented to the Legislature, 10th February, 1904. *Not printed.*

No. 64 . . General Rules and Orders made by the Court of Appeal for Ontario respecting the trial of Election Petitions pursuant to the Controverted Elections Act, R.S.O., 1897, cap. 11, and amending Acts. Presented to the Legislature, 12th February, 1904. *Printed. For distribution only.*

No. 65 . . Return to an Order of the House, of the eighth day of February, 1904, for a Return shewing the names of all persons at Sault Ste, Marie, or elsewhere, who have been paid by the Government under the decision, or determination, to pay the wages of workmen at Sault Ste. Marie, and showing also the amount paid in each case and the nature of the claim in each case. Presented to the Legislature, 15th February, 1904. Mr. *Whitney,* *Printed.*

No. 66 . . Return to an Order of the House, of the tenth day of February, 1904 for a Return shewing the number of students admitted to (a) the Normal Schools of the Province since September, 1903. (b) How many (if any) of such students, prior to admission, taught less than twelve months in a Public School and (c) How many (if any) did not attend a Model School course and secured a certificate of competency therefrom. Presented to the Legislature, 16th February, 1904. Mr. *Hoyle.* *Not printed.*

No. 67.. Copy of an Order in Council, commuting the fees of F. H. MacDonald, Local Master at St. Catharines. Presented to the Legislature, 18th February, 1904. *Not printed.*

No. 68... Return to an Order of the House of the twenty sixth day of June, 1903, for a Return shewing:—1. The total area of Crown Lands under timber License. 2. The total area of Crown Lands under timber License in arrears. 3. The number of timber Licenses in arrear, their locations, respective areas, the names of those persons so in arrears, and the amounts that each of such persons are in arrear, and for what respectively. 4. The number of timber Licenses cancelled since and including 1891, and the number of acres of Licenses so cancelled. 5. The nature and extent of the securities (if any) held by the Government, for payment of such areas, and, the names of the persons so giving security. 6. The number of timber Limits disposed of otherwise than by Public Auction, since and including the year 1891, specifying the details thereof, as to time, place, person and prices respectively. 7. The number of pieces of saw-logs cut under License in the Province of Ontario, each year since and including 1891; the aggregate quantity of lumber, board measure, returned to the Crown Lands Department for each of the said years since and including 1891; the amount of Crown dues collected for each of the said years from the lumber cut, giving the quantity for each separate price charged for dues. 8. The number of pieces of waney or board timber cut under license in each of the said years and the aggregate quantity of cubic feet and the amount of Crown dues collected on the same. 9. The number of pieces of square timber cut and the quantity of cubic feet returned as contained in same and the amount collected for each of the said years thereon, for Crown dues. Presented to the Legislature 18th February, 1904. Mr. *St. John.* *Printed.*

No. 69.. Return to an Order of the House of the fifteenth day of February, 1904, for a Return of copies of all complaints received by the License Department against W. S. Cowan, formerly inspector of licenses for South Wellington; also, for a copy of the report of the investigation into such complaints, including the evidence; also, for a copy of the report of the Inspector who investigated the complaints, and also, for a copy of all correspondence touching the dismissal of the said W. S. Cowan. Presented to the Legislature, 22nd February, 1904. Mr. *Downey.* *Not printed.*

No. 70.. Return to an Order of the House of the nineteenth day of February, 1904, for a Return of copies of all correspondence between the Inspector of Prisons and Charities, or other official of the Government, and the County of Ontario, having reference to the salary of the County Gaoler. Presented to the Legislature 22nd February, 1904. Mr. *Hoyle.* *Not printed.*

No. 71.. Copy of Memorandum of Agreement between His Majesty, represented by the Commissioner of Crown Lands and Edward Wellington Backus, of the City of Minneapolis. Presented to the Legislature 23rd February, 1904. *Not printed.*

No. 72.. Return to an Order of the House of the twelfth day of February, 1904, for a Return, shewing in the same detail as in the Public Accounts of the Province, all expenditures up to 31st December, 1903, on account of the Temiskaming and Northern Ontario Railway, giving in detail the amount paid, to whom and on what account. And, in the case of the payments to the contractors for the building of the road—shewing all the quantities of rock and other material moved: masonry constructed and generally, all quantities on which payments are based, with the amount paid therefor upon each section of road. Presented to the Legislature, 29th February, 1904. Mr. *Matheson*. *Printed.*

No. 73.. Return to an Order of the House of the nineteenth day of February 1904, for a Return of copies of all correspondence between the Government, or any officials thereof, and any person or persons, regarding the establishment of Savings Banks in connection with the Schools of the Province. Presented to the Legislature, 29th February, 1904. Mr. *Preston (Brant.)* *Not printed.*

No. 74.. Return to an Address to His Honour the Lieutenant-Governor of the twenty-second day of February, 1904, praying that he will cause to be laid before this House, a Return of copies of all Orders in Council with reference to the payment of *employes* at Sault Ste. Marie, together with copies of all correspondence previous to, after and in any way relating to such payments. Presented to the Legislature, 1st March, 1904. Mr. *Whitney*. *Printed.*

No. 75 .. Return to an Order of the House of the twenty-sixth day of February, 1904, for a Return of copies of all correspondence with the Government, or other person, relating to the appointment of one Kelly, as constable, or peace officer, in and about Killarney, together with copies of all correspondence between the Government and one Charles Noble in connection therewith. Presented to the Legislature, 1st March, 1904. Mr. Gamey. *Not printed.*

No. 76 .. Return to an Order of the House of the twenty-fourth day of February, 1904, for a Return of copies of all correspondence, papers and pay sheets, between the Government, or any member or official thereof, in connection with the expenditure of all moneys expended last year, on Colonization Roads in the County of Addington. Presented to the Legislature, 1st March, 1904. Mr. Reid. *Not printed.*

No. 77 .. Return to an Order of the House of the twelfth day of February, 1904, for a Return of copies of all correspondence between the Government or any member, or official thereof, or persons on its behalf, and any other person or persons in connection with the appointment of William Coats, as Registrar of the County of Huron. Presented to the Legislature, 7th March, 1904. Mr. Eilber. *Not printed.*

No. 78 .. Statement of distribution of Revised and Sessional Statutes up to 31st December, 1903. Presented to the Legislature, 9th March, 1904. *Not printed.*

No. 79 .. Return to an Order of the House of the twenty-ninth day of February 1904, for a Return shewing: 1. The amount of money paid as, Railway Subsidies from 1867 up to and inclusive of 1903. 2. The name of each Railway and the amount paid as Subsidy thereto. 3. The amount of money voted for Railway Subsidies, but not yet earned. 4. The amounts in acres voted and set apart as Land Grants, during the same period. 5. The names of all Railways which have earned the apportionment of land so set apart. 6. The amount in process of being earned. Presented to the Legislature, 9th March, 1904. Mr. Preston, (Durham.) *Not printed.*

No. 80.. Return to an Order of the House of the Seventh day of March, 1904, for a Return, shewing the number of Saloon Licenses in the different Cities of the Province during the years 1901 and 1903. Also, the number of Saloon Licenses in the Towns of the Province, during the same period. Also, the number of Wholesale Licenses granted in rural municipalities, in the Province, during the same, period. Presented to the Legislature, 10th March, 1904. Mr. *Barr. Not printed.*

No. 81 .. Return to an Order of the House of the Eleventh day of March, 1904 for a Return of copies of all correspondence, between the Government, or any official thereof, and the President of the Children's Aid Society of Brockville, or any other person or persons, in reference to the arrest and imprisonment of certain young lads in 1902, 1903 and 1904. Presented to the Legislature, 18th March, 1904. Mr. *Graham. Not printed.*

No. 82 .. Return to an Address to His Honour, the Lieutenant-Governor, of the fourth day of March, 1904, praying that he will cause to be laid before this House, a copy of all Orders-in-Council, authorizing or permitting an increase in the capital stock of the Peoples' Life Insurance Company, during the last two years, together with copies of all correspondence in any way relating thereto. Presented to the Legislature, 24th March, 1904. Mr. *Gamey. Not printed.*

No. 83 .. Return to an Order of the House, of the twenty-fifth day of March, 1904, for a Return shewing the names of all persons convicted for violation of any of the provisions of the Liquor License Act in the County of Carleton during the years 1901, 1902 and 1903, with the amounts of fines and costs imposed in each case respectively and showing, as well, the particular offence of which they were convicted and dates of conviction. Presented to the Legislature, 29th March, 1904. Mr. *Kidd. Not printed.*

No. 84 .. Return to an Order of the House, of the twenty-fifth day of March. 1904, for a Return, in detail of all payment made by the Commissioners of the Queen Victoria Niagara Falls Park, for the year 1903. Presented to the Legislature, 29th March, 1904. Mr. *Jessop. Not printed.*

No. 85 .. Return to Orders of the House, of the fourteenth, twenty-first (two orders), and twenty-fifth days of March, 1904, for Returns shewing:—

1. The names of the various companies included in the Consolidated Lake Superior Companies, which the Government proposes to aid by the $2,000,000 guarantee. 2. The names of the secured creditors of each company and the amount of the claim of each and the security held by each. 3. The names of the unsecured creditors of each company and the amount of claim of each. 4. Shewing what portion of the Algoma Central Railway is already completed, how much partly constructed and what construction work has been done on the part incomplete. 5. Shewing what portion of the road has been operated and what net earnings, if any, it has shewn. 6. The names of the vessels which it is proposed to give the Province as security, with statement shewing what these vessels have earned, net, in the hands of the Companies. Also, shewing full particulars of all claims, charges, judgments and priorities chargeable against the Superior Consolidated Companies and the Algoma Central Railway; the names of all the creditors and the nature and amount of their respective claims, and particulars of all assets on which are based, and subject to which it is the intention of the Government to guarantee the sum of $2,000,000 to such companies as embodied in the Bill introduced to this House, before the second reading of such Bill. Also, shewing: 1. What lands and securities are governed by the Lien of Messieurs James Conmee, M.P.P., and Charles M Bowman, M.P.P., against the Algoma Central and Hudson Bay Railway Company, for upwards of $400,000, dated on or about the 22nd day of September, 1903. 2. Whether the judgment of James Conmee, M.P.P., and Charles M. Bowman, M.P.P., against the Algoma Central and Hudson Bay Railway Company for upwards of $400,000, and dated on or about the 12th day of October, 1903, is still a charge on the assets of this company. 3. And shewing the amount of the said Judgment at the present time. And also, shewing the names of the allied industries referred to in section 1 of Cill (No. 129), Respecting Aid to the Algoma Central and Hudson Bay Railway. 2. A copy of the Mortgage referred to in subsection 1 of said section 1. 3. A copy of the Mortgage referred to in subsection 2 of said section 1. 4. A copy of the Promissory Note referred to in subsection 3 of said section 1. 5. A copy of the Stock Certificates of the Stock referred to in subsections 4 and 5 of said section 1. 6. A copy of the Trust Deed, or any draft thereof, referred to in section 2. 7. A copy of the Guaranty referred to in section 3. 8. Shewing what amount is referred to in subsection 3 of section 4. 9. How many Directors are provided for the re-organized Company. 10. A copy of the Deed, or any draft thereof, referred to in subsection 10 of section 4. 11 A copy of the plan of re-organization referred to in subsection 11 of section 4. Presented to the Legislature, 11th April, 1904. Messieurs *Hanna* and *Pyne*. *Printed.*

No. 86 . . Return to an Order of the House, of the sixteenth day of March, 1904, for a Return shewing the copyrighted selections and extracts from authors, used in the authorized text-books of the Public Schools, indicating in each case, the pages and the names of the persons or company controlling the copyrights. Presented to the Legislature, 7th April, 1904. Mr. *Nesbitt. Not printed.*

No. 87 .. Return to an Order of the House, of the second day of March, 1904, for a Return, shewing all payments under the San Jose Scale Act, as follows:—1st. Amount paid to the owners of trees destroyed. 2nd. Amount paid to officers of the Province for enforcing the Act, and 3rd. In what Counties the trees were destroyed. Presented to the Legislature, 7th April, 1904. Mr. *Lee*. *Not printed.*

No. 88 .. Return to an Order of the House of the fourteenth day of March, 1904, for a Return, giving copies of all correspondence between any person or official, on behalf of the University of Toronto and any member of the Government, with reference to the construction of a Physical Laboratory for the University. Also, copies of the Statute of the Senate of the University providing for the establishment of a Department of Forestry in the University, together with copies of all correspondence relating to the establishment of such Department. Presented to the Legislature, 7th April, 1904. Mr. *Whitney*. *Not printed.*

No. 89 .. Return to an Order of the House of the sixteenth day of March, 1904, for a Return of copies of all correspondence between the Government, or any Official thereof, and any person or persons, regarding the issue of licenses for the use of pound nets on Lake Nipissing. Presented to the Legislature, 8th April, 1904. Mr. *Little (Cardwell.)* *Not printed.*

No. 90 .. Return to an Order of the House of the Eleventh day of March, 1904, for a Return of copies of all correspondence between the Government, or any official thereof, and any other party or parties regarding the issue of pound-net fishing licenses in 1902 and 1903 in the waters between Killarney and Little Current, known as the North Channel. Presented to the Legislature 8th April, 1904. Mr. *Gamey*. *Not printed.*

No. 91 .. Return to an Order of the House of the sixteenth day of March, 1904, for a Return giving the names of Public School Inspectors since 1870, in Ontario. Also, the class of certificates they hold, or held, and shewing as well, the standing which each one obtained on their respective examinations entitling them to act as Inspectors of Public Schools. Presented to the Legislature, 20th April, 1904. Mr. *Gamey*. *Not printed.*

No. 92 .. Return to an Order of the House of the twenty-fifth day of March, 1904, for a Return of papers and all correspondence in connection with the issue of Patent for the south half of lot No. 8 in the 4th Concession of the Township of Hutton, in the District of Nipissing. Presented to the Legislature, 23rd April, 1904. Mr. *Matheson*. *Not printed.*

No. 93 .. Return to an Address to His Honour the Lieutenant-Governor of the twenty-second day of April, 1904, praying that he will cause to be laid before this House, a Return of a copy of the Judgment of the Judicial Committee of the Privy Council in the case of the Ontario Mining Company *et al.*, *vs.* Seybold *et al.*, together with a copy of the agreement between Counsel for the Dominion of Canada and the Province of Ontario arising out of the argument of the said Appeal. Presented to the Legislature 23rd April, 1904. Mr. *Cameron (Huron.)* *Printed.*

No. 94 . . Return to an Address to His Honour the Lieutenant-Governor, of the twenty-second day of April, 1904, praying that he will cause to laid before the House, a Return of a copy of the Judgment of the Court of Appeal for Ontario, in answer to certain questions submitted, involving the validity of legislation by the Province respecting the profanation of the Lord's Day, and also the notes of argument and judgment of the Judicial Committee of the Privy Council upon the appeals thereto. Presented to the Legislature 23rd April, 1904. Mr. *Little (Norfolk.)* *Printed.*

REPORT OF

THE BUREAU OF MINES, 1904

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Fig. 2.—Yellow Limestone from Kwataboahegan river. Page 180. Photograph of a fragment reduced one-half, to show the highly fossiliferous nature of the rock. The surface of this specimen shows: Orthoceras luxum, Orthoceras procerus (?), Coleolus tenuistriatus, C. tenuicinctum, Pleurotomaria adjutor, Modiomorpha sp., Platyostoma lineata, Bellerophon sp., Euompholus sp., Athyris spiriferoides, Cypricardinia indenta (?), Atrypa reticularis.

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MAPS.

1. Map of Northern Nickel Range. By A. P. Coleman. Scale 2 miles to 1 inch.
2. Map of Northern Parts of the Districts of Algoma and Nipissing, to accompany report of J. M. Bell. Scale, 8 miles to 1 inch.
3. Map of Lake Iroquois. By A. P. Coleman; parts in New York after H. L. Fairchild.

In separate envelope.

To His Honor

William Mortimer Clark, etc., etc., etc.,

Lieutenant-Governor of the Province of Ontario.

Sir:

I have the honor to transmit herewith, for presentation to the Legislative Assembly, the Thirteenth Report of the Bureau of Mines.

I have the honor to be, Sir,

Your obedient servant,

E. J. DAVIS,

Commissioner of Crown Lands.

Department of Crown Lands,

Toronto, 17th March, 1904.

INTRODUCTORY LETTER

To the Honorable E. J. Davis,
Commissioner of Crown Lands.

Sir :—

I beg to submit to you herewith, to be presented to His Honor the Lieutenant-Governor, the Thirteenth Report of the Bureau of Mines.

The Report is in two parts ; Part I, containing statistical and other information concerning the mineral industry of Ontario and a variety of papers dealing with important subjects connected with the industry or with the mineral resources of the Province ; and Part II, to be published separately, consisting of a monograph by Prof. W. G. Miller, Provincial Geologist, on the Limestones of Ontario. The need for a work of the latter kind has been apparent for some years, or ever since the uses of limestone began to multiply and the demand for material suited for specific purposes revealed the dearth of information, or at any rate of classified information, respecting the limestones which abound in Ontario of varying composition and geological age. Previous investigators have described many outcroppings and occurrences of limestone found in the Archaean rocks and constituting also a large proportion of the Silurian and Devonian formations of the Province ; and references to these, with numerous analyses, may be found in the reports of the Geological Survey of Canada and the Bureau of Mines, as well as elsewhere. Many of these reports, however, are out of print and are no longer accessible to the public ; and even if they were available, the difficulty of locating and collecting these references and analyses is so great as to render the information of comparatively little practical value. In addition to massing the data previously on record, Prof. Miller has made many independent investigations, the results of which are set out in his paper, and it is confidently hoped that his treatment of the subject, while not wholly complete, is such as to present to the numerous users of limestone a body of facts and particulars which will be of service to them.

Part I, or the Report proper, contains a report on the Mines of Western Ontario and one on the Mines of Eastern Ontario, the former by Mr. W. E. H. Carter, the efficient secretary of the Bureau, who also performs the duties of Inspector of Mines, and the latter by Prof. Miller, who combines the functions of an Inspector with those of Provincial Geologist. These reports give many useful details of the mines and prospects at which operations were carried on during 1903, and exhibit the condition of the mining industry in the two divisions into which the Province naturally falls for inspection purposes.

Other methods pursued by the Bureau in its endeavors to promote the welfare of the mining industry are represented by the Provincial Assay Office at Belleville, where assays and analyses of mineral samples are made at low rates for the benefit of prospectors and others. the assayer in charge being Mr. A. G. Burrows, who reports upon the work of the office for the year ; the Summer Mining Schools, which have been carried on under the auspices of the Bureau for a number of years and which have for their object the instruction of working miners, prospectors and others, in the identification of minerals and the rudiments of mineralogy, geology and chemistry, of which classes for 1903 Dr. W. L. Goodwin, Director of the School of Mining at Kingston, with whom was associated as instructor Mr. J. G. McMillan, of the School of Practical Science, Toronto, gives an interesting account ; and the diamond drills, two of which are owned and operated by the Bureau for the benefit of owners of mineral lands wishing to explore them by means of bore holes, a summary statement with tables of cost being given, showing the work done with the drills during the year.

Mr. D. G. Boyd, Inspector of the Michipicoton Mining Division, gives a brief report on affairs in the Division during 1903, where mining received a serious setback through the collapse of the Clergue companies, which formerly were actively engaged in raising iron and extracting gold in that locality. It is hoped the contemplated resuscitation of these concerns will be followed by a revival of their mining operations, especially in iron ore, the Michipicoton deposits really owing their development, if not their discovery, to the energy displayed by these companies.

Remarkable finds of the arsenical ores of cobalt and nickel, some of the veins carrying a profusion of native silver, were made during the construction of the Temiskaming and Northern Ontario Railway—the Ontario Government line—through the unsurveyed territory south of the township of Bucke, and notwithstanding the lateness of the season when the discoveries became known, it was deemed advisable that Prof. Miller should visit the spot and make an examination of the deposits. This he was able to do before the snow fell, and the account which was published of these valuable ores aroused much interest. It is reprinted with considerable additions in the present volume under the title "Cobalt-Nickel Arsenides and Silver." As soon as spring opens it is proposed by the Department of Crown Lands to survey the area in which these mineral deposits are found, and to subdivide it into concessions and lots. This will much assist in making a more detailed examination of the geology of the region than was possible during the closing days of last autumn, as well as in ascertaining, if possible, the extent of the mineral-bearing tract and the relations which the deposits sustain to the enclosing rocks, which appear to be in the main the slate-breccia or conglomerate of the type characteristic of the Temagami region.*

The prospect of the early construction of a transcontinental line, traversing the agricultural belt of Ontario lying north of the Height of Land and the connection which the Government of this Province has undertaken to make therewith by extending the Temiskaming and Northern Ontario Railway a sufficient distance to effect a junction, render it a pressing necessity to ascertain in as much detail as possible the nature of the country which will thus be opened up for settlement. It is known that a wide zone of arable clay land stretches almost across the entire width of the Province in a northwesterly direction from the latitude of lake Abitibi, but previous investigations have necessarily been general in their nature, covering, as they did, extensive tracts of territory. Advantage was taken of the sending by the Department of Crown Lands of a number of surveying parties into the country south and west of lake Abitibi for the purpose of sub-dividing it into farm lots, to despatch an expedition into the same area with the view of ascertaining the character of the prevailing rock formations and the likelihood of minerals being found of economic value. Mr. Geo. F. Kay, fellow in Geology at the University of Chicago and a graduate of the University of Toronto, who had already performed field work for the Bureau and had carried on explorations for the Clergue companies, was placed in charge of the party as geologist, and it was deemed advisable to associate with him an agricultural expert in the person of Mr. Tennyson D. Jarvis, demonstrator in the department of Biology at the Ontario Agricultural College, Guelph, who might report on the quality of the soil, the flora

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*Prof. Miller has since re-entered the field, and in a letter to the Bureau dated 26th June 1904, enumerates the principal minerals so far recognized in these unique deposits. "The chief ores are: niccolite, smaltite, chloanthite, native silver, erythrite, annabergite, dyscrasite, pyrargyrite, argentite. Native bismuth is found in all the deposits. Millerite and morenosite occur sparingly. Tetrahedrite and copper pyrites are also found, as also is graphite. Galena, zinc blende and iron pyrites occur in the disseminated form in the adjoining rock masses. Secondary products resembling asbolite and other minerals are common. The oxides of manganese appear to be present. Sulph-arsenides and sulph-antimonides of silver, which have as yet not been analyzed, are also probably associated with these ores, as are the arsenides of iron and various bismuth compounds. No large crystals are found, thus making it difficult to recognize some of the rarer minerals in the field. Microscopic or semi-microscopic crystals of smaltite and one or two other minerals are abundant."

and fauna, and generally the adaptability of the region examined for permanent settlement. The report of Messrs. Kay and Jarvis on the Abitibi region and its agricultural capabilities will be read with interest, and on the whole bears testimony to the general accuracy of preceding explorers, who have reported in favorable terms on the northern heritage of Ontario.

A special appropriation of $3,000 was made by the Legislature in the session of 1903 to defray the expenses of an expedition into the country north of the Height of Land for the purpose of procuring more definite information respecting the deposits of lignite which were known to exist in the valleys of a number of the rivers tributary to James Bay. Other minerals of importance have also been reported from a number of localities in that region, and it was thought possible to combine the work of examining some of these deposits with the main object of the expedition. The party was placed in charge of Mr. J. M. Bell, lecturer in Geology at Harvard University, and a graduate of Queen's University, Kingston, who, while in the employ of the allied companies of Sault Ste. Marie, had spent some time in exploring northern Ontario for economic minerals, including coal. Associated with Mr. Bell was Dr. W. A. Parks, lecturer in Mineralogy and Geology at the University of Toronto, who had also a good acquaintance with the geology of the northern portions of the Province acquired while exploring for the Bureau of Mines, and whose attainments as a palaeontologist qualified him to deal with questions of stratigraphy arising in the field. The difficulties of transporting heavy machinery, such as drilling apparatus, in a region where everything must be taken in in canoes and packed across portages on the backs of voyageurs, restricted the party to such tools as could be carried in this way, and in the case of some of the lignite occurrences the appliances proved inadequate to determine the extent and value of the beds. Nevertheless, the results of the expedition were such as to make it evident that in these lignite seams, as well as in the iron-bearing formations on the Mattagami and Opazatika, the gypsum beds of Moose river, Gypsum mountain and elsewhere, the kaolinic clays of the Abitibi, Soweska, Moose and Wabiskagami, and, lastly, the great peat bogs of the coastal plain surrounding James Bay on the south, the Province possesses resources of great potential value, much of which will be rendered available by the construction of the Government railways already mentioned. The expedition opened up a hitherto unknown portion of the Province by examining and charting lake Kesagami, whose remarkable cliffs and islands of peat are described by Mr. Bell.

Dr. Parks supplies an account of the Devonian fossils collected by him while exploring the Kwataboahegan river, a tributary of the Moose river entering that stream not far from its mouth, thus adding material to the data necessary for a better classification of the rocks in that region than it has hitherto been possible to make. The formations of the most southern part of the Province are proving to have their counterpart in the extreme north, and it is not unreasonable to suppose that these may be found to contain similar deposits of economic minerals, such as petroleum, natural gas and salt. The presence of gypsum—also found in southern Ontario—has already been abundantly established.

One of the most firmly established mining industries of the Province is that which is engaged in raising and treating the nickel-copper ores of the Sudbury region. The mineral-bearing ranges have usually been described as two in number, the southern and the northern. The working mines are all so far situated on the southern range, to which existing railway communication is confined. Dr. A. P. Coleman, Professor of Geology in the University of Toronto, and Mineralogist of the Bureau of Mines, has spent two consecutive seasons in the Sudbury nickel area, and his paper in the present report entitled, "The Northern Nickel Range," presents a continuation of the work begun in 1902, the results of which were given in the Twelfth Report under the heading "The Sudbury Nickel Deposits." Dr. Coleman has arrived at the conclusion that the nickel- bearing area is really comprised in a continuous band of eruptive rock, entirely enclosing a roughly elliptical or boat-shaped area composed in the main of tuffs, slates and sandstones, about 35 miles long and 8 miles wide. This nickel-bearing band on its inner edge is acid in composition and tends to phases of granite or syenite, but becomes more basic and passes into gabbro or norite as it approaches the outer rim, where the ore bodies are found. Dr. Coleman regards the belt of eruptive as probably synclinal in form and as really constituting a gigantic laccolithic sheet, whose up-turned edges rest on rocks of Archaean age both on the north and the south. He will probably complete his examination of the nickel field during the season of 1904, and it is intended to issue a full account of the region and industry, with maps, in the Fourteenth Annual Report of the Bureau, and perhaps also in the form of a monograph.

Dr. Coleman has given much attention to the glacial geology of Ontario, and has for some years past been devoting considerable time to delimiting the boundaries of the ancient ice-dammed lake which once occupied on a larger scale the basin of what is now Lake Ontario. In his paper on the Iroquois Beach in Ontario he traces the northern shore of this lake from Niagara around by Hamilton, Toronto, Port Hope, Trenton and Peterborough until it disappears from view, and discusses the interesting questions of differential elevation, former and present systems of drainage, etc., arising out of or connected with these phenomena of glacial times.

The yearly Reports of the Bureau continue to be in much demand among persons interested in the mineral resources of the Province, so much so that the only Report of which any considerable number of copies now remains on hand is the Tenth, or that published in the year 1901. Of this an extra edition was printed for distribution at the Pan-American Exposition held at Buffalo, N.Y., in that year, the whole of which was not then given away. The entire issue of Bulletin, No. 5, entitled, "Peat Fuel : Its Manufacture and Use," was exhausted some months ago, necessitating its re-publication in the Twelfth Report, of which only a few copies are now left. It is thought that by adopting the system of publishing bulletins or monographs dealing with subjects of importance, of which a considerable number can be struck off, the demand information on special subjects may be met without requiring a larger edition of the annual for Report to be printed than at present. It is, accordingly, proposed to publish a series of such bulletins on important minerals in Ontario, giving all the information which may be available on the subjects of which they will treat. A beginning in this work has already been made, Bulletin No. 5, already mentioned, having dealt with the subject of Peat Fuel, and Part II of the present Report with the Limestones of the Province.

The announcement made in the introduction to the Twelfth Report may be repeated here, namely, that on payment of a reasonable charge the services of Prof. W. G. Miller, Provincial Geologist, may be obtained during a limited portion of the year by persons wishing to have their mineral properties examined and reported upon. Correspondence to this end should be addressed to the undersigned.

I have the honor to be, Sir,

Your obedient servant,

THOS. W. GIBSON,

Director.

Office of the Bureau of Mines,
Toronto, 17th March, 1904.

REPORT OF
THE BUREAU OF MINES
1904

Vol XIII Part I

By Thos. W. Gibson, Director

Statistical Review

The value of the mineral products of Ontario for the year 1903 was slightly under that for 1902, the decrease being wholly in the output of metallic substances, non-metallic products showing a material gain. Values were well maintained in the non-metallic class, in some instances even advanced, but in the metallic list a decided downward tendency was exhibited; hence the aggregate value of the one class of products was greater and of the other smaller than it would have been were the comparison made on the basis of prices prevailing in 1902.

The total output footed up to a value of $12,870,593, the reduction as compared with the previous year being about 4 per cent. The chief decreases in the metallic production were in iron ore and steel, the greater part of the shrinkage being accounted for by the paralysis that fell on the Sault Ste. Marie industries, involving as it did the closing of the Helen iron mine, from which the great bulk of the iron ore raised during the last four years in Ontario has come, as well as the stoppage of the Algoma Steel Works. A diminution in the yield of the precious metals and a smaller output of pig iron, also contributed to the result. On the other hand, 1903 was the record year in nickel and copper, the production of which, both in quantity and value, considerably exceeded that for 1902, or any previous twelvemonth. When the increased facilities for mining and treating the nickel-copper ores of the Sudbury district now being provided come into full operation, the output from this field will doubtless show still further advance.

The most notable increase among non-metallic substances was exhibited by petroleum, where, owing to higher prices, a considerably smaller yield brought a much larger return. Slight fluctuations were shown by some of the other articles of staple production, such as salt, lime, stone and brick, but on the whole the important industries concerned with these materials have improved their position during the year in the matter of prices, and have held their ground in point of production. Portland cement also took a long stride forward during the year; indeed, few products can show so consistent and rapid a rate of increase from the time of its first appearance in the list. Among the other branches of the mineral industry represented in the non-metallic class, there are a number which present unmistakable signs of growth, and which bid fair to rise to a much higher place in the extent and value of their products. Corundum, feldspar, iron pyrites, and calcium carbide are all undergoing favorable development. Mica has stepped well forward, and Ontario, along with her sister Province of Quebec, now ranks as the principal producer of the phlogopite or "amber" mica, so desirable in the manufacture of electrical apparatus.

Just before the snow fell in November last, some remarkable discoveries of nickel, cobalt, arsenic and silver ores were announced from a point in the unsurveyed territory along the line of the Temiskaming and Northern Ontario railway, south of the township of Bucke, and Prof. Miller, Provincial Geologist, was at once instructed to make an examination of the deposits.

In the few days at his disposal before the coming of winter, which put an end to exploration, Mr. Miller ascertained beyond doubt that the discoveries were very rich as well as unique in character. In a slate or slate-breccia formation, and within a short distance of one another, some four veins were found, carrying compounds of arsenic, cobalt and nickel in the form of smaltite and niccolite, and in some of the veins abundance of native silver. Time did not permit of extensive examinations being made, so that it is yet uncertain whether the deposits are isolated in occurrence, or whether others of similar character are likely to be found. The areas occupied by the slate or slate-breccia are, however, widespread and numerous, and there appears to be no reason why the ore bodies should be confined to one small corner. The discoveries were made by men engaged in constructing the line of the Government railway, the railway, indeed, being located almost directly over one of the deposits, and they well illustrate the possibilities of the northern regions of the Province, where so much wealth doubtless yet lies concealed, as well as the propriety of prospecting every square mile of the so-called Huronian formations. A fuller account of these discoveries, with analyses of the ores, is given in this volume by Mr. Miller. The richness of the finds and the possibility of the occurrence of another nickel field within the boundaries of the Province led to the withdrawal of a belt or tract of land ten miles in width on either side of the railway from the northern boundary of the township of Widdifield to the town of New Liskeard, by Order in Council dated 11th November 1903, to the end that such steps might be taken as were required by the public interest. On 6th April 1904 the Order in Council was rescinded, and it was provided that mining locations within the above belt should not exceed 40 acres in area, and that no applicant should be entitled to more than three such locations in any one calendar year. Part of the belt lies within the Temagami Forest Reserve, and to this portion the Forest Reserve regulations will also apply. Among other things, these regulations require any one wishing to prospect for minerals in a Forest Reserve to take out a license costing $10 per annum, and they also make provision for the careful protection of the pine and other timber.

Prospecting for minerals, especially for iron ores, was active during the exploring season of 1903. Much work was done on the various iron "ranges" of the north, and the extension of railway facilities into the Temagami region is likely to lead to the systematic testing of some of the enormous outcroppings of banded ore in that region as soon as drilling plants and other necessary appliances can be taken in.

In the following schedule are given the output and value of the various minerals and mineral products in the Province for 1903, as well as the number of workmen and amount of wages paid in the mining or treatment of each product :

Summary of Mineral Production

Product.		Quantity.	Value. $	Employees.	Wages. $
METALLIC :					
Gold	oz.	10,383	188,036	493	245,490
Silver	"	16,688	8,949	32	8,000
Copper	tons.	5,331	716,726 }	1,437	872,302
Nickel	"	6,998	2,499,068 }		
Iron Ore	"	208,154	450,099	324	166,457
Pig Iron	"	87,004	1,491,696 }	622	283,928
Steel	"	15,229	304,580 }		
Pig Lead	"	25	1,500	20	5,189
Molybdenite	"	85	1,275	5	450
Zinc Ore	"	1,150	17,000	28	7,184
			5,678,929		
Less value Ontario ore smelted into pig iron, and pig iron converted into steel			436,354		
Net metallic production			5,242,575	2,961	1,589,000
NON-METALLIC :					
Actinolite	tons.	550	1,650	8	907
Arsenic	"	257	15,420	24	....
Tile, drain	No.	18,200,000	227,000 }	3,113	771,163
Brick, common	"	230,000,000	1,561,700 }		
" paving	"	3,788,800	45,288 }		
" pressed and terra cotta	"	23,702,610	218,550	207	94,182
Building and crushed stone			845,000	1,270	500,000
Carbide of calcium	tons.	2,507	144,000	66	33,934

Summary of Mineral Production—Continued

Product.		Quantity	Value. $	Employees.	Wages. $
NON METALLIC—Continued					
Cement, natural rock	bbl.	89,549	69,319	74	20,750
" Portland	"	695,260	1 182,799	780	368,504
Corundum, grain	tons.	849	84,900	186	106,332
" cobbed	"	270	2,700		
Feldspar	"	15,296	20,046	51	14,089
Graphite	"	4,400	20,636	63	21,578
Gypsum'	"	4,520	7,910	19	4,325
Iron pyrites	"	7,469	21,693	39	16,327
Lime	bush.	3,400,000	520,000	725	193,500
Mica	tons.	948	102,205	164	45,394
Natural gas			196,535	138	79,945
Peat fuel	tons.	1,100	3,300	12	4,000
Petroleum	imp. gals.	16,640,338			
Illuminating oil	"	7,096,073			
Lubricating oil	"	2,614,313			
Benzine and naphtha	"	832,153	1,586,671(1)	291	165,700
Gas and fuel oils and tar	"	1,968,172			
Paraffin wax and candles	lbs.	2,673,806			
Pottery			160,000	150	57,000
Salt	tons.	58,274	388,097	208	87,995
Sewer pipe			199,971	101	46,486
Talc	tons.	920	2,625	8	1,275
Total non-metallic production			$7,628,018	7,697	2,633,386
Add metallic production			5,242,575	2,961	1,589,000
Total production			$12,870,593	10,658	4,222,386

(1) Value of refined products and of crude oil (2,176,000 imp. gals.) used for fuel and gas-making, etc.

A comparison of the foregoing table with the one for 1893, ten years ago, reveals not only a large gain in the total value of production, amounting to $6,749,840, or upwards of 100 per cent., but also a decided increase in the number and range of the minerals and mineral substances produced. The following articles not appearing at all on the list for 1893 figure, for the values given, in 1903: Iron ore $450,099, pig iron $1,491,696, steel $304,580, molybdenite $1,275, lead $1,500, zinc ore $17,000, actinolite $1,650, arsenic $15,420, carbide of calcium $144,000, corundum $87,600, feldspar $20,046, graphite $20,636, iron pyrites $21,693, talc $2,625, peat fuel $3,300, and paving brick $45,288. The only minerals which disappeared from production during the same period were phosphate of lime and cobalt, of which $200 worth and $9,400 worth respectively were produced in 1893. The former of these two substances was driven out by the competition of the lower grade but more cheaply mined phosphate of the southern States, but the recent finds along the Temiskaming and Northern Ontario railway are likely to restore cobalt ores to the list of products, probably in increased quantity and value. The yield in 1893 was from the nickel-copper ores of the Dominion Mineral Company's mines.

The progress of the mineral industry during the last five years may be traced by means of the table on page 4, from which it will be seen that the value of the metallic output rose from $2,055,592 in 1899 to $5,242,575 in 1903, of non-metallic materials from $6,361,081 to $7,628,018, and of the total from $8,416,673 to $12,870,593, the aggregate gain during the five-year period being 53 per cent.

Gold and Silver

The output of gold for 1903, as returned to the Bureau of Mines, was 10,383 ounces of bullion worth $188,036, a considerable decrease from the yield for 1902, when it was 13,625 ounces valued at $229,828. The product of the gold mines of the Province has, in fact, been growing less year by year since 1899, when at the sum of $424,568 it reached the highest point yet recorded.

The causes for this continued decline are various, and allusion has been made to them in previous reports. The gold ores of Ontario are in the main, so far as yet proven, low-grade in character, and to be made to yield a profit must be worked on a considerable scale, and by companies with sufficient capital and confidence to expend large sums of money in thoroughly proving and developing their properties before looking for large returns. The bane of gold-mining in the Province has been the excessive haste of

Mineral Production 1899 to 1903

Product.	1899	1900	1901	1902	1903
METALLIC:	$	$	$	$	$
Gold	424,568	297,861	244,443	229,828	188,036
Silver	65,575	96,367	84,830	58,000	8,949
Copper	176,237	319,681	589,080	680,283	716,726
Nickel	526,104	756,626	1,859,970	2,210,961	2,499,068
Iron Ore	30,951	111,805	174,428	518,445	450,099
Pig Iron	808,157	936,066	1,701,703	1,683,051	1,491,696
Steel		46,380	347,280	1,610,031	304,580
Pig Lead					1,500
Molybdenite				400	1,275
Zinc Ore	24,000	500	15,000	11,500	17,000
	2,055,592	2,565,286	5,016,734	7,002,499	5,678,929
Less value Ontario ore smelted into pig iron, and pig iron converted into steel				745,000	436,354
Total metallic production	2,055,592	2,565,286	5,016,734	6,257,499	5,242,575
NON-METALLIC:					
Actinolite			3,126	6,150	1,650
Arsenic	4,842	22,725	41,677	48,000	15,420
Brick, common	1,313,750	1,379,590	1,530,460	1,411,000	1,561,700
" paving	42,550	26,950	37,000	42,000	45,288
" pressed and terra cotta	105,000	114,419	104,394	144,171	218,550
Building and crushed stone	667,532	650,342	850,000	1,020,000	845,000
Carbide of calcium	74,680	60,300	168,792	89.420	144,000
Cement, natural rock	117,039	99,994	107,625	50,795	69,319
" Portland	444,227	598,021	563,255	916,221	1.182,799
Corundum		6,000	53,115	83,871	87,600
Feldspar		5,000	6,375	12,875	20,046
Graphite	16,179	27,030	20,000	17,868	20,636
Gypsum	16,512	18,050	13,400	19,149	7,910
Iron pyrites			17,500	14,993	21,693
Lime	535,000	544,000	550,000	617,000	520,000
Mica	38,000	91.750	39.780	102,500	102,205
Natural gas	440,904	392,823	342,183	199,238	196,535
Peat fuel					3,300
Petroleum products	1,747,352	1,869.045	1.467,940	1,431,054	1.586,674
Pottery	101,000	157,449	193,950	171,315	160,000
Salt	317,412	324,477	323,058	344,620	388,097
Sewer pipe	138,356	130,635	147,948	191,965	199,971
Talc	500	5,000	1,400	930	2,625
Tile, drain	240,246	209.738	231,374	199,000	227,000
Total non-metallic production	6,361,081	6,733,338	6,814,352	7,134,135	7,628,018
Add metallic production	2,055,592	2,565,286	5,016,734	6,257,499	5,242,575
Total production	8,416,673	9,298,624	11,831,086	13,391,634	12,870,593

many engaged in it to produce bullion, the effort to do so leading them to lay out their capital upon stamp mills and works above ground before sinking on their veins and demonstrating by drifts and levels that the values contained in the lode warranted the erection of a surface plant. Time and again funds have been exhausted before the existence of payable ore bodies was either proven or disproven, and discouraged shareholders have refused to make further contributions towards what appeared to be a doubtful or hopeless cause. Had the natural and legitimate course been adopted of blocking out ore reserves before putting up expensive surface plants, not so many decaying stamp mills would now be disfiguring the gold districts of western Ontario, and those districts would be in better repute.

Want of judgment, and, in some cases, want of honesty, on the part of promoters and directors, as well as lack of competent and experienced management, have also contributed to the failure. There is good ground for believing that the free-milling ores of this Province, offering as they do no special difficulties of treatment, will yet be mined and crushed at a profit by companies whose operations are superintended by men of skill, experience and technical training.

The producing mines of last year were the Grace, Michipicoton district, owned by the Algoma Commercial Company; the Big Master and the Twentieth Century, both in the Manitou district, the former the property of the Interstate Consolidated Mineral Company, and the latter of the Twentieth Century Mining Company; and the Atlas and Belmont mines in the Hastings county gold field of eastern Ontario. Other properties were worked on a small scale, but with the exception of the Northern Light Mines Company, on Eagle lake, none turned out any bullion, the operations being confined to preliminary prospecting.

Following are statistics of the gold-mining industry from 1899 to 1903, inclusive:

Gold Mining 1899 to 1903

Schedule.	1899	1900	1901	1902	1903
Mines worked ... No.	15	18	11	20	19
Ore treated ... tons.	59,615	46,618	54,336	48,544	32,347
Gold product ... oz.	27,594	18,767	14,293	13,625	10,383
Gold value ... $	424,568	297,861	244,443	229,828	188,036
Men above ground ... No.	307	412	305	341	243
" under ground ... "	356	338	288	385	250
Wages paid ... $	324,024	350,694	287,409	343,984	245,490

The St. Anthony Reef mine, on Sturgeon lake, north of Ignace station on the Canadian Pacific railway, is being equipped with a 10-stamp mill, formerly on the Golden Star, which was taken in over the ice during the past winter, and is expected to be in operation early in the summer of 1904. On A L 282 or the Sunbeam mine, a mill is also to be erected, careful development work carried on for some time having, in the opinion of those interested, shown that the mine will be a paying one.

A find of free gold on lot 5 in the first concession of the township of Shakespeare, not far from Webbwood station on the Sault branch of the Canadian Pacific railway, caused much local excitement on account of the rich and handsome specimens obtained. Development work was at once undertaken and has been continued ever since. The prospects are encouraging, and the property is believed to be valuable.

All the silver produced in Ontario so far has come—with the exception of the trifling quantity found associated with the gold in ores worked for that metal—from the Animikie formation of the northwestern shore of Lake Superior. Here was situated the famous Silver Islet mine, where from a tiny rock projecting above the waters of that lake was raised silver ore aggregating in value some $3,500,000, and on the main land were worked the rich deposits of Rabbit Mountain, the Badger, Beaver, Silver Mountain and other mines. When silver fell from its high estate to 50 or 55 cents an ounce, these mines for the most part went out of commission, but one or two were sufficiently high in grade to warrant their operation, even at the reduced value of their product. For several years, West End Silver Mountain mine has been producing annually about $70,000 worth of silver, but early in 1903 a serious fire occurred, which burned down the shaft and power houses and otherwise injured the property, bringing operations to a close. The production of silver in 1903 consequently fell to the lowest point reached since 1897.

The statistics of silver mining from 1899 to 1903 are as follows:

Silver Mining 1899 to 1903

Schedule.	1899	1900	1901	1902	1903
Ore raised ... tons.	8,000	12,500	11,000	6,250	3,400
Ore stamped ... "	8,000	8,000	7,560	6,250	3,360
Bullion product ... oz.	105,467	160,612	151,400	96,666	16,688
Value of bullion ... $	65,575	96,367	84,830	58,000	8,949
Men above ground ... No.	23	20	30	25	12
" below ground ... "	17	30	35	25	20
Wages paid ... $	29,000	24,000	29,500	36,000	8,000

Nickel and Copper

In nickel, which may be called the distinctive metal of Ontario, the production of the past year reached the highest point yet recorded. The output for several years past has been increasing at an accelerated rate, the quantity produced in 1903 being nearly double that for 1900. In value the advance has been even more decided, the product in 1903 being worth more than three times the product in 1900. To the superior richness of the ores now raised by the Canadian Copper Company, which come chiefly from the Creighton mine, as compared with the lower grade ores of the Evans, Stobie and other deposits formerly worked, the marked increase in the amount of nickel raised is probably in large part due; while the enhanced value arises from the fact that the nickel-copper mattes are now and for the past three years have been brought to a much higher metallic content than formerly, thus conferring a greater value per pound upon the metals contained. The mines of the Sudbury district are now disputing with the deposits of New Caledonia the position of pre-eminence as a source of nickel, and although there is much variety in the statistics given of the New Caledonian production (2) it is evident that the present rate of growth in the output of Ontario will soon give this Province the supremacy, if it has not already attained it.

The nickel contents of the mattes produced by the operating companies in 1903, namely, the Canadian Copper Company, the Mond Nickel Company, and the Lake Superior Power Company, aggregated 6,998 tons in weight and $2,499,068 in value, being in excess of the production of 1902 by 1,053 tons in weight and $288,107 in value. The quantity of ore raised from the mines was much less than in 1902, being 152,940 tons, as compared with 269,538 tons, but the quantity smelted showed comparatively little reduction, since there was put through the furnaces 214,368 tons, as against 233,388 tons last year.

Both the Canadian Copper Company and the Mond Nickel Company smelted considerably more ore than they raised, drawing on their reserves in the roast heaps, where ore may rest for several months during and subsequent to the process of desulphurization, before being sent to the smelters. The Mond Company confined its mining operations to the taking of some ore from a property held under option, and having run all the roasted ore on hand through the smelter, it ceased operations for the time being. Neither was the raising of ore pushed last year by the Canadian Copper Company, whose energies and labor were largely occupied with the extensive overhauling and re-modelling of the smelting plant, which has been going on for upwards of a year. It is expected that the new works, which will produce bessemer matte, will be ready for operation by May or June, 1904. Early in March of the present year (1904) the Ontario Smelting Works, in which the Canadian Copper Company's low grade mattes were retreated and enriched, were consumed by fire, and the company leased the converting plant at Victoria Mines in which to bessemerize its mattes. The mines and smelter of the Lake Superior Power Company were closed down early in 1903, as a result of the financial difficulties in which this and the other Clergue companies became involved. It is understood that there is a considerable stock of ordinary or low-grade matte in stock at the Gertrude smelter.

The schedule which follows shows the progress of the nickel-copper mining and smelting industry during the last five years :

(2) For instance, the amount of nickel refined from New Caledonia ores in 1901 is given by Annales des Mines (whose figures are adopted by The Mineral Industry) as 6,202 metric tons, while Metallurgische Gesellschaft, A. G., places it at 5,210 metric tons. The last-mentioned authority credits New Caledonia with an output of 3,620 metric tons in 1902, and Canada with 4,715 tons. Apparently, however, this authority takes no account of the product of Canadian matte refined in England. The nickel contents of the ore exported from New Caledonia in 1902 is given by Annales des Mines as 7,045 metric tons. As its own tables show, the latter quantity for a succession of years is invariably much in excess of the quantity of nickel actually recovered.

Nickel-Copper Mining 1899 to 1903

Schedule.		1899	1900	1901	1902	1903
Ore raised	tons	203,118	216,695	326,945	269,538	152,940
Ore smelted	"	171,230	211,960	270,380	233,388	220,937
Ordinary matte produced	"	19,109	23,336	29,588	24,691	30,416
High-grade matte produced	"	106	112	15,546	13,332	14,419
Nickel contents	"	2,872	3,540	4,441	5,945	6,998
Copper contents	"	2,834	3,364	4,197	4,066	4,005
Value of nickel	$	526,104	756,626	1,859,970	2,210,961	2,499,068
Value of copper	"	176,236	319,681	589,080	616,763	583,646
Wages paid	"	443,879	728,946	1,045,889	835,050	746,147
Men employed	No.	839	1,444	2,284	1,445	1,277

Judging from the above figures, the percentage of nickel in the ore smelted, or at any rate the proportion of nickel recovered therefrom, has increased materially during the last two years. In 1899 and 1900 the contents of nickel in the matte product was 1.67 per cent. of the ore smelted, and in 1901 1.64 per cent., while in 1902 it rose to 2.54 per cent., and in 1903 to 3.16 per cent., or nearly twice as high as in 1901. As mentioned already, this enhanced value must largely be set down to the credit of the Creighton mine, an extensive body of high-grade ore, which, being easily worked by quarrying methods, is now drawn upon by the Canadian Copper Company for the bulk of its supplies, other mines, though far from exhausted but more expensive to work and yielding leaner ore, being held in reserve.

The greater part of the copper produced in Ontario is the product of the nickel-copper mines of the Sudbury district, but there are also a number of non-nickeliferous copper properties, some of which are now giving excellent promise of becoming large producers. Perhaps the foremost among these is the Massey Station mine, in the township of Salter, where the main shaft is now down to a depth of nearly 600 feet, and in the neighborhood of which are other copper ore bodies undergoing exploitation. Other mines on the north shore of Lake Huron are the Rock Lake and Superior, and west of Lake Superior the Tip-top mine is being developed with promise of proving a valuable property.

Following are statistics covering the operation of these purely copper properties during 1903, with the figures for 1902 given for purposes of comparison:

Copper Mines 1902-3

Schedule.	1902	1903
Ore raised..............tons.	21,800	23,030
Copper in ore, estimated "	794	1,326
Value copper in ore " $	63,520	133,080
Concentrates produced.tons	720	2,500
Value concentrates..... $	28,082	75,000
Workmen employed.... No.	287	250
Wages paid .... $	137,859	171,155

Adding the copper product from the above mines to that from the copper-nickel mines, a total output is obtained of 5,331 tons, valued at $716,726.

Iron and Steel

Compared with 1902, the output of iron ore fell off considerably both in quantity and value, 208,154 tons worth $450,009 being raised, as against 359,288 tons worth $518,445, the previous year. Of the quantity raised, 195,504 tons were hematite and 12,650 tons magnetite. The Helen mine in Michipicoton being now the main source from which Ontario ore is drawn, the business of iron mining in the Province practically came to an end with the stoppage of work at that mine, before the end of the shipping season last year. Apart from a small quantity of ore raised from a hematite property in Hastings county, the only other mine in operation during the year was the Radnor, in the township of Grattan, Renfrew county, where the Canada Iron Furnace Company has for two or three years past been developing a fair-sized body of good magnetic ore. The output is taken by rail to the company's blast furnaces in Quebec, where it is used with a mixture of bog ore.

The fundamental place occupied by iron and steel in the industrial fabric of civilization has given rise to an immense amount of exploration for fresh supplies of workable ore in all regions of the world which are sufficiently accessible to the centres of iron and steel production. The anxiety to uncover new sources of supply has its root in the fact that present reserves, though undoubtedly large, are being steadily invaded, while each succeeding decade, almost each succeeding year, sees a tremendous increase in the consumption of iron and steel. The demand for these products is rising indeed almost in geometrical ratio, more and more being required per capita as civilization advances and brings nation after nation under its sway, as well as in the general progress of the industrial arts. The necessity for new and larger sources of ore supply is therefore a pressing one, and as it is difficult to see how any other material can be substituted for iron and steel, or, indeed, how these can be diverted from many uses in which they are not at present employed, but for which they are well suited, this necessity may almost be considered bound up with the prosperity of mankind in general.

The command of vast supplies of easily worked, conveniently situated, and high-class iron ores, together with similar facilities in the matter of coal and coke, has placed the ironmasters of the United States in a position to produce iron and steel more cheaply than those of most other countries, and in consequence the development of the iron industry on this continent has been more rapid than in any other part of the world. The discovery, particularly in the States of Michigan and Minnesota in the north, and the State of Alabama in the south, of good ores in unprecedented quantity, was what made this development possible, and indeed brought it about. But the iron mines of the Mesabi, Gogebic and Vermilion ranges, and of the Birmingham district, will not for many years continue to withstand the increasing and ever-increasing demands being made upon them, and far-sighted men are beginning to apprehend that serious consequences may follow upon their depletion. Especially are there grave elements in the situation when it is realized that of the known deposits in the principal ranges of Minnesota and Michigan, about 90 per cent. of the tonnage is owned or controlled by one company, the United States Steel Corporation, thus practically making competition impossible and cutting off independent producers from fresh ore when their present supplies are exhausted. Two things will prolong, perhaps indefinitely, at any rate for generations to come, the life of the iron business, and ward off the evil day when pig iron will become scarce and consequently dear. One is the resort by blast furnacemen to ores of lower metallic contents or of inferior quality, and the other is the discovery of new and plentiful sources of high-grade ore.

Of these, the latter remedy is the one which will probably be sought for first, and its pursuit will be assiduous. Present methods of producing iron and steel in America are in the main based upon and suited to ores of good quality, easily smelted, and containing as much as 60 per cent. and upward of metallic iron. Since the opening of the mines on the iron ranges of the Lake Superior States ores of this description have been on the market in abundance, and ores of lower grade, either as regards their percentage of metallic iron or their proportion of deleterious ingredients, have been in little demand, coming into play only in seasons of great activity and high prices, when the margin of profit was sufficiently large to permit of their being used.

In order to retain the advantage of employing ores high in iron, and offering few difficulties of treatment, the strong tendency is to search for new supplies of like quality to take the place of those now being used when the point of exhaustion is reached. The States of Michigan, Minnesota and Wisconsin have been and are now being examined with the utmost diligence and skill to see whether it is possible that nature has repeated the operations which resulted in the formation of those great ranges that have supplied, and will yet supply, so many millions of tons of high-class ore. The opinion of experts is against the probability of similar ranges being found, and the conclusion has been expressed that although many bodies of ore yet undiscovered may be brought to light within the limits already defined, it is not at all probable that extensive ranges like the Mesabi, Vermilion or Gogebic will again be found.

Iron Ores of Ontario

But the forces which produced the Minnesota iron ranges were also at work in what is now Ontario territory. The Mesabi rocks have been traced northward from Minnesota, and at various points give promise of containing valuable bodies of ore. On Hunter's Island, a short distance north of the international boundary line, recent explorations carried on by Duluth parties have, it is said, resulted in locating a large deposit of first-class ore, while at Loon lake, on the Canadian Pacific railway, the diamond drill has penetrated a flat-lying body of first-class hematite of considerable dimensions, also enclosed in rocks typically Mesabi in their character. There is a large extension of Animikie rocks, considered to be the equivalent of those of the Mesabi range, stretching from Gunflint lake on the boundary between Minnesota and Ontario, in a northeasterly direction to a point on Lake Superior east of Port Arthur, and in this area it is probable that other important deposits will be found. The iron range which has within the last two or three years been located in and west of the township of Hutton, northwest of lake Wahnapitae, and in which at least one large body of magnetic ore has been discovered, differs in some of its characteristics from the Vermilion iron-bearing series of Minnesota, its nearest prototype south of the line, and its geology has not yet been fully worked out. Its importance, however, is great, since the deposit referred to is believed to be of large size and to contain much ore of good quality. The iron formation showing banded magnetite in huge outcroppings on the northeast arm of lake Temagami and elsewhere in the neighborhood of that lake appears to be also of the Vermilion type, resembling the latter more nearly than does the Hutton or Moose Mountain range, though differing also in being, like the latter, associated with parellel bands of pyritiferous rock. Magnetic surveys of certain of the locations on the northeast arm have been made, and if this method of examination can be depended upon, there is an immense amount of ore in the deposit, the only point remaining to be proven being whether there is concentration of ore in depth, so as to get rid of the intermixture of silica or jasper so prominent on the surface. It is the intention of the owners to further prospect the locations during the present season, preliminary to putting on a diamond drill when the same can be taken in on the Government railway now being built past the eastern end of the range.

There are many other districts of Ontario, which need not here be enumerated, highly promising to the searcher for iron ore (3), not the least hopeful being some regions lying near the Hudson Bay watershed now almost inaccessible, but which will be brought within reach by the building of the Grand Trunk Pacific railway, and the projected extension of the Temiskaming and Northern Ontario railway. The large deposit of carbonate of iron, or spathic ore, at Grand Rapids, on the Mattagami river, referred to by Dr. Robert Bell in the Report of the Geological Survey for 1875-6, and described in greater detail in the present volume by Mr. J. M. Bell; the iron range near Round lake on the Blanche river, which has not yet been reported upon, but which from the specimens brought out appears to contain both specular ore and magnetite, and the banded hematite and magnetite ranges near Flying Post, on the Ground Hog river, are some of the localities which merit closer investigation, and no doubt will receive it when better means of communication and transportation are provided.

The potential resources of Ontario in iron ore have been greatly extended within the last five years by the discovery of the following iron ranges situated in widely separated portions of the Province: the Michipicoton range in the Michipicoton Mining Division, east shore of Lake Superior, containing the Helen, Josephine, Frances and Brant Lake hematite deposits; the Hutton or Moose Mountain range northwest of lake Wahnapitae, where the ore is magnetic; the lake Temagami ranges, including those on the northeast arm, Vermilion, Iron and Ko-ko-ko lakes, where the outcroppings are chiefly of magnetite banded with jasper, but which also show a little hematite; the Flying Post or Ground Hog river ranges of banded magnetite and hematite; the banded hematite belt of Black Sturgeon lake, southwest of lake Nipigon, and the extensive range of interbanded hematite and jasper stretching, with some interruptions, from the east shore of lake Nipigon to Little Long lake, a distance of some 70 miles, the western and eastern terminations of which on Nipigon and Little Long lakes respectively have long been known.

(3) For a fuller account see Iron Ranges of Northern Ontario, 12th Rep. Bur. Mines, p. 304, etc.

Of workable bodies of ore during the same period there have been discovered, in Michipicoton, the Helen, Josephine and Frances mines, the first of which has up to the end of 1903 produced about 900,000 tons of good ore: the Loon lake deposit, which though taken up many years ago was never actually proven to exist until 1902; the large, though lean, deposits of the Mattawin range; and the ore body on Hunter's island already referred to, all of which are of hematite; also the Hutton township deposit, which is magnetite. In addition to these, masses of excellent magnetic ore have been found at the Radnor mine, Renfrew county, and in the township of Mayo, in the county of Hastings. It is evident therefore that the work of proving the iron ore wealth of the Province is proceeding with considerable speed, and that there is yet not only favorable ground for very many more deposits, but good reason for believing that they exist.

When the time arrives for the utilization of iron ores which are now below the accepted standard on account of their containing sulphur or titanium in objectionable proportions, or because they are too low in iron, numerous deposits in eastern and western Ontario will be available which for one or other of these reasons cannot now be worked. It is not impossible that by reason of improved processes such ore bodies will ere long be drawn upon, since their lower cost as compared with better ores, offers inducements for their utilization. Besides, sulphur can now be controlled or got rid of without excessive cost, if not present in too great quantity, and titanium, it has been discovered, rather improves than depreciates pig iron, and can also in moderate proportion be run through the blast furnace without trouble, while for certain purposes phosphorus is actually desirable, and is sometimes, where absent, even added to the charge. In any event, the furnacemen of the second quarter, or at least the second half, of the twentieth century, are likely perforce to be less averse to handling impure or low-grade ores than their fellows of the present day, for the reason that high-class, pure ores will be scarcer then than they are now.

Pig Iron and Steel

The output of the three blast furnaces of the Province—Hamilton, Deseronto and Midland—for 1903 was 87,004 tons pig iron, the value of which was $1,491,696. Of this quantity, 9,979 tons was charcoal pig valued at $151,470, and 77,025 tons coke iron worth $1,340,226. The production of 1903 was less than that of 1902 by 25,683 tons in quantity and $191,355 in value. This reduction was due in part to the Hamilton furnace being out of blast for repairs during the month of February and part of March. The average value per ton of pig iron at the furnace in 1903 was considerably more than in 1902, being $17.14, as against $14.04. Charcoal iron in 1902 was worth $16.96 per ton, and last year $15.46 per ton, while the prices of coke iron were $14.93 and $17.40 per ton respectively. Contracts are usually made for some time in advance, and these changes in price do not necessarily reflect the state of the market for the period they cover. The demand for pig iron, both charcoal and coke, was perhaps less active than in the previous year, and the tendency of prices, especially towards the close of the year, was downwards.

The product of the Ontario furnaces is all sold in Canada, mostly in Ontario. The coke smelters produce principally foundry iron, also malleable pig and a quantity of basic iron. At Deseronto, where charcoal is the fuel employed, and the ore smelted comes mainly from the Lake Superior district, the product goes principally into malleable castings, and is also used in the manufacture of cast-iron car wheels. Operating expenses were considerably greater than in 1902, owing to the higher level of the three chief elements of cost, namely, iron ore, coke and labor.

The demand for iron and steel continues to be good, and the outlook for business in 1904 is fair, clouded however in the opinion of furnacemen, by the prospect of severer competition from outside sources, principally the United States, where conditions in the iron and steel business are not satisfactory. Canada is regarded as the natural "dumping" ground of American ironmakers, and low water freights and the preferential tariff enable the furnaces of England and Scotland to market their iron here when an outlet for surplus production is required. This, however, is offset in part at least by the bounty of $2.70 per ton on pig iron and an equal amount per ton on steel, paid by the Government of Canada on the home product, as well as the bounty contributed by the Government of Ontario on iron ore mined and smelted in the Province, and the duty of $2.50 per ton which imported pig iron must pay on entry into Canada.

To produce the quantity of pig iron made in 1903, 151,229 tons of iron ore were required, of which 48,092 tons, or 32 per cent., was the product of Ontario mines, and 103,137 tons were imported from the United States.

The steel product for the year—15,229 tons—was much less than in 1902, when 68,802 tons were made. The reason for this falling off was the fact that owing to the paralysis which fell on the great industries at Sault Ste. Marie, the steel plant which ran for several months in 1902, and turned out a large tonnage of steel rails, was idle during the whole of last season. The output for 1903 was wholly the product of the Hamilton Steel and Iron Company, and was made by the open-hearth process.

Following are statistics of the iron and steel making industry of the Province for last year :

Ontario ore smelted, tons......	48,092
Foreign ore smelted, tons......	103,137
Scale and mill cinder, tons....	12,188
Limestone for flux, tons.	49,426
Coke for fuel, tons............	96,540
Value of coke for fuel.......... $	561,614
Charcoal for fuel, bush........	932,630
Value of charcoal for fuel.... $	55,958
Pig iron product, tons.........	87,004
Value of pig iron product.... $	1,491,696
Steel product, tons......	15,229
Value of steel product......... $	304,580
Workmen employed, number...	622
Wages paid........... .... $	283,928

In the following table is given a bird's-eye view of the ironmaking business of Ontario since its revival in 1896 :

Production Iron and Steel 1896 to 1903

Schedule.	1896	1897	1898	1899	1900	1901	1902	1903
Ont. ore smelted ...tons.	15,270	2,770	20,968	24,494	22,887	109,109	92,883	48,092
Foreign " ... "	35,868	34,722	56,555	85,542	77,805	85,401	94,079	103,137
Limestone flux..... "	8,657	9,473	13,799	25,301	24,927	51,452	58,885	49,426
Coke .... "	30,348	27,810	50,407	74,403	59,345	113,119	111,390	96,540
Charcoal ....bush	....	....	....	....	955,437	915,789	968,623	932,630
Pig iron ....tons.	28,302	24,011	48,253	64,749	62,386	116,370	112,687	87,004
Value pig iron...... $	353,780	288,128	530,789	808,157	936,066	1,701,703	1,683,051	1,491,696
Steel. ....tons.	....	....	....	....	2,819	14,471	68,802	15,229
Value .... $	....	....	....	....	46,380	347,280	1,610,031	304,580

Under the provisions of the Mines Act iron ore raised in Ontario and smelted into pig iron in the Province is entitled to be paid out of the Iron Mining Fund a bounty equal to $1 per ton of the metallic product of the ore, provided the amount called for does not exceed $25,000 in any one year. Where the claims on a basis of $1.00 per ton are in excess of this sum, the rate is reduced proportionately. The amount earned and paid out of this fund for the bounty year ending 31st October 1903 was $25,000. The details are as follows :

Name	Tons Ont. ore smelted.	Tons Pig Iron produced.	Bounty $
Hamilton Steel and Iron Coy	30,959	16,631	15,572 40
Canada Iron Furnace Coy.	19,160	10,06[illegible]	9,427 60
Total	50,119	[illegible]	$25,000 00

The quantity of ore eligible for bounty yielding more than 25,000 tons of pig iron, the rate per ton was lowered to $0.936. There has been paid out of the Iron Mining Fund up to the present time the sum of $109,741.01, as follows :

Bounty on Iron Ore 1896 to 1903

Year	Pig iron product Ont. ore. tons.	Bounty paid $
1896 . .	4,000.00	4,[illegible]00 00
1897 . .	2,6[illegible].95	2,6[illegible] 95
1898 . .	8,647 19	8,647 19
1899.	12,752.07	12,7[illegible]2 07
1900.	6,737.80	6,737 80
1901	55,214.00	25,000 00
1902. . . .	53,[illegible].22	25,000 00
1903	26,[illegible].28	25,000 00
Totals . .	170,522.[illegible]1	$109,741 01

The sum originally appropriated by the Legislature for the purposes of the Fund was $125,000, and by the terms of the Act it passes out of existence by effluxion of time on 1st January, 1906. The payments which have now been made leave a balance in the Fund of a little over $15,000, and the prospects are that the amount so remaining will be fully absorbed by the claims made during the current bounty year which ends 31st October 1904.

Lead

A generation ago the Frontenac lead mine in the township of Loughborough was opened up, and a small smelting plant was erected in the city of Kingston for treating the ore. The works were put up in 1879, and ran intermittently until 1881 or 1882. Since that time no pig lead has been produced in the Province until 1903, although more or less galena has been raised at several points, including the Victoria mine at Echo lake, and the Katherine mine in Hastings county. Last year the Ontario Mining and Smelting Company, a concern organized in the United States, with an authorized capital of $300,000, purchased the old Hollandia mine near Bannockburn, in the county of Hastings, cleaned out and extended the workings, and constructed a small furnace for reducing the ore. The runs so far have been mainly experimental, the quantity produced up to the close of the year being about 25 tons, having a value of $1,500.

Molybdenite

Some 85 tons of molybdenite ore was taken from a deposit on the east half of lot 5 in the fourteenth concession of the township of Sheffield in the county of Addington, and shipped to the United States and elsewhere. There were raised from the opening some 500 or 600 tons of rock carrying pyrite and pyrrhotite, with an average of perhaps 4 per cent. molybdenite, from which the quantity shipped was culled. Mr. A. M. Chisholm of Kingston had charge of the operations.

Zinc

Two zinc deposits were worked during the year, the Olden mine in the township of that name, operated by Messrs. J. Richardson and Sons of Kingston, and another in the township of Dorion, in the Port Arthur district, where the Dorion Mining Syndicate carried on development work and took out a considerable quantity of zinc-lead ore during the process.

Actinolite

For many years the mineral known as actinolite has been mined near Actinolite (formerly Bridgewater), Hastings county, in which neighborhood it occurs in considerable quantity. It is ground without destroying the fibre and is then used in the manufacture of fire-proof roofing material, paint, etc. It may also be employed as a "filler" along with the more easily worked and silky asbestos of Quebec in making steam-pipe covering, packing material and such like articles. Mr. Joseph James of Actinolite, was the principal producer last year. As mined, the crude actinolite is valued at $3.00 per ton, and after being ground, at $5.00 per ton. It is for the most part exported to the United States in the latter condition.

Graphite

Three graphite mines last year produced 4,400 tons of crude graphite in all, valued at $20,636. These were the Black Donald mine, in the township of Brougham, owned by the Ontario Graphite Company, the McConnell mine, near Oliver's Ferry, on the Rideau canal, the property of Mr. Rinaldo McConnell of Ottawa, and the Allanhurst mine in the township of Denbigh, owned by Mr. J. G. Allan. There are plants for treating or refining the ore at the Black Donald mine, and was also at Port Elmsley for the material taken from the McConnell mine. There were produced at these plants 380 tons of refined graphite worth $21,000, and 575 tons of the material were shipped for use in the crude state, including the output of the Allanhurst property. Operations at the Black Donald have been interfered with by the unfortunate circumstance that in following the lead under the bed of Whitefish lake, the bottom of the lake was pierced, admitting the water into the workings, and compelling the workmen to make a hasty retreat.

Mica

There was produced from the mica mines of Ontario in 1903, according to returns made to the Bureau of Mines, 948 tons of mica, worth $102,205. A decided change has come over the business of mica mining in this Province. Formerly a large number of small openings, hardly to be designated "mines," were spasmodically worked by their owners, mostly the farmers on whose lands they were situated, during their spare time, or when a rise in prices made it an object to bring mica to the market. Recently, modern business methods have been applied to the production of mica, and the number of properties worked has become much smaller, while at the same time operations have been on a larger scale and more steadily carried on. The output of last year was practically all from three mines, two of them, the 'Lacey and the Hanlan, owned by the General Electric Company, and the third, the Bob's lake, by Messrs. Kent Bros., of Kingston. Mr. J. W. Trousdale of Sydenham, Mr. L. J. Gemmell of Perth, and Messrs. J. Richardson & Sons of Kingston, also produced smaller quantities, from the McClatchey, Donnelly and Freeman mines respectively.

The practice is now generally adopted of simply "rough-cobbing" the mica at the mine as it comes from the pits, and forwarding the product thus obtained to the trimming works, where it is graded, split and cut into marketable sizes and forms. The figures given above as to quantity and value of product represent the "rough-cobbed" mica, and not the output of the trimming works, which employ in the aggregate a large amount of labor.

Ontario and Quebec are perhaps the leading sources of mica supply on the continent, and furnish a very large share of the mica used in the manufacture of electrical apparatus. The variety yielded by both Provinces is almost entirely phlogopite or "amber" mica, the flexibility and resistance of which to the passage of the electric current render it most suitable for this purpose. It is exported principally to the United States, but, as is shown by the table given below, quantities have of late years also gone to Great Britain, whose supplies in the past have been drawn mainly from India. Muscovite or white mica also occurs in both Provinces, but it is usually stiffer in quality, and less amenable to the bending and shaping required in making the insulating parts of electrical machinery.

The disproportion which formerly existed between the value of the larger sizes of mica and the smaller sizes has to some extent been done away by the increasing manufacture of "micanite," in which pieces of mica of all shapes and sizes are built up by means of a shellac cement into any dimension and thickness required. These boards can be cut, planed and shaped with ease, and are almost, if not quite, as efficient in their insulating properties as the mica itself. In making "micanite," the quality, not the size, of the piece is the important consideration, and fragments down to 1 inch by 2 inches in area, which were formerly relegated to the scrap heap, are now made use of in this way.

The producing mica mines of Ontario are situated in the counties of Lanark and Frontenac, in eastern Ontario, but mica of what appears to be marketable quality has also been found in the districts of Nipissing and Parry Sound.

Exports of mica from Canada for the last three fiscal years were as follows. It all came from the mines of Ontario and Quebec :

Exports of Mica

Year.	To United States.		To Great Britain.	
	lb.	$	lb.	$
1901...	761,991	121,310	211,833	26,9[illegible]
1902...	[illegible]	18[illegible],400	1[illegible],388	53,001
1903...	729,4[illegible]	185,193	6[illegible],081	143,736

Talc

The quantity of talc raised in the Province last year was 920 tons worth $2,625. It was produced from two deposits, near Madoc and Gananoque respectively. These are of diverse character, the output of the Madoc mine, which was operated by Mr. C. Henderson of that place being exported chiefly to Newark, New Jersey, where it is used in the manufacture of a popular cosmetic, or "face powder." It is also employed in making the so-called "foot elm" in Batavia, N. Y., and Bowmanville, Ont. The product of the Gananoque deposit, worked by Mr. George Jackson, is more fibrous in its nature, and is employed in the manufacture of fireproof roofing at works in Montreal.

There is a demand for a variety of talc suitable for making the burner-tips used for acetylene gas. It must be of a specially compact character.

Building Materials

There is no lack of building material in Ontario. In the southern portion of the Province where brick, stone and lime are mainly in demand, not only the surface clays but the indurated shales of certain of the Silurian series afford inexhaustible supplies of raw material for the brickmaker, while for lime limestone and sandstone, both the Silurian and Devonian rocks can be drawn upon in innumerable localities and at various points in the geological scale. For heavy construction work, such as railway building, and to some extent for lime-making, the still older rocks of Archaean age which characterize the northern districts are frequently called into use. As brick and stone are heavy articles, which cannot be transported from place to place without large expense for freight charges, this wide distribution of clay and stone is a fortunate circumstance, in that it brings within reach of the majority of people the possibility of obtaining substantial dwelling-houses and other buildings at a minimum of cost. In a northern climate like that of Canada this is no mean advantage, and contributes not a little to the general comfort and welfare.

The production of building materials, including in this term brick, both common and pressed, as well as terra cotta, lime and stone, but excluding cement, was in the aggregate about on the same level as in 1902, although the output of lime and stone was somewhat less and the output of brick somewhat greater than in that year. The figures for the last five years are given in the following table, from which it will be seen that there has been a considerable expansion in the output during the period covered :

Building Materials 1899 to 1903

Material	1899 $	1900 $	1901 $	1902 $	1903 $
Building and crushed stone	667,532	650,342	[illegible]	1,[illegible]	[illegible]
Lime	535,000	544,000	[illegible]	617,000	[illegible]
Common brick .	1,313,750	1,379,5[illegible]	1,5[illegible]	1,111,000	1,[illegible]
Pressed brick and terra cotta .	105,000	114,41[illegible]	1[illegible]	144,371	[illegible]
Totals	2,621,282	2,688,351	3,034,8[illegible]	3,192,371	[illegible]

Stone

Most of the stone quarried for building and construction purposes is limestone, the quantity of sandstone or other kinds of rocks, such as granite, trap, etc., being comparatively small. In the figures for stone is concluded the production of crushed stone or rubble used mainly in the construction of road foundations and concrete masonry, and also as limestone flux in blast furnaces.

For substantial and permanent structures, stone is often preferred, and seems likely to retain its hold, particularly where a quarry product has proved its durability by the lapse of years. Some of the limestone quarries which have been in operation a long time are now able to point to specimens of their product which have withstood the disintegrating effects of exposure to the weather for upwards of half a century. The Queenston Quarry Company, St. Davids, state that Queenston stone was used in the abutments on the Canadian side of the old bridge built across the Niagara river at that point 57 years ago. Four years ago, when the present bridge was built, the engineer took down the old abutments and used the stone in the new work, since it was still practically as good as freshly-quarried material, being without checks or defects of any kind.

The manifold usefulness of a good limestone is illustrated by the product of the Longford Quarry Company's quarries at Longford Mills. Blocks of first-class quality can be turned out in almost any size with natural face on top and bottom, which are used in the foundation of heavy walls and chimneys, also as course stone in buildings, and for bridge work. In the form of rubble it is shipped in large quantities, and as cut and dressed stone it is in demand for window sills, door steps, etc. In addition, it is used as flux for smelting iron ores, and for burning into lime.

Where smallness of cost is a prime requisite, however, and because of greater ease in handling, cement is proving a formidable competitor to stone for uses in which the latter was for long employed almost exclusively. Quarrymen look askance at the new material which is replacing their product in bridge work, foundations and construction work of various kinds, contending that it will prove less durable, and more liable to destruction by frost when exposed to the action of water. Time only will show whether these imputations are warranted, but in the meantime there is little doubt that cement for many uses is pressing hard upon stone.

The same process is observable in the quarrying of stone as in many other branches of the mineral industry in Ontario. The small quarry, worked by the farmer and his boys in a desultory way, and only when there are orders to fill, still survives, and probably will continue to do so for a long time to come in districts out of the freight-charge range of larger works, but year by year more and more of these small quarries are going out of business, their owners finding it not worth while to continue in operation, when their output cannot compete on equal terms with that of more systematically worked concerns, or when they can employ their labor more advantageously in some other field.

Lime

The quantity of lime turned out by the kilns of the Province was apparently about the same as in 1902. There is more or less difficulty in procuring accurate statistics regarding the production of lime, since much of the output is from small kilns, worked spasmodically, whose owners are for the most part engaged in other business, and do not keep accurate records of their production. But in lime, even more than in stone, the day of the small plant is passing away. The rise in the cost of labor, and still more, the growing scarcity and increased cost of wood for fuel, has shorn the small "set" kilns of the chief advantages they formerly enjoyed, and the principal one remaining, namely, lower transportation charges to their markets, does not count for so much in an article like lime as in heavy materials such as stone and brick. Probably the small kiln can still in many instances undersell the larger one, so long as it has lime on hand, but the large stocks and regular supplies which building operations in the cities and towns require can only be procured from works operating constantly, and on a large scale. Consequently, the number of small kilns is decreasing, and the business is more and more coming under the control of the larger, more centrally situated, and more systematically operated plants, which, moreover, being less numerous, are more amenable to the modern methods of eliminating unnecessary competition. The larger draw kilns, too, are more economical of fuel and less wasteful of product than the smaller plant of the "set" or "pot" type.

The demand for lime during the season of 1903 was good, and the outlook for 1904 is regarded as promising. Owing to the advance in the price of fuel and the cost of labor, operating expenses are much higher than a few years ago, perhaps 20 or 25 per cent. higher. The average price of lime has gone up nearly in proportion, being 15.3 cents per bushel last year, as compared with 14.3 cents in 1902, and 13.4 cents in 1901. The competition of cement is being felt to some extent, though this is partially offset by the greater use of lime in industrial works, as distinguished from building purposes.

Toronto offers a large market for lime on account of the extensive building operations which have been going on there for two or three years, and which seem likely to continue for some time to come. Kilns at Limehouse, Acton, Rockwood, Elora, Fergus, Hespeler, St. Mary's, Beachville, Galt, Milton, Kelso, and many other of the numerous places where suitable limestone outcrops within convenient distance supply this market, and other cities and towns in older Ontario have as a rule equally easy access to lime supplies. The analysis of a lime made at Milton, and sold largely in the Toronto market is: Lime 60.08, magnesia 35.67, silica .20, oxide of iron 1.34, carbon dioxide 2.71. The northern portion of Ontario, as for instance, the towns and settlements along the main line of the Canadian Pacific Railway as far west as Fort William, is to a considerable extent supplied with lime from the kilns of Renfrew, Lanark and other counties in eastern Ontario, which also send their product to Valleyfield, Lachute and elsewhere in the Province of Quebec.

Brick

The brickmaking industry of the Province is an extensive one. Abundance of clay has led to a large production and free use of brick for building purposes, and in almost all the cities and larger places of the Province—with the exception of a few towns which, like Guelph, are situated in districts where building stone is abundant and good—brick is the prepondering material. A taste for brick has thus been fostered, and the substantial appearance of such cities as Toronto and Hamilton is in decided contrast to the flimsiness of many frame-built American towns. The number of common brick made last year was 230 millions as compared with 220 millions in 1902, the value being $1,561,700 as against $1,411,000. The higher cost of labor and fuel and the active demand for brick brought about an increase in the average price per thousand from $6.41 in 1902 to $6.78 in 1903. There are decided differences in the price of brick in various parts of the Province, the higher costs prevailing in the cities and the lower values in the country districts. For instance, in Toronto prices ranged from $7.00 to $8.00 per thousand, while in Casselman, in the county of Russell, at the eastern end of the Province, the price was $5.00, and at Sandwich, in the western end, it was $6.00 per thousand. At Waterloo, in the central part of the southwestern peninsula, the cost averaged $6.50 per thousand, and at Lindsay, in the mid-east section, it was the same. Housebuilders in northwestern Ontario had to pay higher prices, as at Fort William, where bricks were worth $9.50 per thousand, 20 per cent. more than in 1902. The demand for brick, as for other building materials, would have been greater throughout the Province generally, and the price been less, as much building has been postponed in the hope that lower prices will be restored.

Pressed brick is made at Toronto, Milton, Brampton and Beamsville. Demand and prices were about on a par with those of 1902.

Other Clay Products

Drain tile is made in many brickyards, especially in the southwestern portion of the Province, where there is much low-lying land, and where it is of prime importance to farmers to rid their lands quickly of the surplus rainfall. The value of the tile made last year was $227,000, an increase of $28 000 over 1902.

Paving brick has not met with that degree of general acceptance as material for street pavements, which was looked for when it was first introduced. Nevertheless, it continues to be in some demand in Toronto, where every year more or less brick pavement is laid down. The paving or vitrified brick made last year numbered 3,788,800 worth $45,288, an average of $11.95 per thousand. The principal makers of paving brick are the Ontario Paving Brick Company, Limited, of Toronto Junction.

The manufacture of sewer pipe is expanding, the value of the product of 1903 being $199,971, as compared with $191,965 in 1902, $147,948 in 1901, and $130,635 in 1900. The makers of clay sewer pipe are the Hamilton and Toronto Sewer Pipe Company of Hamilton, and the Ontario Sewer Pipe Company of Mimico. A small quantity of sewer and culvert pipe is also made from cement.

The following table gives the statistics of production of tile drain, paving brick, sewer pipe and pottery for the last five years :

Product.	1899 $	1900 $	1901 $	1902 $	1903 $
Drain tile	240,246	209,738	231,374	199,000	227,000
Paving brick	42,550	26,950	37,000	42,000	45,288
Sewer pipe	138,356	130,635	147,948	191,965	199,971
Pottery	101,000	157,449	193,950	171,315	160,000

The output of the potteries of Ontario in 1903 had a value of $160,000, as against $171,315 in 1902. The principal products from local clays are flower pots, jardinieres, hanging baskets and other common articles of earthenware. Higher-priced goods or stoneware, such as butter pots, churns, pitchers, filters, etc., are made from imported clay by firms in Brantford and Belleville.

Portland Cement

In the Report of the Bureau of Mines for last year (4), some account was given of the origin and development of the Portland cement industry, and of the rapid increase both in consumption and production since the business was established in the Province in 1891. The expansion in the manufacture of Ontario cement has been remarkable, each year, with a single exception (1894), showing a decided increase over the previous one. The rate of growth during the last five years, taking the number of barrels as a basis, has been as follows: 1899 over 1898, 45 per cent., 1900 over 1899, 38 per cent., 1901 over 1900, 14 per cent., 1902 over 1901, 49 per cent., 1903 over 1902, 33 per cent.

For construction purposes cement is constantly encroaching upon the domain of stone, lime, wood, and even iron and steel, and there is every indication that its use will continue to multiply and extend. Well made and well manipulated cement will withstand exposure to the weather for hundreds, even thousands of years, as the excellently preserved remains of ancient Roman buildings attest, and each recurring conflagration in modern cities shows that while limestone, granite and sandstone will disintegrate and crumble under the influence of intense heat, and steel-frames warp and destroy the structures which they support, such inert and homogenous materials as brick and cement will pass through the ordeal comparatively uninjured. The development of the country, especially by means of the great transcontinental and other railways in progress or projected, as well as the improvements constantly going on in roads and pavements, together with the growing employment of cement for building and other purposes, will undoubtedly sustain and increase the demand. Up to the present time the price has been fairly well kept up, but the tendency appears now to be to a lower level. The following table shows the price per barrel of Portland cement at the place of production since the beginning of the manufacture in the Province:

1891	$2.50
1892	2.34
1893	2.00
1894	2.00
1895	1.94
1896	1.77
1897	1.75
1898	1.97
1899	1.99
1900	1.94
1901	1.60
1902	1.75
1903	1.70

The demand for cement at Ontario factories was good early in 1903, and prices were higher than in 1902, but at the close of the season the demand was fully met at prices about 20 per cent. less than those of a year before. The cause of the reduction was the large importations, chiefly from the United States, where manufacturers have the advantage of cheaper plants and cheaper coal, the latter being a leading element of cost. The total production of Ontario, practically the only Province in the Dominion where cement is made, was last year 695,260 barrels, valued at $1,182,799; while the imports into Canada for the fiscal year ending 30th June 1903 were 2,572,088 cwt., or the equivalent of 734,882 barrels of 350 pounds each, valued at $1,172,067, including duty. These imports were from the following countries:

	Cwt.	Value.	Duty.
Great Britain	701,775	$185,751	$ 45,993.02
Belgium	840,761	261,618	101,781.50
Germany	362,844	129,633	39,731.04
Holland	3,750	1,085	468.75
Japan	53,788	17,485	6,723.50
United States	609,170	305,491	76,306.22
Total	2,572,088	$901,063	$271,004.03

For the seven months ending 31st January 1904 the imports of cement have amounted to 1,675,742 cwt. or 478,783 barrels, of which 555,896 cwt. came from the United States, 444,420 cwt. from Belgium, 321,519 cwt. from Great Britain, and 353,907 cwt. from other countries.

In view of the increasing importations of cement and the number of new plants under construction and likely to place their product on the market at an early date, the prospect before the cement industry is not free from uncertainty, since the capacity of the present plants if fully exercised, would seem to be nearly, if not quite, sufficient to fill the demand. Indeed, those interested in the companies now at work are not slow to express their belief that any increase in productive power is not warranted, and that there will shortly be an era of over-production in Ontario with attendant curtailment or extinction of profits. The duty on cement is

(4) 12th Rep. Bur. Mines, pp. 29 *et seq.*

$12\frac{1}{2}$ cents per 100 pounds, but even this substantial barrier is not, it is claimed, sufficient to prevent extensive "dumping" by U. S. manufacturers in the Canadian market.

There were nine factories producing Portland cement in Ontario last year. These were the plants of the Lakefield Portland Cement Company, Lakefield, the Owen Sound Portland Cement Company, the Imperial Cement Company, the Sun Portland Cement Company, and the Grey and Bruce Cement Company, all of Owen Sound, the Hanover Portland Cement Company, Hanover, the National Portland Cement Company, Durham, and the works of the Canadian Portland Cement Company at Marlbank and Strathcona.

New Cement Plants

Four other plants are in process of construction, namely, those owned by the Belleville Portland Cement Company, Belleville, the Raven Lake Portland Cement Company, Raven Lake, the Colonial Portland Cement Company of Wiarton, and the Ontario Portland Cement Company of Brantford.

Of these the Belleville Company, whose works are situated on the Bay of Quinte, within four miles of the city of Belleville, have completed the railway connecting the plant with the Grand Trunk, a spur of $3\frac{1}{4}$ miles long. They have also built their machine shop and storehouse, two structures 40 by 80 feet, with steel roof trusses and walls of stone. The machine shop has been equipped with tools and power. Foundations for the rotary kilns have been laid, and a coal dock is being built and coal unloading apparatus installed. The buildings of the factory proper are to be of steel, and are under contract to be finished by 1st July. They will be fitted with machinery of the latest design, and the company expects to be in a position to produce cement at low cost, claiming as exceptional advantages cheap water-carried coal and contiguity to the works of the raw materials—limestone and clay. This plant will differ from all the other factories now making cement in the Province in that instead of marl it will use limestone, large quantities of which of suitable composition are situated on the property.

The Raven Lake Company are completing their plant, and expect to be manufacturing cement in April, 1904. The buildings lie immediately between Raven Lake (354 acres in extent) and the Grand Trunk railway, about 1 1-4 miles from Victoria Road station. They are so situated as to permit of taking in the marl automatically and loading the cement direct from the factory into the car. Marl will be dredged from the lake bottom and deposited on a scow, whence it will be conveyed to large storage tanks in the factory by means of compressed air. The capacity of the works will be from 600 to 800 barrels per day. A full line of cement machinery of the best American make is being installed, and the process so far as possible will be automatic throughout. Power will be supplied from Elliott's Falls, 13 miles distant, where hydraulic machinery for the development of 1,000 horse power has been put in place.

The works of the Colonial Portland Cement Company are situated on part of lot 3, Jones range, Keppel township, the property having a frontage of 20 chains on Colpoy's bay, where a wharf is being constructed 800 feet in length. The following buildings have been erected: kiln building, 150 by 300 feet, engine house 50 by 120 feet, boiler house 45 by 105 feet, all with steel walls and concrete walls. The dry grinding building 52 by 106 feet, machine shop 40 by 128 feet, and blacksmith shop 24 by 30 feet are of frame, with metallic siding. The coal grinding building 40 by 120 feet, and stock house 75 by 300 feet, when erected, will be of the same material as the kiln building. A large portion of the machinery for the kiln building is in place, and the company expects to be turning out cement some time during the present year (1904). The plant is connected with the Grand Trunk railway at Wiarton by a switch over 7,000 feet long, and will have a capacity of 1,000 barrels per day, with building room to increase to 1,500 or 2,000 barrels per day.

The factory erected by the Ontario Portland Cement Company is at Blue lake, near Brantford, and will have a capacity of 500 barrels per day. It has been completed and will go into operation during the present spring.

Natural Rock Cement

The output of natural rock cement in 1903 was in excess of that for 1902 by 12,249 barrels and $18,524 in value. The demand for this variety of cement, which is cheaper than Portland cement and is used mainly in the foundations and lower stories of farm barns, silos, etc., was good throughout the year. The average selling price at the factories remained at the same figure as in 1902, namely, 77 cents per barrel, which was 11 cents in excess of the price during 1901. Portland cement appears to be preferred for large and important construction works because of its greater regularity of composition, but for many minor uses, such as those mentioned above, natural rock cement is a perfectly satisfactory article, and can be obtained for much less money. When the price of Portland cement is high, the natural rock article is in better demand and goes up in price, and when Portland cement falls in value, the price of natural rock decreases.

The manufacturers of natural rock cement are Estate of John Battle, Thorold, Isaac Usher, Queenston, Toronto Lime Company, Limehouse, and F. W. Schwendiman, Hamilton.

Following are statistics of Portland and natural rock cement since 1891, when production of the former began in Ontario :

Production of Cement 1891 to 1903

Year.	Natural Rock.		Portland.		Total	
	bbl.	value. $	bbl.	value. $	bbl.	value. $
1891	46,178	39,419	2,033	5,082	48,211	44,501
1892	54,155	38,580	20,247	47,417	74,402	85,997
1893	74,353	63,567	31,924	63,848	106,277	127,415
1894	55,323	48,774	30,580	61,060	85,903	109,834
1895	55,219	45,145	58,699	114,332	113,918	159,477
1896	60,705	44,100	77,760	138,230	138,465	182,330
1897	84,670	76,123	96,825	170,302	181,495	246,425
1898	91,528	74,222	153,348	302,096	244,876	376,318
1899	139,487	117,039	222,550	444,227	362,037	561,266
1900	125,428	99,994	306,726	598,021	432,154	698,015
1901	138,628	107,625	350,660	563,255	489,288	670,880
1902	77,300	50,795	522,899	916,221	609,199	967,016
1903	89,549	69,319	695,260	1,182,799	784,809	1,522,118

Arsenic

The Canadian Goldfields Limited ceased in March 1902 to operate their gold recovering plant at the Deloro mine, Hastings county, from which all the arsenic hitherto obtained in Ontario

Year.	Tons.	Value. $
1899	57	4,842
1900	303	22,725
1901	695	41,677
1902	800	48,000
1903	257	15,420

has been produced, but continued to work the residues and tailing heaps for arsenic during part of 1903. The quantity of white arsenic produced was 257 tons, valued at $15,420, a reduction in quantity of 543 tons and in value of $32.580, as compared with the output for 1902.

Calcium Carbide

The Willson Carbide Works Company of St. Catharines, and the Ottawa Carbide Company, of Ottawa, produced together 2,507 tons of calcium carbide in 1903, worth $144,000, as compared with 1,402 tons worth $89,420 in 1902. The demand was good during the year, and the prospects for business in 1904 are very favorable. The product finds a market exclusively in Canada, and is used almost entirely in the generation of acetylene gas for lighting purposes, and to a small extent only for heating and cooking. The employment of acetylene gas is extending, especially in small towns and villages, where a plant for the manufacture of ordinary illuminating gas would be too expensive. A slight departure in the method of installation has been adopted within the last two years, in that a central plant is now being put in capable of generating the total quantity of acetylene required, the gas being conveyed through pipes to consumers, who pay for it by meter measurement, as in the case of coal gas. By this means the difficulties occasioned by individual generators, many of them not properly cared for, are avoided. That under certain circumstances and with defective or neglected apparatus, there are dangers connected with the use of acetylene, is sufficiently attested by several explosions during the past year, one of them, at Ridgetown, being attended with loss of life and severe injuries.

Following are the statistics of the calcium carbide industry for the last five years :

Calcium Carbide 1899 to 1903

Schedule.		1899	1900	1901	1902	1903
Carbide produced	tons.	1,064	1,005	2,771	1,402	2,507
Value of product..	$	74,080	60,300	168,792	89,120	144,000
Workmen employed	No.	48	32	83	57	66
Wages paid.	$	23,828	72,581	40,788	28,965	33,934

Corundum

There was a small gain in the production of corundum in 1903, in comparison with 1902, the total output being 1,119 tons, valued at $87,600, of which 849 tons was grain corundum, and 270 tons rough-cobbed. The operating concerns were the Canada Corundum Company, whose works are at Craigmont in the township of Raglan, Renfrew county, and the Ontario Corundum Company, working a deposit at New Carlow, Carlow township, in the county of Hastings. The former of these was the first to engage in the industry, and under special arrangements with the Government of the Province, erected a mill for the production of grain corundum and was given control of a considerable area of corundum-bearing lands. Having worked out the problem of concentrating corundum and separating it from the feldspar in which it is chiefly found, as well as the accompanying impurities such as hornblende and magnetite, the company last year put up a much larger plant a short distance from their old one, which is now completed and running, with a capacity of treating 300 tons of corundum rock per day.

An Ore of Aluminium

One of the conditions of the Canada Corundum Company's agreement with the Government was that experiments should be undertaken with the view of producing aluminium and other useful substances from corundum and corundum-bearing rock. The percentage of aluminium in corundum is much greater than in bauxite, from which the metal is now chiefly obtained, and it was thought that if a practicable process could be devised for obtaining aluminium from corundum, the usefulness of the Ontario deposits would be greatly extended, since the leading, if not the only, purpose for which the mineral is at present employed is as an abrasive. The company has necessarily been obliged so far to confine its attention principally to ascertaining the best methods of treating corundum for the uses to which it is ordinarily put, which has been a task sufficiently troublesome, since the ground which had to be covered was practically new. With regard to the experiments for producing aluminium from corundum, Mr. B. A. C. Craig, president of the Canada Corundum Company, writes under date of 12th February 1904 as follows:

"When the Canada Corundum Company was first formed the writer had one of the staff of Columbia University conduct preliminary experiments in this matter. Pure corundum, as you know, is composed in almost equal parts of the metal aluminium and the element oxygen. The affinity between them is very strong, and the problem before the experimenter is to break down this affinity and drive off the oxygen. A certain degree of success was met with in this, but was far from being success of a practical kind.

"In producing aluminium it has been found that the presence of less than 1 per cent. of iron or less than 1 per cent. of silica will destroy the value of the aluminium, making it brittle, and therefore worthless. We were therefore confronted with the preliminary problem of getting our corundum absolutely pure.

"In ordinary concentration, 70 to 80 per cent. purity is all that is required. Using the latest type of concentrating tables, we found that we could achieve a purity of from 95 to 98 per cent. In fact this purity is required if our material is to be made into vitrified wheels. We found, however, that it was difficult and expensive, if not impossible to go much beyond this. In the case of corundum its specific gravity is only about 1.4 greater than that of its gangue. Another obstacle is found in the fact that even when the rock containing the corundum is crushed comparatively fine, the rock does not completely break away, and grains are often found that are composed partly of feldspar and partly of corundum. If the corundum predominates, the particle of feldspar will often be taken over into the corundum. In addition to this, magnetite, iron pyrites and copper pyrites are found to be disseminated throughout the rock. The specific gravity of a grain that is composed partly of feldspar and partly of one of these minerals is often almost exactly the same as the specific gravity of corundum, and therefore comes down with the corundum.

"Another obstacle in producing a 99 or a 99.5 per cent. pure corundum is the presence of hornblende which occurs here and there in the corundum. It is chiefly found in separate dikes, but occasionally crystals of it are found in the same rock with the corundum. Its specific gravity differs from the specific gravity of corundum by less than one-half of one per cent., and this is the minimum difference necessary for separation by mechanical means. Mr. Overstrom, inventor of the Overstrom table, has lately conducted a number of experiments for us, and considers that the only method of separation is by cobbing.

"As it was impossible to get a perfectly pure corundum by mechanical means, the experimenter suggested that it would be necessary to leach out the iron and silica from the corundum by the same or by a method similar to that employed in leaching out the same materials from bauxite. But in bauxite both of these materials occur virtually as a powder, while in corundum they occur as hard distinct grains, and the leaching process would therefore be longer and more expensive. These together with the additional obstacle consisting of the greater cost of corundum than bauxtite, caused us to temporarily abandon the experiments. If you can get absolutely pure corundum by mechanical means, the corundum might be the cheaper ore, but if corundum has to be treated first mechanically and then chemically there is no doubt that bauxite is the cheaper.

"In separating our material on Overstrom and Wilfley tables the crushed material, as you know, stretches out in a thin sheet, the heaviest materials being at the upper side and the lighter tailings at the other. In treating our ore we therefore get on the upper side, iron and iron pyrites, then corundum, then feldspar. The edges of these more or less overlap, but it would seem to the ordinary observer that the middle of the corundum band would be almost absolutely pure and that this could be easily drawn off for the purpose of making aluminium were it so desired. Apart from the presence of grains of feldspar and magnetite, or feldspar and pyrites, etc., a practical difficulty presents itself. It is found that the particles of iron, corundum and feldspar all arrange themselves according to their size. On the upper side of each band is found the smallest grains (apart from slimes that are so fine as to float off) and as you go across each band the grains gradually become larger, the largest grains of each material being at the lower edge. Were you to draw off the middle part of the corundum band you would draw off most of the medium sizes, and as these are the sizes that sell best for abrasive purposes, you would soon find yourself with a great accumulation of unsalable material.

"Another practical difficulty is that if there be any clogging of the screens, spouts, etc., or any inconvenience in the feed so that too heavy a feed comes upon the tables, their work will not be as perfect, and you would always be in danger of getting more than a maximum of one-half of one per cent. of impurities.

"A new method has been suggested for completely eliminating by a mechanical means the impurities that remain after ordinary concentration. The terms magnetic and non-magnetic as ordinarily used, are not scientifically speaking correct. At one end of the magnetic scale we have iron and at the other bismuth. The latter may be called zero. All materials between these are more or less susceptible.

"Taking advantage of this Mr. F. T. Snyder, metallurgical engineer, and Mr. H. H. Waite, chief electrical engineer of The Western Electric Company, have invented a very powerful magnetic separator which separates many substances not generally known to be magnetic. It differs, so far as I know, from all other machines in that the material being treated passes through the line of greatest magnetic density. By means of this machine I understand that they have been able to draw over such materials as zinc blende, and a number of them are in successful operation in Kansas, where they separate zinc blende from the iron pyrites.

"For the purpose of testing this machine on our material, I recently made a trip to Chicago. It successfully separated all the iron from the corundum, and also muscovite mica, but when a more intense current was put on for the purpose of seeing whether it could separate feldspar and hornblende from corundum, the machine in some way got out of balance, as it is termed, and the experiments had to be temporarily abandoned. During my visit there I was shown samples of a red hematite that had been separated from their sandstone gangue. The separation seemed to be a clean one, although when tested with an ordinary powerful magnet, the hematite did not appear to be at all magnetic.

"Apart from this machine, we know of no possible method of mechanical separation. We have by no means given up the idea of experimenting, but until some perfect method of separation of corundum from all other minerals is worked out, there is no use going further.

"We have now installed a chemical laboratory and have secured the services of a Swedish chemist who has had considerable experience in original research work. It is our intention to have him continue experimenting, but we think that it would be better for us to have him give his first attention to other and different lines such as the producing of aluminate of soda and aluminate of potash and other similar minerals.

"The production of aluminium from corundum is something that will take not only money, but painstaking and long continued research. There is no corundum-bearing rock in the district that is pure enough to enable one to use the tailings in the manufacture of pottery."

During the year the Ontario Corundum Company which had been simply rough-cobbing their corundum rock and shipping the richest portions to the United States for treatment, put up a plant on the ground, and are now turning out a very good quality of grain corundum.

A third organization, composed principally of Buffalo capitalists, called Corundum Refiners, Limited, has been formed to engage in the production of corundum, the deposits which it proposes to open being situated mainly in the township of Raglan, east of Craigmont. Mr. P. Kirkegaard, formerly of the Deloro gold mine, is manager.

The subjoined figures show the progress of the corundum business since the first production of 1900:—

Schedule.	1900.	1901.	1902.	1903.
Corundum ..... tons.	60	534	1,137	1,119
Value of product $	6,000	53,115	83,871	87,600
Workmen....... No.	35	68	95	186
Wages paid...... $	10,000	30,406	34,674	106,332

The considerable amount of construction work done during 1903 accounts for the apparent disproportion between the sum paid out as wages and the value of the corundum product in that year.

Feldspar

The potash feldspar which exists in large deposits in the township of Bedford and elsewhere along the line of the Kingston & Pembroke Railway, has come into demand during the last three or four years for export to American potteries, in which it is used for glazing tile, baths, enamelled ware, etc. Last year the production was largely in excess of that for 1902, being 15,296 tons, valued at $20,046. The chief producers were the Kingston Feldspar and Mining Company, of Kingston; the Pennsylvania Feldspar Company, Verona, and Charles Jenkins of Petrolea. At the beginning of the present season the outlook for business was not encouraging, trade being somewhat slack in the New Jersey and Ohio potteries, and there being severe competition from American feldspar, which is nearer the market and is consequently lower in price.

The quantity and value of feldspar produced in Ontario during the last four years were as follows:—

	Tons.	Value.
1900..................	4,000	$ 5,000
1901..................	5,100	6,375
1902..................	8,776	12,875
1903..................	15,296	20,046

Attempts have been made to introduce Ontario feldspar into England, but owing to the different methods of manipulation in vogue there and to competition from Scandinavian and other sources, they have so far not resulted successfully.

Gypsum

The output of crude gypsum last year was 4,520 tons, as against 1,917 tons in 1902. It comes from the deposits in the valley of the Grand river, near Paris, and is worked up into a variety of products, such as wall plaster, alabastine, etc., by the Alabastine Company of that place. A quantity is also used by the Imperial Plaster Company of Toronto in the manufacture of wall plaster, wood fibre, etc. The material known as "wall plaster" is calcined gypsum treated with an animal retarder, and is highly commended for use as a coating for walls in buildings, being when set, harder and more durable than ordinary plaster. Land plaster is ground gypsum intended for use as a fertilizer.

Salt

There is no rock salt produced in Ontario, the wells along the east shore of lakes Huron and St. Clair yielding a strong brine which is evaporated by artificial heat, leaving a product of great purity. The salt beds are found in the Onondaga formation, and were first discovered at Goderich about forty years ago.

The chief producer is the Canadian Salt Company of Windsor, but other plants in operation last year were those of R. & J. Ransford, at Brussels, Seaforth, Stapleton and Goderich; Ontario People's Salt and Soda Company, Kincardine; Carter and Kittermaster, Moore; Sarnia Salt Company, Sarnia; and Grey, Young and Sparling Company, Wingham.

The production of salt in the Province has remained nearly stationary during the last five years, as will be seen by the table given below :

Production of Salt 1899 to 1903

Schedule.		1899	1900	1901	1902	1903
Salt produced	tons.	56,375	66,588	60,327	62,011	58,274
Value of product	$	317,412	324,477	323,058	344,620	388,097
Workmen employed	No.	261	243	189	198	208
Wages paid	$	80,021	72,584	67,024	76,154	87,995

Iron Pyrites

Two deposits of iron pyrites were worked last year, the one producing most largely being that operated by the Madoc Mining Company near Bannockburn. A smaller quantity was raised at the Helen iron mine, Michipicoton. The product is exported to the United States, chiefly to Buffalo and Cleveland, and is used in the manufacture of sulphuric acid.

A peculiar feature in connection with the first-mentioned deposit is that it appeared at the surface as a bed of bog iron ore, and was worked as such. On sinking a short distance the bog ore was found to be succeeded by pyrite, strongly suggesting that the upper layer was due to alteration of the exposed portion of the main body.

The production of iron pyrites during the last three years has been as follows :

	Tons.	Value.
1901	7,000	$17,500
1902	4,371	14,993
1903	7,469	21,693

Natural Gas

The value of the natural gas produced in the Province was somewhat less than in 1902, being $196,535, as against $199,238, though these figures show a large reduction as compared with 1899, when the value of the production rose to the maximum amount, namely, $440,904.

For a number of years the Essex county gas field yielded large quantities of gas, but in 1900 and 1901 the production fell off very much, and in consequence there was great local complaint against exporting the gas to Detroit, the principal place of consumption. Accordingly, the Government of the Province by Order-in-Council dated 26th October 1901 revoked the license of occupation which authorized the exporting company to use the bed of the Detroit river for the purposes of its pipe line, and so brought the export to an end. This step, however, did not have the effect of materially increasing or prolonging the supply to Canadian consumers, and the field is now practically abandoned, the United Gas and Oil Company having notified its customers in Windsor and Walkerville that they would cease to supply them after 1st April 1904. The wells owned and operated by the corporations of the towns of Leamington and Kingsville are no longer adequate for the wants of the inhabitants of these places. Mr. W. A. Smith, town clerk of Kingsville, writes under date of 8th February 1904: "The corporation wells are practically exhausted, and are not producing any gas sufficient to be utilized. The yield has been noticeably declining for over a year, the crisis being reached last July, when the gas supply suddenly ceased. Since then a little gas has reached town and been utilized for domestic purposes, but now it is gone, and we think for good. There are no prospects for a future supply."

The field in Welland has been worked longer than the Essex one, and is still furnishing much gas. Pains are taken to keep the wells free from water, and new ones are constantly being put down. The bulk of the gas comes from the Medina formation, but large wells are also found in the Clinton. A pool in the neighborhood of Dunnville is being exploited, and considerable gas obtained for local use. Recently, gas has been struck in the Medina formation at Brantford, and the product is being utilized under a couple of furnaces in the Cockshutt plough works on the outskirts of that city. Some seven or eight wells have been put down, and gas obtained in several of them, but the total quantity is not great, and it is yet uncertain whether there is a large reservoir. The rock pressure at first was 250 pounds, but has declined to 50.

Returns show that there are 210 wells producing gas in the Province, of which 157 are in the Welland field, and the majority of the remainder in the vicinity of Dunnville. Twenty producing and twelve non-producing wells were put down last year; there were 312 miles of pipe used for conveying the gas to consumers; the number of workmen was 138, and the amount of wages paid $79,945.

Petroleum

Petroleum, of which the Lambton county oil district remains the chief source, is steadily declining in yield. Compared with 1902, the production of crude in 1903 was 1,545,254 Imperial gallons less, and with 1901 4,793,162 Imperial gallons less. The progressive shrinkage is plainly evident from a glance at the statistics of production for the last ten years:

Year.	Imp. gals.
1894	34,912,360
1895	33,351,997
1896	27,380,588
1897	25,556,591
1898	26,978,977
1899	23,615,967
1900	23,381,783
1901	21,433,500
1902	18,185,592
1903	16,640,338

As compared with 1894, the yield has therefore fallen off over 52 per cent., yet the number of wells pumping oil in the Petrolea and Oil Springs fields is probably as great as it ever was. The reduction has been brought about, not by the sudden cessation of oil in any particular portion or portions of the territory, but by a gradual and apparently accelerating diminution in the yield of oil per well. In fact, the oil producing territory of Ontario is unique in the small individual production of its wells, and in the tenacity with which it is worked. Had it been situated in almost any other part of the world it would probably have been abandoned some years ago, but by the use of economical methods its life is prolonged; indeed, the very smallness of the flow and the gradual nature of the process of exhaustion guarantee its existence for a considerable time to come. Additional vitality was given the oil territory of the Province last year by the high prices prevailing for crude, the year closing with a market value of $2.32 per barrel. At this rate the total value of the crude product of the year was $1,103,016, while in 1899 when the closing price was $1.40 per barrel, the total value of crude produced, figured on this basis, was only $944,637, notwithstanding that the quantity was 6,975,629 gallons more. It is clear therefore that price is an important factor in preserving the oil territory of Ontario in production.

Formerly, practically the whole of the crude product of Ontario went to the refining works for distillation, but of late years a considerable and increasing proportion has been used for fuel purposes and in the manufacture of gas. Last year about 2,176,090 Imperial gallons is estimated to have been diverted from the refineries for uses of this sort, or over one-eighth of the total quantity. Even if the refineries had received the whole of the crude produced, there would still have been insufficient to supply the wants of the home market, if it can be held that all parts of the Dominion of Canada ought of right to constitute the market for the refined oils of Ontario. The trade tables show that there were imported into Canada during the fiscal year ending 30th June 1903 the following quantities of crude petroleum and products thereof:

	Gals.	Value.
Oil, coal and kerosene, distilled, purified or refined naphtha and petroleum N.E.S.	14,478,350	$1,965,429
Products of petroleum	554,668	95,225
Crude petroleum, fuel and gas oils (other than naphtha, benzine or gasoline) when imported by manufacturers (other than oil refiners) for use in their own factories, for fuel purposes, or for manufacture of gas	2,143,888	189,689
Lubricating oils, composed wholly or in part of petroleum, costing less than 30 cents per gal.	1,613,943	276,380
Total	18,790,849	$2,526,723

Practically the whole of the above came from the United States. These statistics are sufficient to show how far the Canadian consumption of oil and oil products is from being met by Ontario petroleum.

The refining facilities of the two plants in the Province, those of the Imperial Oil Company at Sarnia, and the Canadian Oil Refining Company at Petrolea, are more than adequate for the entire crude product, and under these circumstances it is not to be wondered at that a strong local agitation has sprung up in favor of reducing the import duty on crude petroleum from five cents per gallon to say two cents. This, it is contended, would enable the refineries to supply themselves with the raw material to keep their plants employed, without injuring the producer of crude in Ontario, as the latter would have the advantage which the freight from Pennsylvania or Ohio would give him with the addition of two cents per gallon duty. Besides, it is argued, if the refineries are unable to obtain sufficient crude oil to warrant them in keeping their stills in profitable operation, and are obliged to close their doors, the market for Ontario crude will be gone, and the producer will not be able to sell at all. These views, it is needless to say, are not shared by all oil-well owners, some of whom fear a flood of crude petroleum from south of the line which would speedily put an end to their industry, and are reluctant to relinquish the benefits which are conferred upon them by the present tariff protection.

It is a legitimate subject of inquiry whether other oil horizons do not exist in southern Ontario below the Corniferous formation to which production has hitherto been confined. The Trenton limestone, so prolific a source both of oil and gas in Ohio and Indiana, underlies the whole of the southwestern peninsula. In the Lambton oil field it lies at considerable depth, and it is a matter involving some expense to reach it. It has been struck at several points, but so far without yielding oil in any quantity. The Imperial Oil Company have drilled to the Trenton at the following places :

Lot 5 in the fourth concession of Brooke township, Lambton county. Well completed 3rd March 1900; depth 3,380 feet.

Lot 5 in the third concession of Peel township, Wellington county. Well completed 22nd August 1900; depth 2,573 feet.

Lot 6 in the fifth concession of Pilkington township, Wellington county. Well completed October 31 1900; depth 2,390 feet.

Lot 4 in the sixth concession of Amabel township, Bruce county. Well completed 18th June, 1901; depth 1,678 feet.

Lot 6 in the eleventh concession of Amabel township. Well completed 16th January 1902; depth 1,470 feet.

Lot 38 in the second concession, north centre diagonal, Keppel township, Grey county. Well completed 3rd May 1902; depth 1,500 feet.

"Nothing," the company states, "was found in any of the above wells to encourage further drilling to the Trenton rock."

Nothwithstanding the diminished yield of crude oil in 1903, the decidedly higher range of prices which prevailed during the year not only prevented the total value of the refined products from falling below that of 1902, but actually brought about a noticeable increase, as the following comparison of the statistics for the two years will show :

Petroleum Products 1902 and 1903

Schedule.		1902.		1903.	
		Quantity.	Value. $	Quantity.	Value. $
Illuminating oil	Imp. gals.	7,720,866	715,513	7,096,073	793,426
Lubricating oil	"	2,765,677	287,219	2,614,313	280,449
Benzine and naptha	"	902,847	104,696	832,153	126,052
Gas and fuel oils and tar	"	2,157,049	83,426	1,968 172	122,074
Paraffin wax and candles	lb.	2,433,127	108,107	2,673,806	129,755
Total			1,298,961		1,451,756

The production of crude petroleum and products of refinement for the last five years are given in the following table :

Petroleum and Petroleum Products 1890 to 1903

Schedule.		1899	1900	1901	1902	1903
Crude produced	Imp. gals.	23,615,967	23,381,783	21,433 500	18,185,592	16,640,338
" distilled	"	23,615,967	23,381,783	17,745,182	15,630,592	14,464,248
Value of crude produced	$	1,747,352	1,869,045	1,305,540	1,298 961	1,024,597
" distilled products	$	1,021,528	1,126,777	989,222	940,104	1,451 756
Illuminating oil	Imp. gals.	11,697,910	11,783,755	9,463,262	7,720,866	7,096,073
Lubricating oil	"	2,087,475	1,980,428	764,861	2,765,677	2,614,313
Benzine and naphtha	"	1,394,530	1,463,599	1 075,9[illegible]9	902 847	832,153
Gas and fuel oils and tar	"	5,410,915	3,669,102	2,652,987	2,157,039	1,968,172
Paraffin wax and candles	lb.	2,792,766	4,599,683	3,489,492	2,433,127	2,673,806
Workmen employed	No.	491	347	351	323	291
Wages paid	$	214,171	163,077	161,042	169 398	165,700

New Oil Fields

During the past year oil has been found in promising quantities at two rock horizons which lie a considerable distance, in the geological scale below the productive horizon in the older fields. While in search for gas in the township of Romney oil was found in the Guelph limestone. Oil was discovered under similar circumstances in the city of Brantford. Very little has yet been done in the way of testing these Brantford wells, but considering the size of the area over which they have been found, they can be said to give considerable promise. The productive horizon here lies in still older rocks than those of Romney, namely the Medina.

The fact that oil has thus been discovered in promising quantities both in the Guelph and Medina, below the Corniferous which is the productive zone in the older fields, should induce the drilling of much deeper wells for oil than has been the custom in the southwestern peninsula of the Province. Last year, for instance, when there was great excitement over oil in the township of Raleigh, which adjoins Romney on the east, and many wells were drilled, no one seems to have thought it worth while to drill below the limestone bed of the Corniferous, which has been considered to be the oil-bearing horizon in the Province. There seems little doubt that oil is to be found at greater depths than it has heretofore been looked for in these fields. Before the oil refiners decide that Ontario is unable to furnish them with sufficient crude petroleum to keep their works in operation, it would be well for them to thoroughly test other formations than the Corniferous.

Brant County

In the latter part of 1903 drilling was begun for gas in the city of Brantford. From two or three wells put down at the Cockshutt plough works a strong flow of gas was obtained. This gas was used in the furnaces at the works for a short time, when the pressure began to lessen and the supply soon became too small to keep the furnaces going. It was then found, however, that two of these wells contained oil, which appears to have gradually oozed in as the gas disappeared. On account of unforeseen delays in getting machinery, these wells have not been systematically pumped, so that it is impossible to say what their daily output of oil is likely to be. With a hand pump, used for only a short time daily, three or four barrels of oil have been taken from one well from day to day. The oil is said to contain about fifty per cent. lubricating material, and is thus more valuable than ordinary petroleum. Six or seven wells have been drilled in the city, four of which are on the Cockshutt property, and only one of the seven is said to contain neither gas nor oil. Four wells have also been drilled on the Bow Park farm, which is distant about two miles southeast of the Cockshutt wells. Gas and oil have been found in these wells. In the last one drilled it is stated that oil began to come almost immediately, after the bottom of the well was reached, and kept rising in the pipe "until now it has come to the top and the gas pressure will force it out, the same as it did in the two wells on the Cockshutt property." None of these wells have been "shot."

The oil contents of the wells would appear to give more promise than the gas, which does not show a high pressure for any great length of time. There will doubtless be sufficient gas to supply Bow Park and other farms on which the wells are situated for years to come, if the use of the gas is confined to the farms.

The horizon, red shales of the Medina formation, appears to be practically the same as that in which gas is found in the Port Colborne and adjacent pools. This horizon is much lower in the geological scale than that of the old Petrolea field, which is in the Corniferous.

The following logs and notes on the first three wells put down on the Bow Park farm have been furnished by the driller. It will be noticed that the first limestone met with in the drill holes is classed as Niagara. The upper part of this really belongs to the Onondaga formation, which immediately underlies the glacial and loose deposits in this field. The Niagara has a total thickness here of about 250 feet, consisting of limestone and the underlying black shale. The strata below the Clinton all belong to the Medina formation.

Report of Well No. 2 on "Bow Park," Drilled December, 1903:

	Feet.
Surface red clay and sand 6 ft., blue clay 55 ft.	61
Hard pan 25 ft., broken stone 2 ft.	27
Niagara Lime, 88 ft. to 340 ft.	252
Black Shale, 340 ft. to 390 ft.	50
Clinton, 390 ft. to 410 ft.	20
Red Medina, 410 ft. to 450 ft.	40
Grey Shale, 450 ft. to 490 ft.	40
White Medina, 490 ft. to 505 ft.	15
Red Shale and Rock, 505 ft. to 510 ft.	5
Red Shale, 510 ft. to 582 ft.	72
	582

Surface water shut off at 91 ft. with 6-inch casing. Deep water shut off at 344 ft. with 5-inch casing. Gas struck at 395 ft., 505 ft. and 508 ft. Pressure 265 lb.

After drawing heavily for about thirty days pressure was reduced to 180 lbs. When shut off altogether pressure ran up 220 lbs.

Report of Well No 1 on "Bow Park." Drilled February, 1904.

	Feet.
Surface clay and sand 18 ft., Blue clay 30 ft., Quicksand 10 ft.	58
Hard pan	10
Niagara Lime (Onondaga), from 68 ft. to 335 ft.	267
Black (Niagara) Shale, 335 ft. to 375 ft.	40
Clinton, 375 ft. to 390 ft.	15
Red Medina, 390 ft. to 430 ft.	40
Blue Shale, 430 ft. to 450 ft.	20
Sand Rock, 450 ft. to 470 ft.	20
White Medina, 470 ft. to 485 ft.	15
Rock and Shale, 485 ft. to 490 ft.	5
Red Shale, 490 ft. to 602 ft.	112
	602

Surface water shut off at 73 ft. with 6-inch casing. Deep water shut off at 338 ft. with 5-inch casing. Gas struck at 490 ft. Pressure 282 lb.

Report of Well No. 3 on "Bow Park." Drilled January, 1904.

	Feet.
Surface clay and sand 13 ft., Blue clay 30 ft.	43
Basket sand 15 ft., Hard pan 7 ft., Stone and broken rocks 5 ft.	27
Niagara Lime, 70 ft. to 330 ft.	260
Black Shale, 330 ft. to 375 ft.	45
Clinton, 375 ft. to 395 ft.	20
Red Medina, 395 ft. to 440 ft.	45
Blue Shale, 440 ft. to 460 ft.	20
Shale and sand rock, 460 ft. to 480 ft.	20
White Medina, 480 ft. to 500 ft.	20
Red Shale, 500 ft. to 611 ft.	111
	611

Surface water shut off at 72 ft. with 6-inch casing. Deep water shut off at 335 ft. with 5-inch casing. Gas struck at 498 ft. Pressure 235 lb. Same quantity of oil came in.

Romney Township

Under date of February 12th 1904 the United Gas and Oil Company of Ontario, Limited, furnish the following particulars concerning the oil wells recently drilled by them. They state, "As to the oil, we have now four producing wells on lot 11 in the second concession of the township of Romney, Kent county, yielding a total daily production of 40 barrels." Since that time, according to press notices, other wells, with a large oil production, have been drilled in the surrounding area. It is stated that one or two of these wells had the character of gushers or flowing wells.

A set of drillings from one of the wells in the above mentioned lot in Romney was sent to the Bureau, together with a statement as to the depths from which they were taken. The surface soil here has a thickness of 135 feet. The well was drilled to a depth of 1,305 feet. Between 1,285 and 1,290 feet the first showing of oil was obtained, and the productive horizon lies between 1,290 and 1,300 feet, in the Guelph formation.

The company asked that it be determined from the samples of drillings sent by them to the Bureau whether the oil from the Romney well comes from the same horizon as the gas in the townships of Mersea and Gosfield. For this purpose they sent a sample, No. 101, from a depth of 1,025 feet in an old gas well in the township of Mersea. Chemical analyses were made of this sample and of three others from the Romney well. The results obtained are given in the following table :

	No. 50.	N. 51.	No. 52.	No. 101.
Insoluble silicious residue	1.32	2.02	1.06	.58
Alumina and ferric oxide	1.56	2.24	1.28	1.56
Lime	29.18	29.38	28 80	29.79
Magnesia	21.61	21.22	20.66	21.53
Carbon dioxide	46.62	46.30	44.39	46.82
	100.29	100.16	96.69	100.19

Samples 50 and 51 show the character of the rock in the Romney well between the depths of 1,290 and 1,300 feet, the productive oil horizon. It will be noticed that there is a remarkably close agreement, in the lime and magnesia percentages, in the analyses of Nos. 50, 51 and 101. Sample No. 52, from 1,300 to 1,305 feet, is also close to these three in its percentage of the same two constituents. There is also a fairly close agreement as regards the percentages of carbon dioxide, and alumina and ferric oxide. In fact the four analyses agree so closely that they might easily represent samples from a single bed or stratum. There therefore seems little doubt that the gas of Mersea and the oil of Romney come from the same horizon in the Guelph formation. This formation lies, of course, a considerable distance below the horizon at which oil is found in the old Petrolea field and where it has been sought for in the township of Raleigh and other areas adjacent to Romney.

Peat Fuel

In the Twelfth Report of the Bureau of Mines a full account of the peat fuel industry, both in Ontario and in Europe, was given by Mr. W. E. H. Carter, Secretary of the Bureau (5), and in the following paragraphs Mr. Carter presents further information on the subject. The output of compressed peat fuel in the Province last year was 1,100 tons, valued at $3,300. It was produced mainly at the factory of Mr. Alexander Dobson, Beaverton, but a small tonnage was also made by Dominion Peat Products at Newington.

Operations during the season of 1903 were confined to the factories noted in the above-mentioned report. New methods and machines applicable to various parts of the process of manufacture have been tried at both the older works and the new plants during the year. New machines for field operations and for compressing peat briquettes have been invented, and others already known to the industry, though not as yet placed in commercial operation, have been modified or improved. Not all of these machines have yet been tried in actual practice, either experimental or commercial, so that no expression of opinion as to their economic value is yet possible.

The very general interest in the manufacture of peat fuel awakened during the past year or so both in Ontario and other parts of Canada, and in many parts of the United States, and even Mexico, has led to the formation of a large number of companies to undertake the business. There is a tendency amongst many of these companies to adopt newly invented or at least untried machines, and while this may of course mean the introduction into the industry of other efficient processes and apparatus, it would be much safer and more satisfactory if at the outset only those processes were employed which had stood the test of actual use.

The more peat is handled and worked the more apparent does it become that in its physical characteristics it is quite unlike any other substance. It requires methods of treatment for drying and compressing—the two fundamental operations in the manufacture of the fuel—which are applicable to peat alone. Accordingly machines and processes which work successfully on such substances as sawdust, coal slack or lignite, alone or mixed with other materials, are not necessarily suitable for peat. It will be time enough to strive for machinery to make cheaper and better peat when the fuel which has already been found commercially satisfactory is being turned out in quantity. Peat briquettes can be and are being made now in Ontario for about $1.50 per ton, and are sold for $3.50 per ton at the works. One plant has during the past year (the third year of its operation) manufactured 1,000 tons and sold the product in small lots from end to end of the Province. This is surely profit enough and proof of success enough to show the business to be a legitimate one.

Of equal importance with the adoption at the outset of only tried and proved machines is the employment of a superintendent or manager who is well acquainted with the machines and processes of the day and with the peculiarities of peat.

(5) Bulletin No. 5, Peat Fuel; its Manufacture and Use, reprinted in 12th Rep. Bur. Mines, pp. 191-234.

The Open-Tube Press

As described in Bulletin No. 5, only two types of briquetting press have been tried on a commercial scale so far. The principle of one is compression against a solid base without friction in the die or mould ; the other, compression against the frictional resistance of the peat briquettes on the walls of the open-tube or bottomless die. Further investigation has exposed a serious weakness, probably the most important one in the latter variety of press, and as the failure strikes directly at the principle of its operation it appears insurmountable. The open-tube or bottomless die is largely used in Germany for compressing lignite and coal dust or fines into briquettes, which would indicate a radical difference between the chemical as well as the physical composition of peat and the other two substances, lignite and coal fines, affecting their amenability to frictional compression in the open-tube die. At Dobson's peat factory at Beaverton trials of the open-tube die press on peat were made more thoroughly perhaps than at any other place in the Province or elsewhere. The failure of the machine there as elsewhere usually showed itself in a cracked or broken die tube. At last to obviate the recurrence of this, a heavy nickel steel die was cast, which withstood perfectly the immense tensional stress occasioned by the frequent binding of the peat in the tube. In outside diameter and length it remained unaltered after a month or more of continual use. It was at the end of this period that the serious failure or weakness above referred to was discovered and set down as the probable cause of all former troubles with the machine. The inside of the tube at about 3 inches below the lip, namely, at the point where the actual compression of the peat into a briquette took place, had worn away until the inside diameter of the tube at that point was one-quarter of an inch greater than the rest of the tube. This meant that with one stroke of the punch a briquette of 2 3-4 inches in diameter was made in this enlarged or worn-out portion of the die tube. With the following stroke and in the formation of the next block of peat the first one, now extremely dense and hard, had to be squeezed down into a diameter one-quarter inch less, namely, 2 1-2 inches in the lower portion of the tube. The inevitable result would be a broken die tube, if not a broken press. The greater the amount of ash in the peat the faster the wear in the tube; but even with peat free from sand, which is rarely found, this wear will take place.

The Whitewater Press

At the Welland peat works, as noted in the last paragraph in the revised edition of the Bulletin incorporated in the Twelfth Report of the Bureau of Mines, one of the Dickson presses was altered to make a quick short stroke, more in the nature of a blow than a punch, the open-tube die being used. This press is generally known as the "Whitewater," since it was at the town of that name in Wisconsin, U. S. A., that the principle was first embodied in a peat press and tried. The results at Welland were not satisfactory enough to warrant following up the idea. The trouble seems to be that the short stroke makes thin plates of peat, which do not always adhere to form a thick enough block, but drop out as or subsequently separate into flat briquettes. This flaking may perhaps to some extent be due to the peat being insufficiently fibrous or lacking in binding material, and need not necessarily condemn a press constructed on this principle. The real trouble will arise after a longer trial, with the wearing action on the die tube, when the result will probably be the same as with the slow-stroke press.

New Peat Factories

A number of peat fuel manufactories were established last year, or companies were formed to establish them, especially in the United States, and many new or "improved" presses, dryers, etc., were invented for use therein. But as to their success or failure little definite can here be said. At East Lexington, Massachusetts, a peat fuel manufactory of large capacity was being completed in the fall. Another was to have been erected on the peat bogs of Worcester and Middlesex counties of the same State. At Calpac, Michigan, and at Whitewater, Wisconsin, peat plants were in operation for a time, the former employing the Dickson press and the latter the Whitewater press above referred to. At South Bend, Indiana, a company has been formed to put up a peat fuel factory on bogs in the vicinity of that place. The machines will probably be made this winter in preparation for work during the coming season of 1904.

In Ontario two recently incorporated peat companies are the Toronto Peat Fuel Company, to instal Mr. A. A. Dickson's latest peat press (on the open-tube principle) and peat dryer on a bog at Picton, where some trials were made during the summer of 1903 ; and the Imperial Peat Company of Guelph, to adopt in a peat fuel manufactory the new White briquetting machine, one of which, of full size, is now about completed (March, 1904), and ready for work this coming season. A working model of this press has been maintained in Toronto for the past year or so, making tests at intervals.

Lignite as a Fuel

At Bismarck, North Dakota, machines are under construction for experimental work on the lignite which occurs in vast beds in that State. The desire is to compress the lignite without the addition of chemicals or binder into briquettes. For the purpose of acquiring all available data on the industry an engineer was sent to Germany to acquaint himself with the practice in that country, where a large percentage of the fuel consumed is in the form of briquettes of lignite or "brown-coal." There, however, a binder is generally necessary, such as tar or the bituminous residue from the distillation of tars.

An interesting communication has been received by the Bureau from Mr. George Gregory Smith, an engineer in Florence, Italy, who has been retained by parties interested in the lignite deposits there, to make a report on that fuel. He states that there is now in sight in the various deposits in Italy about 400 million tons of lignite, and that, with the exception of wood and charcoal, both scarce and dear, lignite is the only fuel Italy has, all her coal being imported. The letter proceeds : "As a fuel, lignite, no matter how thoroughly dried, is unsatisfactory. The result of my investigations, however, have led me to conclude that if lignite is looked upon not as a fuel primarily, but as a chemical substance with fuel as a bye-product, it possesses far more value than it would if used primarily as a fuel either in the form of briquettes or otherwise." He goes on to say that by fractionally distilling lignite, gas, coke, tar and ammoniacal liquor are obtained, the average heating value of the gas by his determinations on Italian lignite being 4,770 calories per litre. Quoting again, "The distillation of the tar results in the following: benzine (crude), lubricating oil, aniline blue (solution), fenol (crude), and tar residue (pitch or extra carbon). The tar residue is then used as a binding material for the lignite coke. This fuel in the form of briquettes has proved extremely satisfactory. The volatile substances in the form of gas, tar and ammoniacal liquor rather more than pay the entire cost of the process, leaving the fuel practically free of cost.

"I have never made any tests of peat, but venture on a suggestion that from some of your bogs at least you might possibly obtain an approximately similar result."

With regard to the suggestion in this last paragraph, no commercial tests of such a process have ever been made in Ontario. There are in Germany, at Oldenburg, and in Russia, at Redkino, plants for coking peat and utilizing the gaseous products and the liquors condensed therefrom. The process is known as the Ziegler process and has been described in numerous journals and consular reports. The chief objection at the present stage of its development is the first cost of the plant, which is quite high on account of the elaborate arrangement for saving the various bye-products. Samples of the bye-products from the coking operation and subsequent fractional distillation of the tar have been obtained by the Bureau of Mines and may be seen here. The samples comprise tar, tarwater, gas-oil from the tar, concentrated tarwater, crude methyl alcohol, 35 per cent. methyl alcohol, 95 per cent. ditto, and crude ammonium sulphate crystals, all from the tar-water.

Lignite or brown coal has been known for many years to exist in the northern areas of Ontario, but beyond a superficial examination of the occurrences along some of the rivers little was done until the summer of 1903 in the way of determining its extent. The exploration party then sent out was equipped with suitable tools and appliances to make borings, etc., and the results of the work are embodied in a report in another part of this volume. Valuable data on the quality and area of the vast peat bogs in that part of the Province were also obtained. These lignite deposits, it may be confidently predicted, will come into use some day, either by being briquetted or distilled by some such method as the Ziegler process.

Peat-making in Ontario

The peat fuel industry in Ontario during 1903 was confined to four points, Beaverton, Newington, Welland and Picton.

The plants at Rondeau, Brunner and Brockville which were expected to reopen have for one reason or other lain idle.

The only change in the plant at the Beaverton factory was the addition of a travelling peat elevator to load the piles of air-dried peat scraped off the field into the tram car. Formerly this work was done by hand. With a few alterations the machine will be adopted as part of the permanent plant this season. At this factory 1,000 tons of peat briquettes were made during the season of 1903. An attempt will this year be made to harvest enough air-dried peat to keep the one press in continuous operation through the winter as well.

With regard to the use of cordwood for fuel under the boiler and dryer, as against crude or cut peat, Mr. Dobson, the proprietor of the works, has satisfied himself that with good mixed wood at $1.30 per cord (which is about a minimum price) it is cheaper to use crude or cut peat. He bought several acres of timbered land and cut and delivered the wood himself, finding that $1.30 per cord was the cheapest it could be done for. The crude peat on the other hand can be cut and piled along the ditches to dry, and subsequently delivered to the works for considerably less per unit of heating power. Next season, therefore, a supply will be dug for future use to replace the cordwood.

The Dobson dryer has been steadily turning out peat at the rate of 3,000 lb. or $1\frac{1}{2}$ tons per hour, drying it from about 40 or 45 per cent. down to 12 per cent. water content.

A Demonstrating Plant

It is the intention of Mr. Dobson and his associates to erect another peat factory similar to, but of double the capacity of the Beaverton works, on an extensive peat bog of reported excellent quality at Caledonia Springs, a few miles east of Ottawa. Such a step is necessary at the present stage of the industry in order mainly to prove the success of his machines and process on a larger scale and on a different bog. The bog at Beaverton is too small to warrant enlarging the present factory; and besides this the peat has characteristics not common to the large majority of bogs in Ontario. This work will be greatly appreciated by all interested in the peat fuel industry as helping to solve certain unanswered questions covering the operation of a much larger plant than the one- or two-press factories now in existence. One question has reference to ways and means of storing the immense quantity of air dried peat required for the factory's winter supply. Must it be covered or housed, or not? Another deals with the advisability of concentrating all the factory operations —mechanical drying and compressing—under the one roof, to which one point the necessarily extensive areas of bog under "cultivation" shall all be tributary, as against the adoption of a maximum capacity factory unit, any number of which could be erected at separated points in the bog, each on an area which would supply it with the necessary amount of air-dried peat. This latter is the usual arrangement in such European countries as Sweden, Germany, Denmark and Russia, where the plants used are for the manufacture of "machine-peat" only.

In connection with this the following figures will give an idea of the field area required to harvest a certain tonnage of peat during one season. Some of the figures are only approximate, so that the results arrived at are not absolutely definite. In the field methods adopted at Beaverton 1 acre is required to spread 10 tons peat for air-drying. But in an average day 2 collections or scrapings may be taken off that area so that a daily product per acre of 20 tons is obtained. At Welland, where harrowing is followed, one scraping only is made per day, but the layer removed is about twice as thick as at Beaverton and amounts to 20 tons per day per acre. Out of a period of open weather six months in duration, at least two-thirds or 120 days should give good drying weather. Therefore the season's product of peat fuel per acre will be 2,400 tons. But in the bogs of Ontario the average amount of peat fuel (finished product with 12 per cent. moisture) per acre for each foot of depth is 215 tons, so that to gather 2,400 tons from the same acre requires a bog about 11 feet deep. Provided this depth of peat is available and the peat factory has an output of 50,000 tons peat fuel per year, the approximate maximum capacity of a 6-press plant, there would according to these figures be required for field operations an area of about 20 acres. If, as with many of the bogs, the depth is but 5 feet, or even 2½ feet as at Beaverton, the area would have to be doubled or quadrupled respectively.

The Newington peat works owned by Dominion Peat Products, Limited, were completed and in operation for a short period. About 100 tons of peat fuel are said to have been manufactured. Nothing further need be added here in the way of description of the plant and machines. It is the intention of the company, according to Dr. Spencer, the president, to continue operation next season and try to establish the factory as a permanent enterprise. No official examination of the factory when in operation has been possible, so that an opinion on the feasibility or success of the process and plant will have to be deferred.

At Welland a new arrangement was made at the beginning of the season by which Mr. Alex. Dobson was given full charge of the briquetting part of the plant and operations, and an order for one of his presses. The Peat Industries, Limited, which owns the factory, was on the other hand to furnish the supply of dried peat in shape for briquetting. For this purpose field operations were continued steadily for a considerable period and something over 500 tons finished fuel as air-dried peat were piled up at several points on the bog. Another new dryer was installed after the design of the original Simpson machine with all the latest alterations or improvements. When the new Dobson press was ready for work the new dryer began operations. It then transpired, according to Mr. Dobson who was on the ground, that the dryer was quite unable to dry the necessary supply of peat. Not more than about 3 tons could be put through in a day, instead of the required 12 to 15 tons. For this reason practically nothing was accomplished towards manufacturing the compressed fuel. Mr. Dobson states that the incapacity of this Simpson dryer was due in part to the excessive amount of water (about 60 per cent.) in the so-called air-dried peat. The chief reason for its failure lies however in the heavy loss of heat by hampering the flow of the gases of combustion from the lower cylinder chamber to the upper, and by radiation into the walls and partitions of the apparatus the combined area of which is too greatly out of proportion to the contained charge of peat. In the effort to make use of all the heat in the gases of combustion a complicated and expensive machine has been constructed, not only without gain but, judging from its operations so far, with a distinct loss, as compared with other dryers, in drying capacity.

Another new peat gatherer was experimented with at the Welland bog for removing the layers of air-dried peat from the surface of the bog. The idea of the machine is somewhat after that incorporated in the ordinary street sweeper with revolving brush drawn by a team of horses. It did not prove a success.

Harrowing for Air-drying

These field operations at Welland have directed attention to a point which has hitherto been largely disregarded or entirely overlooked, namely, the method of loosening the surface of the peat bog by harrows for air-drying. This is a very convenient plan when the bog contains many roots and snags, as at Welland. A harrow will loosen the surface regardless of the snags, where mechanical diggers will probably not work satisfactorily. For this reason the harrowing method has been resorted to at Welland. In Norway and Sweden at the manufactories of moss-litter and peat-meal this method was in extensive use at one time, and is still not entirely superseded by spade digging. The two applications are, however, different, in that the surface growth of moss used for making "litter" and "meal" is much lighter and therefore more easily dried in the air than the peat below, and may consequently be loosened for air-drying in larger fragments than peat; also in scraping off the surface after drying a considerably deeper layer will necessarily be collected, on account of the coarseness of the fragments, than would be permissible with peat, since the latter would not be dry.

It was shown in the Peat Bulletin that just about twice as much air-dried peat per acre was collected from the surface of the Welland bog by the scraper after air-drying than at the Beaverton bog, or about an inch in depth at the former and a half inch at the latter. This may explain why the Welland air-dried peat was not sufficiently low in moisture content for subsequent satisfactory handling.

From the nature of peat, especially the fibrous sphagnum variety of which most bogs are composed, it is not possible to harrow the surface into the fine granular condition most suitable for rapid air-drying. The peat is torn out largely into fragments an inch or more in diameter, only a small proportion having the proper degree of fineness, of about ¼ inch. With a mechanical digging machine, on the other hand, such as has been in operation at Beaverton for several seasons, the peat is cut and broken into fine particles and then spread over the field to dry.

Since therefore it is not possible to scrape off or in any other way collect as thin a layer as desirable of the air-dried product when it has been harrowed it must be left out longer until dried to about an inch in depth. Consequently, in order to harvest the same supply daily from both methods, approximately twice as great a field area will be necessary where harrowed as where dug and spread, other conditions being equal. Owing, however, to the uncertainty of the weather, the latter process reaps an advantage, inasmuch as during every minute of sunshine and wind, an appreciable evaporation of the moisture takes place. During periods of unsettled weather this suitability for quick drying and reaping may make all the difference between collecting a harvest or not.

Peat, after being dried, is remarkably insensible to atmospheric changes. A pile of fairly fine peat will shed the severest and most continuous rainfalls as successfully as a thatched roof, and not be wetted deeper than a few inches. In the same manner, when subjected to the most favorable air-drying conditions, the moisture content in the pile does not alter below the outer layer of two or three inches thickness. These peculiarities may be due in part to the compactness with which fine peat particles lie together; but mainly would appear to be derived from some inert physical characteristic. Peat is a marked non-conductor of heat. This all serves to show that for quick air-drying peat must be finely broken up, and to dry at all must be spread out in thin layers.

On account of the intermittent and insufficient application of the harrowing method to date, it is not possible to settle on what degree of efficiency or success it may have on a large scale. No other method is at present available for bogs full of sticks or roots, so that harrowing will probably have to be resorted to until a mechanical digger shall have been designed to work on bogs containing these obstructions.

Other Peat Works

At the Rondeau bog the waters drained off towards the close of the season by the gradual fall in the lake level, but too late to allow of resuming manufacturing operations. Next season it is proposed to throw up dikes of the peat itself on the exposed sides of the area under treatment, and then, if necessary, to pump out and start work again. A dike or bank of peat is said to be about as impervious to water as clay, which makes diking a very simple operation.

Since the fire at the Brunner works, in which most of the buildings and plant were destroyed or damaged, practically nothing has been done. The company have not yet decided on a future policy.

At Picton there is a large peat bog which, during the past year, was made the basis of an attempt to start a peat fuel industry. Mr. A. A. Dickson erected a plant in which a new horizontal open-tube briquetting press and a new dryer, both after his own design, were installed. Details of the test runs have not been obtainable, and no examination could at the time be made; but from Mr. Dickson's plans of the dryer, the principle of operation of that machine is to take the peat wet from the bog, place it in a cylindrical steam-jacketed chamber, and there, by agitation and the heat from the steam, to reduce the water to the desired content. Further work will be done with the plant at the same place this season, according to Mr. Dickson, this time by and at the expense of the Toronto Peat Fuel Company, with Mr. Dickson as superintendent.

The Milne Gatherer

Two new peat machines, both of original design, have been under development by Mr. J. J. Milne of Toronto for a year or so past. They consist of a peat harrower and gatherer, or collector, and a briquetting press. Although no tests on a commercial scale have yet been made by either, they both deserve a short mention here. The peat gatherer consists of a carriage on wheels to run on rails, from one side of which an arm thirty feet or more in length projects, almost entirely suspended by wires from the top of the carriage. This arm consists of a sheet-iron pipe twelve inches in diameter, with a flexible joint at the carriage end, by means of which it can swing from its first position at right angles to the car and track through 90 degrees back to the side of the track. The outer end of the pipe turns down sharply, at the same time expanding to a rectangular opening or mouth 3 inches by 36 inches in cross-section, which is protected by curved lips and kept at the required distance of about one-half inch from the surface of the ground or peat bog by flexibly affixed runners on either side. Two electric motors are installed on the carriage, one propelling the whole apparatus forward or backward, and the other driving a large fan connected with the collector arm or suction pipe. When in operation the carriage will travel along at the desired speed, sliding the runners and arm over the ground and by means of the exhaust fan suck up the loose particles of peat and discharge them from the outlet pipe into an attached tender car. This car must necessarily have some such covering as canvas, to allow the large volume of air to pass out while at the same time retaining the peat. Such a car has not yet been built, and possibly difficulty may be encountered in separating the air from the peat, since a large amount of the latter will be composed of dust, which may clog the apertures of the cloth sieve. Power is taken by trolley from wires above the track. After the machine has travelled the length of the track and sucked up the air-dried peat from a strip 36 inches wide (the width of the collector lip or mouth) the arm is moved back until the mouth is in position to traverse the adjoining 36 inches. The position of the mouth at right angles to the line of travel is maintained by means of two parallel motion rods and a flexible joint at the top of the diverging mouthpiece. The suction pull exerted by the fan is very strong, but amenable to adjustment. This machine is full size. It is thought that the length of the arm might be increased with advantage to forty feet or so, thus enlarging the area or strip of bog covered by the machine. Also another or second arm might be projected from the other side, the one to counterbalance the other.

The method of loosening the surface of the bog for air-drying, preparatory to collecting, will be by harrowing. Directly behind the mouthpiece of the suction pipe a harrow of the same width as the mouthpiece will be attached to and drawn by the machine, in this way loosening another layer of peat immediately after the first has been removed. By this machine, therefore, the intention is to accomplish the several field operations at one time.

The Milne Press

The Milne briquetting press which, together with the above peat collector, has been set up at the home of Mr. Milne near Markham is a reduced working model, turning out a peat briquette of about one-eighth the weight of the proposed block. The principle of the machine consists in revolving against one another two steel disc or cog wheels whose width is that of the desired peat briquette, say 2½ inches and out of the periphery of each of which semi-cylindrical "compression cavities" are milled of the same diameter as that of the desired briquette. Except for the shape of tooth and cavity the wheels are the same as ordinary cog-wheels. The tooth of one wheel comes opposite the cavity of the other, entering into it one-eighth of an inch. On either side of these two compression wheels where they meet or interlock (without touching, a fraction of an inch clearage being allowed), a steel band composed of a number of thin bands for greater flexibility, is held tight and flat against the wheels for a sufficient height both above and below the point of interlocking, where the compression takes place, to guide the stream of peat dust into the cavities of the wheels, to form the ends to the peat blocks by enclosing the compression cavities, and to hold the compressed blocks below long enough to free them therefrom. The peat is fed by hopper from above and immediately compressed by the tooth of one wheel into a cavity of the other. The side bands move with the compression wheels by contact with them. When the correct feed is maintained a very solid, dense block of peat results having a semi-cylindrical form. There is a slight frictional motion on all the faces of the briquette which gives somewhat of a polish and hardness to the surface of the blocks.

Mr. Milne states that an order has been received from a firm in Indiana for one of each of these machines, and that he hopes to have the same built and installed for operation there this coming season. Until then, or until they have been put in commercial operation elsewhere, it will not be possible to express an opinion one way or other as to what success may be expected with the press. The model works well, but with all such machines the test of time, that is of continuous operation on a commercial scale, is the only one which really counts.

The Industry in Europe

In Norway great interest is now being taken in the peat fuel industry and as it is still in the initial or investigation stage there just as it is here, the information acquired in that country is naturally of value in Ontario. Not only in Norway, but in every other European country where peat forms an article of commerce, the steady progress of the industries arising out of its various utilizations is the raison d' etre of an Association which employs one or more peat engineers and a regular office staff, and possibly maintains and operates laboratories for the chemical examination of peat and its products, with the idea of gathering and disseminating information of value. These Associations all receive Government aid in one form or other, which enables them to periodically publish for free distribution reports of their work with all data and advice for the aid of persons already engaged in or about to enter into the manufacture of peat products.

Much of this work does not greatly interest us in Ontario since in those countries practically the only peat fuel manufactured is the so-called "machine-peat," which, besides containing too much water (25 to 30 per cent.), is too bulky for general competition with either hard or soft coal. Briquetting for a product similar to that of our own plants has been tried at only two or three places in Europe. In addition, the fact that by removing the moss or peat of the marsh or bog good farm land may be reclaimed is just as important, if not more so, in those countries, where agricultural lands are scarce and of national value, as the utilization of the peat itself. A few acres of farm land more or less in this country do not signify much, where the unoccupied areas ars as yet so great. But apart from these differences, the Norwegians require to know as much about the peculiarities of peat and how to best go about its manufacture into fuel as we do.

From the report of progress of the engineer to the Norwegian Marsh Association for the year 1903 several extracts are here given. The first requisite to success in any undertaking to manufacture peat fuel is a suitable bog. This has not yet been fully realized in Ontario. In Norway, where bogs are plentiful, those which cannot be drained are not worked, although in other countries, Denmark and Russia for instance, such submerged bogs are now turning out a large amount of machine-peat fuel every year. It may be necessary in time to make use of our own submerged bogs, but in that event the probability is that the required area will be cut off from the rest by dikes of the peat itself, the water pumped out and the bog then worked dry, as with a naturally drained one.

The Bogs of Norway

The Norwegian rules require not only that the bog must be systematically sounded in order to closely estimate its contents, but that samples be taken from the different layers and analysed for the usual constituents of carbon, volatile combustibles and ash, and a determination made of its calorific or heating value. First class fuel should have no more than 6 per cent. ash; 10 per cent.

ash makes second-class, while 15 per cent. is the limit allowable for all ordinary purposes. The calorific value depends on the degree to which the peat in the bog has "ripened" or "matured," that is, become dense by elimination of part of the gaseous constituents with an increase in the carbon. The minimum for good fuel is placed at 5,000 calories per kilogram which is equivalent to 1,260 B.T.U., calculated on peat free of water and ash.

A bog of not less than 6 feet to 7 feet in depth is preferred. It should be allowed to drain to the bottom for at least a year before commencing to dig, and not until three years after does the bog become sufficiently dry to manufacture machine-peat thereon at the normal minimum cost. The reason for this lies probably in the necessity in most cases of spreading the cut or excavated peat on the surface of the bog for air drying, when the dryer the bog the more rapidly will the moisture evaporate from the incumbent peat. The practice in Ontario in air-drying is also to spread the peat over the surface of the bog. but in a fine granular condition instead of in bricks, so that the same time may be required here to attain the minimum cost. If the upper stratum of live or light moss is not to be made use of, time may be saved by burning off the top to the dense peat underneath into which the fire will not penetrate. By this means an excellent level and dense surface is obtained on which to begin the field operations of digging or excavating and spreading.

The higher the bog relative to the surrounding country and the freer it stands from any fringe of bordering trees the greater will be the sweep of wind across the drying fields. Wind is by far the most important factor in the air-drying process.

In European countries bogs must be reasonably clear of roots and sunken timber, even though their method of raising the peat is by hand with the spade. With us, as before mentioned, unless snags are almost entirely absent the mechanical excavator as now made cannot operate.

Besides the above properties of a suitable bog there are no doubt others which enter into its practical utilization to an important degree, but which only the experienced manufacturer can fully appreciate. On the other hand, no expert would be justified in passing an opinion on the value of any bog until he has before him the results of the analytical determinations. The quality of peat cannot be judged by the eye.

Swedish Tests

During the past year numerous tests were made in the locomotive engines on the Government railroads in Sweden using peat for fuel, then peat and English coal mixed, and lastly peat, coal and lignite briquettes mixed, with results which showed that except for its bulkiness peat could be fired in the engines with as good results as coal and without much more trouble or labor, but that when mixed with coal, or coal and lignite briquettes, its relative bulk was advantageously reduced, and at the same time a fire superior in calorific value to either of the fuels alone was produced. In convenient situations, it was therefore the instructions of the Government that peat be bought for railroad use as above and for heating all the railroad buildings, stations, etc. The English coal used cost in Sweden $4.32 per ton, and the peat $2.56 per ton. This of course was machine-peat.

Peat Meal

The other most important utilization of bog moss and peat in European countries is for the manufacture of "peat-meal." Suitable material for this consists of the live moss or that just recently dead and not yet greatly decomposed. This when dried and pulverized will absorb and retain liquids in greater quantity and more readily than any other plant growth, and it is on account of this property that it is manufactured and sold as peat meal.

It is usual where the bog is composed of such moss on top and good fuel peat in the lower strata, to manufacture first peat-meal or moss-litter, and then peat fuel. The largest peat-meal works in Europe are located on an extensive marsh at Helenaveen, Holland, and belong to the Griendtveen Moss Litter Company, where 150,000 tons of peat-meal are turned out yearly. The factory employs 100 men all the year round, and during the summer months an additional 500 cutting and harvesting the peat from an area of about 12,000 acres per annum. The meal is marketed all over Europe, and even in America. There are factories in Norway and Sweden and other European countries, but all of considerably smaller capacity. The process of manufacture consists of cutting out the peat by hand with spades in thin layers, spreading these on the surface of other parts of the bog to air-dry sufficiently to allow of its being handled, and then stacking the bricks in covered racks through which the wind may blow, and complete the air-drying operation. Containing now about 25 per cent. of moisture the peat is taken into the factory, finely pulverized to pass about one-eighth inch mesh, and then completely dried by mechanical means into the finished peat-meal of commerce.

The chief use of the meal is for sanitary purposes, where it is particularly valuable in absorbing and secreting the liquids and odors and as a medium to facilitate their subsequent transportation. Not only does all litter used in stables and cow sheds consist of this peat-meal but whole towns depend on it in their sanitary arrangements where, as is common enough in many Norwegian and Swedish centres, the modern household water facilities are rare. When saturated in these uses it becomes a most valuable fertilizer, and is sold or disposed of for use in the cultivation of land. As an indication of its value both in sanitation and as a manure it may be remarked that it has been determined by careful observation that when used as a litter in the stable peat-meal will gather for each full-grown animal as much as 31 lb. more per year of the more easily soluble ammonium salts than straw litter will.

Forty comparative tests were made of the fertilizing strength of these two manures, peat-meal and straw, by which it was found that land cultivated with the former produced per acre 660 lb. more of potatoes than that cultivated with the latter, and this at the extra outlay of only 60 cents, which is the cost per acre of fertilizing with the peat-meal manure.

Of the other important uses of peat-meal one consists of mixing it with molasses in the proportion of 70 to 80 per cent. of the latter to 20 or 30 per cent. peat-meal for a fodder for cattle. The meal dilutes and preserves the molasses without however in any way adding to its nutritive value, and makes handling and transportation easy. The Germans and Austrians use the food for their live stock quite extensively. Experimental lots have been made in Ontario of first-class quality, and if a market were worked up here its manufacture might become important.

Peat Board and Paper

In several of those European countries where peat and its products have become articles of commerce, the use of peat-meal in the manufacture of paper and board is attaining considerable proportions on account of its cheapness and suitability. This value of peat moss or meal has not been overlooked in Ontario; it is even possible that before the present year is out we shall have one factory in operation preparing the peat pulp. The only suitable variety of moss seems to be sphagnum, on account of its length and strength of fibre, and it occurs in abundance and of good quality in this country.

During several years past experiments have from time to time been carried on in Ontario with the view of utilizing mosses for the above purposes, but not until last fall has any intention of following up the trials by operation on a commercial scale been shown. A party of men interested in the paper business were at that time investigating plants and processes both here and abroad, and finally purchased the Canadian rights to the patents on a mechanical process invented in Austria for making from peat moss an article known to the paper and allied trades as "half-stuff," without the use of chemicals or boiling. One of the Austrian machines was brought over and set up at Beaverton, near a suitable bog belonging to these parties, and test runs of several days' duration made in which a quantity of "half-stuff" was produced. This was afterwards successfully converted into pulp board and leather board of good quality on the ordinary machines at another place.

The patent holders and others have since formed themselves into The Peat Board Company, Limited, capitalized at $250,000 in shares of $100 each, and with head office at Toronto. According to its prospectus the company has purchased three machines with a combined capacity of 30 tons of half-stuff per day. The estimated cost of the plant is $75,000, and it is proposed to erect it on a bog at Cannington, near the southeast side of lake Simcoe.

This half-stuff is to be used by the company in making paper, card board, leather board, mill board, fibre board, etc., to take the place of pulp made from straw, wood or other materials. The original plant using this process was erected about two years ago at Admont, Austria, where according to the prospectus of The Peat Board Company, it has continued in profitable operation since, finding a ready market for the product. The cost of manufacturing this peat board at that place is given as $9.00 per ton. In this country it will, it is thought, cost at least $12.50 per ton, which is just about one half the present market price of straw board, and one third that of wood board. The quality of peat board made by this process is said for many purposes to be superior to that made from straw pulp and equal to that made from wood pulp. It is quite odorless, a valuable property where used for packing and shipping provisions.

The new plant will, according to the present intentions of the company, be erected for operation this season.

Mining Lands Disposed Of

There were sold and patented under the provisions of the Mines Act in 1903 6,437 acres, as compared with 3,985 acres in 1902, the purchase money received by the Department of Crown Lands being $15,123.89 as against $8,202.52 the previous year. The area of lands leased under the said Act was also greater than in 1902, being 33,427 acres as compared with 25,549 acres,

Sales

District.	Number of grants.	Acres.	Amount. $
Rainy River.......	23	1,957	4,691 40
Thunder Bay......	8	843	1,926 00
Algoma	12	1,037	1,810 50
Elsewhere.........	23	2,600	6,695 99
Total	66	6,437	15,123 89

Leases

District.	Number of leases.	Acres.	Amount. $
Rainy River.......	102	12,948	12,948 50
Thunder Bay.....	53	9,265	9,262 00
Algoma............	13	1,425	1,342 76
Elsewhere.........	67	9,789	9,624 35
Total	235	33,427	33 177 61

and the sum received as first year's rental amounting to $33,177.61 as against $25,288.38. Rentals on account of the lands leased in previous years amounted to $13,117.94 ; receipts for leases converted into freeholds were $7,117.75, and for miner's and prospector's licenses $2,241.40. The total income therefore derived from mining lands for the year was $70,778.59.

Mining Companies

There were 43 joint stock companies incorporated under the laws of Ontario during 1903 to engage in the various departments of the mineral industry, with an aggregate authorized capital of $35,534,000, as compared with 58 such companies with a capital of $48,650,000 in 1902. Twelve extra-Provincial companies took out licenses to do business in this Province, with a combined capital of $12,000,000, the number of similar companies in 1902 being 15, with an aggregate capital of $17,375,000. As usual, much the larger proportion of companies outside the Province desirous of operating in Ontario came from the United States, English capital being but slightly represented; and not a few of the corporations organizing under Ontario laws had their origin south of the line, where the profits as well as the hazards attendant upon the mining industry are better understood than in Canada, and where there are men of capital experienced in mining enterprises, not averse to risking a portion of their means in the hope of securing large returns. There is however a class of companies which has done not a little to bring undeserved discredit upon the business of mining in Ontario. It is by no means an unknown thing for an individual or individuals from the United States to come over to this Province and buy for a small sum an undeveloped or partly developed prospect, paying for it either in cash, or partly in cash and chiefly in promises of stock. Returning to their own country, they organize a company with a large share capital, and proceed to issue a prospectus. This is usually a highly-colored affair containing as few facts as possible regarding their own property and as many glowing generalities regarding the class of mining in which they are professedly engaged as can be found room for. If the company is formed for copper, the wonderful returns from the Calumet and Hecla mine are set out in detail, or if for gold, the Homestake mine in North Dakota or the Treadwell mine in Alaska are described with minuteness, the inference of course being that if the low-grade ores which have made these mines famous yield profits so immense, the prospects for their own mine, the ores of which are so much richer, are positively unequalled anywhere. There is an invitation to come in on the "ground floor," usually enforced by a schedule showing the fortunes made by lucky investors who bought low-priced mining stocks elsewhere which afterwards rose in value five hundred or a thousand fold. The stock of these companies is not offered for sale in Ontario, but is disposed of exclusively in the United

States, chiefly among people ignorant of mining, but greedy for profits. In some cases particular classes are attacked, such as clergymen or post-office employees, whose calling affords little outlet for the speculative spirit, and the very smallness of whose savings seems to urge them to take this sure method of doubling or trebling them. So long as foreign corporations not authorized to do so by license from the Lieutenant-Governor in Council do not seek to sell their stock in Ontario, the laws of the Province are powerless to reach them, or to protect the people of a foreign country. Nevertheless, the operations of such concerns tend to injure the mining business here, and to make it more difficult to procure capital for honest and legitimate enterprises.

Of the mining companies incorporated and licensed last year, five were for oil, four for oil and gas, one for gas, six for iron, three for copper, fourteen for gold, two for peat, seven for cement, and one each for coal, iron and nickel, molybdenum, stone, mica, gold and copper, and asbestos, while six were miscellaneous or undeclared in their objects.

Following is a list (1) of the joint stock companies incorporated under the provisions of the laws of Ontario during the past year, and (2) of the foreign companies licensed to carry on business here :

Mining Companies Incorporated 1903

Name of Company.	Date.	Head Office.	Capital.
			$
Belleville Portland Cement Company, Limited	26 December, 1902	Belleville	2,500,000
Blenheim and Harwich Oil Company, Limited	14 January, 1903	Blenheim	150,000
Eastern Canada Coal Company, Limited	30 January	Toronto	2,000,000
Imperial Peat Company, Limited	7 May	Guelph	1,000,000
King Edward Mine, Limited	10 June	Bruce Mines	200,000
Moose Mountain, Limited	30 January	S. S. Marie	100,000
National Iron and Nickel Corporation, Limited	21 January	Toronto	5,000,000
New York and Lake Erie Oil and Gas Company, Limited	22 June	Windsor	1,000,000
North Shore Copper and Smelting Company, Limited	24 April	Toronto	250,000
Standard Cement Company, Limited	26 February	Toronto	500,000
St. Mary's Portland Cement Company, Limited	28 April	St. Mary's	600,000
Toronto-Hamilton Portland Cement, Limited	18 July	Toronto	350,000
Toronto Peat Fuel Company, Limited	23 September	Toronto	40,000
Williams Iron Mines Company, Limited	14 October	S. S. Marie	3,000,000
The Belmore Bay Gold Mining Company, Limited	4 March	S. S. Marie	1,000,000
The Bissman-Gray Molybdenum Mining and Reduction Company of Ontario, Limited	31 July	Fort Erie	1,000,000
The Camp Bay Mining Company, Limited	20 May	Niagara Falls	90,000
The Colonial Oil Company, Limited	13 May	London	100,000
The Coronation Gold Mining Company, Limited	14 February	Ottawa	1,000,000
The Crowland Natural Gas Company, Limited	4 November	Port Colborne	80,000
The Damascus Gold Mining Company, Limited	13 November	Bridgeburg	250,000
The Erie Oil Company, Limited	27 March	St. Thomas	100,000
The Grimsthorpe Mining Company, Limited	20 November	Toronto	150,000
The Hanover Portland Cement Company, Limited	26 March	Hanover	500,000
The Hermina Mining Company, Limited	17 June	S. S. Marie	2,500,000
The Horse Shoe Quarry Company, Limited	14 February	St. Mary's	40,000
The Hutton Mining Company, Limited	14 January	S. S. Marie	100,000
The International Iron Mining Company, Limited	29 October	Port Arthur	1,000,000
The Iron and Steel Company of Canada, Limited	21 August	Belleville	300,000
The King Edward Oil Company, Limited	18 September	London	100,000
The Kipp Oil Company, Limited	7 October	Chatham	150,000
The Loon Lake Iron Company, Limited	10 June	S. S. Marie	3,000,000
The Lucinda Gold Mining Company, Limited	21 August	S. S. Marie	100,000
The Manitoulin Portland Cement Company, Limited	28 August	Windsor	1,000,000
The Peninsular Oil and Gas Company, Limited	15 July	Chatham	100,000
The Shakespeare Gold Mining Company, Limited	21 October	Shakespeare Tp.	2,000,000
The Star of the East Gold Mining and Milling Company, Limited	23 September	Peterborough	1,500,000
The Sultana Gold Mine, Limited	27 May	Rat Portage	1,000,000
The Temiscaming and Hudson Bay Mining Company Limited	29 July	New Liskeard	25,000
The Vera Mining Company, Limited	28 August	S. S. Marie	1,000,000
The Wakefield Mica Company, Limited	22 June	Ottawa	50,000
The Waterford Oil and Gas Well Company, Limited	26 December, 1902	Waterford	60,000
The Western Ontario Portland Cement Company, Limited	39 January	Attwood P. O.	500,000

Licensed Mining Companies

Name of Company.	Date.	Head Office.	Capital.
Gold Standard Mining Company	26 December, 1902	Aberdeen, S. Dakota	$1,000,000
Great Northern Oil and Gas Company	30 April, 1903	Chicago, Ill.	2,000,000
International Asbestos Company	21 April,	New York City	50,000
Long Lake Gold Mining Company	31 July	Manchester, Eng.	£5,000
Northern Development Company	28 August	Phœnix, Arizona	$1,250,000
Provident Mining Company	31 August	Phœnix, Arizona	1,000,000
Vermilion Bay Mines Company	10 June	Wilmington, Delaw're	1,000,000
The Belmont Gold Mine, Limited	9 October	Hebburn-on-Tyne	£80,000
The Eagle Copper Company	17 June	Sault Ste. Marie, Mich	$50,000
The Eagle Lake Gold Mining Company	23 September	Phœnix, Arizona	2,000,000
The International Gold and Copper Company, Limited	16 January	Phœnix, Arizona	3,000,000
The Mikado Gold Mining Company, Limited	6 November	London, Eng.	£45,000

Mining Accidents

In 1903 the number of mining accidents reported to the Bureau of Mines was 18, involving 23 men and causing 7 deaths. Except in the number of fatalities, which is somewhat smaller, there is but little from the record of the previous year. On account, however, of the neglect of some of the mine operators to report all accidents, both slight or serious as well as fatal, these figures have not as definite a value as is desirable in indicating the safe operation of the mines. Not so much improvement is noticeable at the large mining camps as at the small isolated mines, since at the former comparatively little carelessness is tolerated at any time. At the latter the Inspectors find that as a rule it is only necessary to draw attention to any undesirable practices, and at the same time to the requirements of the Mines Act, to have the changes made. In this way the law is becoming better understood and more generally observed in principle as well as letter throughout the Province.

There still appears to be some misapprehension with regard to the provisions of the law when accidents occur. Full instructions will be found in the Mines Act, R. S. O. 1897, consolidated form, section 82. These are to the effect that when loss of life or serious personal injury to any person employed in or about a mine occurs by reason of any accident whatever, the owner or agent of the mine shall within the next twenty-four hours send written notice of the same to the Director of the Bureau of Mines, and in the case of a fatal accident to the Inspector of Mines as well. The Bureau makes a practice of then requiring subsequent reports from time to time until the injured person has completely recovered, or otherwise.

Should the accident be fatal it is advisable to notify the coroner immediately and have an inquest held, even though it appears clear that no blame can be attached to any one but the victim himself, for the protection of the mine owners or operators as well as for the elucidation of the facts, which is always easier at the time than later on.

Canadian Copper Company

At the Canadian Copper Company's works at Copper Cliff, eight accidents occurred during the year, of which only one proved fatal. In this one James A. Hodgins was on Thursday, 15th January 1903, at 1.15 p.m., run over by a yard engine, and two days later died from the effects of his injuries and the subsequent amputation of his leg below the knee. He was employed as coupler in the train crew, and when placing some coke cars over the bins back of the smelter stepped off the rear of the engine tender to effect the coupling. At this point the tracks run over a short length of open trestle and the ties having become covered with ice Hodgins slipped through and the wheels of the tender passed over one leg which lay across the rail. The crew removed him to the doctor's office; later he was taken to St. Joseph's hospital in Sudbury where his leg was amputated, and his death took place the following day.

Dr. R. B. Struthers, coroner, held an inquest before a jury who rendered a verdict to the effect that no blame was attached to the train hands, but that the road where the accident took place was not in a fit condition for the train men to work on in safety, and they recommended it to be put in proper condition without delay. These trainmen were provided with a platform on the rear of the engine tender from which to do the coupling, so that had deceased stopped to consider he need not and probably would not have left the engine.

The remaining seven mishaps were more or less serious. On 23rd January Walter Creighton was thrown from an engine, paralyzing his arm for about four months.

On 25th January Peter Marshall had his hand crushed in a gear wheel at the Creighton mine rock house, disabling this member for nearly six months.

On 18th February Gusta Nasi had his arm and leg burned at the west smelter by a slag explosion, from which he did not recover until August.

On 18th May Jacob Kallio went down No. 2 mine in the skip, which practice is strictly forbidden by the Mines Act, and had his leg broken. This laid him up until January, 1904.

On 30th June while working at the erection of the new smelter plant James Morrison was struck by a falling derrick and had arm, rib and collarbone broken, from which injuries he did not recover until January 1904.

On 10th September Basil Ferari had his leg crushed by a car of rock dumping on him while working at the new plant. It was necessary to amputate the leg, and this has kept him in the hospital up to the present time (March, 1904).

On 14th October John Jokinen's leg was fractured at the Copper Cliff mine rock house, and as a result he was laid up until February 1904.

Victoria Mine

A minor accident was reported from the Victoria mine by which on 25th March at 3.00 p.m. while working in the smelter, Napoleon St. Jean was severely burned by a discharge of matte from one of the converters. His head, back and heels suffered considerably. He was placed in charge of the mine doctor.

Elizabeth Mine

The Elizabeth mine, the property of the Anglo-Canadian Gold Estates, Limited, was the scene of an accident which fortunately did not prove very serious. On 19th April at 5 a.m. two machine runners, John Oleson and James Murdoch, were loading their drill holes preparatory to blasting. Oleson being farther in the drift started lighting his fuses first. Murdoch had in turn lit three out of his four fuses, but had difficulty in starting the fourth, and stayed so long that one of Oleson's charges exploded close beside him without, however, injuring him. Before he reached the shaft, only 10 feet away, a second one of Oleson's went off and the flying rock cut his legs rather severely in places. He also suffered severe contusions and bruises. Medical aid was summoned from Port Arthur by wire and Murdoch, the only one hurt, put in a good way to quick recovery. He was three weeks later reported well again.

Helen Mine

At the Helen mine, Michipicoton Mining Division, three accidents were reported during the year by the mines manager of the Lake Superior Power Company, and all were caused in the same way, namely by rock becoming dislodged from the open pit walls and rolling down on the trammers working on the floor below. Although the company states that the pit walls were scaled every day to remove any loose or dangerous rock, it seems that still greater care in the work, or else an altered system of mining by which the danger and the miners are somewhat farther removed from each other, might be instituted. In all open mining in such changeable weather conditions as exist in Ontario, it is not invariably possible to make perfectly safe and sound such rock walls, especially where these are badly fractured, and the only safe alternative is to keep the workmen away from the walls.

The first mishap occurred on 7th April to two trammers Toni Frikovitch and Fred Meaiten, who were struck by loose stones rolling down from above. The heads and bodies of both were badly bruised, but after three months' care in the hospital and elsewhere their recovery was complete.

The next accident happened on the 27th of the same month by which J. Verrault was fatally injured. In this case also the deceased was a trammer working on the pit floor when a mass of rock of some 150 pounds weight became dislodged from the pit wall and rolled down the steep incline. All the other trammers got out of its way, but Verreault apparently became too confused to move and was struck on the head and almost instantly killed.

In the third accident on 30th June, P. Prebencore while in the open pit was struck on the head by another piece of rock falling from the side of the wall and severely injured. He was removed to the hospital and at later report was progressing favorably.

Big Master Mine

At the Big Master mine, Manitou lake region, at 10 a.m. on 20th August one of the miners, Albert Johnson, while working underground was fatally injured. He formed one of the machine crew stoping between the first and second levels. His partner climbed to a stope platform a short distance above, and in the act dislodged a home-made wooden bucket or box used for lowering steel, which struck deceased on the head, causing fracture of the skull.

Johnson died from the effects of the injury five hours later. It is difficult to attach the blame to any one; the miners were probably themselves careless as to how they placed the box on the platform, and on this occasion left it too near the edge where a slight jar would knock it off. An inquest was not considered necessary by the coroner at Wabigoon.

Loon Lake Mine

The most inexcusable calamity of the year occurred at the Loon lake iron mine near Wilde, Algoma Central railway, on 14th September at 11.30 a.m. by which two miners, William Pelkonen and Peter Thompson, lost their lives. They formed part of the day shift sinking a vertical shaft which had then reached a depth of about 160 feet with a cross-section of approximately 6 by 10 feet. Beyond a short collar and one length of ladder therein no timbers of any kind had been placed in the shaft, although the management state that a string of hanging ladders was occasionally suspended to the bottom from the top, or from the tunnel connection at 70 feet depth, and was in place at the time of the accident. It appeared, however, to have been the usual practice to enter or leave the working by the bucket alone, and one may surmise that no active opposition to this was offered by the manager or the shaft contractor foreman, since notices forbidding same, in accordance with the requirements of the Mines Act, were not posted, and the shaft was not properly timbered so that the men could safely travel otherwise. A length of even 100 feet of hanging ladders in a vertical shaft is much too great when affording the only means of ingress and egress. Such ladders are merely temporary arrangements at best, to bridge the necessary drop of 30 or 40 feet from the timbers to sinking operations in the shaft bottom. The timbering should follow down with the sinking at about this safe height above blasting operations at the bottom of the shaft.

When examined later by Inspector Carter, the hoist and connected apparatus such as rope, sheaves and derrick worked satisfactorily. On the occasion of the accident the two deceased took their places on the bucket and then signalled to the hoist man down the hill. He started to lower the bucket which was now suspended in the shaft mouth. With the brake off the rope did not however pay out and the hoistman without first setting the brake again ran around in front, caught hold of the hoist rope and shook it to start the bucket. This he did so effectually that the rope went out with a jerk, threw him down, and before he could recover and jump to his feet the bucket and men had dropped to the bottom of the shaft. Both men were found dead in the bucket, having apparently been killed instantly.

A coroner's inquest was held on the day following, the jury bringing in a verdict to the effect that "the said Wm. Pelkonen and Peter Thompson met their deaths through the neglect of the Loon Lake Mining Company in allowing the men to descend in a bucket contrary to the law."

Belmont Mine

The Belmont gold mine was the scene of two accidents during the year. In the first on 26th May four miners, E. Yeomans, T. Cody, A. Lyman, and H. Reid, were leaving the mine by No. 3 shaft about 6 a.m. at the end of their shift. They had been working in the bottom of the shaft in the sink below the 400-foot level, and had climbed the ladder to the 300-foot level, there getting on the skip on the west track to ride to the top. This they knew was in direct disobedience to the rules and regulations duly posted in the shaft-houses, prohibiting riding in the skip under penalty of fine and dismissal. This penalty had on several former occasions been enforced. When at about the 200-foot level something went wrong with the hoist and the skip dropped back to about 40 feet below the 300-foot level before the brake caught it again. On striking the chain placed across the 300-foot level where it usually stood, it rolled over to the east track, throwing out all but Reid, who managed to hang on, and as a result came out but slightly injured. Yeomans dropped into the sink, and Cody and Lyman into the east skip which was standing somewhere near the 400-foot level. The four were quickly brought to the surface and placed under the doctor's care; but Yeomans died during the night. Cody and Lyman, though badly bruised about the head and arms, had no bones broken and gradually recovered, while Reid was not much the worse for his shaking up. The coroner was notified and held an inquest, the depositions to the above effect being placed on record.

The second mishap occurred on 24th October whereby a young man named W. Darcy was seriously injured in No. 10 incline shaft. The kibble in descending dislodged a piece of rock from one of the wall plates where apparently it had fallen out of a loaded bucket. The rock rolled down and struck Darcy on the back of the head, cutting him badly. However after a month or so he completely recovered and went to work again.

Table of Mining Accidents 1903

No.	Date.	Mine or works.	Name of injured person.	Result of injury. Slight.	Serious.	Fatal.	Above ground.	Below ground.	Nature of injury.	Cause of accident.
1..	Jan. 15..	Canadian Copper Company.	James A. Hodgins	....	....	1	1	....	Leg fractured; subsequently amputated; death ensued.	Run over by yard engine while coupling cars.
2..	Jan. 22..	Canadian Copper Company.	Walter Creighton	....	1	....	1	....	Arm paralyzed	Thrown from engine.
3..	Jan. 25..	Creighton	Peter Marshall	....	1	....	1	....	Hand crushed	Caught in gear wheel in rock house.
4..	Feby. 18..	Canadian Copper Co's. west smelter	Gusta Nasi	....	1	....	1	....	Arm and leg burnt	Slag explosion.
5..	Mar. 25..	Victoria	Napoleon St. Jean	....	1	....	1	....	Head, back and heels burnt	Hit by a splash of molten matte from converter
6..	April 7..	Helen	Toni Frikovitch	....	1	....	....	1	Head and body bruised	Hit by loose stones rolling into open pit.
			Fred Meaiten	....	1	....	....	1	" "	
7..	April 19..	Elizabeth	Jas. Murdoch	....	1	....	....	1	Legs cut and body bruised	Hit by rock from blast.
8..	April 27..	Helen	J. Verreault	....	....	1	....	1	Killed	Hit by rock falling from pit wall.
9..	May 18..	Canadian Copper Co's No. 2 mine.	Jacob Kallio	....	1	....	....	1	Leg broken	Going down mine in skip.
10..	May 26..	Belmont	E. Yeomans	....	....	1	....	1	Killed	Skip dropped in shaft with men in it.
			T. Cody	....	1	....	....	1	Head and body cut and bruised	
			A. Lyman	....	1	....	....	1	Arms and body bruised	
			H. Reid	1	....	....	....	1	Bruised	
11..	June 30..	Helen	P. Prebencore	....	1	....	....	1	Head bruised	Hit by rock falling from pit wall.
12..	June 30..	Canadian Copper Co's new smelter.	Jas. Morrison	....	1	....	1	....	Arm, rib and collar bone broken	Struck by falling derrick.
13..	Aug. 14..	Superior	William Arbour	....	....	1	....	1	Killed	Fell out of bucket.
14..	Aug. 20..	Big Master	Albert Johnson	....	....	1	....	1	Killed	Struck by falling drill-steel box.
15..	Sept. 10..	Canadian Copper Co's new smelter.	Basil Ferari	....	1	....	1	....	Leg crushed and subsequently amputated	Car of rock dumped on him.
16..	Sept. 14..	Loon Lake	Wm. Pelkonen	....	....	1	....	1	Killed	Dropped in bucket down shaft.
			P. Thompson	....	....	1	....	1	"	
17..	Oct. 14..	Copper Cliff	John Jokinen	....	1	....	1	....	Leg fractured	Working in rock house.
18..	Oct. 24..	Belmont	W. Darcy	....	1	....	....	1	Head cut	Hit by falling stone.
	Total	Total casualties 23		1	15	7	8	15		

Government Diamond Drills

The two diamond drills owned by the Government were in active demand and steady operation during the year. The larger or "C" drill, capable of boring to a depth of 1,200 or 1,500 feet, had been in the service of one company from February 1902 until September 1903, and after that worked for another party to the close of the year. The smaller or "S" drill, with a capacity of about 500 feet depth, served on the other hand a large number of property owners on a variety of mining prospects. Both drills were manufactured by the Sullivan Machinery Company of Chicago, the larger boring a core an inch and an eighth in diameter, and the smaller a core fifteen-sixteenths of an inch in diameter. The operations of both are under the direct supervision of the Bureau of Mines through the drill managers, who are appointed by this Department. E. K. Roche is manager of the "C" drilling plant, and W. W. Roche of the "S" drilling plant.

The original regulation under which the Bureau of Mines bears 35 per cent. of the cost of operating the Government diamond drills on the property of parties procuring the services of the same expired on 31st December 1903, but has been extended for a further period of two years, namely, until 31st December 1905. The cost of operation begins at the date of ordering the drill to proceed to any particular deposit and ceases on the day it completes work thereon. It includes all freight and other charges for transporting the drill, travelling expenses of the drill manager and any other of his employees whom it may be necessary to take with him, and supplies for the plant, in addition to the actual cost of the drilling after the plant has been set up and put in operation. As a general rule the unskilled labor, that is the men in addition to the drill manager and his two drill runners, may be more cheaply obtained from place to place as the drill moves about.

A small pamphlet has been published by the Bureau of Mines for the guidance of any wishing to secure one of the drills, which sets forth the "Rules and Regulations for the Control and Working of Diamond Drills." A copy of this may be secured on application to the Director.

A number of mining companies throughout the Province have purchased drilling plants of their own, preferring to conduct exploration of their properties on their own account, among them the Consolidated Lake Superior Company owning the Helen and Josephine iron mines and the Gertrude and Elsie nickel mines, the Canadian Copper Company owning nickel mines near Sudbury, the Mond Nickel Company owning the Victoria and other nickel mines, the Ontario Graphite Company owning the Black Donald graphite mine, the General Electric Company owning numerous mica mines, the Wiley Bros. of Port Arthur and a number of others. Where diamond drill exploration is likely to be continuous, as is the case at most of the above companies' mines, it pays such operators to maintain their own drilling outfits as part of the mining plant. The Government drills were obtained more for the purpose of aiding the exploration of mining prospects or for use in determining the value of an ore body whether developed or not, than for permanent work at any one mine where drilling forms a part of the regular mining operations.

The table given below summarizes the boring operations completed since last Report. It includes nearly two years' work of the "C" drill and a year's work of the "S" plant. The holes bored aggregated a total length of 7,012½ feet, as against 2,224 feet for the "C" drill alone during the season of 1902, the respective total costs of the two periods being $21,786.07 and $4,487.21, and the net costs to the operators $14,273.83 and $2,916.70. The most extended explorations with the drills during the time included in the table took place in eruptive rocks, which are much harder on the diamonds than most other formations. The drilling by the "S" plant in 1902 was on the other hand chiefly in the softer rocks, which largely explains the greater cost per foot drilled, $3.15, during the past season, as compared with that during 1902, namely $2.02, and the almost doubled cost per foot of diamonds, namely 81 cents as against 44 cents.

The "C" Drill

In February 1902 the larger of the two drills was placed at the service of Mr. J. M. Clark to explore for iron in the vicinity of Steep Rock lake, Rainy River district, Mr. R. H. Flaherty being manager of the exploring party. As to the geology of this area and the probability of striking merchantable bodies of soft ore (hematite) considerable has already been written (5), and it will suffice to say here that the prospects are considered good. Although

(5) Bur. Mines, Vol. XI. pp. 131-134, and Vol. XII., pp. 306-309.

the drilling has not yet proved the existence of large bodies, hematite was nevertheless found and in connection with very extensive deposits of iron pyrites of which the iron ore is perhaps a secondary product by alteration. The drill explored three different locations, 864 X, 254 X, and 857 X, and on these there were bored respectively two holes with a total length of 800 feet, two holes with a total length of 716 feet and four holes with a total length of 1,268½ feet; the eight holes aggregating a length of 2,784½ feet. The rocks drilled were of various kinds including hornblende and chlorite schists, traps, cherts and silicious bands of considerable width carrying iron pyrites. On account of their frequently fractured nature a total length of 852½ feet in six of the holes had to be reamed out and 2-inch casing inserted. The surface drift composed of clay and boulders varied in depth from a few feet to over 50 feet, and in three of the holes 3-inch standpipe had to be placed to an aggregate length of 93 feet.

The drill was retained by Mr. Flaherty until about the end of August 1903, having been in continuous operation for about 18 months. The total cost of the work was $12,256.78, or $4.40 per foot, and the net cost to the operator $8,080.79, or $2.90 per foot; and the gross cost of the diamonds amounted to $1.32 per foot drilled.

In September the drill was taken east to explore for coal in Dufferin county for Messrs. W. G. Fisher, T. M. Brown and R. Scott of Alliston, Ont. The drill was set up on the east half of lot 10 in the fourth concession of Mulmur township, and one vertical hole bored to a depth of 1,027 feet through rocks of the Silurian system consisting of shale, sandstone and limestone, for the most part solid and not difficult to drill. Trouble was, however, experienced in sinking the 76 feet of 3-inch standpipe through the overlying mixture of sand, gravel and boulders to bedrock. At 170 feet depth the water was "lost," that is, disappeared in a fissure in the rock, which necessitated cementing the hole to the bottom and re-boring to the above depth. Otherwise the drilling progressed smoothly and at reasonable cost. At a depth of 768 feet, at the top of 12 feet of black shale probably belonging to the Utica formation, some gas was struck, but this did not last. No coal was found, as might have been expected in these rocks, which are considerably older than the Carboniferous formations, below which no coal of organic origin has ever been found.

The period of drilling extended from 30th September to 11th December, the total cost of the work being $2,449.08, or $2.38 per foot, and the net cost to the operators $1,591.91, or $1.55 per foot. The gross cost of diamonds per foot amounted to 57 cents.

The "S" Drill

The last operation of the smaller of the two drills during 1902 was for Mr. John H. Smith at Port Colborne and extended into the month of February 1903. An account of this work was given in last year's Report of the Bureau of Mines. From Port Colborne the drill was in March shipped to Sault Ste. Marie, Ont., and thence by the Algoma Central Railway to the Superior mine to explore the copper ore body on that property for the Superior Copper Company of Sault Ste. Marie, Ont. Already a good deal of mining had been accomplished from the six shafts on the copper-bearing deposit and the ore found to consist of a matrix of quartz intermixed with green trap carrying chalcopyrite. The vein traverses both the trap and granite formations along the contact of the two, and in these and the ore body the drilling was done.

The drill bored 8 holes, one from the bottom of No. 2 shaft and the rest from points on the surface, the aggregate length being 356 feet. The work covered a period of about two months, all drilling ceasing on 19th May. The gross cost amounted to $1,753.10, or $4.92 per foot, and the net cost to the operators to $1,139.51, or $3.20 per foot, while the gross cost of diamonds per foot was $1.80.

The next point of operation was on the north shore of Lake Huron in the Indian Reserve and 16 miles northeast of Little Current, Manitoulin Island, where Messrs. Thomas Conlon, Francis T. Conlon and John J. Conlon of Little Current wished to explore for iron ore. The drill worked here from the latter part of May until 15th June, less than a month in all, the holes being bored at about 320 feet from the shore in quartzite and trap rocks, a dike of the latter intersecting the former at this place. The only indications of iron met with appear to have consisted of fragments of the ore in the drift boulders and an occasional softer band of the quartzose rock impregnated with hematite. The work was, however, stopped before any decisive information as to the possible occurrence of iron had been obtained. Three holes were bored to a total length of 207 feet at a cost of $745.37, or $3.60 per foot, and a net cost to the operators of $484.49, or $2.34 per foot.

The gross cost of diamonds per foot was 30 cents.

Messrs. Steinhoff and Gordon of Wallaceburg were the next applicants to receive the drill. They desired to explore the country in the vicinity of the town of Wallaceburg, county of Kent, for coal. The rocks of this area belong to the Devonian system and consist of clay shales. The drill was in operation here for about two months from the first part of July until September, boring 5 holes of an aggregate length of 1,529 feet through a variable depth of surface clay to and through the shale formation to the bottom where it overlies limestone. In several of the holes a seam or two of about 1-16 inch thickness of coaly material was struck, but nothing more. In most of the holes standpiping had to be driven to bedrock, the depths ranging from 54 feet to 218 feet, and in this last extreme length, 2-inch casing was also necessary on account of the soft ground. This work was considerably the cheapest done by the drills during the year on account of the soft rock and of the level country which allowed of quickly and cheaply shifting the drill plant from one hole to another. The total cost amounted to $1,290.32, or 84 cents per foot, and the net cost to the operators to $838.70, or 54 cents per foot, while the gross cost per foot for diamonds was only 1 cent.

The drill next went to Parry Sound district to explore for iron for Mr. J. B. Miller of Parry Sound, on lot 29 in the eighth concession of Foley township. It remained in operation here for about two months during September, October and November, at a point where a vein of magnetic iron outcrops and had previously been opened up by a 17-foot shaft. The iron deposit lies in a formation of gneiss and was found by the borings to be lenticular and without sufficient average width or continuity to warrant further mining upon it. None of the holes were very deep, the nine aggregating a total length of 582 feet. The total cost of the work was $1,595.11, or $2.74 per foot, and the net cost $1,036.82, or $1.78 per foot. The gross cost of diamonds came to $1.02 per foot, not too high considering the hard nature of the rock drilled.

Immediately on completion of the drilling in Foley the plant was shipped to Burk's Falls and thence hauled to the Nickel Cliff mine on lot 17 in the eighth concession of Armour township, Parry Sound district, the drilling to be done here for C. F. Kenneweg of Cumberland, Maryland. A short account of the mine is given in the Eleventh Report of the Bureau of Mines, page 286, at the time of writing which (1901) it was being worked in an exploratory way for a deposit of nickel-copper ore found outcropping on the surface. The mineral occurred in a matrix of schist and quartz which formed a lens or pocket in a trap at a short distance from a contact with gneiss. Three diamond drill holes were bored through the overflow of trap and into the underlying gneiss, but without finding any more ore. The rocks were rather badly fractured, which necessitated occasional cementing and which in one hole nearly caused the loss of both the casing and the drill bit by binding. However, the cost of the work was quite reasonable. The drilling lasted from the end of November 1903 until the middle of February 1904. The total cost amounted to $1,696,31, or $3.21 per foot, and the net cost to the operator to $1,101.61 or $2.09 per foot, while the gross cost of the diamonds per foot was 67 cents.

Summary of Operations With Diamond Drills

Firm or Company.	Location of drilling.	Kind of mineral.	Rock drilled through.	Total depth drilled	Total cost.	Total cost per foot.	Net cost	Net cost per foot.	Gross cost of diamonds per foot.	Drill
				ft.	$	$	$	$	$	
J. M. Clark	Steep Rock lake, District of Rainy River.	Iron	Hornblende and chlorite schists, traps, chert and silicious mineralized deposits.	2,781.5	12,256.78	4.40	8,070.79	2.90	1.32	C
W. G. Fisher *et al*	East half lot 10, concession 1, Mulmur township, County of Dufferin.	Coal	Shale, sandstone and limestone	1,027	2,449.08	2.38	1,591.91	1.55	.57	C
Superior Copper Company	Superior mine	Copper	Trap and granite	356	1,753.10	4.92	1,139.51	3.20	1.80	S
Thos. Conlon *et al*	Howland township, Manitoulin Island.	Iron	Trap and quartzite	207	715.37	3.60	484.19	2.31	.30	S
Steinhoff and Gordon	Vicinity of Wallaceburg; in Chatham and Sombra townships.	Coal	Shale	1,529	1,298.32	.84	838.70	.54	.01	S
J. R. Miller	Lot 29, concession 8, Foley township, District of Parry Sound.	Iron	Gneiss	582	1,595.11	2.74	1,036.82	1.78	1.02	S
C. F. Kenneweg	Lot 17, concession 8, Armour township, District of Parry Sound.	Nickel and Copper	Trap and granite	527	1,696.31	3.21	1,101.61	2.09	.67	S
Total				7,012.5	21,786.07		14,263.53			
Average						3.11		2.03	.81	

Michipicoton Mining Division

By D. G. Boyd, Inspector

While the past year has been the quietest as regards the taking out of licenses and staking of claims in the history of the Division since its inception in 1897, more actual mining work has been done than ever before.

The Helen iron mine was shipping ore steadily at the rate of 1,400 tons per day, and the Grace gold mine was in constant operation and producing bullion until the disastrous break-up occurred in the Lake Superior Power Company, by which both of the above mines were owned and operated.

At the Sunrise gold mine a shaft was sunk during the winter of 1902-03, to a depth of 100 feet, and the results were so promising that arrangements were made to instal machinery and push the work; the same results were obtained at the Mariposa mine, where a shaft was sunk 200 feet. At the Manxman gold mine, the 10-stamp mill was completed, and several runs made with encouraging results.

Owing to the scarcity of business the office at Michipicoton River was not opened until the 11th of July, and remained open only until the 15th of August.

During the year 101 miner's licenses were issued (including renewals), and 97 mining claims were registered. The total amount of money received was $2,051.50, being $1,010.00 for miners' licenses, $55.00 fees for transfer of claims, $691.00 fees for additional claims, and the balance, $295.50, fees for patents. These figures show a decrease of $672.50 from the receipts of 1902.

Helen Iron Mine

The Helen iron mine was inspected on 22nd July, when Mr. R. W. Seelye was superintendent, formerly in charge of the diamond drill work at the Frances mine. Mr. Seelye had a crew of 198 men, and was getting an output of 1,400 tons of ore per 24 hours.

A new double-compartment vertical shaft was sunk 168 feet, being 6 feet by 14 feet inside the timbers. This shaft will be used instead of the main shaft, mentioned in last year's report for hoisting the ore. On the second level at the bottom of this shaft, 1,600 feet of drifting had been done in various directions under the ore body.

The method of mining was the same as in 1902, and most of the ore had been milled down to the old first level.

No new machinery has been put in, but the new power house was completed and all the machinery was installed in it.

Mariposa Gold Mine

The Mariposa mine, consisting of claims J D 1, J D 2, J D 3, J D 4, aggregating about 120 acres, and situated five miles east of Michipicoton river, was inspected on 24th July. The property is owned by the Mariposa Gold Mining Company, Limited, with head office at S. S. Marie, Mich.

All of the work has been done on J D 1, formerly claim "Mariposa" No 319, where there is an inclined shaft 208 feet deep, 8 feet by 12 feet in section sunk to the west of the vein. At the first level (100 feet deep) a crosscut has been driven east a distance of 36 feet, striking the vein at 24 feet, and on the second level (200 feet deep) a crosscut has been driven east 27 feet. The shaft has a short collar, but below this no timbers whatever. A continuous string of ladders extends to the bottom, but is not kept in good shape, many rungs being out. The men made a practice of riding in the bucket. The shaft is surmounted by an open headframe, and the hoisting is done by a bucket on skids.

The engine house adjoining the shaft contains a 60-h.p. locomotive type boiler, a 5-drill Ingersoll-Sargent air-compressor, a duplex-cylinder single drum hoist, cylinders 8 by 10 inches and drum 4 feet by 4 feet, and a boiler feed pump No. 2 Northey duplex. The shaft is unwatered by a No. 5 Cameron sinking pump.

At the camp, which is situated about one-quarter of a mile southwest of the shaft, the buildings consist of boarding and bunk houses, office, storehouse, stable, etc.

Instructions were left to commence timbering the shaft immediately, to make a partition between the two compartments, and a proper ladderway with platforms, also to carry all down to within a safe distance of the blasting operations, and to prohibit the men riding in the bucket.

Manxman Gold Mine

The Manxman mine was visited on 7th August. At that date work was suspended owing to repairs being made in the mill, which has been completed and made several runs, but never did natisfactory work. A few men were at work getting out ore for a mill test. No additional mining work has been done since the last report, as enough ore was in the dump to keep the mill running a c ms de.a'):e time. Mr. Angus Gibson was in charge.

Kitchi-Gammi Gold Mine

The Kitchi-Gammi Gold Mining Com pany, Limited, purchased the claims formerly owned by Messrs. Murray and Douglas and L. E. Lum, situated near the high falls on the Michipicoton River, being numbers 577, 602, 625, 624, 680 and 681, and commenced new work.

An inclined shaft situated midway between the shaft on the "Zagloba," No. 602, and the shaft on the "Continuity," No. 598, was sunk to a depth of 110 feet and a drift started south at 100 feet.

An open engine house was situated at the shaft and contained a 27-h.p. upright Jenckes boiler, and a Jenckes duplex hoist, which were formerly on the "Zagloba" claim.

Mr. W. J. Douglas was in charge of a crew of 7 men. Date of inspection, 7th August.

Grace Gold Mine

Mr. P. N. Nissen, who had charge of the development of this property from the beginning, resigned his position in November 1902. At the time of inspection, 13th August, Mr. R. H. Paterson, formerly of the Cordova mine, was in charge, with a crew of 65 men, 30 of whom were miners.

Underground work: first level, north, stoping a distance of 124 feet through to the surface. Second level, north, stoping a distance of 80 feet, 30 feet high. Second level, south, stoping distance of 140 feet, 50 feet high, and 150 feet from shaft, a stope 3) feet, 15 feet high. Third level, north, 108 feet drifting.

An additional boiler, 40-h.p. return tubular, has been installed, also a 3-drill Ingersoll-Sargent air compressor. The compressor formerly in the shaft house and the new one are both installed in the engine room in the mill building and are driven by the mill engine. The air is piped to the mine in the 4-inch pipe, formerly used for conveying steam. The mill has been running steadily since it was started.

Sunrise Mine

The contract for 100 feet mentioned in last year's report was completed by Mr. Tremblay, but owing to the incline and location, it was abandoned, and a new vertical shaft was started which was 20 feet deep on the 13th August. New buildings were being erected and preparations made for setting up machinery, consisting of a boiler, hoist, air-compressor and pump, which were at that time somewhere on the road between the mine and Wawa. Mr. W. A. Stowell was in charge.

Josephine Iron Mine

At the Josephine iron mine work on the shaft was stopped, and diamond drilling was commenced again under the management of Mr. R. W. Seelye.

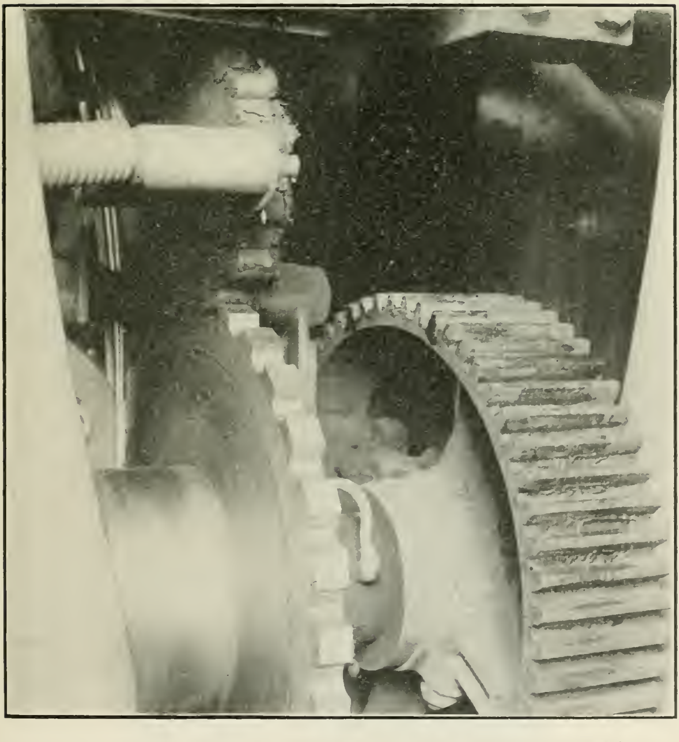
Nothing was being done at the Frances mine, and as far as I could learn nothing was going on at the Emily gold mine, Dog Lake.

Appended is a list of licensees, giving place of residence, number of license, and number of claims (if any) registered during the year. Where not otherwise indicated, the licensees are residents of Ontario.

List of Licensees

Licensee.	Residence.	No. of License.	No. of claims.
Anderson, A. M	S. S. Marie	1363	
Andre, G	Michipicoton River	1359	
Andre, J	" "	1363	
Barton, S	S. S. Marie	1387	
Becker, O	Michipicoton River	1330	
Beebe, W. D	Pleasantville, Pa	1350	1522, 1535, 1545
Begg, T. J	White River	1395	
Brown, A. F	Michipicoton River	1401	1472, 1474
Buckley, H	S. S. Marie	1412	1478, 1529
Buckley, J.P	Detroit, Mich	1411	1479, 1505
Cameron, A	White River	1397	
Cameron, J. O	Michipicoton River	1328	
Campbell, T	S. S. Marie	1389	1492
Carr, J	Michipicoton River	1382	1531, 1534
Carroll, J	Anaconda, Mon	1356	1499, 1500, 1501
Chapelle, B	Harrisville, Mich	1308	1455, 1467, 1489
Cressey, E. W	Bay City, Mich	1410	1490, 1503
Davidson, J	Ottawa	1394	1539
Davis, J	Wawa	1340	
Dickson, J. L	"	1385	1450, 1484, 1485
Donovan, J	Michipicoton River	1400	
Douglas, J. W	S. S. Marie	1377	
Downey, L	Wawa	1366	1511
Doyle, J. P	"	1314	1483, 1488
Dycie, J. G	Michipicoton River	1329	
Dycie ,M	" "	1307	
Dysinger, C. M	S. S. Marie, Mich	1346	1496, 1497, 1509
Edey, M. C	Ottawa	1390	1536, 1543, 1553
Edey, R. W	Billerica, Que	1391	1537, 1541, 1551
Eldridge, R. C	S. S. Marie	1386	
Ferguson, M	Michipicoton River	1379	
Fitzpatrick, H	Wawa	1367	1510
Fournier, H. A	Michipicoton Harbor	1342	1469, 1481
Francis, G. F.	Pakenham	1408	
Ganley, J	S. S. Marie	1358	1524
Gibson, A	"	1360	
Godon, A	Missanabie	1335	
Godon, E	"	1378	
Godon, J	"	1337	
Godon, N	"	1336	
Godon, T	"	1362	
Graham W	Michipicoton River	1383	1528
Gravelle, A	Wawa	1352	1504
Grumbine, S	Titusville, Pa	1413	
Hall, A	Michipicoton River	1384	1527
Henry, R	S. S. Marie	1347	1502, 1507, 1508
Hogan, S. D	Michipicoton River	1368	1520, 1532
Hunt, J	" "	1399	
Keenan, C. E	Michipicoton River	1376	1523
Keenan, J	" "	1355	1526
Kitchi-Gammi Gold Mg. Co., Lt'd	S. S .Marie	1306	1452, 1453, 1456, 1457, 1460, 1461
Lawlor, J. H	Michipicoton River	1361	
Legge, C. H	Gananoque	1405	1546, 1547
Legge, J	"	1404	1518, 1548, 1549
Letellier, J. T	Wawa	1331	
Lewis, M	Detour, Mich	1372	
Lewis, W. H	"	1348	
Lynch, D	Michipicoton River	1374	1519
Manxman Gold Mg. Co	S. S. Marie	1373	
May, E	Michipicoton River	1334	1458, 1459
Miller, E. H	St. Thomas	1324	1464
Miller, G. L	"	1323	1465
Miller, I. M	"	1316	1463, 1466
Miller, R. J	"	1315	1462
Morin, J	S. S. Marie	1375	
Morin, J	Wawa	1407	
McDougall, L	White River	1396	
McDougall, W. H	"	1380	
McGillivray, W	Ottawa	1391	1538, 1540, 1552
McKay, J	S. S. Marie	1345	
McKenzie, A	Detour, Mich	1371	
McRae, P. J	"	1353	

Flint Lake gold mine and mill, 1903.

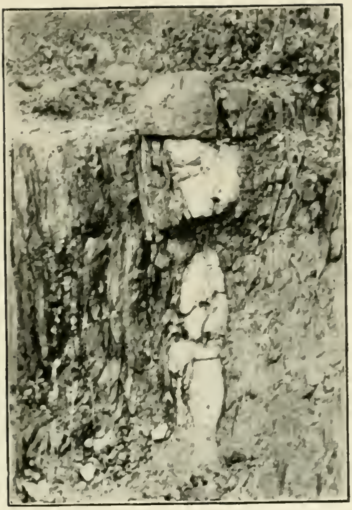


Milne Peat press, showing die- or sprocket-wheel in which briquettes are compressed.

Twentieth Century gold mine, 1903.

Gold Standard mine; shaft buildings and rock dump.

Flint lake gold mine, showing open cut.



Vein in Little Master gold mine, showing lenticular form characteristic of veins in Manitou region.

Combined gold mine, showing flat quartz vein overlain by trap.

List of Licensees—*Concluded*

Licensee.	Residence.	No. of License.	No. of claims.
Neary, A	Michipicoton River	1388	
Parks, G. F	Wawa	1357	1477, 1491, 1530
Pettit, R	S. S. Marie	1409	
Pononish, A	White River	1318	
Pratt, W	Michipicoton River	1354	1533
Preneveau, G	Missanabie	1339	1468
Reed, G	Michipicoton River	1402	1471, 1476
Reed, Susan	" "	1403	1475
Ripley, L. V	Eau Claire, Wis	1326	1495
Ripley, M. T	S. S. Marie	1327	1496
Rogers, G. H	Ottawa	1393	1542, 1544, 1550
Rothschild, B	Wawa	1344	
Rothschild, H J M	"	1381	
Rothschild, M. D	"	1343	
Sage, H.	Albany, N.Y	1325	1494
Shafer, F	S. S. Marie, Mich	1338	1451
Shotts, G. W	S. S. Marie	1321	
Smart, Mrs. T. R	Wawa	1364	15[illegible]3
Smith, A	Michipicoton River	1369	1525
Standish, M	S. S. Marie, Mich	1370	1514, 1515, 1516
Sutton, E. S. B	" "	1398	1517
Taylor, G. H	Michipicoton Harbor	1414	
Taylor, H. P	S. S. Marie, Mich	1329	
Taylor, R. H	" "	1319	
Touchette, J	Missinabie	1322	
Travis, R. L	Michipicoton River	1341	1486, 1487
Trembley, J	Wawa	1406	
Walker, W	Wawa	1365	1512
Ward, W	Pleasantville, Pa	1349	1521

4 M.

Provincial Assay Office

By A. G. Burrows

The Provincial Assay Office was established in 1898 by the Bureau of Mines, with a view of aiding the mineral development of the Province. Prospectors and others are afforded a means of obtaining reliable assays and analyses of their finds at a nominal cost. It has been found of advantage for those exploring the unsettled portions of the Province where there are no facilities at hand for examining their specimens. The office has also been of service where properties are being prospected and are not yet supplied with assay offices and other means of testing the ore.

The office is located in the city of Belleville, on Victoria avenue, where a two-story brick building is utilized for the purpose. The lower flat is used as an office, with a grinding and pulp room in the rear. The second floor is fitted up with an assay and analytical rooms.

During the year 814 samples were submitted for assay and analyses, and 165 specimens were reported on as to identification and commercial value.

Work for Bureau of Mines

The following services were performed for the Bureau of Mines during the year :

Issuing reports on samples submitted by Government geologists and explorers from the newer portions of Ontario. These included iron ores from the new ranges of Nipissing, gold and silver ores from the Rainy River District, and silver-cobalt-nickel samples from the recent finds on the line of the Temiskaming and Northern Ontario railway.

Issuing check analyses on pulped samples of iron ore representing the average of Ontario ores smelted at Ontario furnaces, on which it is proposed to claim the bounty provided by the Iron Mining Fund.

Making analyses of a series of limestones and clays of the Province, for a report on the utility of these materials in the industrial arts, as cement manufacture, sugar refining, furnace lining, pottery, etc.

Work for Private Parties

The following services have been rendered the public during the year :

Issuing reports, consisting of assays, analyses, identifications, and other commercial tests. While fees on a reduced scale are charged for this work, it is required that they be paid before reports are issued. Where the samples are of sufficient size, a portion of each is retained for future reference. The assays, etc., are the property of the person submitting the sample, and duplicates cannot be issued without his order.

Supplying information where possible to owners of mineral lands who desire to be placed in touch with purchasers, and also advising as to value, uses, etc., of their materials.

Making check determinations and control assays in case of disputes as to correct values. It has been found that most variations are due to improper sampling, rather than to mistakes by the chemist or assayer.

Sending samples of typical ores and minerals to prospectors, who desire to use them for reference in their explorations.

Laboratory Determinations

The following tabular list shows the determinations made in duplicate during the year :

Assays

Mineral.	For Bureau.	For Public.	Total.
Gold (amalgamation) ...	3	1	4
Gold (fire assay)	45	401	446
Silver	41	197	238
Platinum	....	9	9
Nickel	16	19	35
Copper	19	78	97
Zinc	1	11	12
Manganese	7	9	16
Tin	....	1	1
Cobalt	5	....	5
Lead	1	11	12
Molybdenum	....	2	2
Antimony	....	1	1
Bismuth	....	1	1
Total	138	741	879

Analyses

Determination	For Bureau.	For Public.	Total.
Metallic iron	43	64	107
Alumina	106	20	126
Silica	108	37	145
Lime	106	17	123
Magnesia	106	18	124
Ferric oxide	108	30	138
Sulphuric acid	119	52	171
Moisture	140	13	153
Alkalies	92	7	99
Organic matter	21	1	22
Phosphorus	7	16	23
Volatile combustible	25	2	27
Fixed carbon	25	4	29
Titanium	5	19	24
Chromium	1	....	1
Miscellaneous	233	30	263
Total	1,245	330	1,575

Total number of samples for assay	814
" " identification ..	165
Total	979
Total assays	879
" analytical determinations	1,575
" identifications and qualitative analysis	165
Total determinations	2,619

Laboratory Methods

The laboratory is equipped for the following determinations :

Gold and Silver

(1) By fire assay, using gasoline as fuel. Ores containing sulphur and arsenic are given a preliminary roasting before fusion, which is found to give better results than desulphurization during fusion. A small gasoline furnace has been added to the equipment of the assay room, which is very useful where only a few assays are to be made. The balance for weighing the buttons is sensitive to one-one hundredth of a milligram, which gives assay values as low as 20 cents a ton.

(2) By amalgamation assay to test the free milling properties of the ore, using about 2 lb. of pulp.

Platinum. By fire assay.

Copper. By cyanide titration and electrolytic methods.

Nickel. By electrolytic method, using a set of powerful potash cells for the current.

Lead. By titration with ammonium molybdate.

Zinc. By titration with potassium ferrocyanide.

Manganese. By Volhard's titration method.

All other determinations are made by standard methods. Samples are pulped to 100-mesh, and those requiring further treatment are ground in an agate or diamond mortar to an impalpable powder.

Certificates are made out on samples analyzed at ordinary temperature, unless otherwise stated in the report. Ores carrying moisture sufficient to prevent grinding are dried at 100 C. and analysis is carried out at that temperature. One assistant was employed during the year.

Fees amounting to $839.05 were collected and remitted to the head office. Samples brought personally to the office are examined free of charge, except where a quantitative estimation is required. Circulars of rates, canvas bags and mailing envelopes are supplied free of charge to those desiring to send in samples.

Summer Mining Schools

By W. L. Goodwin

I beg to submit herewith a report on the Summer Classes conducted in the mining camps of the Province during the Summer of 1903.

The Season's Itinerary

After spending Friday and Saturday, May 22nd and 23rd, in making preparations, I left Kingston on Monday, May 25th, accompanied by Herbert Van Winckel. Arriving at Calabogie the same day, I was met by manager Ganong of the Black Donald graphite mine. Next day I proceeded to the mine and opened a class there, which was continued till Monday, June 1st. On May 28th I drove to Calabogie, 14 miles, met a number of men who had specimens to be examined, and returned in time for the class in the evening. On Tuesday, June 2nd, we left the Black Donald, drove to Calabogie, and took train for Parham station. A drive of eight miles brought us to the Olden zinc mine (Messrs. James Richardson & Sons), where a class was opened at 6.30 p.m. the next day, and closed on June 9th. The drive back to Parham station was made on June 10th, where we took train for Sharbot lake. Van Winckel returned to Kingston and I took the C. P. R. to Havelock, where I was met by Mr. J. G. McMillan of the School of Practical Science, Toronto, who shared the work with me from that time onward. We drove to Cordova Mines where, in the absence of the manager, we were received by mine captain Holland. The class was begun the next day, June 11th, at 4 p.m. and continued until June 17th. Cordova Mines left behind on the 18th, we proceeded by way of Toronto and North Bay to Sudbury, which was reached June 19th. We drove immediately to Copper Cliff, where the class was opened the next day at 7 p.m. and closed on Friday 26th. On June 27th we left Copper Cliff by the C. P. R. "Soo" branch, reached Massey station on the same day, where we were met by manager Joseph Errington of the Massey copper mine, who kindly drove us and our luggage to the mine a distance of about 4 1-2 miles. The class was begun the same evening at 7 p.m. and was closed on Friday, July 3rd. On Saturday we returned to Massey station, went by train to Sudbury, and thence by the main line westward to Wabigoon which was reached on Monday, July 6th. Here we took the steamer to Budro's landing, 22 miles, then by stage over the Government road to Gold Rock. With the exception of a short distance near the landing, we found this road in very bad condition. A class was opened at the Big Master mine at 7 p.m. the same day and closed on Saturday, July 11th. On Monday, July 13th, the journey was continued by steamer along the Upper Manitou Lake, eight miles, to the Twentieth Century mine. This camp was substituted in our programme for the Elizabeth, which had in the meantime been closed down. We were met at the landing by manager Dryden Smith, who provided transportation for our luggage. The class was opened the same evening and closed on Saturday, July 18th. On the following Monday the steamer Minneola conveyed us and our luggage back to Gold Rock, from which point we retraced our journey to Wabigoon. There by invitation I lectured that evening in the school house to an audience of about fifty. We left by the night train for Port Arthur, where we arrived

July 21st, expecting to catch a train the same day to take us out over the Canadian Northern to Kashaboie, the station for the Tip-top mine. It was found that the train of that day was not to stop at Kashaboie. The journey was continued the following day however. From Kashaboie we packed our much reduced luggage a mile back along the track, guided and assisted by the engineer of the tug which the Tip-top company run on the Upper Shebandowan lake. The company's freight cart carried us and our luggage a mile and a half to the landing, from which we steamed comfortably 5 miles in a westerly direction to the end of the lake. A tramp through the wood four miles brought us to the Tip-top mine, beautifully situated on Round lake, where Captain Richard Sandoe made us welcome. The class was opened the next day, July 23rd, and closed on Wednesday, July 29th. On Thursday, July 30th, we returned to Port Arthur, transportation to Kashaboie station being again kindly furnished by the company. The manager, Thomas R. Jones, who had arrived at the camp in the meantime, accompanied us out. On Friday, July 31st, we left Port Arthur by steamer for Sault Ste. Marie. I continued my journey to Kingston, arriving on Monday, August 3rd, while Mr. McMillan proceeded to the Helen mine to open a class there. He left Sault Ste. Marie Saturday, Aug. 1st, by the steamer Minnie M. and reached the Helen mine on Aug. 2nd. A class was opened Aug. 3rd and closed on Saturday, Aug. 8th. Mr. McMillan then went to the Grace mine where a class was opened on Monday, August 10th, and closed on Saturday, August 15th. He left Michipicoton on August 16th, reached the "Soo" on Monday, August 17th, and took the Algoma Central Railway train to the Superior copper mine. A class was opened on Tuesday, August 18th, and closed on Monday, August 24th.

Classes were thus held in eleven mining camps, covering the Province from Kingston to Wabigoon. Free transportation of our heavy luggage was given by the Canadian Pacific, the Grand Trunk, the Kingston and Pembroke, Canadian Northern and Algoma Central Railway Companies.

Black Donald Mine

The road from Calabogie to the Black Donald is in part a country road leading westward from the village up the turbulent Madawaska, and in part a new road made by the company from James Legris' house to the mine. It is a very well built road, the survey for which was being made when the writer visited that district the summer before. It is quite equal to the ordinary country roads in that district, and is used by the Ontario Graphite Company for drawing in supplies, and hauling the graphite to the station at Calabogie. It also considerably shortens the distance for farmers going between the Black Donald district and Calabogie. The mine is close to the south side of Whitefish lake (one of the innumerable lakes of that name, although this one seems to have no whitefish in it; why not call it the Black Donald Lake ?) As often happens in such cases the largest and best part of the deposit led the miners under the lake, where an unlucky shot one day let in the water in a veritable flood ; but another shaft had been sunk and graphite was being taken out steadily. Diamond drilling operations were going on, for the purpose of locating a deposit farther away from the lake. Mr. W. K. Ganong of St. Stephen's, N.B., the manager, gave every assistance in making preparations for carrying on the class. A vacant dwelling house was fitted up, and the class was opened with an attendance of 18, practically the whole camp, mostly North of Ireland men, with a sprinkling of French Canadians and Germans. The interest in the class was sustained till the last day, and we were joined by a number of farmers and others living in the district about the mine. This brought up the total number in attendance to 27. The average daily attendance was 15. Members of the class brought in samples of molybdenite found a short distance from the mine (lot 17, in the third concession Brougham township). The molybdenite is found on the hillside near the old portage road around the rapids at its lower end. It is not very plentiful. While I was meeting the men in Calabogie on the morning of May 28th, a prospector named Bradford showed me samples of copper pyrite from a prospect which he described as about 12 miles from Calabogie.

The graphite deposit itself is interesting, the mineral being associated with calcite, a little pyrite, copper pyrite, mica, etc. The graphite is a mixture of flake and amorphous, from which the flake concentrates easily. Mr. Ganong accompanied me on a short trip across the lake to examine a hill very prominent on account of the red color of the soil, evidently formed by the decay of a highly pyritic rock. Some specimens taken where the rock outcropped could not have contained less than 30 per cent. of pyrite.

An interesting trip was made with John Moore, prospector and farmer, and the discoverer of the Black Donald mine. We collected crystallized black hornblende and fine large masses of actinolite and tremolite, also crystals of light green hornblende near the power house, two miles below the mine. Hornblende is plentiful in the neighborhood. Mr. Moore showed us a number of samples of molybdenite collected at various localities in the neighborhood.

Olden Zinc Mine

This place was reached by an eight mile drive from Parham station which was rendered rather exciting by the very steep hills and sharp curves. Mr. James Adams, foreman, was in charge for Messrs. James Richardson & Sons. The mine was discovered by Mr. Leslie Benn, who lives in the neighborhood. He still continues prospecting, and is extending our knowledge of the zinc-bearing area in that district. The ore consists of zinc blende with a little galena in crystalline limestone. Pyroxene, vesuvianite, and in some parts of the vein considerable quantities of iron pyrite, are present. The ore is being stoped out from the surface, but the stope is timbered and filled in as the work advances. Near the surface there is galena mixed with the ore. At a greater depth the galena disappears almost entirely. Nineteen men were employed, mostly farmers living in the neighborhood, and they seem to make very satisfactory miners.

The class was held at 6.30 p.m. in the men's sleeping room. The attendance was almost perfect, and it was a great pleasure to give instruction to such appreciative and intelligent men.

Accompanied by Mr. Leslie Benn, the writer tramped over the surrounding country—a series of valleys, flanked on both sides by granite which has resisted erosion better than the intermediate limestone, areas of which are found here and there. It is in these places that minerals may best be looked for. Specimens of copper pyrite, pyrrhotite, molybdenite, and serpentine were examined for Mr. Chas. Foy of Mountain Grove. Serpentine was collected on the south shore of Long lake, about opposite Drew's house. Specks of molybdenite were noticed in some places. Sphene crystals were collected from the cliff near Mr. Coleman Cronk's. A prospecting pit near by shows pyrite, copper pyrite, pyrrhotite, and zinc blende. Specimens of corundum, hornblende, etc., were examined for Mr. M. J. Flynn, driller; and members of the class brought in specimens of bog ore found about two and a half miles north of the mine on the farm of Barney Quinn, lot 6 in the sixth concession of Olden township, also specular (micaceous) hematite from the farm of David Bartram, lot 7 cimens of zinc blende from the Olden mine molybdenite was noticed.

The kindness and hospitality of the foreman, Mr. Adams, and of the other employees, and indeed of the whole neighborhood, made our stay very pleasant. The total number in attendance was 22, and the average daily attendance 19.

Class at Cordova Mine

Work was begun at 4 p.m. in Cordova Hall on June 11th and another class was held in the evening at 7.30. Instruction was carried on along the same lines as those described in former reports. Considering the large number of men employed, the attendance was neither as large nor as steady as might have been expected.

In the absence of the manager, Mr. D. G. Kerr, the acting manager, Mr. Holland, received us and made us comfortable. As on former occasions, we were the guests of the company, and everything was done to forward the aims we had in view. Here we had opportunities of collecting considerable quantities of tourmaline, crystals of pyrite, beautiful milky white quartz and chlorite.

The total number in attendance was 33, and the average daily attendance 14.

Copper Cliff

The classes here were held in the Gorringe Assembly Hall, as in former years. Many changes were noticed since the last visit. The company have built a hospital near the site of the old general office at a cost of over $30,000. It is handsomely furnished and is under the superintendence of Dr. Coleman. The running expenses are met by fees paid by the employees. The site of the new smelting works was being levelled on the brow of a rugged hill, and I was much interested in the explanations given me by Mr. A. P. Turner, the president of the company. Improvements in the old west smelter had greatly increased the output.

The attendance here was not satisfactory in point of numbers, although very much so in regard to the steady work done by those who did attend. The total number in attendance was 12, with an average daily attendance of 8, but it must be acknowledged that the class did not reach the men for whom it was intended, namely the miners. Possibly a change in the place of meeting might improve matters. The Gorringe Club is more frequented by the officials and the office men than by the miners.

in the seventh concession. In some spe- There are however special difficulties in carrying on this work in large places like Copper Cliff.

Massey Copper Mine

This lies about three miles northwest of Massey station. A branch of the railway was being built at the time when we were there, but at present all traffic is over a wagon road four and a half miles long.

The ore is copper pyrite, carrying less than $1.00 in gold. The shaft is down 400 feet and sinking was going on for the 500-foot level. Some beautiful crystallizations of copper pyrite on crystals of quartz and calcite had been taken out and handsome specimens were presented to us by Edward Moore, Thomas Moore and others of the miners. Some iron pyrite was noticed in the ore, and considerable specular hematite. Copper pyrite and specular ore were collected for future use.

The foreman, Mr. O. Summers, took us underground and gave us a good opportunity of inspecting the mine and collecting specimens. Mr. Joseph Errington, the manager, and Mr. R. C. Barclay, the treasurer, made us welcome. One of the cottages just being built was fitted with tables and seats for the class, which was opened at 7 p.m. on June 27th. The attendance was fair, averaging ten daily with a total of 25 in attendance. Here, as in other places where a night shift was worked, another class was held at 4 p.m.

Having a few hours to spare at Sudbury on the way from Massey station to Wabigoon, we drove out about 7 miles to see some prospecting being done by Mr. T. A. Edison. A number of test pits were seen, about two miles northwest of Mount Nickel. Diamond drilling had also been done, and one hole, it was stated, had been put down 270 feet. Nickel ore in small quantities was noticed about some of the test pits. The ground where this work was being done was unusually level and free from gossan.

Big Master Mine

The work here was very satisfactory. The force at the mine attended the classes almost to a man. In looking over the names, one was struck with the large proportion of Swedish and Norwegian names. Some of these men were old acquaintances from the Mikado and the Black Eagle, but others have been in Canada only a short time, and were either totally ignorant of English or were still struggling very hard with the language. However, by sandwiching these with those of their countrymen who spoke English well, and who acted as interpreters, we were able to give them the benefit of the instruction. This gave us a hint, which we found very valuable in a camp visited later, where the foreigners not speaking English were in very large numbers.

A class was opened at 7 p.m. and was held daily at that hour and also at 4 p.m. The total number in attendance was 33, with an average daily attendance of 21.

The Big Master is situated near the shore of the lovely Manitou Lake, the water of which, cold and pure, is supplied to the mining camp. Mr. Pickering, the manager, ascribes the uniform good health of the camp to the pure water. There had not been a serious case of illness for two years. Perhaps something also is due to the fine lot of men whom Mr. Pickering's sympathetic management had brought together. The shaft house is 1,550 feet from the shore of the lake, where the mill is situated to which the ore is carried by a wire trolley system. One feature of the mine is the cage for hoisting the men, a thing not often seen in our gold mines. On July 9th Capt. Shovells took us below, and we had an opportunity of seeing a first-class mine shaft.

Our stay was all too short in this lovely place, and we were sorry to part with manager and men.

The Twentieth Century

Here are a number of parallel quartz veins in which the prevailing mineral is pyrrhotite with some iron pyrite, copper pyrite and a little zinc blende. Chlorite is common as vein matter. Some of the quartz veins are 30 or 40 feet broad—immense bodies, if they prove rich enough to work.

The men here, as at the Big Master, were very much interested in the study of minerals. Classes were held at 7 p.m. and 4 p.m. The total number in attendance was 29, and the average attendance 20. Here too we found some of our Mikado friends. The manager, Mr. Dryden Smith, spared no pains to make our stay pleasant and profitable. We had the freedom of the camp, insluding the raspberry patch (about two miles square) and the fish preserves (the whole of the Manitou)! We succeeded in catching lake trout in the middle of July, a thing unheard of before.

Tip Top Mine

This mine is the property of the New York-Canadian Copper Company. The superintendent, Thomas R. Jones, and the mine captain, Richard Sandoe, were towers of strength to us.

The classes here contained representatives of many nations, Canadians, Yankees, Cornishmen, Swedes, Finlanders, Austrians, Frenchmen, Norwegians, and Irishmen, with an outer fringe of Ojibways. Many of the foreigners here unable to speak English, but experience at the Big Master had shown that it was possible to reach these. The first thing I did after settling down in the camp was to ask for an interview with the leaders among these foreigners, and in such cases the leaders are the English-speaking. Captain Sandoe introduced me to two brothers Charles Jacopsen and Jacob Jacopsen, who spoke English very well, and who also seemed to have a polyglot acquaintance with Europe. The nature of the work was explained to them, and it was suggested that, with their assistance, their countrymen and other foreigners might be able to take advantage of our visit to the camp. They fell in readily with our plans, and as a consquence the whole camp attended the classes, and with a total attendance of 40 the average daily attendance was 31, not including the Indians. The writer was much impressed with the eagerness of these new citizens of ours, not only to learn about minerals, at which they were not one whit behind the English-speaking miners, but also to learn the language of the country. Some of them had small readers, giving the names of minerals, mining tools, etc., in English and Finnish, and they were using these as text books to learn English. From conversation with a number of those who could speak English, both at the Tip-top mine and at other places in Ontario, I have formed a high opinion of the Finlanders as a desirable class of immigrants. They speak enthusiastically of the freedom they enjoy in this country, and declare without reserve that it is their ambition to become good Canadians.

The Tip-top mining camp is the most beautifully situated of any the writer has had the pleasure to visit. The houses and offices are stretched along the sandy beach of Round lake and are sheltered by magnificent pines, which have been spared by fire and axe. The offices and dining and sleeping camps occupy the centre. South of these are a number of log cabins built by the Finns and Austrians, and away to the north about half a mile removed are the wigwams of the Ojibways, a number of whom are employed in cutting wood, and occasionally in catching fish for the camp.

A visit was made to the old Huronian mine which had been closed for about 17 years. It is about 15 miles west of the Tip-top mine, and is reached by crossing Round lake four miles, traversing a one-mile portage into Crooked river, which with a small lake at each end winds its way about 6 miles farther, and then over a half-mile portage into Jackfish lake, which is about 2 and a half miles across. From the opposite shore of this lake a walk of about one mile through the woods brought us to the Huronian. The ore is said to be a very rich one. It contains iron and copper pyrite and galena, and also, it is said, sylvanite. On the way to this mine we met an old prospector, Ben. Shaw, who had been camping there alone all summer looking for a lost gold vein. He went back with us and did the honors of the deserted mine. We found the whole location choked with undergrowth, and $30,000 worth of lumber, machinery and supplies rusting and rotting at the mine and on the portage to Savanne—a dismal sight.

To return to the Tip-top mine. On July 24th Capt. Sandoe showed us over the workings. We found a wide vein (60 feet) of copper pyrite with quartz, magnetite, iron pyrite, pyrrhotite, and a mineral carrying cobalt—probably smaltite. The ore carries gold and silver. Much of it is high-grade. The vein can be traced half a mile east and west. The shaft house is three-quarters of a mile east of Round lake. To the north of the ore body is a fine-grained rock, apparently quartzite. To the south is a diorite, at first somewhat schistose and containing light-colored iron pyrite. Farther away it shades into a coarse-grained and then into a fine-grained diorite. Pyrite was seen even in the fine-grained diorite. Hornblende crystals of considerable size were abundant. Feldspar is fine-grained. The sand on the shore of the lake was panned, and magnetite and limonite were found in the concentrates. In conversation with manager Jones, it was learned that the Finns and Austrians are well educated, and that they are unusually satisfactory as employees.

It was ascertained from Mr. Jones and from the assayer, Mr. W. F. Smeaton, that A. L. 282, the gold mine farther west, also under the management of Mr. Jones, is being satisfactorily developed. A good deal of ore is blocked out preparatory to putting up a stamp mill. Roads to these mines are sadly needed. As such roads often become generally useful for settlers, as in the case of the road to the Black Donald mine, it would seem only just that the Government should share in building them.

The Helen Mine

The men employed here, to the number of about 250. are mostly of foreign birth, including Finns, Italians, Austrians, Hungarians, Poles, Swedes, Greeks, etc. The great majority do not understand English, accordingly difficulties were experienced in organizing the classes. The manager kindly placed the reading room at Mr. McMillan's disposal for the purpose, and the classes were held at 4 p.m. and 7 p.m. as usual. The total attendance was 27, and the average daily attendance 18. The attendance was made up entirely from the Canadians and Americans employed.

The Grace Mine

Mr. McMillan reports the attendance here as somewhat uncertain. Out of the twenty who were present at different times, including two from the Mariposa mine, only one-half attended in any one day. Pyrite, pyrrhotite, mispickel, and a little copper pyrite were noticed in the Grace vein. At the Manxman Mr. McMillan noted pyrrhotite (said to contain 1 per cent. cobalt), pyrite, copper pyrite and graphite. One complete set of minerals. labelled. was left at the Manxman. one at the Mariposa, and one at Mr. Boyer's camp. Several sets. unassorted, with a copy of the tables for each man were also left at these camps.

Superior Copper Mine

The opening of the class at 4 p.m. on Tuesday, August 18th, was cancelled because of an accident which resulted in the death of one of the miners. A start was made at 7 p.m. The number of men employed at this mine was about 25. They were sinking with a double shift in No. 6 shaft. which was down 150 feet. During the preceding winter and spring, sinking had been carried on in two shafts with about 50 men employed. The ore is copper pyrite in quartz, with a very small percentage of iron pyrite. In No. 1 shaft, which is down 75 feet, a considerable quantity of galena is present for the last fifteen feet. The country rock on the east side is granite and on the west greenstone.

The total number in attendance at this camp was 24. and the average daily attendance was 16.

General Remark

The usefulness of these Summer Classes cannot be doubted, but it is quite evident that they succeed better in the more isolated camps of moderate size than they do in those which have grown to the dimensions of villages or towns. In the smaller camps the men live together and move as one body. In the larger camps they are more or less scattered, and it is hard to get them to assemble after the day's work.

It is my duty again to call attention to the considerable amount of illiteracy among native young Canadians. This is apparent in the districts visited. In a few instances whole families of young men were observed who could not read or write. When the cause was enquired for, the answer was "six miles from the nearest school." In a country with districts of scattered population, such as we have in Ontario, conditions like these are perhaps unavoidable, but this serious menace (for illiteracy is always a menace) would be to a considerable extent avoided by the system of school vans and central schools now being introduced into some parts of Canada. Much might also be done (it is never too late to mend) by fostering the reading camp system which is being so enthusiastically and sensibly pushed forward by Mr. Fitzpatrick of Nairn Centre.

Several mine managers spoke of the dangers to their men due to the existence of saloons. In one case an illicit groggery was kept open a short distance from the mine. Upon asking the manager why it was not closed up, the reply was that the justice had refused to do more than inflict fines, although the law distinctly provides for imprisonment. The fines were cheerfully paid and the illegal sale went on. In another case a license was granted to a saloon within the prohibited six miles of a number of mining camps. The more isolated mining camps are often resorted to by men who have an honest desire to conquer what has become to them an overpowering temptation, and to build up in the pure atmosphere of the forest a constitution enfeebled by drunkenness. The law has provided that the temptation shall not come nearer than six miles, and men who are thus fleeing from temptation have a right to be shielded as the law provides.

Mines of Western Ontario

By W. E. H. Carter, Inspector

In the western portion of the Province beyond Lake Superior the condition of the mining industry depends largely on that of the gold mines, since these greatly exceed in number all the other mines, and during the past year or so all the gold mills operating on a commercial scale having shut down for one cause or other, a general depression throughout the region has resulted. In point of numbers probably as many mining properties are under development as at any period in recent years, but in most cases work proceeds on a small scale and in an exploratory way. The Mikado mine has shut down indefinitely for reasons given below. The Sultana on the other hand has reopened to continue the search for the faulted portion of the big ore body. There are many other good properties, such as the Big Master, fully equipped with at least mining machinery, if not milling plant also, which, if they had been properly developed, might be figuring as active paying propositions to-day.

Unbusinesslike mining methods constitute without doubt the chief cause of the present depression in the industry, and tend in many ways to keep capital out. No improvement can be hoped for until the mining public realize the absolute necessity of employing as managers of their mines only men who are qualified by technical education as well as experience to shoulder the responsibilities of a mining engineer. Continued loss of money at most of these mines because a contrary state of affairs exists, cannot but harm the reputation of the whole area as a profitable field of mining investment.

Exploration for iron continues on the various ranges from Temagami west to Atikokan, but latterly on a somewhat reduced scale on account, no doubt of the weakness of the iron market in the United States, and the consequent temporary faling off of interest in outside fields. A good deal more iron land has been acquired in the Hutton and Temagami areas, some of which in the latter will in all likelihood be worked this season in the neighborhood of the new Temiskaming and Northern Ontario railway, the only road as yet offering facilities to the district for shipment. In the vicinity of Loon lake, north of Sault Ste. Marie, several mining companies are actively exploring and developing the specular ore of that range with promise of developing productive mines. Ore production from the Helen mine in the Michipicoton area has ceased entirely on account of the financial difficulties of the operators, the Lake Superior Power Company. With the solution of these, mining will be resumed, it is expected, at an early date.

In the Lake Huron north shore copper area a few of the large number of prospects have continued in steady operation along comprehensive plans of development, with the result that several valuable ore bodies have been brought in sight. The Massey Station and Superior mines are good examples. Some smeltings of ore from the former have been made at the Victoria mine furnaces which have been temporarily leased from the Mond Nickel Company for the purpose. Some blister copper of good quality has resulted. The

Rock Lake mine closed down indefinitely last spring as the climax of continued unbusinesslike methods of mining. The development of the mine has been neglected so persistently that this unfortunate state of affairs cannot be ascribed to any known want of value in the ore body. In the western part of the Province the now well-known Tiptop copper mine is about ready for production of high-grade ore on a commercial scale, and the owners are seriously considering the installation of a smelter at the mine. This would lend impetus to the development of other copper properties in the same area.

In the nickel district about Sudbury the entire production still remains practically in the hands of the one concern, the Canadian Copper Company, subsidiary to the International Nickel Company. This company is able as a result to maintain the price of nickel at a high figure, which prohibits to a certain extent its more general adoption in the arts. Extensive additions are being made to the smelting works by which an increased output at smaller cost will be obtained. Last year's operations with the old plant made the record production of 6,998 tons of nickel.

One or two additional active operators in this nickel field are needed who will undertake to refine the metal as well as mine and smelt to matte. Unless they refine they might as well remain out of the business, since there is only one nickel refinery in operation on the continent and that belongs to the Orford Refining Company of New Jersey, which is controlled by the International Nickel Company and refines matte from this company's properties only. The Mond Nickel Company has not yet resumed operations at Victoria Mines. Considerable prospect mining was carried on during the summer months on an outlying area of the nickel belt in Levack township.

The recent finds near Haileybury, along the new Temiskaming and Northern Ontario railway, of cobalt-nickel arsenide ores, some of which are exceedingly rich in silver, have attracted a large degree of attention, and prospectors will no doubt rush in on the lands being restored to exploration. A quantity of the ore is this winter being mined and hauled out for distribution to probable purchasers and refiners, and for testing in order that a suitable process of treatment may be arrived at. It is to be hoped the work of refining the various metals will all be done at the mines; there appears no reason why it should not.

One of the oldest mining industries in the west has again revived in the reopening of some of the old lead and zinc properties in or around Dorion township, near Thunder bay, lake Superior. Already several hundred tons have been raised from one mine, and other companies recently incorporated to mine here expect to do as well on others.

It may be remarked as an indication from the miner's point of view of the state of the industry that wages on the whole are good, employment not scarce, and the condition of the mines as regards safety generally improving. Although the number of casualties reported during 1903 was the same as during 1902, an appreciable decrease is noted in those occurring underground and in the fatalities.

Gold Mines

Sultana

In May 1903 the former owners, the Sultana Mine of Canada, Limited, sold the entire Sultana property for a minority stock interest to the Sultana Gold Mine, Limited, Rat Portage, Ont. The working capital for the renewed development has, it is understood, been subscribed largely by a few local men, amongst whom is Mr. J. F. Caldwell, managing director pro tem. To Mr. Caldwell, one of the original owners, is mainly due the successful operation of this mine and its present activity. Since the close down in the spring of 1902 a few men have been retained to keep the surface plant in shape and carry on any repairing necessary. J. Johnson, mine captain, has remained in charge and will shortly increase the present force of 9 to about 15. Since May 1903, when the workings were again unwatered, the mine timbering has been overhauled where necessary, and two bulkheads placed at the south end of the workings, one on the 2nd level at 140 feet north of the Crown Reef vein, and one in the winze connecting the 2nd and 4th levels on that vein and at 60 feet below the 2nd level. In this way the heavy inflow of water from the Crown Reef workings will be excluded from the rest or northern main portion of the mine, where development is now to be continued.

The 7th level northeast drift followed the diamond drill holes to the end, a total distance from the shaft of 607 feet, but found that the gold values in the quartz vein (1) at the face were too low to warrant devoting more attention to it. At about 500 feet from the shaft in this drift another quartz vein was cut through lying entirely in the trap, but at this point carrying only low gold values. It followed in its S. 30 degrees W. direction to where it will enter the granite, a pay chute may, it is thought, be found since all the pay ore so far has been confined to the granite formation.

The other vein or branch off the original lode which on the surface lies about 100 feet west of the latter and at the lake shore, has hitherto not been given much attention. According to the plan for future explorations, drifts will now be run to it from a suitable point in the second or fourth level south in the old workings. The other mining work proposed consists in sinking the shaft from the eighth to the ninth level, for which purpose the timbers are now being completed from the seventh down to the eighth level. There are scattered quartz stringers in the shaft bottom, but no defined vein. These will be drifted on and another attempt made to locate the faulted main lode.

Burley Mine

This is one of the properties in the vicinity of the Sultana mine. An attempt was made several years ago to locate the extension of the Sultana vein on the Burley locations, D 193, D 193 A and 271 P, which are practically all under water, by means of a caisson built in the water and a shaft sunk from it. Descriptions of the works with plans will be found in the Report of the Bureau of Mines Vol. VIII. pp. 46, 52 and 64.

From June 1899 until the summer of 1903 the property lay idle. It is now owned by the Coronation Gold Mining Company, Limited, Rat Portage, Ont., with J. Burley Smith as manager. A force of eight men was engaged pumping out the shaft preparatory to carrying on further development. According to Mr. Smith the workings measured as follows: Shaft, 202 feet deep; first level, 108 feet deep; southeast drift 56 feet. Second level, 175 feet deep; southeast drift, 65 feet; northwest drift, 16 feet.

(1) Bur. Mines, Vol. XI., p. 251.

The water was making in the shaft so fast that the united efforts of the pumps to lower it below the first level were almost futile. Leakage around the bottom of the caisson may partly account for the heavy inflow; but another serious cause may lie in the opening or washing out of fissures from the lake bottom down. If some co-operative arrangement could be arrived at between the owners of the two adjoining properties, the Sultana and the Burley, by which either the Burley workings would be permanently closed as such and any ore bodies therein reached and developed from the Sultana workings, or sufficient of the adjacent Sultana property along the shore be granted to the Burley as a site for their power plant instead of necessitating its installation on the caisson, there would be much better chance of success for the Burley undertaking. Negotiations to this end were reported to be on foot at the time of my inspection, 14th September 1903.

Mikado Mine

No inspection was made of this mine on the occasion of my trip of inspection in September 1903, since operations had been suspended there the previous April. The stamp mill had been closed in November 1902. From the manager, Mr. N. McMillan, I learn that until December the workings were kept pumped out, and that the last mining done brings the measurement underground to the following :

No. 1 (vertical) shaft, depth 325 feet. Fourth level, depth 240 feet; north drift 760 feet (235 feet increase). At intervals along the latter several quartz veins were struck of about 3 feet width one assaying $19.00 per ton and the others from $3.00 to $5.00; but all pinched out again within short limits. This drift is in trap schist. At 1,000 feet north of this shaft another diamond drill hole was bored at an angle of 60 degrees west through granite first, then trap, then soft vein matter composed of mixed quartz and trap schist, and lastly trap to the bottom. Values in the vein, judging from the drill cores, were quite low.

From the incline shaft no further mining has been done, but in the ninth level south a diamond drill hole was bored at a flat angle of 270 feet south tapping No. 3 vein at 261 feet or 1,061 feet south of the incline shaft, and finding it about 10 feet wide, but with values in the core samples of only some $2.00 per ton. Several smaller intervening quartz veins poor in values were pierced before reaching No. 3 all of which are traceable on the surface, according to Mr. McMillan, in nearly the same relative positions.

The company has now decided to indefinitely suspend operations. If any other operator should desire to prospect the ground further on the chance of finding in some of these veins richer ore bodies or pay chutes, the company, I am informed, holds itself ready to consider such a proposition.

The Golden Horn

Mining progressed steadily during the year to the date of inspection, 13th September 1903, and considerable satisfactory development was accomplished; but excepting a little more surface stripping it is still confined to the one quartz vein. The position of manager is now occupied by Mr. B. T. Thorne, with Ed. Hammill as foreman and a force of 14 men.

The shaft is 255 feet deep, an increase of 71 feet. First level, east drift unchanged; west drift 176 feet turning then south 72 feet to connect with the old shaft, which lies 10 feet farther, for better ventilation; at 51 feet south of the turn another mixed quartz and schist vein was struck which apparently does not outcrop at the surface; in the face also more quartz appears, probably forming part of the vein on which the old shaft was sunk, the quartz carrying galena, blende and pyrite. Second level, depth 166 feet (new); east drift 175 feet, and west drift 176 feet, with sumps in both and a small Cameron pump unwatering from the east one. Third level, depth 235 feet; east drift 52 feet; west drift 57 feet with, at 16 feet in, a crosscut running south 38 feet, to continue across the formation and intersect the other parallel veins outcropping on the surface in this direction.

Reference was made in the Eleventh Report of the Bureau of Mines, pp. 251 and 252, to the vein in the mine workings, and to this may now be added the fact that it is very irregular in width, waving in and out from a mere stringer to a solid quartz body 3 1-2 feet wide. The one solid band occasionally breaks up into several, which then interband with the chloritic schist forming a well-defined deposit several feet wide. Unless the gold values extend into the wall rock it can hardly pay to work the mine for this one narrow quartz band, even though it were unusually rich. Careful and systematic sampling would soon elucidate these points. Of course the other veins on the property may contain pay chutes but not enough effort has yet been put forth to find this out.

The shaft maintains a uniform incline north of 81 degrees; the timbering therein is kept in first-class condition.

A new 3-inch Ingersoll air-compressor has been installed. The rest of the plant is the same as at last inspection. For this a new power house has been erected. The other additional camp buildings consist of several private dwellings and a machine and blacksmith shop, of neat appearance and well painted.

A suitable dynamite magazine has been erected in a safe place; but no thawing house as yet. For the placing of this latter and for a general improvement in the practice of handling the explosives, instructions were given.

Crown Point

Descriptions of this property and of the work done below and above ground will be found in the Bureau of Mines Reports, Vol. IX. p. 59, and Vol. X. pp. 79 and 92. It is now three years since the mine closed down. In August 1903, according to information received from Mr. R. J. Elliott, manager for the present owners, the Crown Point Mining Company, Limited, sold the entire property to the Black Cat Mining Company, Cincinnati, Ohio, president S. P. Kineon.

The intention is to resume mining development at once, and to aid this by installing more mining machinery.

Olympia Mine

This property, mentioned in the last report of the Bureau of Mines, was under development at that time, a shaft being sunk. During most of the summer of 1903 a force of 15 men or thereabouts continued putting down the same shaft. Work was suspended, however, in September.

Mines Contract

Mr. J. W. Cheeseworth, manager of the Mines Contract and Investigation Company, whose head office is in Toronto, informs me that during 1903 exploratory development was done on five of the company's properties, on Clytie and Rush bays, Lake of the Woods, and in the Seine river country. The company is said to have control of mining locations aggregating about 11,060 acres situated in various parts of the Rainy River District. These it develops a little to show to better advantage their size and value for a sale. The forces employed in this work are usually small, in each case numbering from three to five men.

Great Northwest Mine

The property by this name consists of part of numerous locations situated on the north side of Clytie bay, lake of the Woods, controlled by the Great Northwest Mining Company of Toronto. It lies three-quarters of a mile northeast of the Indian Joe mine. Under manager J. Williams a force of six have been employed sinking a shaft since the spring of 1903. The shaft is 33 feet deep, vertical, and 8 by 10 feet in size and is sunk in a dike of schistose felsite light-green in color. A few grains of pyrite were visible, but no other sulphides. All mining is by hand, and the men are living under canvas.

Instructions were given to erect a dynamite magazine at once.

Indian Joe

This property, described in the last Report, has continued under development steadily, except for an idle period in the spring, up to 12th September, 1903, J. Williams being manager with a force at present of only 5. During most of the summer 16 were employed.

The main shaft has reached a depth of 85 feet. First level, depth 80 feet, east drift 50 feet, with at 30 feet in, a crosscut south 8 feet; west drift 45 feet, with, at 30 feet in, crosscuts south 45 feet and north 20 feet. The shaft is sunk in a disturbed and schistose band of slaty trap which strikes east and west with nearly vertical dip, and contains a few parallel stringers and pockets of quartz.

The shaft is in good shape, hoisting being done by bucket on skids. The mine buildings include a shaft house 20 feet high, and a power house in which are installed a 4-drill air compressor, a duplex cylinder single drum hoist winding 7-8-inch steel rope, and two locomotive type boilers of 35-h.p. and 125-h.p. respectively. There are only two camp buildings as yet.

An explosive magazine has been built in a safe place; but some instructions were necessary for safer methods of handling the dynamite.

Cameron Island

The last accounts of this property were published in the tenth Report Bureau of Mines, pp. 79 and 92, for the year 1900. Since then no work had been done until the summer of 1903, when a 10-stamp mill was purchased and sent in for erection by next summer if possible. Two or three men are now placing foundations for the building and plant. The owners are still the Cameron Island Mining and Development Company, Limited, for whom T. F. Morrison remains in charge of the property.

Gold Reefs

A partial description of this property was given in the last two Reports of the Bureau. Development continued until the summer of 1903, when work was again suspended. The shaft was sunk 185 feet deep on an incline of 60 degrees south. First level, depth 100 feet; east crosscut 40 feet; west crosscut 45 feet. Second level, depth 185 feet; west crosscut 45 feet; east crosscut 48 feet; south drift 43 feet.

The island on which the mining has been done and the camp erected has an area of about two acres. Near it are other small rocks and reefs above or near the surface of the water, the formation of all being protogine. A slight disturbance has faulted the formation in a northeast-southwest direction along a number of parallel planes, leaving schistose bands five inches or so in width in the otherwise massive rock. The shaft has followed down one of these schistose bands on an incline of 60 degrees south, but in or along the line of strike. There was no wall or plane to determine this particular incline for the shaft and it might have been at any other angle. At 80 feet depth another fault plane was struck running nearly at right angles to the others and traceable on the surface. The crosscuts from the shaft followed along it, at both the first and second levels.

The disturbed bands are altered to a light green chlorite schist, through all of which, both on the surface and underground, narrow, irregular quartz stringers are scattered in the proportion of 5 to 10 per cent. of the whole. The massive formation also contains quartz stringers, but in smaller and more irregular quantity than the schistose portions. The gold is said to occur in connection with all or any of the quartz and to be free. Very little of any other mineral, such as iron pyrites, is visible. Judging from a few assays, the gold is not uniformly distributed, and until a thorough assay examination is undertaken, it is impossible to say where the values lie, or what part of the whole location should be developed to extract them.

Combined Mine

This mine which has been shut down for several years was re-opened a month or so prior to my visit in September, 1903. Numerous accounts of the operations of the former owners, the Combined Gold Mine Company, and of the geology of the locations will be found in the earlier reports of the Bureau of Mines, the most complete being in Vol. VII. pp. 43-45, Vol. VIII. p. 61, and Vol. IX. p. 50. The Camp Bay Mining Company, Limited, of Buffalo, N. Y., and Niagara Falls Ont., have since taken over the property, and placed Sidney Pinchin in charge as superintendent with a force of nine men.

The mine lies about two miles east of the south end of Camp bay, Lake of the Woods, or about 50 miles by steamboat south of Rat Portage, and is connected with the bay by a trestle railroad running mostly through swamps. The mill at the bay end ran for a month or so during the fall of 1902. It is now idle again, and will probably remain so until the mining development blocks out ore sufficient to ensure steady production. New camp buildings have been erected at the mine end, to avoid travelling back and forth from the old camps on the lake shore.

Mining is now confined to one location, on which a number of open cuts and short shafts had already been sunk. Of the latter, three lie near the present point of development and within 80 feet of one another along an east and west line, the east one 26 feet deep, the middle 15 feet deep, and the east 10 feet deep, and all connecting underground with the same level of 80 feet in length. The No. 2 or middle shaft is now being straightened for a skip road to follow down the vein to the north, the impression being at this point, it turns or folds down with a steep incline north. There is no doubt about the vein lying practically flat to the south of these shafts, numerous openings showing the quartz beneath only a few feet of the trap and felsite country; and to the north about 350 feet beyond the shafts the vein outcrops again at a number of points, so that taken together with other indications and findings, there appears little doubt that this sudden dip to the north of No. 2 shaft is merely a pronounced syncline in the vein. Similar characteristics exist at the other exposures over the area of 600 by 1,200 feet in which the vein has been found. The quartz averages from 5 to 6 feet in width in a horizontal fissure of the trap, the accompanying felsite having apparently been ejected subsequently along the same plane.

The new power-house at the mine workings contains a 30-h.p. boiler and a duplex cylinder hoist engine. For the handling and thawing of the dynamite safer methods were advised.

Flint Lake

This property, of which a partial description was given in the last Report of the Bureau, comprises mining locations McA 285 and 286, S 430 and 431, and a water location S 433 on Cedar river about 2 miles distant from the mine, aggregating 408 acres. Development is confined largely to McA 285, which has an area of 138 acres.

When inspected in September 1903 superintendent W. B. Drummond had a force of 15 employees, some at mining and the rest on mill construction. The mill is a Krupp ball mill and as soon as completed in the fall it was intended to make a test run on all the ore now on the dump, which amounts to between 400 and 500 tons.

Mining development has been confined as surface work largely to the outcroppings of the vein on the rocky ridges. At the northwest end of the main exposure a combined open trench and tunnel runs in 80 feet, and from here the ore was being gathered for the mill test. No. 1 shaft lies 200 feet southeast of this and is now closed and full of water. No. 2 shaft is 80 feet farther southeast, 15 feet deep, and also closed. At separated intervals for several hundred feet farther southeast the vein has been stripped and cross-cuts and trenches made in it.

The vein follows what appears to be a true fissure striking N. 70 degrees W. through a country of somewhat slaty trap whose strike is however N. 81 degrees W. The faulting movement has more or less altered the two walls to a talcose schist, and where this is pronounced quartz has been deposited in stringers and lenses across a maximum width of 8 feet. Visible gold occurs in a fine state occasionally in the quartz, and with the latter some calcite and a small amount of pyrite is intermixed.

The mill building on the lake shore was completed last year, and near it are several camp dwellings. From here to the mine, a distance of some 400 yards, a wagon road has been constructed. The mill power plant consists of a 125-h.p. return tubular boiler and a large horizontal engine set up in the same building. Besides the large revolving ball mill, which is to crush and amalgamate the ore, the remainder of the building is occupied with the various tanks appertaining to the cyanide process. Cyanidation will not however be included in the first tests to be made this fall.

A safely situated dynamite magazine has been erected; but both with regard to the storing therein and the thawing at the mine, it was necessary to give directions for better and safer methods.

Nino Mine

After some further development at this mine during 1903 operations were again suspended in September. Supplies were then being taken in by canoe from Whitefish rapids, the terminus of steamboat navigation from Rat Portage. The mining machinery belonging to the property which has lain on this portage for a year or more may be taken into the mine this winter.

Virginia Mine

The last account of operations, including a general description of the property, was given in Vol. IX. Bureau of Mines pp. 46-47. A little more development was done underground during August 1903 and more camp buildings erected, but after that all was closed down again. This property covers a number of mining locations on Sturgeon lake, about 10 miles by canoe route west of Whitefish rapids, Regina bay, Lake of the Woods.

Eagle Lake Area

Since the opening of this area there have been only two or three operators actively mining, and two of these, the Northern Light Mines Company and the Grace Mining Company, now own most of the located properties at the west end of Eagle lake, which seems to be the most valuable portion of the territory. Mill tests have been made at intervals through the year at the small Eldorado mine plant, of ore from the properties of the various companies with returns in gold that are very encouraging. As all the developed properties lie within a few miles of each other on the islands and the mainland, and all near the shore, the most feasible scheme for ore reduction appears to be the erection at a central point of a large enough mill to handle the ores from all the properties, some six or seven in number at present, especially since most of the developed veins are rather small to form the only source of ore supply for a 10-stamp mill.

The important gold-bearing veins of the area are confined to the granite formation over a width of a mile or more from its contact with the green trap, which contact crosses Eagle lake with a tortuous but on the whole northeast-southwest strike. The quartz of the veins in the trap on the northwest side of the contact has not yet been found to carry gold in paying quantities, even the veins actually in the contact being generally lean. Those in the granite will, on the other hand, pan gold, even to the merest stringers of quartz, the metal occurring therein usually free and visible both in coarse and fine grains. The commonly associated sulphides are almost entirely absent.

The mines of this area were on this occasion inspected during the last week of September, 1903.

Golden Eagle

After passing through the hands of several parties and receiving a little development from each, it looks as if the property would revert again to the original owner, N. Higbee; and if so, it will probably undergo more continuous and systematic mining than hitherto. In August 1903, 29 tons of the ore were run through the Eldorado mill, producing $307.50 in gold, or $10.60 per ton, according to the statement of the manager.

Grace Mine

This property covers mining location M H 251, on the west side of Eagle lake and is owned by the Grace Mining Company, Limited, Ridgeway, Ont., and Buffalo, N.Y. The president and manager of the company is J. H. Casslor, and mine foreman R. McKinstry, the force at the mine numbering 5. Development of the auriferous deposits has progressed fairly steadily for two years past. No. 1 shaft lies a few hundred feet back from the camp on the lake shore and at the top of the hill. It is 28 feet deep, vertical, and 6 by 9 feet in size, on a vein of trap and quartz striking about northeast, and filling a fissure which traverses both the granite and the contact between it and the green trap. The combined vein filling is not much over a foot in average width, the quartz making about half of this and varying from an inch to 26 inches in width. The quartz carries galena, blende and pyrite and an unusually thick sprinkling of visible gold. A mill test of 3 tons of the ore is said to have given $83.00 gold per ton on the plates, which is quite possible judging from the vein material now on the dump. It is a question, however, whether it will pay to mine such a narrow ore body.

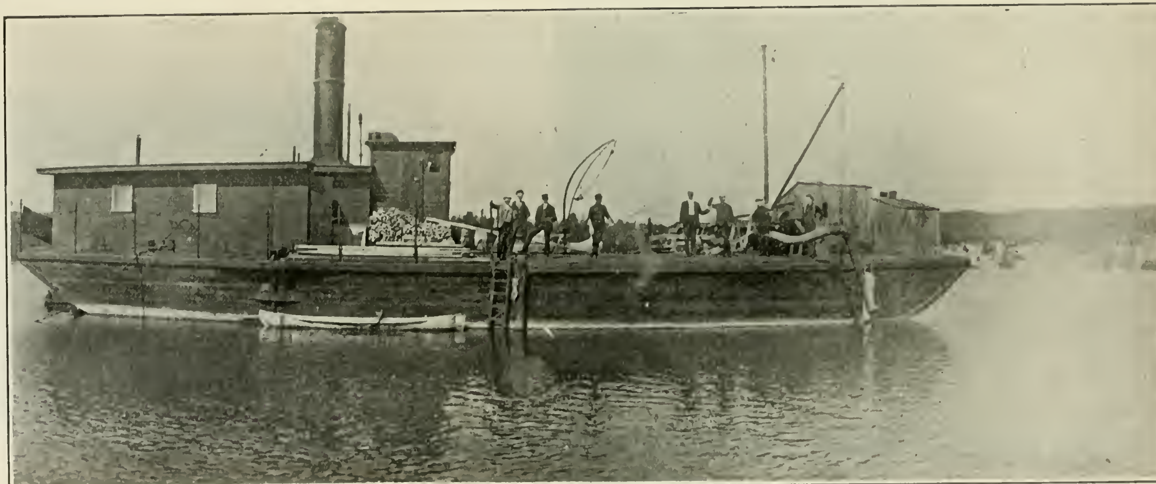
No. 2 shaft at 96 feet southwest of No. 1 is 29 feet deep, vertical, and 6 by 9 feet in size on another narrow gold-bearing stringer of quartz, entirely in granite and parallel to No. 1 vein.

On the lake shore at about 1,000 feet southwest of No. 1 shaft a tunnel has been driven 128 feet northwest into the granite hill, and at the face crosscuts

Manxman gold mine, Michipicoton Mining Division, 1903.

Manxman mine; quarrying auriferous dike.

Eldorado gold mine and mill, Eagle Lake: 1903.



Iron sand concentration plant of North Shore Reduction Company at outlet of Nipigon River

Shakespeare gold mine; auriferous body of quartz and chloritic schist.

Shakespeare gold mine, showing vent or natural opening.

another northeast-southwest vein which is exposed on the surface 90 feet above. Drifts were run on it 33 feet northeast and 37 feet southwest. The so-called vein is of indefinite outline, being composed of a mixture of quartz stringers in schistose granite along a sheared zone of this country rock.

Instructions were necessary for the remedying of certain improper practices in handling and storing dynamite. The camp includes boarding and bunk houses, office, stable, etc. In front of it a dock has been constructed for the company's small steamer.

Buffalo Mine

The above property is known both by this name and by its location number, M H 246, and is situated on the west shore of Eagle lake between the Eldorado and Grace mines. The Northern Light Mines Company, the owners, during the summer did a considerable amount of exploratory mining, of which N. Higbee was in charge. Several camp buildings have been erected on or near the shore. From the shore line a tunnel has been driven west 30 feet crosscutting to the lode, which was then followed southwest for 78 feet farther. At 553 feet west of the tunnel No. 1 shaft was sunk, 28 feet in depth and vertical. To the southwest of this a pit and a 15-foot shaft, called No. 2, have also been sunk. The auriferous deposit consists of a mixture of altered schist and quartz filling a sheared zone in a pink granite formation. At No. 2 shaft the disturbance appears to have taken two directions, both northeasterly, one running to No. 1 shaft and the other to the tunnel. The width of both branches varies from about 10 feet to 25 feet. All mining had ceased some time previous to my visit.

Eldorado Mine

This is another of the Northern Light Mines Company's properties mentioned in former Reports of the Bureau of Mines. No mining has been done since the beginning of 1903, when a shaft was sunk at the mouth of the original open cut to a depth of 60 feet along the incline of the vein 73 degrees northwesterly. The vein of quartz fills a well-defined fissure from 3 to 5 feet wide in a green hornblende granite and strikes north 70 degrees east. Most of the ore from this work has been milled in the 2-stamp plant erected a short distance from the mine. The milling machinery includes simply the two 1,000-lb. stamps with amalgamation table and a 20-h.p. boiler. On the other side of this point and in a sheltered bay the camp has been built, including living and boarding houses, office, two private dwellings, etc.

Mr. N. Higbee, general manager for the company, was in charge of the work at this mine.

Baden Powell Mine

The Northern Light Mines Company acquired this property in April 1903. At the time of inspection the force of employees numbered seven, under manager N. Higbee. Mining had progressed since the spring and two mill runs were made at the nearby Eldorado plant on an aggregate of 28 tons of the ore. The gold recovered amounted to about $40.00 per ton, according to the manager.

The main open-cut on the vein has been enlarged to a length of 50 feet and a depth of 35 feet with shelving ends. A shaft way is shortly to be timbered down the centre, and thereafter all work confined to sinking. At 200 feet southwest of it a new shaft has been sunk 50 feet deep, vertical, and 6 by 8 feet in size, but is at present closed.

There are three veins of probable importance cutting across the southwest end of this South Twin island, and all traverse the same granite formation with approximately the same northwesterly strike, but varying in dip. No. 1 vein, on which most of the development has been done is the most southwesterly of the three. No. 2 lies 300 feet northeast of No. 1, and is composed of quartz lenses intermixed with a sheared zone of the granite about 5 feet in width. No. 3 vein lies 300 feet still farther northeast beginning at the shore of the island near the camp. It averages between 3 feet and 4 feet in width.

New camp buildings have been erected on the easterly side of the island and on the other side, near the mine workings, a new office.

The company recently built a 40-foot steamboat for service between Vermilion Bay station, C. P. Ry., and the mines

Viking Mine

A short account was given of the first operations in 1900 of this mine in the Tenth Report of the Bureau of Mines, page 96. Since then it has passed into the hands of the Viking Mining Company, of Toledo, Ohio. A new contract for continued development had at the time of my visit just been let, the mine having been closed since the spring.

A shaft had been sunk on the vein in the granite to a depth of 80 feet, 6 by 9 feet in size and inclining 80 degrees southeast with the dip of the ore body. All this was done by hand drilling. The vein maintains a width of 4 to 6 feet of quartz intermixed with the accompanying narrow dike of trap, which was ejected into the same fissure.

Only one camp building has so far been erected, since the force has not exceeded 3 or 4 men at any one time.

S 500

Auriferous veins were discovered on this location by E. Higbee and associates and last winter worked by them. The property is situated on another small lake about 2 1-2 miles southwest of the southwest end of Eagle lake, and contains 225 acres. According to N. Higbee, from whom this information was obtained, there are three veins on the property. Two are parallel with northeast strike, one averaging 10 feet in width and the other 6 feet, and the third, 2 feet in width, cuts across these at right angles. The formation is granite, through which a tunnel was driven 50 feet, crosscutting the 10-foot vein on the way in. Considerable other work was done in the way of stripping the veins at numerous points over the surface.

Ideal Mine

The Ideal Mining Company of Detroit, Mich., has acquired a mining location covering the north 80 acres of lot 8 in the first concession of Van Horne township, Rainy River district, and during the past season erected a camp building or two and did a little mining work. This last consists of a shaft 36 feet deep and some surface stripping. Machinery is being ordered for installation next season, when work is to proceed on a more comprehensive scale. This mine is reached from Dryden.

Redeemer Mine

When inspected on 23rd September 1903, the force numbered 9 under superintendent Gus Larson. The mine lay idle until the new machinery was installed in March, because without this it had been found difficult to keep the water out of the workings. The shaft is now 130 feet deep and maintained vertical. At 60 feet depth a short pump level was run from which water is now raised. The first level is at a depth of 100 feet, but nothing more than the station has been cut out as yet. The intention is to sink to 230 feet before doing much drifting. Satisfactory timbering has been placed in the shaft to a depth of 60 feet, the remainder to follow at once.

The machinery in the adjoining hoist house includes a 35-h.p. boiler, a 3-drill Rand air-compressor supplying power to the two air drills, and a small hoist operating the bucket in the shaft. The shaft head-frame is constructed solidly of square timbers and not covered in. A good dynamite magazine has been erected at a safe distance from the workings, and for thawing this winter a proper thaw-house will be built. More buildings for the camp are to be added shortly, the lumber being now on the ground. The Government constructed last season a 2-mile road from the terminus of the steamboat route from Dryden in to this mine, and to the Gold Moose beyond.

The mine now exhibits a well-defined vein from 7 to 10 feet wide from the surface down, composed of quartz and green trap (the country rock) intermixed. Iron pyrites impregnates the whole to the extent of about 1 1-2 per cent.

An adjoining location on lot 6 in the first concession of Van Horne, known as the Lost mine, was extensively explored over the surface during the summer by Gus Larson, superintendent of the Redeemer. The quartz vein has been stripped for about 500 feet and is from a few inches to 18 inches in width. It fills a true fissure with a strike east and west, and dip 63 degrees north in the green trap of the area and according to Mr. Larson, carries a good deal of free gold. No other work has been done since.

Gold Rock

This property consists of mining location H P 405 and adjoins the Big Master mine to the south, on the shore of Upper Manitou lake. It is owned by the Gold Rock Mining and Milling Company, of Detroit, Mich.. and Gold Rock, Ont., for whom J. M. Sweeney is manager and secretary. Last winter and again this summer two shafts were sunk about 1,500 feet apart, one 50 feet deep and the other 60 feet deep A heavy inflow of water necessitated the suspension of work until mining machinery could be installed.

Two camp buildings were erected to house the force of 8 men.

Reliance Mine

This property was originally called the Independence mine. It is owned and operated by the Reliance Gold Mining and Milling Company, Limited, of

Detroit, Mich., under the superintendence of T. Armstrong with a force of eight. For 6 months previous to inspection mining had been confined to sinking another or No. 2 shaft at 300 feet southwest of No. 1 shaft, to 97 feet in depth. First level, depth 80 feet; north drift, 75 feet; south drift 75 feet The shaft is timbered and has a good ladderway. Hoisting is done by means of bucket, block and tackle and horse, with a good brake on the rope.

The quartz vein extends down the shaft and along the north drift. In the south drift it disappears at 10 feet from the shaft.

Instructions were given to build a dynamite magazine at once.

Twentieth Century

Active development marked the past year's operations at this mine, so far as the erection of surface plant is concerned Underground development has not advanced in nearly the same proportion, so that with the 20-stamp mill ready for a continual supply of ore we find the mine producing only enough to keep one or two of the batteries in the mill running from 2 to 11 hours a day. Out of the force of 32 employees, 8 are miners

Underground development is still confined to the main shaft, which is now 340 feet deep inclining uniformly 83 degrees south. First level, depth 80 feet; unchanged. Second level, depth 160 feet: east drift 20 feet; south crosscut 26 feet, cutting through a 2-foot quartz vein at 20 feet in; west drift 18 feet, then turning north for 47 feet. At 12 feet north from the turn the main vein was struck and drifted on west 93 feet, the quartz gradually decreasing in width from 10 feet at the east end of the drift to 3 feet at the west face. Third level, depth 240 feet; west drift, 159 feet; at 15 feet in, crosscuts run north 42 feet, and south 85 feet, and in the latter at 31 feet south another drift runs west 78 feet on a one-foot vein of quartz; at 20 feet in the main west drift and overhand stope 40 feet in length extends along the drift and is timbered over, and up the centre of it an upraise was driven to the second level; at 130 feet in the west drift the quartz vein again appears in irregular stringers from there to the face, it having pinched out from the end of the stope to that point. Fourth level, depth 320 feet; west drift 15 feet, with at the face crosscuts south 5 feet and north 71 feet. At the face of the north crosscut what appears to be the main quartz vein had just been broken into at the time of my inspection, 28th September 1903.

The surface plant has been entirely re-arranged since the erection of the 20-stamp mill, all the power machinery now being stationed in the one building adjoining the mill. This part of the plant includes the original 3-drill Rand air compressor; one-half of a 12-drill Ingersoll air-compressor; the mill en-hoist engine, the drums 4 inches diam-hoist engine, the drum 4 inches diameter by 2 feet 6 inches face, using 3-4 inch steel rope, one drum operating a skip in the shaft, and the other another skip from the shaft head up a trestle road 350 feet in length to the ore bins in the top of the mill. The milling plant includes only the stamp batteries and the amalgamation plates, the ore not requiring concentration. At the top of the building there are two large ore bins one above the other, and between them the rock crusher is set up.

It was again necessary to give instructions for the adoption of safe practices in handling the dynamite.

Giant Mine

Another location, H W 185, has been added to the original two locations comprising the property, H W 74 and 75, and adjoins these to the east. The owners are the same, but P. Paulson has been made superintendent. The force numbered 7 at date of inspection, 27th September 1903. Mining had been confined to the shaft on H W 75 and it was then 212 feet deep, inclining 80 degrees westerly. First level, depth 200 feet; east drift 150 feet, with a crosscut from the face 24 feet south. This east drift will be continued to strike the ore shoot which is exposed on the surface at 260 feet east of the shaft. The shaft follows down a shattered zone of slaty trap carrying a few irregular stringers of quartz, and the first level east drift is still in the same. There appears little excuse for having sunk at this point where no ore exists, when at 260 feet east a well-defined quartz vein carrying visible gold outcrops as the only chute in sight likely to produce pay ore. The shaft is timbered with a solid collar 40 feet deep and below this to the bottom with square frames solidly lagged. The ladder-way is partitioned from the hoist-way but the ladders extend without platforms from top to bottom. An open head-frame carries the sheave for the bucket hoisting cable, which runs thence into the adjoining hoist house.

New camps consisting of office, bunk and boarding house, etc. have been built on location H W 185. A satisfactory dynamite magazine has been built, but was not kept in a cleanly condition

Gold Standard

The Gold Standard Mining Company of Morris, Minn., have changed their point of operation from their first location G 340 (2) on Sairey Gamp lake to location H W 271 of 40 acres situated on the northwest side of Nelson lake. These two locations are about a mile apart. The steamboat runs down the Manitou lakes about 35 miles from Gold Rock to a short portage on the west side of Lower Manitou, from where the journey to the mine continues by canoe for two miles farther. E. E. Hall is manager and employed 16 men at date of inspection, 26th September 1903. Operations began here in October 1902, since which time camps have been erected, consisting of bunk house, office, stable, hoist house, etc., a 3-4 mile road constructed between Sairey Gamp and Nelson lakes, and the waters of Sairey Gamp lake raised about 2 1-2 feet for better navigation by a dam at their outlet into Manitou lake. A few feet from the shore of Nelson lake, the shaft has been sunk 95 feet in depth, vertical, and 6 by 9 feet in size. The collar extends to a depth of 15 feet. Below this are square frames carrying the partitions between the two compartments and the ladderway to a depth of 50 feet. First level, depth 80 feet; east crosscut 110 feet with at the face a rise at 45 degrees incline 36 feet farther west. Mining is now confined to sinking in this shaft. On either side of the shaft along the outcrop of the quartz vein two pits were sunk from 6 to 15 feet deep. The shaft head frame is 12 feet high and open. Hoisting is done by bucket operated from the adjoining hoist house by a small engine and a 30-h.p. boiler. The quartz vein cuts through a formation of compact granular trap with a strike about north 25 degrees east and is distinctly lenticular, varying in width within short distances from a foot or so to 8 feet. The dip is not apparent from the surface exposures, and as the shaft was started down at about 25 feet west of its outcrop and has not yet met the vein with depth, not much else is known regarding its size and value.

Big Master Mine

At the time of inspection, 25th September 1903, W. Shovells was acting manager with about 30 men in the employ of the company, with mine foreman Malcolm Speer and mill foreman G. R. Vary. During the fall of 1902 two separate mill runs were made of 16 days each, from each of which about $5,000 worth of bullion was obtained, according to the manager. From then until May of this year it remained idle, but since then has run continuously. Frue vanners now replace the original strake table, which did not effect the concentration of the ore satisfactorily.

The mine also lay idle from January to April, but since then mining has been more or less active in the production alone however of the ore milled. Practically no further development has resulted during this time. All ore in sight from the surface down to the second or lowest level has been taken out, so that the mill will be forced to close down shortly for lack of ore. It is unfortunate that a more businesslike plan of development in blocking out plenty of ore in advance has not been adopted. The second level northeast drift was continued 35 feet farther to a total distance of 278 feet; at 180 feet northeast, in the pay chute, a winze is being sunk, and directly above it a connection made, partly through the open stope, with the first level and from there again with the surface, up which ladders are placed, providing a second outlet from the mine. This pay chute which lies northeast of the shaft has a length of 80 feet along the vein, and an average width of 8 feet, both of which dimensions it maintains fairly closely from the surface down. The average value is given as about $8.00 per ton. The big or east vein lying to the southeast of the above is also reported to have a pay chute, which is 90 feet long and about 5 feet wide, lying directly opposite the one mined in the west vein. These pay chutes are well defined from the rest of the vein, in that they each consist of a sudden enlargement of the quartz to about double its width elsewhere. It is stated by the manager that the quartz of the west vein carries values pretty well throughout, but that except at the so-called pay chute it is too narrow to mine at a profit.

The surface plant was unchanged with the exception of the addition of another boarding house, and a private dwelling.

Little Master

A short reference was made to this mine in the last Report of the Bureau of Mines, in which it was noted that all mining work was confined to location A L 206 bordering on the northwest shore of Mud lake, which is a short distance east of Upper Manitou lake. In addition to this the Summit Lake Mining Company owns the following locations: A L 207, 208; H W 31, 35; G 16, 17, 19, 21, 22; and G 18, all in the vicinity of Mud and Summit lakes.

(2) Bureau of Mines, Vol. V., p. 100.

The company is building a 2-mile road from the mine northwest to connect with the Government road between the waters of Manitou and Wabigoon lakes. S. V. Halstead is manager and S. H. Williamson, foreman, under whom 14 men are employed.

Mining has been going on for the past year or so and at the date of inspection, 25th September 1903, it was confined to sinking No. 3 shaft, which is to be made the main working shaft. It is now 50 feet deep, vertical, and 7 by 12 feet in size, with a solid collar to a depth of 24 feet, but beyond this there are no other timbers, not even ladders, the men entering and leaving the mine in the bucket. Instructions were given to suspend hanging ladders in the shaft immediately, to complete the timbering to within a safe distance of the bottom, and otherwise to comply with the Mines Act regulations for the safe operation of shafts, which prohibit riding in the bucket.

No. 1 shaft lies 200 feet west 20 degress north of No. 3 shaft and up the hill 106 feet higher, and is 50 feet deep, vertical, and 7 by 12 feet in size. The first level is at the bottom and consists of a crosscut 26 feet west. This shaft has been temporarily closed until connection can be made underground by crosscut and upraise with the No. 3 working.

No 2 shaft lies about 350 feet northeast of No. 3 shaft, and a few feet higher up the hill. It is 100 feet deep, vertical, and 6 by 9 feet in size. First level, depth 80 feet, with crosscuts west 20 feet and east 30 feet.

Hoisting in No. 3 shaft is done by bucket, the rope after passing over the sheave on the open head frame descending the hill over trestles a distance of about 400 feet to the hoist house. The machinery here installed includes a small Jenckes hoist and a 28-h.p locomotive type boiler. The camp located on the lake shore about 400 feet from the mine workings comprises boarding and bunk houses, office, stable, etc. The company have ordered mining machinery of greater capacity amongst which will be an air-compressor, and if possible the new plant will be set up during the winter of 1903-4.

The formation covering the location consists of the green trap of the Manitou gold area, which here has been disturbed and altered along a number of roughly parallel lines to a chloritic schist. In these schistose bands, which strike in the same direction as the more solid trap, quartz has been deposited either as a general dissemination of interbanded stringers over the entire width of the altered area, or as one continuous lenticular vein. No. 3 vein is of the former class and contains only a very little quartz, while No. 1 vein is of the other variety, having an average width of about one foot. This latter vein is rich in free gold, but on account of its small size can hardly be considered of commercial value.

Similar deposits have been opened up at numerous other points on the property by means of test pits.

National Mine

This property consists of location H W 78 bordering on Three Hundred lake northeast of Upper Manitou lake, the mine workings lying about 200 feet north of the Government road. S. V. Halstead, acting as manager for the National Gold Mining Company of Detroit, Mich., the owners of the property, has during the past year with a force of about 10 men sunk a shaft 100 feet in depth, vertical, and 6 by 9 feet in size. The first level is at a depth of 98 feet with drifts north 25 feet and south 25 feet. Hoisting was done by buckets and a small Jenckes hoist engine. The latter and a 25-h.p. boiler are situated a short distance from the shaft and covered by a temporary shelter.

The miners live in a camp about a quarter of a mile southeast of the shaft on another location.

Just what the shaft was sunk on, in the way of an auriferous deposit, is hard to determine, as the rock dump exhibits nothing but compact green trap, and the surface nothing in the way of a quartz vein in the immediate vicinity of the work. The only visible vein in connection with the shaft occurred as a stringer 8 or 10 inches in width at about 100 feet south of the shaft; at other points across the strike of the formation, other splashes or lenses of quartz exist, but indicate no ore body, being merely a common characteristic of this green trap area.

All operations were suspended here a few days previous to my visit of inspection on 24th September 1903

King Edward

This property consisting of H W 171, 240 acres in extent, is situated west of the upper end of Lower Manitou lake and borders on both Carlton and Trout lakes. It has been acquired by English capitalists represented in this country by F. Bolton, Wabigoon. A force of 6 men have since June been extensively exploring the surface showings of quartz and other auriferous deposits on the location and have sunk a large number of test-pits and crosscuts. At the date of inspection, 27th September 1903, all work had just ceased until next year, when it is expected a definite plan of comprehensive development will have been decided on. One log shanty constituted the camp.

A large portion of the location covers a boss of biotite granite which lies in the green trap belt of the Manitou area and near its western edge, forming one of many similar bosses separated from the main body of the Laurentian gneiss to the west. As a result of severe metamorphic disturbances, this boss of gneissoid rock exhibits two main lines of faulting or shearing, one of which with its northwesterly trend gives the country its fairly definite strike. The other crosses the first at right angles, or approximately north 30 degrees east. Two classes of ore deposits exist, one filling true fissures as solid quartz veins from 5 to 6 feet wide in a north 30 degrees east direction, and the other composed of schistose zones 10 feet or more in width through which quartz stringers are interbanded in about equal quantity with the enclosing schist.

Most of the mining done is comprised within an area of about 400 by 800 feet, and in this the pits disclose three prominent veins of the first or fissure class, and two of the latter or banded variety, or possibly only one, since the two trend roughly towards each other where uncovered in the pits. The quartz in all the deposits carries iron and copper pyrites, galena and blende, the first named also occurring in appreciable quantities in the schistose vein matter. Very little free gold has been seen, and the few samples taken for assay were insufficient to enable one to form any idea of the value of the veins.

St. Anthony Reef

Manager J. S. Steele, of the Jack Lake Gold Mining Company, the owners of the above gold property on Sturgeon lake, reports the following details of operation since last inspection and plans for future development. Mining ceased in March 1903 and since then no other work has been done. From No. 2 shaft the east crosscut from the bottom was driven 105 feet, and the west crosscut 35 feet with from the face of the latter a drift 20 feet long. From the bottom of No. 3 shaft the east crosscut was driven 90 feet, striking an 8-foot vein at 19 feet in on which short drifts were run; and the west crosscut driven 15 feet. At 80 feet south of No. 2 shaft an inclined shaft was sunk 18 feet deep. More surface trenching was done at scattered points over the locations. The company intends to put in more mining machinery and a stamp mill, and with this in view has purchased the entire surface plant of the Golden Star mine in the Seine River district. It will be taken north to the St. Anthony mine this winter (1903-4).

Shakespeare Mine

This property has been recently acquired for the auriferous ore body it contains. The location consists of 80 acres of lot 5 in the first concession of Shakespeare township, Algoma District, situated about one and a half miles due northeast of Webbwood, Sault branch C. P. Ry., or about three miles by road. It is now owned and operated by the Shakespeare Gold Mining Company, Limited, Sault Ste. Marie, Ont., which is capitalized at $2,000,000. James Cronan is superintendent, and James McKenzie mine captain, under whom the force numbers 11.

Since the commencement of the present development about six weeks prior to the date of inspection, 29th October 1903, a camp has been erected including boarding and bunk house, office, stable, blacksmith shop and magazine; a half mile of road has been constructed from the mine down to the main highway in the valley, and considerable surface mining done.

That portion of the ridge which contains the ore body has very little surface covering, making easy its superficial examination by crosscut and testpit over a distance of about 500 feet northeast and southwest. At a central point a tunnel runs into the bluff to crosscut the deposit, its length to date being 30 feet. This ore is made up of interbanded lenses and stringers of quartz and chloritic schist, the latter more or less altered to a light, highly quartzose material by severe squeezing of the rocks and the subsequent circulating waters which deposited the quartz and gold. As an evidence of the latter action may now be seen cavities in the rock throughout the affected area ranging in size from the most minute passages up to a vent 5 feet in diameter, all of them lined with contorted masses of quartz, and occasionally acicular streaks of both quartz and flakes of chlorite. The gold was deposited both in the quartz, and along the walls in the schist enveloping the bigger lenses, some of the finds of the yellow metal equalling in size and value the best that the western Ontario gold areas have to offer.

The limited amount of development gives to the ore body a width of at least 50 feet, and a length of about 250 feet at the end in which the tunnel lies. To the southwest of this about 100 feet, more pay ore comes in with as great a width as the other, but with its length not yet determined. Films of native copper have been found interlaminated with the schist, and in one of the pannings made by the mine captain he thought he detected native platinum. The sulphides, chiefly iron pyrites, are confined almost entirely to the linings of the above mentioned cavities in the ore.

The chloritic schist of the deposit constitutes the body of this extensive ridge; but at intervals another darker rock of much the same material has been ejected in dikes of various widths trending along the same northeast and southwest strike. The contact with the granite lies to the north on the other side of the valley, probably half a mile away.

AL 282 or Sunbeam

This mine has continued in steady operation from the date of the last previous inspection to that of 7th October 1903 under the same owners and mining staff. There is a temporary reduction in the number of employees at present to 13.

All mining has been confined to the one working reached by the main shaft. This shaft is now 318 feet deep, and is still sinking on the same incline of about 45 degrees northwest. First level, no further drifting; the northeast drift has been dammed to catch the surface water (practically the only water which enters the mine) which is then pumped to the surface. Second level, depth 195 feet; northeast drift 244 feet; southwest drift 179 feet with at 30 feet in, a sump. Third level, depth 295 feet; northeast drift 120 feet; southwest drift 145 feet. From 25 feet in the northeast drift, third level, water is pumped to the surface from a sump.

A new open head frame has been erected over the shaft 15 feet high, and at 10 feet distant a small hoist house in which a new duplex cylinder single drum steam hoist has been installed, winding the 1-inch steel cable from the bucket in the shaft. At the foot of the hill below the shaft a 125-h.p. boiler in a separate building furnishes steam to the hoist and pumps. A new blacksmith shop and storehouse have also been built, and at safe distances from the shaft so as to avoid further danger to the workings by fire.

Although locally varying greatly in width owing to its lenticular character, the quartz vein will average in all the levels a good workable width of between 4 and 5 feet from top to bottom of the shaft. The values according to the manager, T. R. Jones, are considerably better in the lower levels than above. They appear to lie in a series of parallel pay chutes from 15 to 30 feet in length along the vein, and separated by as many feet of low grade or lean quartz. These pay chutes dip somewhat steeply northeast in the vein. The vein proper, which includes a width of one or more feet of schistose granite intermixed with quartz stringers on either side of the main quartz band above referred to, maintains a much more uniform width of 6 to 7 feet throughout. It is reported that commercial values in gold exist in this schistose portion of the vein as well as in the clean quartz band, and if so the gold is probably in the interlaminated stringers and bands of quartz therein.

By later word from Mr. Jones I learn that it is the intention of the company to erect a 10-stamp mill at the property during the winter or spring of 1904, and that as a good deal of the plant is already on hand, brought in by the former owners several years ago, the mill will probably be in operation early in the summer. Stoping on a sufficiently large scale will necessitate increased mining plant in the way of more boiler power, air compressors for air drills, etc., all of which are also to be installed.

AL 278 and 200

These two adjoining locations are situated about one-quarter of a mile south of the Seine river, near Island falls. They were surveyed and superficially prospected several years ago, but no mining of account done until the summer of 1903, when, under the superintendence of Henry J. Tharles, the Little Rock Consolidated Mining and Development Company, Limited, of Buffalo, N.Y., sent in a small force of miners and sank a shaft. The workings are reached by canoe route from Hematite siding or, as it is called, the Hospital, on the C. N. Ry., 5 miles east down Sapawe lake to Whiskey Jack creek and thence by a 2 3-4-mile trail north over a very rough, rocky and swampy country.

No buildings have yet been erected, a tent being used instead. The shaft is 50 feet deep, 7 by 9 feet in size, and inclined 80 degrees west-southwest. The quartz vein outcrops on a hill about

300 feet long, which rises out of the surrounding flat swampy land, consisting of a medium grained gray hornblende-biotite granite, the hornblende and biotite more or less altered to chlorite. This appears to have been faulted, the fault plane striking N. 32 degrees E. and dipping at about 80 degrees to the southwest. In it the quartz vein has been deposited. At the northeast end it shows first at the shaft, down which a width of 6 to 8 feet is seen. From here for 200 feet southwest to where it disappears under the swamp it maintains a width of 10 to 12 feet, and at two places has been opened out by surface cuts. The vein filling is mainly quartz, but this contains an intimate mixture of black hornblende and schist, locally varying in quantity. A little iron pyrites was visible.

From a report on the properties made by Mr. F. Hille, of Port Arthur, I gather that the vein can be traced northeasterly with a very uniform strike through both these locations, and that it was found to be auriferous, at places showing free gold.

Walsh Mine

From J. J. Walsh, late owner and still manager of this mine, I learn that in the spring of 1903, a 3-gravity stamp mill with gasoline engine power equipment was set up on the shore of Sapawe lake, and some lots of the ore from both No. 1 and No. 2 veins tested, giving good returns in gold. No. 1 vein is that described in the tenth Report of the Bureau of Mines, p. 107, as the Sapawe lake property. No. 2 vein lies about 800 feet inland from No. 1, and on it only stripping so far has been done. The old pit on No. 1 vein was sunk to a 50-foot shaft.

Recently the property was sold to parties who intend, it is reported, to become incorporated as the Sabawe Lake Gold Mining Company. A contract for further sinking on No. 1 vein has been let.

West End Silver Mine

Subsequently to the last inspection of this mine in November 1902, the operations received a serious set back in the loss by fire of the large new shaft and power buildings, and in the consequent heavy damage to most of the machinery. The newly timbered shaft enclosed by this building was also wrecked or scorched to nearly 100 feet in depth. Previous to this, mining and milling with the new and enlarged plants had progressed for two months, (February and March 1903) ; but afterwards all work ceased until June, when with Mr. H. Shear as general manager again, a small force started rebuilding and repairing. They are still engaged at this and now (January, 1904) have about finished so that operations can be resumed as soon as sufficient working capital is raised. With the ore now in sight in the mine levels and old stopes, not much financial aid should be necessary to set the whole on a paying basis again.

At a recent meeting of the owners, the Consolidated Mines Company of Lake Superior, Limited, the following officers were elected: president, C. P. Russell; secretary, M. A. Myers; treasurer, John Hourigan; general manager, H. Shear; and directors, A. J. Thompson and A. M. Wiley.

The last mining consisted in taking out ore from the stopes between the 2nd and 3rd levels east of the shaft, and in driving the 3rd level east to a length of 765 feet (an increase of 215 feet).

The shaft has been straightened where necessary and re-timbered with square frames at 6-foot centres from the top to the 4th or bottom level, solidly lagged, and divided into two compartments, one for an inclined cageway and the other the ladderway. The incline of the shaft is 73 degrees north. The guides for the cage extend 28 feet above the shaft house floor, allowing about 15 feet for overwinding. With the safety attachment and the hood in place men may with safety travel on the cage.

To the new surface plant enumerated in the last Report a 6-drill Rand air compressor, duplex air and steam, has been added. In the mill there are now 20 stamps and 9 Frue vanners which, with a capacity on this ore of 4 tons per stamp per day, are capable of treating 80 tons daily.

The proposed and recommended new dynamite magazine has not yet been built. A suitable thawing house heated with steam is now used. At the camp the new store and office building is completed, and several more small private dwellings are now in course of erection.

Iron Mines

Loon Lake (C.P.R.)

A description of the iron claims at Loon Lake siding C. P. Ry., near Port Arthur, and of the work done to that date on them is contained in the Bureau of Mines Report, Vol. XII., page 310. The diamond drilling then under way was continued until near the end of 1903 by the same party, Mr. Rinaldo McConnell of Ottawa, under the management of Mr. W. Demorest. The owners are not in a position to state definitely the extent of the finds, so that nothing of interest can be added to the last account.

North Shore Reduction

The iron-bearing sands which occur in places along the north shore of Lake Superior have for years excited considerable interest, but not until the past summer has any thorough attempt been made to work them. Although the sands are found both on the shores of the lake and beneath the waters of the rivers and bays, it is probable that in the latter cases local enrichments may occur by the re-working and re-concentration of the sands through the action of the waters, for which reason mainly the wet sands are being dealt with first. This involved a radical departure from the usual processes of magnetic concentration which are adapted to dry material only. To extract the magnetic iron from the wet sands necessitated the invention of entirely new machines.

The North Shore Reduction Company which has undertaken this task, has made application to the Government of the Province for certain areas of magnetic iron sands both above and under the water at several points along the north shore of Lake Superior. One of the areas lies at the mouth of the Nipigon river where it empties into Nipigon bay, and here on the sand from the bottom of the river the first attempts at separation were made during the summer of 1903. Mr. J. Walter Curry, K.C., City Crown Attorney, Toronto, is representative of the company, and Mr. S. N. Smith, electrical engineer of Minneapolis, was in charge of the work at Nipigon, where he employed an average of about 18 men until work was suspended for the winter.

Not much is yet known of the character of the sands in the river bottom at Nipigon, or whether they will be found richer in magnetite than the sands composing the high cliffs at the river's mouth. Mr. Smith thinks that an average content of 10 per cent. magnetite (about 7 per cent. metallic iron) exists, but as no systematic sampling of the ground has yet been undertaken, it is not possible to say whether the actual percentage will run as high as this or not. The grains of magnetite as well as of the quartz sand itself are small, the former probably all less than 40-mesh size. The iron would appear to be fairly uniformly disseminated through the sands of the cliffs, judging from the lack of any pronounced black streaks or areas.

Since the spring of 1903 the company have been assembling a suitable plant (see illustration) to test their process on the spot. It consists of a barge about 25 by 80 feet plan, by 10 feet depth, fitted with boiler, duplex driving engine, propeller and rudder. The remainder of the interior is taken up by a high speed engine operating the sand pump and concentrating apparatus; a smaller engine connected to the electric generator which supplies current for the magnets and lights; and a complete machine and blacksmith shop outfit. On the after-deck are the living apartments, and forward are the sand pump and outfit, including sufficient suction pipe to reach to the bottom of the river at any point, and the magnetic separating table or concentrator.

It would be premature to describe in detail the process as exemplified by this first separator, since considerable further experimenting is yet necessary to perfect its operation which may entirely alter the design. This machine consists, however, essentially of a rubber belt 3 feet wide with rough egg-shell surface and raised edges which travels up a slightly inclined plane on three brass rollers, the end ones 5 feet apart and the intermediate one acting as a tightener. The lower surface of the belt travels nearly horizontally and close to the launder underneath of the same width, along which the sand sluice from the pump flows in a stream about one inch deep. Inside the lower roller a magnet revolves at high velocity while charged with electricity from the generator by means of contact brushes on an extension of the magnet shaft past the bearing of the roller. At first a high voltage was tried, but since, it has been found, I believe, that a low voltage and high amperage gives the best results.

As the sand flows beneath this lower roller at not more than half-an-inch distance therefrom, the magnetite is picked up and held against the belt by the magnets until the belt has carried it around and on to the upper surface. During this passage around the lower roller the peculiar application of the current causes the particles of iron to roll over and over on one another, during which a stream of water is sprayed from above to wash out any included particles of sand picked up with the iron. From here the iron travels quietly to the upper roller where it is washed off by water.

The company also purchased a 40-foot tug for exploratory and freighting work. The old Hudson Bay Company's store houses on the shore below the town site of Nipigon serve as warehouses and headquarters for the plant for the present. The company expect to accomplish a larger measure of commercial success next summer at this place with a plant of increased capacity, since experiments with the process and apparatus are to continue during this winter at Chicago.

Argenteuil Mining Co

The above company of Jackfish, Ontario, and Saginaw, Michigan, is developing mining location A L 383, 323 acres, for iron. The property lies about 1 1-2 miles north of Jackfish on the C. P.Ry, and on Jackfish bay, Lake Superior. Mining has progressed here intermittently since 1900 under the management of Mr. A. F. Beattie, the force at the present time, October 1903, numbering 11.

No 1 shaft was sunk 50 feet, vertical, and 5 by 7 feet in size, and then work was suspended.

No. 2 shaft, 170 feet distant from No. 1 shaft and 120 feet back from the lake shore, is 25 feet deep, vertical, and 7 by 12 feet in size, and is now being sunk to the 100-foot level.

A tunnel was driven towards No. 1 shaft from a point 440 feet distant, and when 420 feet in, work was suspended in favor of No. 2 shaft. The ore, according to Mr. Beattie, consists of an irregular body of hematite in a granite formation.

The surface plant has up to the present consisted only of the camp buildings—office, boarding-house and blacksmith shop. Now however a hoist and boiler-house and shaft-house are being erected for the small hoist engine and the 20-h.p. boiler, already on hand.

Williams Mine

The property by this name covers a number of lots adjoining the Loon Lake or Breitung mine to the east, both bordering on the shores of Loon lake, and is reached by a 1-mile branch line from the Algoma Central railway at Wilde, thence by boat across the lake, and from the dock by three-quarters of a mile of wagon road to the mine. The land taken up consists of the following adjoining lots at the corner of four townships in Algoma District: lot 11 and N. 1-2 of lot 12 in the 6th concession of Anderson; S. 1-2 of lot 12 in the 1st concession of Hodgins; S. 1-2 of lot one and S. E. 1-4 of lot 2 in the 1st concession of Deroche; N. 1-2 of lot 1 and N.E. 1-4 of lot 2 in the 6th concession of Jarvis, comprising in all 1,100 acres. It is owned by the Williams Iron Mines Company, Limited, which was recently incorporated under the laws of Ontario with a capitalization of $3,000,000 in shares of $1.00 par value. The head office of the company is at Sault Ste. Marie, Ont.; president, John E. Burchard; vice-president, F. B. Lynch; treasurer, M. W. Harden; and secretary and general manager, Chas. C. Williams. Under superintendent, C. W. Jessup, the force numbered 20.

For more than a year previous to the commencement of the present development by this company early in 1903, the iron-bearing zone was explored in an unusually thorough manner by the present superintendent and a small force. For a distance of two miles southeasterly from the Loon lake mine, past Loon lake and through these lots, the ground has been stripped at intervals along the strike of the vein formation. On the findings of that work the present mining was undertaken. A shaft is being sunk on the Deroche lots 100 feet in depth to date, vertical, and 5 by 8 feet in size, but with no drifting therefrom as yet. Solid timbering follows down close to the sinking, with partition between the two compartments, and ladderway with platforms, all in good shape. Unwatering is done by a No. 5 Cameron sinking pump. A boarded in head frame of square timbers 22 feet high to sheave covers the shaft. The remaining work consists of a tunnel 65 feet in length driven west into the hill at a point about 100 feet south of the shaft; and in the same vicinity several test shafts from 20 to 30 feet deep through the drift to bed rock.

The iron-bearing formation continues through to this mine from the Loon Lake or Breitung mine, in connection with which latter it was partially described in an earlier Report (3). At the Williams property however it is possible to collect additional information on account of the extensive surface strippings. The formation consists of a

(3) Bur. Mines, Vol. XI., p. 263.

fine-grained greenstone, light to dark in color, which is probably essentially a diorite, although no subsequent determination of this point has been yet made. It appears to be a wide dike of eruptive origin, traversing the older Laurentian hornblende granite of this region with a northwest-southeast strike its southwest contact lying about 300 feet distant from the mine workings at both properties. These workings represent the relative position of the iron-bearing zone at these two points, and in all probability closely so in the distance between, since the formation tends to maintain a constant strike over considerable distances. The iron-bearing zone follows the bottom of a deep valley from Loon lake to this mine and beyond, and as far as examined appears to represent the central line of a metamorphic disturbance which by both pressure and faulting, imparted considerable schistosity to the rocks for a width of at least 600 feet, wherein it approaches a slate in its lamination. Polished surfaces are common throughout this area, a proof of movement in the general disturbance. It is along this central portion that the iron is found in small lenses or bands and stringers intimately intermixed with the formation, the ore consisting of an iron black to lustrous specular hematite, compact columnar, or fibrous, to finely foliated. No large or continuous iron body has yet been uncovered, and judging from the surface exposures and the shaft the ore if struck in large merchantable quantity will not be entirely clean, but be associated with more or less brecciated slate and trap similarly to the ore at the Loon lake mine.

On the southwest side of the valley the formation is a dark greenstone, generally slaty, though granular and blocky in places, merging at the bottom into a much lighter colored, highly feldspathic rock aphanitic in texture which continues to the northeast. It weathers gray, but in the body has a light greenish-gray color. Throughout both varieties of rock a general deposition of quartz has taken place, in minute stringers to massive veins several feet wide, trending usually with the strike of the enclosing formation. The quartz all carries considerable red and brown hematite and where this has separated out into bands of clean iron up to 6 feet in width, it is of the specular variety. A banded jaspery ore is the result.

Narrow dikes of trap some quite different in composition from others cut across the formation nearly at right angles to its strike.

Mr. Jessop informed me that the ore is of as good or better quality than any now on the market, assaying 60 per cent. and over of metallic iron, 0.015 per cent. sulphur and 0.009 per cent. phosphorus.

Loon Lake Mine

This property was formerly called the Breitung mine and is described in the Tenth Report of the Bureau. An addition to the property of 218 acres of land under water in the central portion of Loon lake increases the aggregate holdings of the company to 1,219 acres in the townships of Deroche and Jarvis. The Breitung Iron Company, Marquette, Mich., still owns the property, according to the statement of the manager, but by a secondary arrangement the operation of the mine is now in the hands of a new concern, the Loon Lake Iron Company, Sault Ste. Marie, Ont. The latter company has a capitalization of $3,000,000 in shares of $5 par value; president S. B. Martin, and secretary and treasurer, P. J. Hart. Mr. Martin acts as manager also.

The new power plant is located up the hill at a short distance below the mine workings, instead of on the lake shore as formerly. New machinery has been installed comprising a 60-h.p. boiler, a 3-drill Ingersoll air-compressor, and in an adjoining building a rock crusher and some car loading fixtures. The hoist stands farther up the hill and just below the shaft in a temporary shelter. The one and three-quarter mile branch of railway from the main line of the A. C. R. has been completed in to the mine.

The tunnel was continued northwest into the hill to a length of 298 feet (131 feet increase) and at 210 feet crosscuts run 37 feet southerly, and 65 feet north to northeast; the latter connecting with the shaft. At 13 feet in the former a winze is being sunk on an incline of 75 degrees S., 58 feet deep to date, with a crosscut 12 feet long from the bottom. In the tunnel crosscut a small hoist operates the bucket in this winze. Instructions for safer operation of this machine and the hoisting apparatus were necessary.

The shaft is situated about 180 feet northwest of the mouth of the tunnel and is 175 feet deep and vertical: at 71 feet depth the northeast crosscut from the tunnel connects. Beyond a short collar no timbers or ladders have been placed in the shaft, nor any means of entering or leaving other than by the bucket. The attention of the management was drawn to this neglect, and instructions were given to immediately timber the shaft, and to place hanging ladders temporarily for use instead of the bucket. From the south side of the shaft mouth an incline chute was sunk to the tunnel through the country rock, and all ore from the shaft now drops down here to be trammed out the tunnel to the dumps.

Some diamond drilling was done during the summer, but not pursued to great enough extent either in depth or number of holes to give much information as to the ore body.

In the last Report it was stated that iron had been found at places across a width of some 400 feet of the slate formation. It appears now from my recent examination when the snow was off the ground that outside of a central ore body, which may be called the main or important occurrence of iron, the other outcroppings consist apparently of narrow lenses or bands of the slate impregnated with iron, or of quartz veins running with the formation containing some hematite. The tunnel workings show very well the nature of the main iron body. It has a width of about 50 feet southwest-northeast, with the same strike as that of the slate formation, namely northwest-southeast, and dips with it at about 60 degrees S. W. The central portion contains the cleanest iron. Outside of this the ore is a mixture of brecciated slate fragments and iron-black hematite, occurring along fairly well defined bands in rich and lean portions. The ore to the northeast is bounded somewhat sharply by the barren slate, while on the southwest side, before the actual disappearance of the iron, quartz lenses and irregular stringers appear in increasing quantity, gradually excluding the hematite. This was observed to be the case at every exposure—surface, tunnel and crosscut, and bottom of winze. The shaft has been sunk entirely in the barren rock, the ore dipping away from it, but with the intention of cross-cutting southwest to it from the bottom.

The stock pile of ore below the tunnel mouth contains probably 1,500 tons, averaging, according to the manager, about 50 per cent. metallic iron, 0.05 to 0.25 per cent. of sulphur, and traces of phosphorus.

Further instructions were given to replace the present dynamite magazine by another situated at a safe distance from the new workings, and to build and use a suitable powder thawing house. At the camp an office has been built.

Locations in Aberdeen

On 26th October 1903 an examination was made of certain locations situated about 15 miles north of Desbarats, on which diamond drilling was in progress to test a body of specular hematite traversing these locations. The work was being done by Mr. E. F. Krelwitz of Duluth, Minn., who held options on the S. part of lot 11 and the N. part of lot 12 in the fourth concession of Aberdeen township; and the N. parts of lots 1, 2 and 3 in the fourth concession of Aberdeen additional. In May and June four men were engaged in prospecting along the surface of the outcrop, on which a number of shallow test pits and crosscuts were then sunk. About the middle of September diamond drilling commenced, and since then about 1,000 feet has been bored in a number of holes in the one locality.

This outcropping of iron has been known for a number of years (4), and about 7 years ago a line for a branch railroad was located into it, but nothing important in the way of mining was done until this year.

The sedimentary rocks of the Huronian period, consisting here of quartzites from white to pink, and from red to brown in color, cover a belt of this country from south of the C. P. R. track to a short distance north of these iron locations, a width north and south of probably twenty miles. In driving across it no break was visible in any of the many exposures, until within a few miles of these locations, where bands of slate conglomerate begin to intersect the quartzites at wide intervals, all the bands running roughly northwest-southeast. On one of these slate areas, which underlies a fairly deep valley from a quarter to a half mile wide between hills of quartzite, the iron properties have been located. The slates are generally finely laminated, grayish black in color, and have a course of northwest southeast, with a dip here and near the iron-bearing zone of about 50 degrees S.W. Their southwest contact with the quartzites would indicate an intrusive origin, since the outer edge of the latter formation is intersected by several dikes of slate from a few feet to 30 or 40 feet wide, separated by other bands of about the same width of the now much altered quartzites. The iron, which in its massive form is an iron-black and bluish compact columnar hematite, and where disseminated a bright but fine specular

(4) Bur. Mines, Vol. X., p. 188.

variety, occurs in these several detached bands of quartzose material. Over a length of more than 100 feet a vein of massive iron averaging a foot in width stands up above the surface clinging to the southwest wall or face of the hill, the other wall having fallen away. On either side of this are other less continuous bands, pockets and stringers of the iron intermixed with the vein rock. There is thus a maximum width where exposed on the surface of about 6 feet of merchantable ore. The dimensions of the ore struck in depth by the diamond drill holes had not at that time been made public, although I was given to understand the iron shows at least as well lower down as on the surface.

A microscopic examination of a thin section of this vein-bearing rock was kindly made for me by Dr. A. P. Coleman. It was found to consist largely of quartz with some orthoclase and plagioclase, and throughout all a dirty-looking material, probably the iron. The constituent grains are more or less rounded and have been enlarged by secondary deposition of quartz, etc. There appears little doubt that it is a partially re-crystallized arkose or quartzite. Its relations to the other rocks—the slate and the quartzite or arkose—carry out this belief.

Word was received from Mr. E. F. Krelwitz towards the end of the year, accompanied by plans showing the sections of the four diamond drill holes bored for him. Holes were bored from each of two adjoining points where the drill was set up, all from the northeast side of the ore body, and pointed at an angle into the hill to cross-cut the ore at depth. Iron was struck in three of the holes at depths of 150, 60 and 160 feet respectively. The fourth hole, apparently, was hardly deep enough. At the above depths the respective widths of the ore were as follows: three bands 1 foot wide in an 8-foot width of the formation; two bands 2 feet wide separated by 2 feet of quartzite; and 10 feet in one band. The slate on one or both sides of the iron-bearing quartzose rock is ferruginous for widths of several feet. The borings also struck bands of the altered quartzite which do not outcrop at the surface, but appear to be cut off and surrounded by the slate. These several interbanded bodies of slate and altered quartzite and also the iron ore in the latter dip about vertical. Mr. Krelwitz proposes to continue drilling here early in the coming year.

Copper Mines

Tip-Top Mine

The owners and the mine staff remain the same as at former inspections with this difference, that to the latter W. Smeaton has been added as assayer. At the time of my visit, 5th October 1903, the force numbered 28: but this was shortly after reduced for a time.

Underground development has continued steadily and good progress been made in opening up the copper deposit for future ease in stoping. The shaft is now 200 feet deep, an increase of 40 feet. A uniform incline of 75 degrees N. is now being maintained which is taking the shaft down in the footwall rock a few feet back of the ore, the dip of which is too irregular to follow. In the first level, east drift, is an overhand stope 30 feet long by 30 feet high by 8 feet wide; west drift 40 feet, with an overhand stope 20 feet long by 20 feet high by 8 feet wide. These two stopes begin just beyond pillars left on either side of the shaft—as do also the stopes in the lower levels. Second level, west drift, 52 feet, with at 20 feet in an upraise, now an ore chute, to the first level, and around its foot a stope 20 feet long by 20 feet high by 8 feet wide, timbered over into an ore pocket; east drift, 63 feet, with an overhand stope 20 feet long by 5 feet high by 8 feet wide, timbered over. Third level: from face of station chamber, the drifts run east 42 feet and west 36 feet. Fourth level (new), depth 200 feet: north cross-cut 72 feet. These lower workings were allowed to fill with water to the 3rd level. This development work consisting of drifts and stopes follows as closely as possible the footwall of the ore body, the remaining ore nearly all lying on the hanging wall or north side. The ore body will average probably 12 feet in width, judging from the present work, throughout all the underground workings. It is the intention to continue drifting on the various levels both ways to open up more ground as soon as arrangements are settled for treatment of the ore.

Except for the lack of the partition below the 2nd level, the workings are in good condition. It was instructed that this be placed in as soon as possible. Hoisting is done by bucket as before, but now the ore is dumped directly into cars to be trammed to the sorting bins and tables. Thence it is elevated to one of the three stock piles of coarse firsts, fine seconds and coarse thirds, the average copper content of which is about 8 per cent. About 4,000 tons of this ore was raised from development work during the past year.

An interesting find was made in the way of a new mineral in the ore while driving the upraise from the 2nd to the 1st level on the west side of the shaft. It was noticed first as minute steel-gray crystals disseminated through the mixture of iron and copper pyrites, from which it is with difficulty distinguishable. After sorting out the ore containing it and sampling the 20 tons or so obtained, assays gave about 2 per cent. cobalt in addition to the copper.

At the mine an assay office has been built and equipped for the use of both this and the A L 282 gold mine. The small air-compressor has been replaced by a 6-drill Ingersoll compressor, and a 35-h.p. locomotive type boiler added to the former one. At the camp on the lake shore another large log building for offices and sleeping rooms, together with several more private houses, has been recently added.

Instructions for safer practices in dealing with and thawing the dynamite after removal from the magazine were necessary.

Pattison Prospect

This recently opened copper prospect on mining location R 760 of 46 acres is situated about two and one-half miles south of the 136 mile-post west of Port Arthur on the C. N. Ry., on the south shore of a small lake. It is owned by Martin Pattison and associates of Superior, Wis., and has been under development by them most of this season with a force of 10 men. The total holdings of these parties in the vicinity aggregate 200 acres. Besides giving the above information, Mr. R. M. Pattison states that the development work has consisted in sinking a 50-foot shaft and in doing a good deal of surface stripping. The copper occurs as chalcopyrite impregnating a green eruptive rock.

Two camp buildings have been erected, and a shaft head frame and blacksmith shop put up.

Black Bay Mining Co

Owing to the out of the way situation of the mine belonging to this company a visit could not be made on the occasion of my tour of inspection; but on 5th October 1903, I obtained the following information from the superintendent, Martin Sorensen: The offices of the above company are at Fort William, Ont., and Willmar, Minn., and the secretary is M. G. Riggs. At present only four men are employed. The mining locations consist of McA 217 of 75 acres and E S 106 of 171 acres, situated on the southwest shore of the Black bay peninsula and southeast of Pearl River station, C. P. R. A shaft has been sunk 119 feet deep, vertical, and 7 by 10 feet in size. First level, depth 85 feet; west drift 30 feet and now driving. The rocks passed through consist of amygdaloids to 112 feet depth and after that sandstone. Not a great deal of copper has so far been found in the shaft workings, and it is now proposed to continue explorations by diamond drill.

The surface plant comprises boarding and bunk house and office. All mining has been done by hand drilling so far.

The company own a 35-foot steam tug which plies between Fort William and the mine.

Massey Station Mine

The road bed for the line from the C. P. R. tracks has been completely graded in to the mine 3 miles from Massey Station, but rail laying has been deferred until the spring.

With the steady progress in mine development the shaft has reached the depth of 550 feet, an increase of 220 feet, maintaining fairly closely the initial incline of 87 degrees N. The first, second and third levels have not changed. Fourth level; east drift 133 feet with a crosscut 25 feet south at face; west drift 225 feet. Fifth level (new), depth 365 feet; the station chamber is cut and drifts run 12 feet east and west. Sixth level, depth 450 feet; station chamber cut and drifts started only. Seventh level, depth 530 feet with no drifting yet. Work is now confined to sinking and to driving the fourth level west so that when far enough west an upraise to the surface can be quickly made. A second outlet such as this will be imperative before stoping can commence, both as a means of proper and adequate ventilation and for an auxiliary ladderway.

The timbering in the shaft has been allowed to get too far behind the sinking, and instructions for its completion were given to the superintendent.

In the remodelled surface buildings about the shaft there are now two hoist engines, the old one and a new Lidgerwood link-motion single drum hoist of about 20-h.p. capacity.

At the camp a residence for the superintendent and a number of other private dwellings have been erected. A short distance south of the mine buildings stands the new powder thawing house heated by steam from the boiler room.

The ore body maintains the same characteristics in the bottom levels as above, and is of about the same width and richness in copper. The ore occurs in a series of more or less overlapping and succeeding lenses, which accounts for the local crookedness of the drifts, though these in the main continue along the same line. Crosscutting at the end of each lens discloses the next not far removed, about 10 feet or so to one and the same side each time. The ore-bearing rock is slate, a description of which and of the ore body generally will be found in previous Reports of the Bureau of Mines.

Under superintendent Jos. Errington a force of 35 men is employed.

Hermina Mine

This property includes portions of several lots near the western boundary of Salter township, Algoma District, the mine workings being reached by a 6-mile road west of Massey Station and past the Massey Station mine. The operators have recently become incorporated under the laws of Ontario as the Hermina Mining Company, Limited, with offices at Sault Ste. Marie, Ont., and Calumet, Michigan, and with a capitalization of $500.000 in shares of $5 each. The president is James Herman, secretary Peter Primeau, treasurer W. B. Anderson and mine manager R. H. Macdonald. The employees number 14.

A two-mile extension to the main wagon road from Massey Station has just been cut out by the company to their workings. For a camp several old lumber shanties on the property have been made use of by renovating and enlarging. They consist of office, boarding and bunk houses and stable, and are situated near the centre of the property. For the storing and handling of powder it was advised that a magazine be erected and a proper thawing apparatus and house provided at once.

Since the commencement of work by the present owners in the summer months of 1903, all the mining done has been of an exploratory nature, and confined to the surface, with the exception of one vertical shaft which is 30 feet deep. A large number of test pits and crosscuts were examined at widely scattered points.

The locations cover an area of trap intrusions in granite, the two in contact with the light-colored quartzites of this area on the south, and on the north with the unbroken pink granite country. The latter formation is a hornblende granite, the hornblende in very small percentage and altered more or less to chlorite. The trap is a compact dark green to black rock, composed largely of hornblende. It traverses the granite in roughly parallel dikes striking from east and west to southeast and northwest, with widths of a foot or so, to over 100 feet. Over the locations a number of quartz veins carying chalcopyrite in varying amounts have been found, in all but one instance lying embedded in these trap intrusions with the same strike. This one case is in the 2-foot vein at the shaft. It traverses the granite as a fissure vein, but is intersected and disturbed by a narrow dike of the trap, which indicates that these veins in the granite belong to an earlier period than those in the trap. The origin of the latter was probably due to a metamorphic disturbance which faulted and sheared the less resistant trap, leaving fissures or altered bands along which the quartz and base metals were deposited. These veins are composed of quartz, and more or less altered trap, interbanded, one of them at the northeast boundary of the property, averaging probably 25 feet in width in a length of 600 feet, in which it outcrops at frequent intervals. Chalcopyrite occurs in it in most places, but only in the recent crosscut at its southeast exposure does this approach a merchantable percentage in the surface showings. Beyond the boundary line on the next lot the vein was explored by shafts and surface work a few years ago by the Nickel-Copper Company of Ontario, Limited, at a point where the quartz is over 40 feet wide. The work, however, produced a rock dump very low in copper.

The other veins, one of which is now under development at the southeast end of the lots, are smaller, ranging from 1 foot to 3 feet in width.

Rising Sun Mine

On lot 9 in the second concession of Morin township and at 24 miles by road north of Bruce Mines, C.P.R., a shaft is being sunk on a copper prospect by T. P. McNulty, contractor, and five men, for W. F. Ashton, manager of the Copper Queen mine, five miles farther north, and representative of some capitalists of Calumet, Mich., who have purchased the property.

Operations commenced in the first week of August, my visit of inspection being in the following October, 1903.

A branch road about one-third mile long had been cut in to the workings. One log building composes the camp. At the shaft a 12-h.p. vertical boiler and a duplex cylinder single drum hoist have been installed, but without housing as yet. The drum of the hoist, and also the sheave on the head frame are much too small for the 1-inch steel rope used in hoisting the bucket.

The shaft is 53 feet deep, vertical, and 5 by 7 feet in size with a short collar but no other timbering. It lies in one of the wide eruptions of trap found cutting through the outer fringe of the granite formation to the north, the trap consisting of the typical brecciated greenstone which forms a most persistent belt east and west between the Laurentian on the north and the rest of the Huronian rocks to the south to Lake Huron. The included rock in the greenstone which gives it this brecciated appearance consists of pink granite in all sizes from fragments to boulders of many tons weight picked up during the original ejection of the trap. The granite consists chiefly of quartz and pink feldspar, the hornblende and chlorite contents forming but a very small percentage of the whole and being often entirely absent.

The shaft explores a vein of intermixed quartz, calcite and brecciated fragments of the pink granite and green trap. Only a very small amount of chalcopyrite was visible to the present depth, and owing to the heavy covering of drift further exploration in the vicinity was precluded.

The contract calls for a 100-foot shaft, so that work will continue until this depth is reached. Later a more permanent camp may be erected.

Copper Queen Mine

At the commencement of work here by the Copper Queen Mining Company, Limited, nearly two years ago, the Government road north from Bruce Mines and past the Rock Lake mine was continued four miles farther north up to this mine, amongst the high hills. The distance from Bruce Mines is about 30 miles, and from Rock Lake 17 miles. The property comprises about 960 acres of mining lands in Morin township, Algoma District, made up as follows: South half of north half and north half of south half of lot 3, north half of lot 4 and north quarter of lots 5, 6, 7 and 8, all in the fourth concession, and the south quarter of lots 5, 6, 7 and 8, in the fifth concession, and the south quarter of lots 5, 6, 7 and 8 in the fifth concession. The locations lie between the Thessalon river on the west and Sheldon lake on the east.

Mining is progressing under the management of W. F. Ashton, with Angus Macdonald as resident foreman, and a force at date of inspection, 22nd October, 1903, of 7 men.

No. 1 shaft is 140 feet deep, inclining 80 degrees N. for the first 80 feet, and vertical for the remainder. Down the side of the hill on which this shaft was sunk a tunnel was run in west in length 135 feet, connecting at its face with the shaft at 80 feet depth therein. At 115 feet in the tunnel a cross-cut runs 30 feet north. This working is closed for the present.

No. 2 shaft, situated about 1,500 feet west of No. 1 shaft, is 85 feet deep, vertical, and 6 by 9 feet in size, and now sinking, this being the only working place at present. There is on open head frame over this shaft 20 feet high to the 2-foot sheave. The shaft collar extends to only 15 feet depth, without timbering or ladders below, the men entering and leaving the mine by the bucket. This practice is strictly forbidden by the Mines Act, as the foreman and miners here are aware. Instructions covering these points were given at the time.

A number of test pits were sunk and the surface stripped at several places between the two shafts on the various showings of copper-bearing veins.

The power plant is at No. 2 shaft in the one building comprising a 54-h.p. locomotive type boiler; a 6-drill Ingersoll air compressor; a 30-h.p. duplex cylinder link motion single drum hoist engine winding ¾-inch steel rope, and the bucket in the shaft, and pumps. On the shore of Sheldon lake 750 feet to the north a small pumping plant operated by compressed air supplies the boiler and camp with water. The camp adjoins to the east, consisting of boarding and bunk houses, office, warehouse, stable, blacksmith shop, etc.

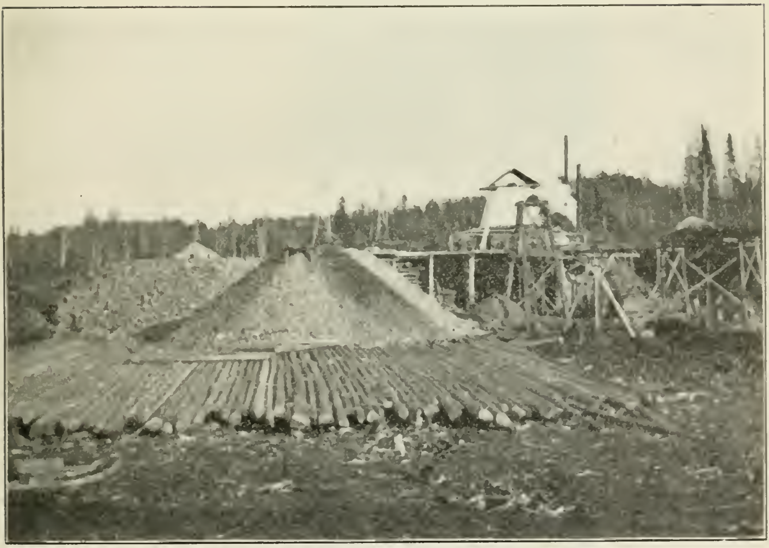
Instructions were found necessary to provide for the safe storing and handling of the dynamite.

The veins under development lie along the south contact of an eruption of trap with the granite of this area. (See geology of Rising Sun mine, page 80). The trap extends north for a width of at least 400 feet, while to the south the granite continues without further interruption apparently, for nearly a mile, when another dike of trap is seen. This latter rock is the brecciated greenstone of the district, and the granite is pink and low in its hornblende constituent. By a later disturbance the greenstone dike was fissured along several parallel lines for a width of 50 feet from the granite contact, and in this area lie the

Williams iron mine near Wilde station, Algoma Central and Hudson Bay Ry

Tip-top copper mine. 1903.

Tip-top copper mine, 1903.



Tip-top copper mine, showing shaft house and ore dumps.

Superior copper mine [illegible]

Copper Queen veins composed of intermixed quartz, and brecciated greenstone carrying a small percentage of chalcopyrite. Considerable coarse specular hematite is intimately associated with most of the chalcopyrite, small nodules of the the latter being surrounded by the former. At the No. 1 shaft and tunnel workings the quartz vein explored is nearly clean of other rock matter, and has a width at the crosscut at 115 feet in the tunnel of 20 feet. It carries only a very small amount of chalcopyrite except in the few cases of local enrichment. Although the several parallel veins above mentioned are separated by apparently barren bands of trap, the whole width of 50 feet or so north of the granite is considered as vein matter. No. 2 shaft was started down vertically through the trap at a short distance north of the outside deposit of quartz with the intention of intersecting the vein lower down. This is a doubtful policy to adopt in the initial development of a prospect where every foot sunk should be made to open up and define vein matter.

Ranson Mine

This is now reached by a 10-mile wagon road recently completed by the company in conjunction with the Taylor Copper Mining Company, whose mine it also serves. The road runs southeasterly from Dam Creek siding, Algoma Central Railway. The force at present numbers 11, under superintendent J. C. Burns.

The underground development to date is as follows : No. 1 shaft, on the southeast quarter of lot 12 in the fifth concession of Chesley township is 213 feet deep, inclined 65 degrees N., and 7 by 12 feet in size. The first level is now being opened at 200 feet deep. The shaft is well timbered with square frames supporting the pole skids for the bucket, the partition between the two compartments, and the ladderway. The power house adjoins the shaft house containing the same mining plant as enumerated in the last report.

No. 2 shaft lies about one mile west of No. 1 shaft, in depth 75 feet, inclining about 55 degrees N. This is supposed from the outcroppings between to be on the same bands of quartz in the trap as No. 1 shaft. Work was suspended here, however, about a year ago. No. 3 shaft is about a mile southwest of No. 1 shaft and near the old original camp. It was sunk 47 feet deep and then closed.

The camp has been added to by several small log buildings. Some instructions for the safe handling of dynamite were necessary.

The No. 1 shaft follows down a vein of quartz which at the surface is 6 or 7 feet wide, but which gradually narrows until at about 60 feet depth it is replaced by narrow quartz stringers running iregularly through the trap. This state continues to the bottom, the quartz content being quite small. A fair percentage of chalcopyrite occurred near the surface, judging from the ore on the dump, but in the lower part of the workings it has nearly disappeared. This vein lies in and parallel with a dike about 100 feet wide of brecciated greenstone, in pink hornblende granite. The brecciated inclusions in the trap consist of fragments of the adjoining granite ranging in size from pebbles to immense boulders, one of which more than fills the shaft. After considerable squeezing this dike was evidently attacked by aqueous solutions which deposited the quartz and the sulphides to form the present veins and stringers. Both trap dike and quartz vein strike west 20 degrees N.E., 20 degrees S., and dip at about 65 degrees to the N.E. The disturbed area in which quartz occurs measures about 50 feet across, and all of this is considered to be copper-bearing. No development yet undertaken has been done for the purpose of proving this.

Bruce Mines

There is little of change to note with regard to this property. The same force of 20 men and sometimes more is retained keeping the workings pumped out and in shape both above and below ground for a resumption of mining on short notice. From the manager, Mr. Louis Abrahams, I learn that some intermittent drifting has progressed on the 362-foot level from No. 4 shaft and on the 382-foot level from No. 2 shaft, the intention being to connect these two, which are pointing one towards the other. No rock has, however, been hoisted. The shipments from the old dumps of tailings still continue to the smelters in the nickel-copper camps about Sudbury from which sufficient profit arises to maintain the present force at the mine.

Rock Lake Mine

All operations were supended here in July 1903. It appears that the company is short of money or at any rate tired of putting more up with little return. If more judgment had been exercised in the initial development the mine might be in steady operation to-day. The company, however, adopted the policy of expending large sums on surface works, including a 200-ton concentrator, before ascertaining by underground development whether or not the ore body required or warranted it. If mining had even then continued steadily in advance of the stoping, instead of allowing the small amount of ore in sight to be exhausted, the property might now offer a more tempting mining venture than it is. As it is, practically nothing is known of the vein below the second of 200-foot level, for although the shaft reaches a depth of 400 feet it was sunk vertically through country rock, the vein dipping away to tne southwest, and almost no drifting was done on these lower levels.

From the company's solicitor in Sault Ste. Marie, Ont., I learn that the property is now for sale, or lease under some form of working option. Before any further attempt at milling and concentration is made the ore body should be thoroughly explored and developed sufficiently in advance of the ore blocked out to insure a steady supply when stoping begins again.

Taylor Mine

This mine was not inspected last year since all work therein was suspended in August. From Mr. R. H. Taylor, one of the directors of the company, I learn that the shaft reached a depth of 112 feet with at the 50-foot level drifts 25 feet with, at the 50-foot level, drifts 25 that the company have not money enough to continue development for the present. Three men are getting out a supply of cordwood and looking after the plant.

Superior Mine

Under the same management as at last inspection mining development has progressed steadily to the date of inspection 19th October 1903, with at present a force of 24.

Shafts Nos. 1 and 4 remain unchanged. No. 2 shaft was sunk to 130 feet depth (an increase of 40 feet) and then temporarily closed. No. 3 shaft, depth 115 feet (10 feet increase). The second level crosscut was continued southwest to a length of 70 feet. No. 5 shaft, 100 feet deep (75 feet increase), with drifts from the bottom 15 feet northwest and 15 feet southeast, and a 12-foot crosscut. Work has been suspended here also. This shaft lies 450 feet northwest of No. 3 shaft, the most southeasterly working. No. 6 shaft, 1,100 feet northwest of No. 3 shaft or 650 feet northwest of No. 5 shaft, is 190 feet deep (175 feet increase), with the first level now starting at 100 feet depth.

All development is at present confined to No. 6 shaft. This has struck a very rich shoot of copper in the quartz vein, the chalcopyrite content continuing in its richness to the bottom. The sulphides in No. 5 shaft gradually diminished until at the bottom, with nothing of commercial quantity left, it was thought advisable to change the point of development to No. 6 shaft. At the latter a substantial head frame has been erected and boarded in, and a few feet north a hoist shed built from where the hoist formerly in the engine house operates the bucket in this shaft. A dry-house and a blacksmith shop were also added. The hoist runs by compressed air from the power house.

Instructions were necessary forbidding riding in the bucket and looking to the safer handling of the dynamite.

Nickel Copper Mines

For various causes only a few of the nickel-copper mines have produced any ore this year, and none of them continuously. The Victoria mine is still closed, although the same company have been developing and raising ore from another property. The smelter at Victoria has, however, run most of the year in order to clean up all remaining ore on the roast heaps. At the Copper Cliff camp mining has been until late this fall intermittent, and in progress at but two or three of the mines of the Canadian Copper Company, while certain radical changes in the methods and in mining and smelting plant might be the better put under way, and in order that the underground explorations, by diamond-drill principally, mentioned in my last report, might be completed. The mines of the Lake Superior Power Company (Gertrude and Elsie) have been closed since the failure of this and its parent corporation, the Consolidated Lake Superior Company, to meet obligations last spring.

Canadian Copper Company

As stated above, only a limited amount of ore has been raised this year up to this date of my inspection, November 1903, and most of that came from the Creighton mine, sufficing, with the reduced smelter output, to keep the roast yards well stocked. The work of exploration of the different ore bodies outlined in my last report has been carried as far as intended for the present, and as a result all of the mines that are to be worked in the near future put in a state of readiness. Also the proposed consolidation of smelting and allied operations at one point has been rapidly proceeded with. The building for the new smelter plant is nearly completed and other changes in the surface arrangements, in the railroads, roast yards, power plants, etc., have gone on concurrently, so that this winter the plant can be installed for the most part without hindrance from the weather.

The old original or east smelter has been dismantled and all plant removed. At the west smelter no alterations of account have taken place, since with the completion of the new plant this one will also be abandoned. It is being maintained, however, as formerly, and a number of the furnaces are kept in constant blast. Certain satisfactory results have been recently obtained in the course of the continued experimentation with the furnaces, according to the superintendent, these being an increase in capacity of these nominally 100-ton furnaces to about 250 tons, namely, by increasing the pressure of the cold blast (from 10 oz. to about 16 oz.) At the same time the grade of the matte is said to have risen from the former content of 30 per cent. nickel and copper to 35 per cent. The experiments with these water-jacketed furnaces in pyritic smelting using hot blast (mentioned in my last report) continued until sufficiently definite conclusions were arrived at, which, Mr. Baird states, are promising enough of ultimate success to have warranted consideration of them in the design of the new furnaces, and the arrangement of the plant for the furtherance of the pyritic process therein later on. While the stove for heating the blast worked well, its capacity was insufficient for the furnaces; and also the area or cross section of the furnace above the tuyeres was too large to effect the requisite oxidation. The boshes of the new furnaces will be designed to provide for this important detail.

The new smelter site lies in a direct line between the two former smelter plants, at about 1,600 feet southeast of the west smelter, and 3,200 feet northwest of the east one, and on a clay and rock elevation above and facing the extensive clay flat to the south and southwest. From the bottom or converter-room floor of the smelter building, the drop to the level of this flat will be about 20 feet, which is considered ample for the discharge and dumping of slag from both the converter and the blast furnaces higher up. In placing the foundations for the various structures a great deal of excavation both in the clay soil and in the solid rock was necessary and also considerable filling. Stone and brick have been used for the walls while all interior framing and fitting will be of iron and steel. A full description of the new plant will, however, be deferred until its completion. Suffice it to say, that there will be only two blast furnaces, each of 550 tons daily capacity, water-jacketed, 17 feet high and 50 by 204 inches at tuyeres, and 70 by 204 inches at the top, to use cold blast at about 40 oz. pressure; and a number of bessemer converters, to take the matte in the molten state direct from the settling wells. The standard guage track has been laid from the main or No. 3 roast yard, which lies to the north about half a mile, around to and over the ore bins at the smelter at a 5 per cent. up grade, while from the tracks in the flat below and to the southwest another branch line runs in. On the east side of the smelter building stands the new power house, to contain all accessory machinery for the smelter plant and the electric generators for power and light in all parts of the company's properties.

At the west smelter, in a small shed adjoining the power rooms, a large vertical straight-line air compressor, or blower, was set up for use in the recent tests with the hot blasts.

No. 1 roast yard contains about 12 heaps. It will continue to be used as a roast yard until the new smelter is in operation.

No. 2 roast yard has been done away with, which makes possible a more comfortable atmosphere around the town of Copper Cliff.

No. 3 roast yard, now the main one, and soon to carry on within its extensive limits all roasting operations, has increased considerably in length since last inspection. The heaps here number about 50, all of ore, in all stages of progress. The new heaps, however, are being built only about quarter the size of the former ones, each set of four now occupying the same space as one formerly did. A second line of tracks has been laid down the north side of the heaps. Loading and unloading of the roast heaps will be done by swinging arm derrick, to operate from the railway tracks, transferring the ore from flat car to heap and vice-versa. One such derrick is now on hand.

The same dangerous practices in the thawing and storing of the dynamite at the roast yards, and which were condemned and forbidden on my former inspection, were still in use; but assurance was given by the new superintendent that my instructions in the matter would be complied with immediately.

Ontario Smelting Works

The Ontario Smelting Works, form operated as a separate concern, has now become part of the property of the Canadian Copper Company, and all business connected with it is transacted at the company's head office. Mr. H. J. B. Baird, who was superintendent of this plant alone, has been appointed general superintendent of all the smelting and roasting operations of the company, Mr. P. R. Bradley succeeding him in the former position. Under him the employees number 151.

The changes in the plant noted as proposed or under way at the last inspection have been completed, and are now in operation. With the three calciners and the briquetting plant the smelting charge is furnished in such shape that one furnace is now able to treat the whole supply of low grate matte from the smelter. To increase the efficiency of the calciners, a second high stack has been built. A necessary cooling arrangement for the roasted fines from the calciners before mixing with binder and briquetting was built consisting of a horizontal revolving cylinder 3 feet in diameter by 110 feet long with spiral angle irons inside to help convey the material from end to end. The cylinder stands outdoors without cover where it keeps sufficiently cool. Additions to the power plant consist of a purifying system for the boiler water and another steam engine of 100 h.p.

Copper Cliff Mine

Mining stopped here a day or two prior to my visit. The mine had been producing ore most of the year, and it was decided to thoroughly explore the country by diamond drilling from the bottom levels of the mine in order to determine definitely the amount of ore to be looked for, and whether or not this will warrant certain important improvements in shaft and surface works for more economic ore extraction than the present conditions allow. The drilling will commence immediately.

In the early days at this mine ore containing less than about 5 per cent. nickel and copper was thrown on the dump as not worth treating, and in this way nearly 5,000 tons accumulated. With the improved methods and also because this ore and its gangue makes a good flux, the ore from this old dump is now being used in the smelters along with the roasted ore.

All mining since last inspection has been confined to the 13th and 14th levels, the latter of which is still worked from a winze from the 13th level, the shaft not yet having been projected below the latter. The following measurements of mining done are taken from the office plans and are to date of May 1904. In the 13th level southeast drift (from end of crosscut west from shaft) the stope at the face and extending up to the 12th level has been considerably enlarged from the bottom up. In the northwest drift a good deal of ore has been taken from a new overhand stope 100 feet long by 7 to 9 feet wide and 50 feet high. The winze from beneath this stope follows down this same ore body and stoping has progressed on it around the winze to a length at top (13th level floor) of 30 feet and at bottom (14th level floor) of 65 feet. Recently it has been worked deeper as an underhand stope to 35 feet below the 14th level at about the same length. Its average width is between 8 and 9 feet. The opposite or southeasterly drift on the 14th level was carried to a length of 212 feet (132 feet increase) and just beyond the shaft an overhand stope 66 feet long by 8 feet wide and 9 feet high run. From 156 feet in this drift a hole was bored by diamond drill 140 feet southeasterly piercing two lenses of ore about 20 feet apart, one 25 feet wide and the other 12 feet. Being directly beneath the stopes in the southeast ends of the 13th and 12th levels above, the new finds doubtless constitute the lower extension of the ore there worked.

These occasional new discoveries by diamond drilling of ore bodies in the lowest level of the mine and below the original main chute which pinched out on the 13th level, indicate that this latter has not actually terminated, but merely broken up into a number of divergent smaller lenses or chutes, and although none of these have approached the size of the original deposit, their continuity both in dimension and in value (nickel copper contacts) has made it well worth while mining them and searching for more. The irregularity in the divergence of the different lenses from the base of the old deposit is such that further search by drilling in other horizontal directions and in depth may quite reasonably be expected to result in the location of still more ore.

No. 2 Mine

Before abandoning the open pit as a working place the ore mentioned at last inspection as remaining on the north wall under the overhanging portion and the arch, and all that on the south wall in front of and surrounding the old shaft for a depth south from the pit wall of about 30 feet has been broken out and raised. The old shaft, therefore, is no more and very little but rock now remains on the walls. The 3rd level or pit floor measures 100 feet east and west by 220 feet north and south.

Shaft, depth 402 feet (12 feet increase) ending in a 20-foot sump below the 5th level. The timbers for the double skip road and the ladderway with partition between have been carried from the fourth down to the fifth level. The winze sunk from the old shaft station now lies out in the open pit, covered over, the stope just below being reached from the bottom of the old shaft. From here an underhand stope has been opened out to about 40 by 60 feet plan and 30 feet deep surrounding the winze to the 4th level, down which all the ore is milled for hoisting from that point. The roof of this stope is carefully scaled as the work proceeds and preparations made for its subsequent examination when the floor has receded out of reach. Fourth level, unchanged. Fifth level; a wide and a high drift has started from the shaft station to run north under the ore body.

In addition to the wire rope signal apparatus, one for each skip road, an electric system has just been installed between the different levels, the surface and the hoist room. In the rock house the former 9 by 15-inch jaw crusher has been replaced by a 15 by 24-inch of the same type. The boiler battery contains seven units all fitted with underfeed mechanical stokers and forced draught.

No. 3 Mine

The shaft was carried down from the second to the third level shortly after my last visit; and on the completion of the timbering therein with the double skip road and ladderway, all work was suspended underground and the water allowed to rise until such time as the ore from this mine is needed. A little more drifting was done on the third or 165-foot level, but no stoping.

Creighton Mine

Except during the month of June mining has continued here steadily, but not all the time has ore been raised. Stoping in the open pit had been suspended for a short time previous to my inspection and work confined to sinking the shaft down to the next or second level, 140 feet deep (80 feet below first level). A uniform incline of 57 degrees 30 minutes is maintained from top to bottom. Just now the station chamber is being opened and the timbering of the shaft with double skip road and ladderway completed. One drift will run north under the centre of the pit, and when far enough in will be upraised to the pit floor, so that ore may be milled down and hoisted from this second as well as the first level. So far all the ore raised has been broken from the pit walls on the northeast and west sides increasing the opening to a length east and west of 110 feet and a width north and south of 60 feet. The winze from the pit floor to the west of the level station will shortly be connected with the second level drifts for good ventilation. In the rock house one of the two former 9 by 15-inch jaw crushers has been replaced by a 15 by 24-inch jaw crusher, and the grizzlies have been altered to separate the small and large sizes. Also the end bump sorting tables are being replaced by travelling belts whereon the sorting will in future be done. Adjoining the rock house to the east, a machine shop containing lathe, drill and accessories, has recently been built. Trestlework now carries the rails from the M. and N. S. Railway siding up to and above the boiler room door, so that the cars may dump the coal there. A few more dwellings have increased the extent of the little village at the mine.

In the work of defining the ore body over 5,000 feet of diamond drill holes were bored and as a result at least 3,500,000 tons of ore shown up, according to the statement of the superintendent. The ore body seems to have the form of a lenticular chimney, its greater width or strike running about east and west and its dip north at about 50 degrees along and in direct contact with a foot wall of granite. The great width of the deposit and its average nickel-copper content of about 5.5 per cent. are maintained with but small variation to the bottom of the holes at about 300 feet vertically. When the surface outcroppings outside the tested area are taken into consideration the above estimate of ore in sight is well within the mark to this depth.

The present small development force of 35 men will, it is stated, be increased almost immediately to about 100 men in order that the maximum output of about 600 tons of ore per day may be raised from now on.

Victoria Mine

No inspection of this mine was made, since it has remained closed down. From Mr. A. B. Hixon, the mine captain, I learn that after raising all loose ore and rock from the underground workings, and then also the pump and other machinery, the whole was for the present abandoned and the water allowed to rise. The smelter has, however, continued in operation on the ore from the roast heaps in order to clean all this up. It is expected that by the end of this year, 1903, this will have been accomplished, when operations at the smelter also will be suspended.

The ore raised since June at the North Star mine, which is about 5 miles west of Copper Cliff, has been shipped in here and all not smelted dumped along the trestle road leading up to the furnaces. These shipments will probably continue until June 1904, when the company's lease on that property expires.

In Wales where the Victoria matte was treated Dr. Mond's nickel refinery has remained idle since the close of 1902, when the Government suspended all operations pending an inquiry into the sanitary state of the process. It is likely to be started again ere long, and the resumption of mining at the Mond properties here is also said to be contemplated.

North Star Mine

A note was made in my last report of certain work done at this mine by the Mond Nickel Company in 1902, by which nearly 5,000 tons of ore were raised and shipped to the Victoria smelter. The option under which the mining was then done has been extended, according to the superintendent, until June 1904 and last spring mining commenced again. About 7,000 tons additional nickel-copper ore has since been raised and shipped by rail to the Victoria smelter and there either converted into matte or stocked.

The property consists of adjoining parts of lot 9 in the second and lot 9 in the third concession of Snider township, Algoma district, and lies about 9 miles west of Sudbury by the M and N. S. Railway from which a quarter-mile siding has been run into the mine. The owner is A. McCharles, Sudbury, the mine captain, A. B. Hixon, and the foremen Tom Tuttle and James Langden, the force numbering 39.

Mining development consists of the following: an open trench along the ore body about 150 feet in length by 5 to 20 feet (average about 15 feet) wide by 90 feet deep and inclining 70 degrees north. The foot-wall is smooth and solid but the hanging wall irregular and fractured, requiring frequent scaling. To the west of the pit and in continuation of it the surface was blasted off to a depth of 6 feet for 60 feet farther. By means of two swinging arm derricks on the north side of the opening and by buckets and a double drum steam hoist, the rock is raised to the surface and dumped immediately into the railway cars for shipment. A chain ladder runs down the footwall affording the only means of access, and one none too safe or easy, to the workings. It was recommended to commence preparations for mining hereafter at greater depth under a roof formed by the present floor of the pit, and for hoisting either by skip or by bucket on skids, since the overhanging wall is interfering with the bucket and rope in the present method.

The mining machinery consisting of 3 locomotive type boilers aggregating 150-h.p., a 5-drill Rand air compressor, and a duplex cylinder, double drum hoist of about 18-h.p. capacity was installed this past spring and the log buildings erected there for it. The camp at the junction of the siding with the main line of the railway is made up of office, bunk and boarding houses, another small dwelling and stable.

Previous to the present mining the company bored about 4,500 feet by diamond drill in some 24 holes, the deepest being about 300 feet. Most were drilled from the north side of the ore body since it dips in that direction, and in the vicinity of the present workings, where the most promising surface indications existed. Ore was found in nearly all of the holes varying in width according to the nature of these irregular deposis and at not more than from 4 to 6 feet away from the granite contact beneath the foot or south wall. This contact strikes north 60 degrees E. with dip of about 70 degrees N. 30 degrees W. A description of it from a surface examination made before the present mining had begun will be found in the 12th report of the Bureau of Mines, page 248. The norite in which the pyrrhotite and chalcopyrite lie contains scattered small inclusions of granular quartz and of granite. The ore itself averages about 35 per cent. of rock matter intermixed as rounded fragments to small boulders. The chalcopyrite occurs for the most part along or near the walls. The values in nickel and copper aggregate about 4 per cent. on the average, the nickel being in excess of the copper.

Gertrude Mine

All work both in the mines and in the smelter, was suspended here early in the summer on account of the financial embarrassment of the operators, time and subsequent to my last inspecthe Lake Superior Power Company, one of the corporations subsidiary to the Consolidated Lake Superior Company, Sault Ste. Marie, Ont. Previous to that tion the mining work had, according to the superintendent, developed new ore bodies of considerable extent in some of the other shafts. From all of these a large tonnage of ore was being raised and the smelter kept in operation to its full capacity. All the matte so far produced is still in stock at the smelter.

Mr. Thos. Travers, superintendent, is keeping only a few watchmen at the property.

Lead Mines

In the townships of Dorion and McTavish and the surrounding area northwest of the upper end of Black bay, lake Superior, deposits of lead and zinc have been known to exist for many years. Their occurrence has been described in the reports of the Geological Survey of Canada, 1866-69 and 1872-73 and in the Report of the Royal Commission, 1890. The geological systems of this area include both Huronian and Cambrian, the latter in Dorion and the immediate westerly vicinity, made up largely of Nipigon rocks, such as grey sandstones, indurated red marls and variously colored compact limestones. Separated areas of gneiss are occasionally well developed in the above, and it is in connection with all of these rocks that the veins are found, following well defined lines of faulting. In a matrix of quartz, calcspar and barytes occur galena, blende and some copper pyrites in pockets, bands and disseminated. Some of the veins attain a width of 25 feet, although from 6 to 8 feet appears to be more near the average.

It is on one of these veins which lies off the northwest corner of Dorion township that the present development is being done by the Ontario Lead and Zinc Company, of Superior, Wis., E. C. Kennedy, president. About a year previous to October 1903, other parties carried on exploratory mining on the vein for a while. The property is reached by what was once a good road, but is now only a trail running 8 miles westerly from the C. P. Railway siding, 2 miles southwest of Wolf station.

Considerable ore was in the earlier days shipped from some of these veins to smelters in the United States and other countries, so that it does not appear unreasonable to expect that if they were now thoroughly examined again ore bodies would be found which could be profitably worked under the increased and more economical facilities of to-day. Although in large part the occurrence of the ore in the veins is somewhat pocketty, and thinly disseminated, yet enriched areas or pay chutes have been known and mined, as for instance at the Lead Hills or Enterprise mine, in McTavish.

Mines of Eastern Ontario

By Willet G. Miller

The mines embraced under this heading are situated in the region bounded to the northward by that part of the Canadian Pacific railway which stretches from the Ottawa river to the northern part of the Georgian bay.

In a paper published two years ago the writer showed that the mineral industries in this part of the Province exhibit as great a variety in kind as do those to be found in probably any other part of the world of equal extent of territory (1). Among the metals or ores produced during the past year are gold, with associated silver, copper, iron, zinc, lead and molybdenum. Pigments or paint materials are represented by white arsenic, which is also used extensively in the manufacture of plate glass, and for other purposes. Among substances used for refractory purposes, or to withstand high temperatures, is graphite or plumbago, which is also now used as a base for paints. Our mica finds its chief use as an insulating material in electrical machines. The region under review is the world's largest producer of corundum, the best abrasive or grinding and polishing material known. Two mills, with a combined capacity of over 200 tons a day, for the concentration of this mineral were built during 1903. There has been an increased output of feldspar, a mineral found in large deposits in this part of the Province and used extensively in the pottery industry, and for other purposes. The production of actinolite and other minerals, which are ground and used as roofing materials, has been carried on during the past year on about the same scale as during former years. The preparation of short fibre asbestos was begun in 1903. During the last three or four years eastern Ontario has been a producer of iron pyrites, a mineral which is used in the production of sulphuric acid, and work was done on two or three new properties of promise in 1903. A small amount of talc was raised at the only developed mine of this mineral in the Province. Talc is used chiefly in the paper industry.

Eastern Ontario possesses a number of important mineral industries which cannot properly be placed under the heading devoted to mines. The crushed stone industry is growing. There are many important quarries from which stone suitable for any building or structural purpose is obtained. The marble industry is only in its infancy although the Province possesses large deposits of material suitable for the production of this ornamental stone. The lime production scarcely seemed to equal the demand in the more southeastern districts during the past season. The clay industries are capable of large expansion. The output of peat is likely to increase now that processes for the briquetting of this fuel have been more highly perfected, by inventions during the past year. During the last twelve months important discoveries have been made in connection with petroleum and natural gas, which encourage us to hope for new sources of supply of these substances in the Province. Salt, and mineral or medicinal waters should also be considered in reviewing or enumerating the mineral industries of the Province.

Corundum Mines

Important additions have been made during the last year to the equipment of the two companies mining corundum in Renfrew and the adjoining part of Hastings county. The Canada Corundum Company which has been

(1) Journal Can. Mining Inst., Vol. 5, pp. 233-256.

operating in Raglan township for some years erected a mill which will handle two hundred tons or more of crude rock in twenty-four hours, the plant formerly in use by the company having a capacity of not much more than one-tenth of this. The Ontario Corundum Company whose works are in Carlow township formerly shipped considerable hand-picked rock to the United States for concentration. The company have now erected a modern plant which prepares the corundum for market at the mine, and has a capacity of about one and a quarter tons of concentrates per day. Reproductions of photographs of the mills of both of these companies will be found in this report.

A charter was secured during the last few months for another company, known as the Corundum Refiners, Limited. This company proposes to carry on mining and milling operations in the northeastern part of Raglan township.

Canada Corundum Company

Quarrying and concentrating were in progress at the mine and works of this company on a scale similar to that of former years until about the end of 1903. The old mill was then dismantled, part of the machinery being added to the new plant which began operations in the first quarter of 1904.

The new mill is situated at the eastern end of the southern face of the hill on which the corundum rock is quarried. This hill affords an excellent site for a modern concentrating plant. The top of the mill is about 85 feet above the foot of the hill, thus affording an opportunity for feeding the rock from the quarries into the crushers at the top and allowing the crushed matter to pass by gravity down through the various machines to the bottom of the mill, where the corundum having been separated from the rock matter is dried and bagged for shipment, with a minimum use of elevators.

Following is a brief description of the equipment of the mill and the method of handling the rock :—

The hill on which the quarrying operations are carried on faces south and has an average slope of about 20 degrees. The dip of the rock conforms with the slope of the hill and the corundum-bearing layers,—syenite and syenite-pegmatite—outcrop at numerous points over the face of the hill. Several quarries, some of which have a depth of 20 feet or more, have been opened into these layers. Drilling is done by compressed air. After the rock has been blasted down, the large pieces are block-holed and broken up. The barren portions of the rock are sorted out, and the corundum-bearing material is carried by horse-car to the top of the mill, which is on a level with the quarries now being worked, and dumped into a bin which has a capacity of 350 tons of rock. From this bin the rock goes to a large crusher, 15 by 24 inches. The crushed material is then carried by belt conveyors to smaller crushers, one Gates, style A, and two Blake, 9 by 15 inches. From these crushers the rock goes to bins, thence by conveyor to set of rolls, of Overstrom special design. Then it goes to two sets of trommels, 11 feet in length, half going to each set. From here the undersize passes to elevators and the oversize to rolls. The crushed product is elevated to two sets of trommels, 2½, 2, 1½, 1¼, ¾, mm. From the trommels the material goes to 24 Overstrom and 4 Wilfey tables. Jigs are being added, it being thought that by their use the material can be crushed coarser and the production of a high percentage of fines will thus be avoided. After being concentrated on the jigs the corundum can be reduced to the sizes required for the market and further refined on tables or pneumatic jigs if necessary. From the Overstrom and Wilfey tables the concentrates go to bins, 50 tons capacity each, where they become partially dry by draining. They are then carried by belt conveyor to a dryer, which consists of double-deck steam tubes. After being dried the concentrates are elevated to bins in the top of the grader room. They are then run over magnetic separators, two of the Noble pattern and one invented by the company's staff, which remove the magnetite, and are then sized and graded. If the material is now not considered sufficiently pure, it is run over a set of tables or Hooper pneumatic jigs which are situated in this part of the building. From the tables the now thoroughly cleaned concentrates go to dryers and from the Hooper jigs direct to storage bins. It may be added that these Hooper jigs are said to be able to treat about 5 tons of material, between 30 and 70 mesh, in 24 hours, but if the mesh is larger or smaller than this their capacity is less.

Steam power is used in the mill, the boiler house being a separate building. Water for the boilers and concentrating plant is obtained by a ditch which runs from a creek to the mill. The large rivers York and Madawaska, run through a wooded and sparsely-settled country, where wood for fuel is cut into logs and floated down to the mill.

A tramway, constructed during the past year, connects the mill with the York river. This tramway is less than a mile in length and affords an easy way of conveying the corundum concentrates, which are put in bags holding 100 lbs. each, to a boat during the season of navigation, which carries them a distance of about 15 miles to Barry's Bay station on the Canada Atlantic railway.

Ontario Corundum Company

This company continued operations till the latter part of 1903 on lines followed during previous years. The corundum-bearing rock was hand-picked, and the high-grade material thus obtained was shipped to the United States for concentration. In addition to this, some of the material was roughly concentrated at the quarry. At the end of the year the new mill was completed, and high-grade corundum concentrates are now being shipped. This mill is much smaller than that of the Canada Corundum Company, but very satisfactory results are being obtained as regards the quality of material. It cannot, however, be expected that a plant of this size will turn out concentrates so cheaply as a larger one.

The mill is situated near the point where corundum was first discovered on the eastern Ontario ranges in 1896. This is on lot 14 in the fourteenth concession of the township of Carlow. The power used is steam, and water for the boilers and for washing and concentrating purposes is obtained from the small stream which runs close to the mill. After being crushed the rock goes to mullers, similar to those formerly used in North Carolina for separating the decomposed rock, chlorite and other minerals from the corundum. At the Ontario mill the fines are thus washed away, no attempt being made to save them. The coarser material after being dried and sized is concentrated on four Hooper pneumatic tables. The concentrates from these is of a high-grade.

The product of this mill is drawn to the York river, at a point a few miles up stream from the Canada Corundum Company's wharf, and shipped by boat to Barry's Bay railway station.

Feldspar Mines

Work was done during 1903 on several feldspar properties in the area in Frontenac county east of the Kingston and Pembroke railway, and adjacent to Bedford and Verona stations.

The chief of these properties, the Richardson mine, has been described in former reports of the Bureau. The spar in this deposit has made a demand for itself, owing to its good quality, among the pottery manufacturers in the United States. It has, however, not yet found its way into Great Britain, owing to the peculiar state of the trade in that country.

Additions have been made to the plant and to the shipping facilities at the mine during the last twelve months. A cableway has been installed for carrying the spar from the quarry to the lake, about half a mile distant, where the spar is loaded on scows. Thence it is taken across the lake to a short portage to another small lake, and floated by scows to the end of the branch railway line at the old Glendower iron mine. In winter the spar is teamed direct to the railway. From here it is taken by train to Kingston, about 30 miles, and thence by boat across Lake Ontario.

The spar is ground to the marketable form, an impalpable powder, in New Jersey. In addition to its use in pottery, which causes the chief demand for it, feldspar is also used as one of the constituents of the bond in wheels made of carborundum and other abrasive materials, for grinding purposes. The Richardson quarry is approximately 600 feet long, 200 feet wide, and the western face has a height of about 50 feet.

The Jenkins mine, a short distance from the Richardson, shipped about 800 tons of feldspar during the season, and had 300 tons on hand at the time of my visit in October. The spar was shipped to Trenton, N.J., and to East Liverpool, Ohio.

Another property that was worked lies between the Richardson mine and Verona station. It is known as the Worth. The owners ship the spar to Charlotte, N.Y., where they have a mill for grinding.

Mica Mines

Ontario leads the world as a producer of nickel and corundum, and she is not far behind any other country in the production of the unique mineral mica, India, Quebec and the United States being the other chief producers. The mica of India and of the United States is the muscovite variety, which is harder and not so well adapted for use as an insulator in electrical machines as the phlogopite or so-called amber mica produced in Ontario and Quebec.

Mica may be called the electrical mineral, not because it is charged with electricity, but on account of the fact that with the increase in use of electrical machines it has grown greatly in importance as a commercial material. In the old days white mica was used in stove fronts, in windows and in small quantities for other like purposes. The amber mica which was mined along with phosphate in eastern Ontario 15 years ago or less had little commercial value, and for the most part was thrown aside with the waste rock. These old dumps have since been worked over for their mica, and mines which were opened as phosphate properties are now worked for mica only.

The phlogopite deposits of Ontario and Quebec are usually irregular in character, and mining such deposits is considered by many to be a hazardous undertaking, financially. The mica is sometimes followed down in a chimney-like form. At other times the deposit has the character of a vein with distinct walls, but while the vein material may continue to unknown depths the mica may suddenly disappear. It has also been found in one locality that at a certain depth in two or three deposits the mica becomes milky in appearance and therefore practically valueless. This milkiness is said to be due to the presence of minute crystals of rutile. The question as to why the character of the mica thus changes with depth is as yet unanswered.

Muscovite mica is a constituent of coarse granite or pegmatite dikes. The deposits of this variety of mica are therefore likely to be much more regular than those of phlogopite. Muscovite has been worked only to a small extent in Ontario. Some deposits containing a very clear white variety were opened at the foot of the Blue mountains in Methuen township some years ago. The dikes here are syenite and nepheline-syenite pegmatite. The mica does not appear to have been found in them in sufficient quantities to pay for extraction. Granite-pegmatite dikes were opened up at the head of Mazinaw lake, in the northern part of Frontenac county, some years ago but little has been done on them since.

The mica mining now in progress in eastern Ontario is practically confined to two areas, one of which is tributary to the village of Sydenham, in Frontenac county, and the other to the town of Perth, in Lanark county. One or two mines, however, are outside these areas.

Two important papers have recently be published on mica. One of these is entitled "The Mica Deposits of India" and is written by Mr. T. H. Holland of the Geological Survey of India, Calcutta. The other deals chiefly with the mica deposits of central Canada, its author being Mr. E. T. Corkill. This paper is to be published in volume VII. of the Journal of the Canadian Mining Institute.

General Electric Company

This company, whose extensive works in the United States are well-known, mine their supply of amber mica in the Provinces of Ontario and Quebec, and have a number of well developed properties in each Province. In the autumn of 1903 their mines in Quebec were closed, and operations have been concentrated during the winter on their Ontario properties, the chief of which are the Lacey mine, near the village of Sydenham, and the Hanlan mine, a few miles from the town of Perth. Heretofore the company have obtained their supply of muscovite chiefly from India. It appears to be their intention now to endeavor to procure it on this continent. With this object in view they are opening a mine in New Hampshire, and have also secured properties near the head of Mazinaw lake, in Addington county, Ontario. The company, through their energetic resident superintendent, Mr. G. W. McNaughton, are doing the most systematic mica mining that has been done in this Province.

The Lacey mine has been frequently described, and is one of the most remarkable mica deposits ever worked in any country. In the early years of its history it was an important producer of phosphate, mica then being of much less value than during later times. The mine is now equipped with an up-to-date plant. With the exception of the addition of the plant, there is nothing of special importance to report concerning the working of this mine for the past year. The company own a diamond drill and have been systematically testing the Lacey mine and a number of their other deposits during the past twelve months.

The company have also done work on other properties in the township of Loughborough. Among these is the Ashley, lot 10 in the eleventh concession, near Gould lake, and the Gosage, east half of lot 5 in the eigth concession.

In the township of North Burgess, Lanark county, the company have worked the Hanlan mine continuously. The deposit is vein-like in form with definite walls. The workings have now reached a depth of 105 feet, with a stope 150 feet in length and an average width of 8 feet. Underhand stoping is the method followed in mining.

The larger crystals of mica in this mine apear to be associated with pyroxene, calcite and phosphate, while the smaller ones occur with the latter two minerals only.

On the Burns lot which adjoins the Hanlan, work has been done in the old pits, and the deposits have been tested by the diamond drill. This lot was worked for phosphate years ago, and considerable mica has been obtained from the old dumps.

The General Electric Company have mica trimming works at Sydenham and Perth.

Kent Bros.' Properties

This firm worked two mica properties during the year, but at the time of my visit work had ceased temporarily. The work at the Stoness mine was confined to a new pit, the old workings, which reached to a depth of about 400 feet not having been unwatered.

The work of the firm was concentrated on the mine at Bob's lake, in the township of Bedford. This deposit was opened up some years ago, but at that time it is stated the quality of the mica was not considered suitable for the market. During the past year a large amount of mica has been mined on the property, the working force consisting of from 20 to 25 men. At their trimming works in Kingston the firm have employed 65 hands, and it is probable that a more suitable building will be erected for this work during the coming year.

Other Loughborough Mines

Messrs. Richardson Bros. of Kingston, purchased a mica property, lot 7 in the ninth concession, about one mile east of the Lacey mine, during the year and have had a force of men at work in the pit and in the trimming-house. This deposit is vein-like in form, the walls being very sharp and distinct. The vein matter consists of white calcite, through which is set dark crystals of mica, thus making one of the most striking deposits of the mineral that the writer has seen.

Mr. E. L. Fraleck worked an open pit about 40 feet deep on lot 8 in the tenth concession for some time. This is situated between Gould and Blue lakes. The work ceased when the winter season set in.

Work was also done by other operators on lots 8 in the eighth, and 7 in the ninth concessions.

North Burgess

In addition to the Hanlan and Burns. already mentioned, several other mica properties in this township were operated in a small way during the year.

Bedford

In this township work was begun in the autumn on a mica deposit on lot 6 in the eighth concession, thus making it necessary to credit two working properties to this township, the other being the Bob's Lake mine, mentioned above.

Actinolite and Asbestos

At the village of Actinolite, formerly Bridgewater, in Hastings county, Mr. Joseph James has continued the grinding of actinolite and other minerals in the production of roofing material which finds a market in the United States. This industry is of interest from the fact that it is the oldest continuously operated mining industry, with the exception of the production of stone and clay products, in Ontario, Mr. James having begun operations about 1884.

The International Asbestos Company, with head office in New York, have erected a small plant, which is run by water-power, at Bridgewater, and have been extracting short fibre asbestos during the year from rocks quarried in the township of Elzevir.

The character of these deposits and the chemical composition of this asbestiform mineral are discussed in the Third Report of the Bureau of Mines, pages 97 to 99. It is there shown that the Elzevir mineral is not the serpentinous variety to which the name asbestos is generally given in commerce, but that it is a fibrous variety of amphibole, with characteristics resembling very closely those of the rare variety known as antholite. It is stated that the better quality of this asbestos which is milled at Bridgewater is employed for boiler coverings, and that the finely ground material is used for wall plaster under the name asbestal.

Talc

The talc mine on the outskirts of the town of Madoc, known as the Harrison mine, has a depth of 53 feet. The shaft is 18 by 20 feet in cross section, with short drifts which prove the merchantable talc to have a width of at least 34 feet. A few carloads of the mineral were shipped during the past year to New Jersey, where it is ground and distributed to the trade.

Graphite

The working graphite mines were pretty fully described in last year's Report. Hence it is unnecessary to repeat the description here.

Work was carried on at the Black Donald, which is reached via Calabogie station, on the line of the Kingston and Pembroke railway, throughout the year. Considerable diamond drilling has been done in testing the deposits. The flooded portion of the mine mentioned in the last Report has not been unwatered, but estimates have been obtained for the building of a coffer-dam to shut off the water of the lake.

The McConnell graphite mine and works, in Lanark county, some miles from the town of Perth, were in operation throughout the greater part of the year. At the time of my visit in November, the mine had just been shut down, but the mill was running.

Some work was done on a graphite property a few miles from Kinmount station in Victoria county.

Gold Mines

As many gold properties have been worked during the last twelve months as in former years, but owing to the unfortunate closing down of the Belmont mine in the second half of the year the output of the precious metal in this part of the year has been reduced. Considering the location, equipment, and other characteristics of the Belmont, it would seem that it should not remain idle long. If the old company do not feel in a position to go on with the work, it is to be hoped that a re-organization will take place, which will bring about the resumption of operations. Taking into account the cheap water power which has been developed by the company, the low price of labor and supplies in this district, and the fact that the mine is situated within half a day's travel from the city of Toronto, it is believed that ore can be treated as cheaply at this mine as at any mine in the world. A little work has been done on claims adjacent to the Belmont.

Three properties along the Central Ontario railway were operated during the past year. Development has been carried on almost continuously on the Cook property, adjacent to the Deloro mines, and during the first half of the year the Atlas mill and mine were worked. A cyanide plant for treating the auriferous mispickel concentrates was added to the equipment of this mill. The stock of concentrates, which had accumulated at the mill, were satisfactorily treated. It is to be regretted that the consolidation into one company of the Atlas, Deloro and adjoining properties has not been carried out. If worked under one management costs could be greatly lessened.

The Sovereign mine is situated near Malone station on the Central Ontario railway and was formerly known as the Feigle. The hill on which the ore bodies are found was worked over in a very unsystematic manner years ago. The ore which, at times, was very rich, was found in somewhat irregular deposits that appear to lie rather flat. The mine is now being operated by the Sovereign Gold Mining and Development Corporation of Ontario, Limited, whose main office is at 477 Ellicott Square, Buffalo, N.Y. The work now being done is chiefly on the extension of old pits and openings which are near the boundary line of the old Gladstone property. A boiler house was erected during the past year. There is a 10-stamp mill, put up in 1891, on the property. This mill has been kept in good repair and it is expected that it will be started up at an early date. A force of about 20 men is employed under superintendent Henry Lloyd.

Mr. W. A. Hungerford and associates have re-opened the Craig mine, which is situated a few miles from Bannockburn station, and additional plant has been put in. This property is described in the seventh Report of the Bureau of Mines. It is there said to comprise the south half of lots 4 and 5 in the third concession of the township of Tudor, 100 acres. Considerable stripping was done on the property by the original owners, and in the latter part of 1895 a company was organized to work it, which sank a shaft to a depth of 100 feet, since which time, until last year, it has lain idle.

Farther east in this district two or three gold properties have received some attention. The Star of the East property near Perry's rapids, Myer's Cave P. O., on the Mississippi river in Barrie township, Frontenac county, has had some work done on it. Samples of this auriferous ore carry quite massive iron pyrites. The Boerth mine, on lot 29 in the seventh concession of the township of Clarendon, Frontenac county, was also re-opened during the past year, and it is the intention to continue work during 1904. This mine has been described in former Reports of the Bureau, Vol. IX., p. 93, and Vol. XI., p. 203, The ore consists of auriferous quartz and mispickel. The treatment by stamp milling and cyaniding, practised at the Deloro and Atlas mines in the township of Marmora is adapted to it. There is a ten-stamp mill on the property. Two shafts have depths of about 120 and 35 feet respectively, according to former reports published by the Bureau, and there has also been considerable ore taken out of open cuts.

Copper Mines

Work was done with a few men on three or four of the Parry Sound copper properties during the past year. The shaft of the Consolidated mine on Spider lake is said to have a depth of 150 feet. It has a collar, and timber every 14 feet down but no partition. The top of the shaft is covered with a door. There is a steam hoist. No work was being done on the day of my visit.

The Ontario Colorado Mining Company, whose property lies at the outlet of Spider lake, had a shaft down to a depth of 56 feet in September. The headquarters of this company is in Detroit.

The chief work done on the Wilcox during the past year was in an open cut near the mill.

An interesting discovery of copper pyrites, which I have not had an opportunity of examining, is that in the bottom of the Coe iron mine, near Eldorado station in Hastings county. Hematite has been shipped from this mine for a number of years. This ore is said to have given place to copper pyrites in the bottom of the shaft.

Zinc and Lead Mines

The Richardson zinc mine, near Long Lake P. O., in the township of Olden, Frontenac county, has been worked with a small force of men throughout the year. Mining has been done chiefly by stoping ore from the area surrounding the upper part of the shaft, although a little sinking has been done, the shaft now having a depth of 100 feet.

The rock in which the deposit occurs is crystalline limestone of the Grenville series. The ore at times occurs in a distinct vein-like form, which breaks up into stringers and enlarges into pockets of considerable size. It consists of rather dark-colored zinc blende, through which is intermixed more or less galena. The material shipped is hand-picked at the mine to 40 per cent. or over of zinc. This usually carries from 10 to 15 per cent. of lead. The pure galena appears to carry about 20 ounces of silver to the ton. The buyers however allow nothing for the silver, and nothing for the lead unless it runs over 10 per cent. The ore is sold in Europe. Material carrying a lower percentage of the metals than that mentioned is left lying on the dump.

During the year the Hollandia lead mine, near Bannockburn station, was reopened, and equipped with a hoisting and small concentrating plant together with a small experimental furnace, with which some tons of lead were smelted. It is the intention of the owners to continue the development of this mine.

The mill contains crushing machinery together with trommels and four double compartment Hartz jigs. In the smelter are so called Missouri air furnaces which have a combined capacity of six tons of lead a day. A blast furnace is to be erected at once which will have a capacity of ten tons a day. The shaft has a depth of 61 feet.

In the first quarter of 1904 work was resumed on the Frontenac lead mine, in Loughborough township, which has lain idle for many years. A description of this mine and its plant is given in the Reports of the Geological Survey of Canada. Work is being done on a new opening, which has reached a depth of about 15 feet, and lies some distance from the old mine. The ore consists of galena and zinc blende in crystalline limestone. The deposit is similar in form to that of the Olden zinc mine. In the openings formerly worked zinc was not associated with the lead. The following analysis of an approximately average sample, taken by the writer, of some 50 tons of the ore now being mined shows the relative proportion of the metals :—

	Per cent.
Lead	18.12
Zinc	8.10
Silver	1.20 oz.
Copper	none.

Iron Mines

There are few changes to record in connection with the iron mines of the eastern part of the Province during the past year.

The chief shipper, the Radnor mine, produced about the same quantity of ore in 1903 as during the preceding year. The ore extracted here is all taken from open pits. Before being shipped it is hand sorted. A considerable amount of low grade ore is produced which is left lying on the dump. Experiments have been made with a view to concentrating this material by means of magnetic separators. The pits are in the form of a semi-circle, the ore occurring in a bed-like mass which has a very regular dip of about 35 degrees from all points on the edge of the semi-circle. It is said that diamond drill holes put down some distance in from the edge of the semi-circle have proved that the thickness of the ore and the dip remain fairly constant with depth. It was pointed out in a former report that granite dikes cut the ore in this deposit. A narrow stringer or veinlet of galena is also seen to have the same relation to the ore in one of the pits. The ore from this mine is shipped via Caldwell station, to the company's furnace at Radnor Forges, Que.

The Mineral Range Iron Mining Company, whose properties lie a few miles from L'Amable station, Hastings county, have been at work during the past year. Roads have been built, and a number of test-holes have been sunk by means of the calyx drill in the ore bodies.

The discovery of copper pyrites in the bottom of the pit of the Coe iron mine at Eldorado has already been mentioned. It would appear that a considerable change has taken place in the character of the ore in this mine.

Small amounts of iron ore have been produced from other mines in the eastern counties during the past twelve months.

This eastern district is well supplied with water powers, and it would seem that the time has arrived when some of the iron mines, now lying idle in eastern Ontario, can be profitably worked by first hand-picking the shipping ore, and subjecting the leaner material to magnetic concentration. Ores of similar character are successfully concentrated in New York state and elsewhere.

A rather full account of the distribution and character of the iron deposits in a part of eastern Ontario has been published by the Geological Survey, Ottawa. It is by Mr. E. D. Ingall, and its title is "On the Iron Ore Deposits Along the Kingston and Pembroke Railway."

Iron Pyrites

The property known as the Jarman mine, near Bannockburn station, has been worked on about the same scale during the last twelve months as it was for two or three years previously. Mr. Nichols, the chief owner of this property, has been developing a deposit of the same mineral during the last summer and autumn near the line of the Canadian Pacific railway, a few miles east of Tweed station. This deposit was opened up years ago as a gold prospect and a small plant was installed on it, but the only value of the ore is in its sulphur contents. The shaft had reached a depth of about 60 feet at the time of my visit, in the autumn. Mr. Rising has succeeded Mr. Jarman as superintendent of both these properties.

The Jarman pyrite mine has a depth (April, 1904) of 175 feet, with three levels, as follows: First at 64 feet, north drift 150 feet, south 180 feet; second at 113 feet, north drift 148 feet, south 138; third at 175 feet, north drift 105 feet, south 105. Shipments were delayed during the winter by railway blockades. The shaft on the property near Tweed has a depth of 135 feet, with some drifting.

Messrs. J. E. Harrison, C. E. Smith and others have done some work on deposits adjacent to the last mentioned one.

Other Mineral Industries

A number of mineral industries of eastern Ontario have been mentioned in the introduction. As these industries do not come under the heading of mines they cannot properly be dealt with in this place. The chief features in connection with the year's operations of most of them are dealt with in the report of the Director, where it is shown that there have been important developments in the petroleum and other industries. One of the most important group of our industries is that which uses limestone as a base. The distribution, character and uses of our limestones are described by the writer in a special paper published as Part 2 of the Thirteenth Report. Since the detailed report on peat was published last year developments of interest have taken place in this industry. The clays of the Province are growing in importance yearly and a special report on them would be of service. From the table of statistics of our annual mineral production the relative importance of the several industries will be seen.

Cobalt-Nickel Arsenides and Silver

By Willet G. Miller

Late in the autumn of 1903 the discovery of deposits of cobalt-nickel-arsenic and silver ores in the northern part of the Province was made public. Little importance seems to have been attached to the deposits by those who first saw them, it being thought that they carried a small amount of copper, the niccolite being mistaken for this metal. Mr. T. W. Gibson, the Director of the Bureau of Mines, however, when on a visit to the district in October, received specimens of the minerals, and recognized that they represented valuable ore. The writer was, accordingly, instructed to make as thorough an examination of the deposits and surrounding area as could be made at the season of the year, snow having already begun to fall in the district, before his arrival in the first week in November.

The deposits were discovered during the building of the Temiskaming and Northern Ontario railway, the Government line which is now under construction from North Bay junction, on the Canadian Pacific, to the head of Lake Temiskaming. The road-bed of this new railway runs almost over the top of the first of the deposits discovered. The ore bodies lie five miles south of Haileybury, one of the two sister villages on the Ontario side of the northern part of Lake Temiskaming. Haileybury, following the railway, lies about 106 miles north of North Bay station, which is, by the Grand Trunk railway, 227 miles north of the city of Toronto.

The Deposits Described

As the value of the deposits was learned only a short time before the surface became covered with snow, very little prospecting has been done in the surrounding area. The discoveries were made by men employed on the railway, and not by regular prospectors; hence the work has not been done as systematically as it might have been.

When I visited the locality, four veins had been located in the vicinity of a small body of water known as Long lake, which is not shown on existing maps. It lies about one-half mile south of the southern boundary of lots 8 and 9 in the first concession of the township of Bucke. The reports of other finds were not verified.

Each of the four veins visited was found to carry cobalt. Nickel also appears to be present in all of them; but as the weathering of the cobalt compounds masks, at times, the nickel colors, this latter metal was not definitely recognized in two of the deposits, although it doubtless occurs wherever the cobalt is found. Three of the veins are rich in native silver. The veins occur in unsurveyed territory, and, as the locations are as yet unnamed, we shall speak of them as Nos. 1, 2, 3 and 4. The outcrop of No. 2 lies about one-half mile southwest of No. 1, and No. 3 the same distance southwest of No. 2. The outcrop of the fourth vein is about one-half mile southeastward of No. 2.

The accompanying plan shows the locations which were surveyed since my visit, with the position of the veins.

Very little work has been done on any of the veins, and as the surface is pretty well covered with moss and soil, it is impossible to state what is their horizontal extent.

All of the veins cut through one or both of the formations known in the district as Huronian slate and breccia-conglomerate or agglomerate. The

Copper Queen mine, shaft and hoist house.

Copper Queen mine, 1903.

Shaft house, Ranson copper mine.

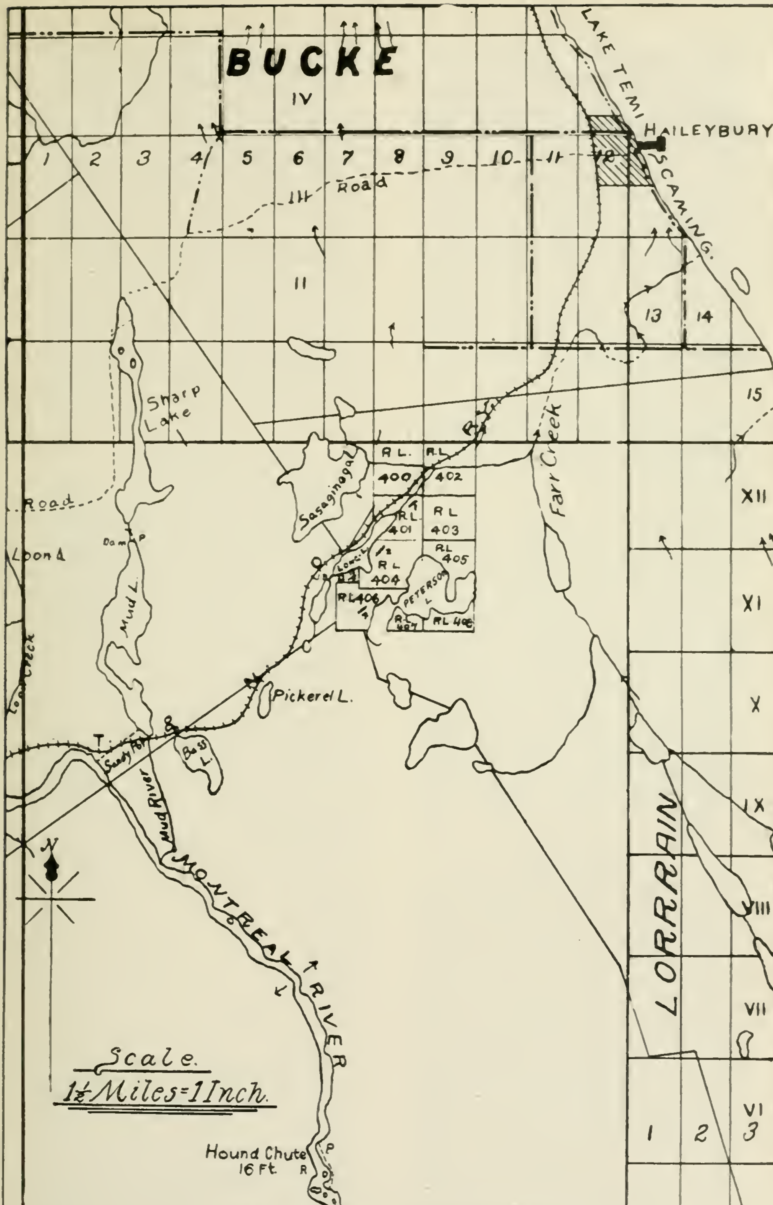
Baden-Powell gold mine, showing open trench.

Massey Station copper mine, 1903.

Helen iron mine from the north

Mineral Range Iron Mining Company. No. 3 mine.

Mineral Range Iron Mining Company. No. 1 or Childs mine.


BUCKE
IV
LAKE TEMISCAMING.
HAILEYBURY
1
2
3
4
5
6
7
8
9
10
11
12
Road
II
13
14
15
Sharp Lake
Road
Sasaginaga
RL. 400
RL 402
RL 401
RL 403
RL 405
RL 404
RL 406
PETERSON L
RL 407
RL 408
Farr Creek
XII
XI
X
IX
VIII
VII
VI
1
2
3
Dam
Loon L
Mud L.
Loon Creek
Pickerel L.
T.
Bass L.
Mud River
MONTREAL RIVER
LORRAIN
Scale.
1½ Miles=1 Inch.
Hound Chute
16 Ft.

latter rock is considered to be composed of volcanic ejectamenta—grains and fragments of rocks of various kinds which have become consolidated. The slate conglomerate of older Canadian writers, Logan and Murray, is a variety. The slate along the railway cuts, in the vicinity of Long lake, occasionally contains fragments of pink granite, which are, at times, a couple of inches or more in diameter. On the faces of some of the vertical cliffs, the well-banded slate at the bottom is found to pass gradually into massive breccia-conglomerate at the top, the fragments in the latter being of varied composition and ranging in size, from small grain-like fragments to pieces of rock a foot in diameter.

The presence of dikes or sheets of some of the darker-colored eruptives was suspected, but they were not definitely recognized. In the field they would resemble rather closely some of the more massive varieties of the slate and finer-grained breccia.

The slate and agglomerate have a slight dip, and the veins referred to cut them almost vertically. The strike of veins Nos. 1 and 3 is approximately northeast and southwest; that of 4 is east and west; that of 2, northwest and southeast. Diabase and gabbro invade these fragmental rocks in some parts of the district, and appear to underlie most of the area. Whether the veins penetrate these igneous rocks beneath the slate and agglomerate has yet to be determined. About three miles to the northward of Long lake, Silurian limestone overlies the Huronian, but the limestone is undoubtedly of younger age than the veins.

Deposit No. 1

Vein No. 1 lies east of the railway track, at the edge of a swamp, about one-quarter mile north of the end of Long lake. It has been uncovered at three points, which are within a few yards of one another. As the surface of the rock is low here, and little of it is exposed, it is difficult to tell much about the form of the deposit. Medium grained, dork-colored agglomerate is found on one wall. At the widest opening the deposit has a width of over 6 feet, but the vein matter is more or less mixed with rock. The ore consists of niccolite, or the arsenide of nickel, and smaltite, the diarsenide of cobalt, together with much native silver. Niccolite contains theoretically, 43.9 per cent. of nickel and 56.1 of arsenic. Smaltite carries 28.2 per cent. of cobalt and 71.8 of arsenic. It may be added that the ore of nickel now worked in Ontario, the iron sulphide or pyrrhotite of Sudbury, in which nickel occurs not as an essential but as an accidental constituent, carries, on the average, less than 5 per cent. of the metal. On weathered surfaces the vein matter is coated with the beautiful pink decomposition product, cobalt bloom. The green nickel stain is also seen on some surfaces, but is usually masked by that of the cobalt. This nickel compound is probably the arsenate, annabergite, but nickel silicate may also be present. The secondary mineral, arsenolite, was seen on some specimens. The native silver occurs as films, or leaves and fine threads, or moss-like forms, through the nickel and cobalt minerals, especially in the niccolite, as well as in cracks in the rock and in the calcite veinstone. In weathered portions of the ore the silver shows distinctly. Some lumps of weathered ore weighing from 10 to 50 lb. carry a high percentage of silver. One sheet composed chiefly of silver, attached to a rock surface, had a thickness of nearly 0.375 inches and a diameter of about 1 foot. Professor Wm. Nicol has recognized the antimonial silver, dyscrasite, as was suspected in the field, in association with the native silver. Mr. A. G. Burrows found a sample of dyscrasite from ore body No. 1 to carry 84.08 per cent. silver with a strong qualitative reaction for antimony, none for arsenic and only traces of sulphur; which is very near the formula Ag_6Sb. Prof. Nicol also proved the presence of chloanthite, $NiAs_2$. It is associated with the niccolite, and also occurs, pretty free from cobalt, in some of the nodular masses in the calcite.

An analysis was made by Mr. Burrows of the pure chloanthite taken from a sample of the vein matter of ore-body No. 1 containing the ore in small concretions which gives the following percentages :

Nickel	23.24
Cobalt	4.11
Silver	2.78
Antimony	none
Sulphur	2.18
Arsenic	67.17
Total	99.48

The silver appears to have crystallized earlier than the niccolite, which has been deposited around it. The cobalt arsenide has formed still later than the niccolite.

Little laboratory work has yet been done on the specimens collected. Analyses of the ore, unless of samples representing a large quantity, are of little economic value, although they are of scientific interest. A sample composed essentially of niccolite contained 5.02 oz. of silver to the ton, and nickel 26.64, cobalt 6.16, arsenic 45.64 per cent.

A small hand specimen of the rock, which occurs mixed with the ore and gives it the character of a brecciated vein, shows a sharp contact between the fine grained slate, ash rock, and a medium grained rock of similar composition.

As so little work has been done on this ore body, it is difficult to determine whether the three openings belong to one vein, or whether the ore occurs in a more irregular deposit, although the chief opening appears to be on a vein-like body. The ore is undoubtedly very rich, containing values in nickel, cobalt, silver and arsenic, and a comparatively small vein could be worked at a handsome profit.

Deposit No. 2

Deposit No. 2 is distinctly vein-like in form. The ore here is a mixture of smaltite, and probably some closely related arsenides of cobalt, such as safflorite, and niccolite.

The following table gives the results of analyses which have been made of samples from vein No. 2:

—	1	2	3	4	5
Cobalt	16.8	16.7	16.76	19.80 }	21.70
Nickel	7.0	6.8	6.24	4.56 }	
Iron............	6.3	7.5	......	6.20	8.89
Arsenic .... }	69.0	62.0	66.60	60.30	63.55
Sulphur........ }		7.0	3.37	4.09	5.38
Insol. silica, &c.	0.9	......	......	2.40	0.60
Water...........	......	......	......	2.00	......
Totals......	100.0	100.0	......	99.35	99.92

Analyses 1 and 2 were made by Mr. O. S. James; the former represents a hand specimen from near the surface, and the latter is from a depth of about twenty feet; 3 and 4 are of average samples collected by the writer, the former from the uppermost opening and the latter from the middle or main opening, the analyst being Mr. A. G. Burrows. It was evident that sample 3 was somewhat weathered, as it showed considerable cobalt bloom. Analysis 5 is by Dr. J. Waddell. It represents a specimen collected by Prof. Nicol. This specimen was not taken, like 3 and 4, with the object of determining the average composition of the vein. Prof. Nicol states that a qualitative analysis showed the presence of small amounts of copper and lead, and the absence of antimony, bismuth and zinc.

This ore-body, unlike the other three examined, carries no silver in the parts so far uncovered. At the time of my visit three openings had been made on the vein over a length of 300 feet. The massive ore has a width of 14 inches, but vugs in the wall-rock, 2 feet or more from the vein, are filled with cobalt bloom. The rock of both walls is slate. The walls are well defined, and the vein dips almost vertically, the strike being toward the southeast. The vein lies on the hillside, a few hundred yards east of Long lake and the railway, and, unlike ore-body No. 1, is at a height of about 70 feet above the water level. Although the width of this vein is not great, the character of the ore is such as to make it promising at the present price of the metals contained in it. During the winter it is said that a shaft was sunk to a depth of 30 feet on the vein. The ore at this depth is not so massive, being intermixed with rock.

The ore has a massive appearance, and a rather dark-grey color, where not coated with cobalt bloom. When examined carefully, however, in hand specimens, especially if a polished surface be examined with a magnifying glass, it is seen to be a mixture of a gray mineral, which is chiefly smaltite, and the reddish mineral, niccolite. Smaltite and the corresponding arsenide of nickel, chloanthite, are claimed by most authors to pass into one another by the substitution of cobalt for nickel, and vice versa. Niccolite, in the analyses quoted by Dana and others, carries only a small percentage of cobalt and iron, while smaltite and the other diarsenides of cobalt frequently contain much iron and nickel. In the ore under consideration, the cobalt and nickel appear to be, for the most part, in distinct compounds. In the analysis quoted (No. 1) if we consider the 7 per cent. of nickel to exist as niccolite, and the percentages of iron and cobalt, 6.3 and 16.8, respectively, to exist as smaltite, the theoretical percentage of arsenic in the ore should be 68.47, instead of 69, as found by analysis. The percentage of niccolite by weight would be 15.94, or about one-seventh part of the whole by volume, since niccolite has a somewhat higher specific gravity than smaltite. The specimens, when examined with the magnifying glass, agree with this. The niccolite has crystallized earlier than the smaltite, which forms the ground-mass through which the niccolite grains are set.

Minute, brilliant, silver-white or tin-white crystals occur sparingly, embedded in the wall-rock and in the ore. The crystals occur in cubes, and in combinations of this form with the pyritohedron, or rhombic dodecahedron, and octahedron. Prof. Nicol who has measured some of these on the goniometer has found them to be smaltite. The white or gray colored arsenides show a tendency to form globular or spheroidal masses, with a radiated structure. Some of these masses in the calcite have a diameter of over half an inch. The ore is at times somewhat porous, spaces being left between the globules, which are tarnished almost black on their surfaces. Where not coated with cobalt bloom, the weathered surface of the ore has a dark color, not unlike that of the wall rock. On a fresh surface, the more massive ore resembles mispickel, but is somewhat darker in color. Small grains of quartz are found sparingly in the ore. The proportion of nickel to cobalt in this case is less than that in No. 1. Tetrahedrite is found in small quantities, associated with the smalite. Mr. A. G. Burrows found a sample of this mineral to possess the following percentage composition :

Copper	36.04
Sulphur	22.86
Antimony	21.86
Zinc	8.14
Iron	9.84
Cobalt	none
Nickel	none
Lead	none
Arsenic	Not det.
Total	98.74

A deposit carrying galena and copper pyrites lies a short distance southeast of vein No. 2. Very little of its surface is uncovered and no analyses have been made of the samples collected. Grains and small masses of copper pyrites were seen in the slate, in the railway cuts, in the vicinity of deposit No. 1.

Ore Bodies 3 and 4

Ore body No. 3, so far as could be seen, is similar in character to No. 1. It lies at the southern edge of Long lake. The ore consists of native silver, smaltite and cobalt bloom, and, in all probability, niccolite also.

The location on which this deposit is situated is known as the McKinley and Darragh claim. A sample of the ore which weighed fifteen and one-quarter ozs. and showed native silver together with smaltite and considerable cobalt bloom, was found by Mr. Burrows to possess the following composition :

	Per cent.
Silver	11.10
Cobalt	15.08
Nickel	5.56
Arsenic	49.68
Sulphur	2.55
Gold	none
Iron	6.38
Insoluble	5.50
Undetermined—water, etc.	4.15
Total	100.00

Vein No. 4, although having the smallest width of the four, is, in many respects, the most interesting of the group. Here a perpendicular bare cliff of rock, 60 or 70 feet high, faces west. The vein, whose width averages not more than 8 inches, cuts this face at right angles, and has an almost vertical dip. The vein is weathered away, leaving a crack in the face of the cliff 2 feet, in some places 4 or 5 feet, in depth. When I saw it first, it had not been disturbed. Thin leaves of silver up to 2 inches in diameter, were lying on the ledges, and the decomposed vein matter was cemented together by the metal, like fungus in rotten wood. It was a vein such as one reads of in textbooks, but which is rarely seen, being so clearly defined and so rich in contents. It was found impossible to get a fresh sample of the ore with the prospecting pick, the vein being so much decomposed. The weathered specimens, however, in addition to the native silver, contained cobalt bloom; and the unaltered ore will be found, in all probability, to consist of smaltite and niccolite, in addition to the silver. It may also be added that, in one part of the vein, a distinct banded structure was noticed. Across a distance of 8 inches there were 12 or 14 layers of ore lying parallel to the walls. At the bottom of the cliff the vein cuts thin-banded, dark-gray or greenish and at times almost black slate, which has a slight dip. This slate passes gradually, so far as could be determined from the steep character of the cliff, into coarse breccia-conglomerate in the upper part. The fragments in the conglomerate consist of quartz, slate, granite and other rocks.

On some of the weathered surfaces of the native silver specimens there are small, black, spheroidal masses, with little luster. These appear to be the hydrated oxide of cobalt, heterogenite. Some of the deposits on the silver resemble asbolite. The carbonates of cobalt and nickel are also probably present. Antimony and sulphur have been detected in the ore of veins 1 and 2. Detailed analyses are required to determine the character of some of the silver-bearing minerals, which are present in small amounts. Bismuth, copper and manganese, in an association of ores such as we have in these deposits, are to be looked for.

A sample of the much weathered ore from vein No. 4, which appeared to contain less silver than most of the samples collected was found by Mr. Burrows to have the following percentage composition: Silver 16.60, cobalt 3.91, nickel 1.42, arsenic 19.79, gold none. This ore is brownish to yellowish in color, and has an earthy appearance. Its color is due to the presence of several decomposition products, the oxides of iron, cobalt and nickel. A small amount of cobalt bloom is present.

Three other weathered samples in which native silver was distinctly visible possessed the following percentage composition:

	1.	2.	3.
Silver	23.97	27.00	26.24
Cobalt	2.85	2.80	8.34
Nickel	0.97	1.00	5.26
Arsenic	18.30	19.30	13.28

The percentage of silver in 3 represents a value of $5,237.60 a ton.

A Unique Occurrence

These recently-discovered ore bodies lie about 90 miles northeast of the town of Sudbury, in the vicinity of which are situated the well-known nickel mines. The ore of the latter is of a different character from that of the Haileybury deposits, being essentially pyrrhotite and copper pyrites. The rock associated with the Sudbury deposits, which are not veins, but deposits of irregular shape, is norite, a variety of gabbro; the ore itself is claimed by most writers to be essentially of igneous origin. It is thus seen that there is little in common between the ore bodies of the two localities, with the exception that nickel is a characteristic metal of each. The Sudbury pyrrhotites carry a small percentage of cobalt in addition to nickel. The minerals niccolite, danaite, and other arsenical compounds, have been found in some of the Sudbury deposits, but only in small quantities.

It is of interest to note that a deposit of sulpharsenide of iron, mispickel, was discovered a few years ago near Net lake, which lies about 25 miles to the southwestward of the Haileybury deposits. This mispickel, however, does not carry appreciable amounts of nickel, cobalt or silver.

On the Quebec side of lake Temiskaming, about nine miles to the northeastward of the Haileybury deposits, an ore body known as the Wright silver mine was discovered many years ago by some of the early explorers of that region. During recent years this deposit has been worked for its lead and silver contents. The deposit is unique in character, the wall-rock being Huronian breccia-conglomerate, the fragments in which are, at times, cemented together by argentiferous galena. The silver contents of the pure galena in this deposit vary from 18 to 24 ounces to the ton of 2,000 lbs., but the intermixture of rock matter considerably lessens these results. Iron pyrites has been found intimately associated with the galena and is doubtless the source of the trace of gold usually present in the ore (1).

Silver-bearing galena with copper pyrites is also found on an island in Cross lake which lies southeast of lake Temagami, and at Lady Evelyn lake. "Some of the most important of such veins noticed, occur on the 'Matawapiki,' as the last stretch of Lady Evelyn lake before reaching the Montreal river, is called" (2). These quartz veins are found on both sides of the lake here and occur at the contact of the intrusive diabase and the banded slate, and in the latter. The minerals are galena, copper pyrites, iron pyrites and zinc blende.

An analysis of a sample of the ore from Cross Lake, which consists of galena and copper pyrites in calcite, shows it to possess the following values per ton: gold $2.00, silver $9.20, copper $4.20, lead $4.00, or a total of $19.40 (3).

The only area in Ontario, or central Canada, which has hitherto been found to contain deposits of rich silver ore is that which lies near the head of lake Superior, nearly 500 miles from Haileybury. While native silver has been found in considerable quantity in these deposits, the sulphide, argentite, is the more characteristic ore. The Silver Islet mine, near Port Arthur, is well known to those interested in the metal industry. Deposits of somewhat similar character, which occur on the mainland, have also been frequently described. The report on "Mines and Mining on Lake Superior," by Mr. E. D. Ingall, of the Canadian Geological Survey, gives an account of this silver-bearing area.

The silver veins in the vicinity of Port Arthur, like those of Haileybury, cut through slate, but the Port Arthur slates are held to be of later age—Animikie—than those of Haileybury, which are what is called, in a general way, Huronian. Much work remains to be done on our metamorphic and igneous

(1) Report Geol. Survey, 1897, p. 148 I.
(2) Ibid, p. 141 I.
(3) Tenth Report, Bur. Mines, p. 180.

rocks before the various formations can be correctely correlated. Both the Port Arthur and Haileybury slates have been cut through by diabase and related rocks.

The Slate-Breccia

The rich silver-bearing veins in the Port Arthur district, like those of Haileybury, occur for the most part as vertical fissures, which cut fragmental rocks whose beds lie in a nearly horizontal position. Although the fragmental material of which the silver-bearing rocks are composed is not similar in the two district, the writer is inclined to believe that the ash rocks and agglomerates of Haileybury are of almost, if not exactly, the same age as the Animikie slates of the head of lake Superior.

In this paper the term slate has been used in referring to the fine-grained and delicately laminated rocks through which the Haileybury veins cut. This term properly refers to argillites and should not be used except as a convenient field term for all the finely laminated rocks in the area. Thin sections when examined under the miscroscope show that the specimens so far investigated represent ash rocks. Coarser varieties, in which the fragments possess a size similar to that of the grains of minerals in a medium-grained igneous rock, are found to be made up of pieces of orthoclase, plagioclase, trachytic material, chlorite and calcite, which is an infiltration product. The layers of some of the slate-like rocks which lie at the bottom of the cliffs have not been examined in the laboratory.

A correlation of these Haileybury rocks with the slates and tuffs of the area which was marked as being doubtfully Cambrian on Dr. Robert Bell's map of the Sudbury district would be interesting.

Dr. A. E. Barlow has given a very interesting account (Geol. Surv. Can., Vol. X., p. 194 I), of the contact between a granite and the overlying fragmental rocks in the vicinity of Baie des Peres, on the opposite side of lake Temiskaming from Haileybury. He has shown that this is, so far as has been observed, a unique occurrence—some of the Huronian fragmental material overlying the granite having been derived from the weathering of this rock in situ. The present writer some years ago recorded the occurrence of a small outlier of Grenville limestone in the vicinity of lake Keepawa, east of lake Temiskaming. This limestone and the associated garnetiferous schist have been much disturbed by an intrusion of granite apparently similar to that of lake Temiskaming. It would therefore appear that the Baie des Peres fragmental rocks which rest on the eroded surface of the granite are very much younger than the Grenville series of the indefinitely so-called Laurentian. The question then arises—are we at present certain that th Baie des Peres fragmental rocks are older than the Animikie?

It is known that rocks similar in character to those of Haileybury lie to the northward. In the writer's report on "Lake Temiskaming to the Height of Land" published in Vol. XI. of the Report of the Bureau of Mines, 1902, the following statements are made concerning the slate and breccia-conglomerate or agglomerate in the area examined. P. 217: "Slate is also seen at the outlet of the lake, passing into a conglomerate a short distance down the river. The latter rock appears to overlie the former." P. 219, "On the east shore near this point, the rock has a bedded appearance, the layers being ten or twelve inches thick, slate forming the lower layers with an impure quartzite above. Along this lake these rocks dip at a low angle, 15 degrees, to the southwest. The quartzite, or graywacke carrying quartz grains, lies above the slate, and the conglomerate appears to overlie the quartzite. If this is their order, they have either been inverted or they possess a different relationship from that given for similar rocks by the Geological Survey in the report on the lake Temiskaming map sheet. The question as to their relationship is of economic interest on account of the occurrence of iron ores." P. 220, "The slate along the shore here has a dip of about 7 degrees to the eastward or towards the island just mentioned. A hill up the shore to the northward was found to be composed of conglomerate containing fragments of slate, quartz, gray granite, and a porphyritic gray granite, together with a few red jaspar pebbles associated with hematite. The conglomerate appears to overlie the slate and the whole dips towards the islands, which also contain conglomerate." The word "appears" was used in these sentences on account of it having been held by other writers in the field to the south that the conglomerates or agglomerates were the basal rocks. The present writer having made a hasty examination of the area did not wish to state positively that the rocks, as he saw them, occupied their original relative position, although they appeared little disturbed. Some of the agglomerate is very loosely cemented together.

Cobalt Ores Elsewhere

Although cobalt and nickel minerals have not been found in quantity near Port Arthur, it is interesting to know that the ore of the Silver Islet and some of the other mines was at times coated with cobalt bloom. Niccolite and other minerals carrying cobalt and nickel occur in small amounts in some of these deposits. The only deposits in which quicksilver has been found in Ontario is that of Silver Islet, where chloride of silver is also said to occur as a decomposition product.

Small quantities of cobalt, nickel and silver-bearing minerals occur on Michipicoton island, lake Superior. Arsenical compounds of the first two metals have been found at several other localities in Ontario and at Calumet island, Quebec. Cobalt bloom occurs sparingly in some of the magnetite deposits near the town of Madoc, in eastern Ontario. It will be noticed that the association of minerals in these Haileybury veins is not unlike that found in some well-known deposits of Germany and other countries. Since these German ore bodies have been worked for many years methods for extracting the metals, cobalt and nickel, from ores of this kind are well proved. Hence little experimenting will have to be done on the Haileybury minerals.

Although little prospecting has been done in the vicinity of the Haileybury deposits, it would appear from the discoveries already made that ore-bodies occur there which can be worked profitably for the metals which have been mentioned. It is scarcely probable that nickel will be found in sufficient quantity in these deposits to interfere materially with the lower grade, but large, deposits of the Sudbury area.

Slate and agglomerate, similar in character to those of Long lake, cover a very large and as yet little prospected area in northern Ontario. The rocks along the government railway a considerable distance south of the deposits described in this paper, contain indications of the presence of cobalt ore.

It is stated in The Mineral Industry that "cobalt, which is used in the arts, chiefly in the form of oxide, is obtained from New Caledonia, Australia and Germany, and smelted in France, Germany and Great Britain, the Messrs. Vivian, of Swansea, being the chief buyers in the last-named country." Cobalt oxide is produced at one plant in the United States. It is said that a refinery is being erected at Mine La Motte, Missouri, for the extraction of cobalt and nickel, which are obtained as by-products in lead smelting.

The ore of New Caledonia, which is the world's largest producer, shipping about 3,000 tons yearly, is cobaltiferous wad, containing 25 to 30 per cent. manganese and 2 to 8 per cent. cobalt oxide (CoO). The ore of New South Wales is similar in character. In both countries the cobalt ore is a decomposition product, and occurs in irregular deposits.

"At the end of 1901 and the beginning of 1902 the price of cobalt ore, containing 4 per cent. cobalt, in New Caledonia, was forced up higher than circumstances warranted. For a long time the price in Europe did not justify more than 90 fr. per ton being paid for this quality of ore at the mines, but the price steadily rose to 330 fr. (about $66) until recently, since when it has receded." The black oxide of cobalt sells at from $2.26 to $2.30 per lb., or the metallic cobalt in the compound brings about $3 per lb. It would thus seem tnat the refiners should make a much larger profit than the miners. The market will not, however, stand a greatly increased production without the price materially decreasing. It is claimed that there has been a combination among refiners to keep up the prices of cobalt products.

A paper recently published, "Cobalt Mining in New Caledonia," by Mr. Colvocoresses, Eng. and Min. Journal, Nov. 28th, 1903, gives a later account of the industry in that country. It is shown that in 1902 the output was 7,512 tons, or nearly double that of any preceding year, the statistics being given from 1889. The prices have kept up better than it was expected they would two years ago, being in September 1903, 350 fr. (about $70) for 5 per cent. ore, with a rise of 12 fr. per ton for each 0.1 per cent. above.

The Abitibi Region

By George F. Kay

In compliance with instructions rereceived from Mr. T. W. Gibson, Director of the Bureau of Mines, an examination was made of the region southwest of Lake Abitibi, which is situated on the boundary between the Provinces of Ontario and Quebec. Part of the area examined was surveyed into townships during the past summer by the Department of Crown Lands.

The object of the expedition was to make a complete report on all points of interest regarding the economic geology and mineralogy of the area. Mr. T. D. Jarvis, B.S.A., of the Ontario Agricultural College, Guelph, accompanied the party during the first five weeks. He directed his attention to the soil and flora, and the result of his work will be found as an appendix to this report.

The party consisted of Mr. T. D. Jarvis, Guelph; H. Davis, King; George McGregor, Sudbury; Joe Blackburn, Copper Cliff, and myself. We took train from Sudbury to Metagama station on the Canadian Pacific Railway. From there, we followed the Hudson Bay Company's route to Fort Mattagami, and thence down the Mattagami river to a portage about three miles below where Niven's 1898 east and west line crosses the river. Here the work began, which was carried on continuously for more than two months. The return trip was made by way of the Blanche route to New Liskeard at the head of Lake Temiskaming.

The work was carried on by following canoe routes and by inland trips made from these routes. This is the only method practicable in a region covered with forest and without roads of any kind.

The routes followed within the area dealt with in this report, and from which inland trips were made, may be summarized as follows :

1 : Eastward from Mattagami river to Night Hawk and Frederick House lakes.

2 : From Frederick House lake, by way of Moose lake and Driftwood river, to Abitibi river.

3 : Up the Black river to the first falls.

4 : From the first falls on the Black river to Fort Matachewan on the Montreal river.

5 : From Wataybeeg lake down the Wataybeeg river to the Black river.

6 : Up the Black river from the first falls to where it is crossed by Speight's north and south line of 1902.

Several of these routes have already been described in the reports of the Bureau of Mines (1) and of the Geological Survey (2).

But in order that the points from which the inland trips were made may be more clearly indicated, and in order that a more connected report of the whole area may be presented, it has been thought advisable, in certain cases, to again describe features dealt with by the former explorers in this region. The routes from the Black river to Fort Matachewan and from Wataybeeg lake to the Black river are here described for the first time.

This report will de divided in three parts, as follows :

Part I. : The features of each part of the area examined.

Part II. : The features of the area as a whole, its topography, its resources, etc.

Part III. : The rocks of the area, their megascopic and microscopic characters.

(1) Bur. Mines, Vol. 8, pp. 175-180; do. Vol. 9, p. 129; do. Vol. 12, pp. 185-187; Report of Survey and Exploration of Northern Ontario, 1900, pp. 27-29.

(2) Geol. Sur. Can. Sum. Rep. 1901, pp. 121 122.

Part I: Physical Features

Mattagami to Night Hawk

The portage, which leaves the Mattagami river about three miles below the crossing of Niven's east and west line of 1898, indicated by its condition at the time of our visit, that it was rarely used. It runs eastward, and is about one mile twenty chains in length. The first eighty chains is wooded with spruce, balsam, birch and poplar; the soil is a gravelly sand; and the last twenty chains passes over a jackpine plain. A low ridge crosses the portage about forty chains from the river; it consists of greyish green chloritic schist. Along this ridge a short distance to the south of the trail is a small segregation of glassy quartz. The portage ends at a small lake surrounded by jackpine and spruce. Its shores are low, its water is clear, and its bottom very soft.

Delbert and Jarvis Lakes

A portage of ten chains over a gravel ridge reaches Delbert lake, which is eighty chains long, and has an average width of about twenty chains. Near the north shore about forty chains from the portage is an island of rather soft, chloritic, somewhat schistose rock, with small segregations of quartz. Similar rock is exposed along the north and south shores. The strike of the schist, where best shown, is nearly east and west, the dip being nearly vertical.

A trip was made northward from a small bay to the north of the west point of the island. The first twenty chains reveals several outcrops of schistose rock; then follows low ground covered with small spruce for one hundred and twenty chains; the succeeding sixty chains are marshy, but low ridges of basic eruptive rock are here and there exposed. No soil of value was seen.

The portage from Delbert lake is nearly straight south of the island. It is twenty chains in length and leads to Jarvis lake, which stands at a somewhat higher level than Delbert lake. Between the two lakes is a ridge of metamorphosed basic rock, carrying iron pyrites. Jarvis lake is about sixty chains long and averages about twenty chains in width. It is divided into two distinct parts by a constriction. Several outcrops of rock, resembling those of Delbert lake, are on the southern shore, but their more distinct schistosity suggests that they have been subjected to greater dynamic action. The outlet of the lake is at its eastern end; it is small and unnavigable. The portage is on the southern shore about fifteen chains from the outlet.

A trip was made southward from where the portage leaves Jarvis lake. The distance to Niven's east and west line is about two miles. The area passed over was mainly rocky, the rocks being greenstones and schists, in places carrying iron pyrites. Some fairly good poplar, spruce, birch and cedar were seen.

Niven's line was struck near IX. M. 45 chains. This line was followed eastward to VIII. M. 50 chains. Near IX. M. 35 chains is an outcrop of green schist with a strike N. 60 degrees W., and a dip of 60 degrees. The timber along the line consists of black spruce, cedar and poplar. Just to the east of VIII. M. 50 chains is an outcrop of fine grained greenish eruptive.

We went northward from VIII. M. 50 chains until we crossed the portage leading from Jarvis lake; the first twenty chains consists of clay soil covered with good spruce and balsam; this is followed by rocky undulating country, the rocks being green schists. At a distance of sixty chains from the line, a creek flowing east of south was crossed. About ten chains beyond the creek is an outcrop of light-colored altered acid porphyry. From here to where the trail was intercepted the country is quite level, parts being low and covered with dead tamarac.

The portage from Jarvis lake is about one mile sixty chains in length and leads to a fairly large stream. In the first three hundred feet from the lake there is a rise of about twenty-five feet over a ridge of chloritic schist; the next thirty chains reveals no rock but a somewhat level area covered with spruce and poplar; this is followed by wet ground well wooded with cedar and spruce for about fifteen chains; then the surface rises and exposures of decomposed eruptive rocks are to be seen, some of which contain small segregations of glassy quartz. The rock exposures are more or less continuous for about fifteen chains, when low rather swampy ground was again entered. This continued to the end of the portage.

The stream where reached is about eight feet wide and sluggish. This sluggishness is due to the fact that beaver are at present operating here, and by their dams are raising the water. Many evidences of moose were seen along this stream. The creek runs east of north and was followed for about one mile and twenty chains, when a portage was taken to the east. The creek is very crooked and has a marshy area on either side. The banks are of clay. The portage is rather difficult to locate; it leaves the creek from a point of spruce on the eastern side. It is about one mile sixty chains in length and ends at Porcupine lake. This trail passes over a low area for about twenty chains, when it crosses a large outcrop of acid volcanic tuff; beyond, the trail passes over a low area, in places wet and covered with spruce, balsam and tamarac. About one mile ten chains from the creek, a stream fifteen feet wide and two feet deep was crossed, flowing S. 50 degrees E. The remaining part of the portage is low with no rock exposures.

Porcupine lake and its surroundings have been described by Dr. Parks (3), therefore a detailed description need not be given here. The rocks are confined to the southern and eastern shores, the north shore being low. The outcrops are considerably decomposed, and are of a basic type; the presence of serpentine suggests that the original rock was olivine-bearing. On a rocky island in the lake, distinct glacial striae were seen with a direction S. 30 degrees W. This lake abounds with pickerel and pike.

Whitney Township

An inland trip of four miles was made eastward into the township of Whitney, from a point on the shore of the lake about twenty chains south of the outlet. The first twenty chains from the lake are fairly level and covered with good spruce; at a distance of about forty chains is a low swampy area with cedar twelve inches in diameter and forty feet in height, and with spruce twelve inches in diameter; the next sixty chains is fairly level, the soil being clay, the timber spruce, balsam, birch and poplar. At a distance of about one mile twenty chains from the lake, a low outcrop of quartzose mica schist was seen. Beyond this, the soil becomes gravel and sand, until at about one mile forty-five chains a muskeg was entered, which continues until two miles sixty chains from the lake is reached; the muskeg extends some distance to the north and south and is covered with small spruce. Beyond the muskeg the country becomes level and the soil clay. At about three miles ten chains, a creek ten feet wide and three feet deep was crossed. It flows in a northerly direction, and its banks are of clay. Farther east, the region is level, consists of clay soil, and is timbered with small spruce.

(3) Bur. Mines, Vol. 8, p. 176.

The Porcupine River

The outlet of Porcupine lake is in the northeast corner. Where it leaves the lake, it is shallow and about fifteen feet wide. For half a mile it flows through an open marsh, beyond which, it widens to about fifty feet. At two miles down, a small stream enters from the southeast. A portage route leaves this creek for Night Hawk lake (4). About four miles beyond this small creek, there is a shallow rapid over boulders. From the creek to the rapid the shores are low; the timber is chiefly spruce and poplar.

For one mile twenty chains west from the rapid, the region is level, the soil clay, and the timber chiefly spruce, balsam and poplar. A large creek flowing nearly north was crossed at about one mile thirty chains. Beyond this creek, the region becomes more swampy; occasional outcrops of schistose rock protrude. At a distance of two miles forty chains from the river, the region is rather low and level and is covered with small spruce.

A trip was made eastward from the Porcupine river about two miles below the small rapids. While we were making this trip, the canoemen followed the river with canoes and supplies, and we joined them where Niven's meridian line crosses the river. Our trip was straight east, and at the end of about three miles, we again struck the Porcupine, here flowing southward. The area crossed lies in the township of Hoyle. At a distance of about twenty chains east, from our starting point, a creek fifteen feet wide and flowing to the Porcupine was crossed; it has a swift current and dark water. At a distance of one mile thirty chains, another creek, which flows southward, was crossed. The area lying within this large bend of the Porcupine is fairly level and consists of clay soil. The Porcupine was followed from the crossing of Niven's meridian line to Night Hawk lake. Its course is rather crooked, and in most places its shores are low and timbered with fairly large spruce. There are two small rapids which can be run. The rocks observed along this part of the river were principally schists, but on a small island in the river near Night Hawk lake is an outcrop of slate with a strike N 75 degrees E.

Night Hawk lake has been described by Parks (5) and Burwash (6). Only the notes which were taken while going to points from which inland trips were made will be added here.

(4) Bur. Mines, Vol. 8, p. 176.
(5) Bur. Mines, Vol. 8, pp. 175-176.
(6) Bur. Mines, Vol. 6, p. 180.

A stream enters the lake from a large marshy area on the west shore about three miles south of the mouth of the Porcupine. This stream was ascended for about a mile, and then a trip was made westward to Niven's meridian line. The creek, for some distance before it empties into the lake, winds through a marshy area. Submerged camping grounds and drowned trees over areas of many acres indicated that the season had been one of more than ordinary rainfall. From the creek westward to Niven's line the area is level and the soil sandy. Outcrops of coarse-grained hornblende-mica dolerite (7), and olivene dolerite were observed on a point extending into the lake south of the mouth of the creek mentioned above.

The Redstone river, which enters the lake about seven miles south of the mouth of the Porcupine, was next ascended. The first rapid is just above where the river was first crossed by Niven's meridian line, namely, near M. 117. The rapid is due to a ridge of dark green, fine-grained, aphanitic rock. Below the rapid, the river has low, marshy shores, its average width being about one hundred feet.

From this first rapid a trip was made eastward to the shore of Night Hawk lake. The distance is about two miles sixty chains. The first forty chains from the river is undulating and timbered with good spruce and birch. Beyond, the region gets lower, and in many places marshy. Near the lake the surface rises somewhat and the timber increases in size; no rock was seen.

A trip west from the rapids struck the Redstone again in about one mile. The soil is in places clay, and in places sand. Just above where the river was struck, is a long shallow rapid over boulders. Below, the river is crooked and filled in many places with driftwood. The Redstone is not used by the Indians above the first rapid. About half a mile above this first rapid, is an exposure of greenish aphanitic rock. Just above this outcrop, a stream thirty feet wide enters from the left. The Indians say that the Redstone takes its rise in a large muskeg several miles to the west.

Indians were camped on a small island in Night Hawk lake, a short distance out from the mouth of the Redstone. We camped on an island about one mile south of this, and there found that potatoes, squashes and onions, which had been planted by the Indians, were in a thriving condition. The soil of the island consists of fine stratified clay, underlain by soft greenish altered eruptives. Where the rocks are not covered they exhibit exceedingly well the gouges, grooves and striations produced by the Glacial ice. The striae on the northwest point of the island have a direction S. 10 degrees E. On the west side, the laminae of the clay are horizontal and contain numerous well-formed yellowish concretions. Some of them show distinctly that they have had stems or other organic material as nuclei, and that growth has taken place by the accretion of layer upon layer. Some features in regard to concretions are not yet fully understood, although considerable study has been given to them (8).

McLeod's point lies to the south of the island. Here huts have been erected on a bluff of till, which rises to a height of nearly thirty feet above the level of the lake. Nearly all the boulders in the till are of Laurentian and Huronian aspect. After some search a Devonian fossil was discovered. This had, no doubt, been carried down in the drift, during the Glacial period, from the Devonian to the north. A short distance eastward along the shore is a low area, beyond which are cliffs of stratified clay, which rise from twenty to twenty-five feet above the level of the lake. The stratification extends to the very top. The cliff has an almost vertical face and extends along the shore for about three hundred and sixty feet. It has a fairly steep slope at both the east and the west end. At the west end, facing the lake, the laminae are crumpled and contorted. The contortions are more marked near the top of the cliff than at the bottom, and, when followed eastward along the face of the cliff, soon die out horizontally. They are probably due to a readjustment of the beds, and not to alternate freezing and thawing, or to ice push, although these factors may have contributed to some extent.

Night Hawk River

The Night Hawk river was next ascended for about six miles, and then a trip was made to the westward. For the first twenty chains of the trip from the river, the soil is clay; the succeeding sixty chains is rather low and swampy, the timber being spruce and balsam of fair size. This is followed for forty chains by a fairly level gravel

(7) Dolerite is used in this report to include the diabases and certain rocks of similar composition, but which do not show the ophitic texture. See Part III.

(8) Amer. Naturalist, Sept. 1884; Concretions from the Champlain Clays, by J. M. Arms Sheldon.

area; beyond this, for forty chains, is considerable swamp and open marsh. Between the second and third miles from the river, is a ridge of fine-grained chloritic rock carrying iron pyrites. This ridge is about sitxy-five feet above the surrounding marshy area, and from its summit the country northward was seen to be low and somewhat marshy as far as Night Hawk lake. Westward from the ridge, low ground was again soon reached. From here on, the surface is in many places wet and covered with small spruce. At a distance of about three miles forty chains from the river, a wide marshy creek was encountered, and as the country for some distance ahead had the appearance of being wet and marshy, we considered it advisable to proceed no farther.

Frederick House Lake

Having returned to the river, we went back to Night Hawk lake and thence to Frederick House lake. The part of Night Hawk lake, passed through in going to the outlet, contains many islands, some of which consist of bare rock and some of stratified clay. The shore at several places presents high cliff-like exposures of distinctly laminated clays. The widths of the laminae vary; some are less than one inch, some more than eight inches. These clays also contain exceedingly well-formed concretions.

Frederick House river, which unites Night Hawk and Frederick House lakes, has a slow current and is about two hundred and fifty feet in width. It flows through a low swampy area, and no outcrops of rock were seen between the two lakes.

From a bend in the river about two miles south of Frederick House lake, a trip was made westward into the township of Matheson. The first half mile from the river is level, the soil being in part clay and in part gravel; this is followed, for about one mile, by swampy ground, when a stream fifteen feet wide and flowing S. 40 degrees W. was crossed. Beyond the creek, the region is low and marshy, the soil being chiefly sand and gravel, and the timber spruce, birch and poplar.

Very little time was spent on Frederick House lake, as Dr. Parks had already described it (9). A small, rocky island in the southeastern part of the lake was examined; the rock is fine-grained and aphanitic, its surface showing flowage structure. This is no doubt a surface volcanic. Distinct glacial striae on this island have a direction S. 5 degrees E.

(9) Bur. Mines, Vol. 8, p. 177.

A trip was made into Dundonald township from the head of a large bay, which lies northeast of the rocky island mentioned above. The first mile and forty chains is a rolling area of clay soil, clothed with poplar, birch and spruce; the succeeding sixty chains passes over a jackpine plain, interrupted here and there by narrow stretches of swamp. At a distance of two miles forty chains from the lake is a low outcrop of silicious, fine-grained rock, very similar to that on the rocky island of Frederick House lake. Three miles from the lake the region is dry and level, the soil sand and gravel. The same general features are presented for some distance farther to the east.

Frederick House to Abitibi

In the south end of Frederick House lake is a constriction, which leads into a narrow lake extending south for about two miles. This lake has clear water and is surrounded by small spruce and poplar. Near the constriction a Hudson Bay Company post once existed. Its factor, it is said, having been held in disfavor by the Indians, was cruelly murdered by them. A portage leads from a small creek in the southeast corner of the narrow lake to a small lake with low shores covered with spruce and poplar. This lake abounds with large pike.

From the south shore of the small lake a trip was made westward to Frederick House river. The first mile is rolling, the soil in places is clay and in places sand; the timber is poplar, birch, spruce and in places cedar of fair size. From the rolling area there is a rather sudden descent to a spruce swamp, which extends to the river.

Township of German

A trip was also made eastward from the south end of the small lake into the township of German. At a distance of less than twenty chains is a small kettle lake, and in the course of the next mile three more lakes of similar origin were seen. These lakes are surrounded by steep banks of gravel and contain most beautifully clear water. The area passed over in the first two miles was a rather open jackpine plain; in places large scattering white pine were seen and some poplar and birch. Between the second and third miles, the surface is rather low, in places swampy. Near the third mile, clay soil begins and continues for more than forty chains. Between the third and fourth mile, a high tree was climbed and the following notes taken :—

For fully five miles to the eastward, the region is fairly level and appears to be covered with spruce, poplar and tamarac. To the north and south as far as the eye can reach, the region is of low relief and of rather monotonous appearance.

Having returned to camp, we followed the route in a southeasterly direction over an open jackpine plain to a small lake, from which a portage of about two miles leads to another small lake. From the north shore of this lake, a trip was made westward. For twenty chains there is a jackpine plain, then follows a rolling area covered chiefly with spruce and poplar. At about sixty chains, a shallow marshy creek, from a small lake to the north, was crossed. Westward from the creek for about ten chains, the region is high; the soil is clay, and the timber spruce, birch and poplar. Still farther west, the region is fairly level, in places marshy.

Moose Lake

Continuing our course from the small lake, we crossed a portage about two miles twenty chains long. It runs somewhat south of east and ends in a small pond, from which a very winding stream was followed to Moose lake. The first forty chains of the portage is undulating, the soil being clay, the timber spruce and poplar of fairly large size; the next sixty chains passes over a fairly level jackpine plain; then comes a wet and marshy area, over which portaging is difficult. It is a typical spruce swamp and continues to the end of the portage.

The creek which passes out of the southeast corner of the small marshy pond is very crooked and has a width of about twenty feet, except where nearly choked by alders and other shrubs. The area bordering this stream is low and marshy and clothed chiefly with spruce. The soil of the banks is clay. Paddling steadily, it took about two hours and thirty minutes to go from the small pond to Moose lake. For some distance before the lake is reached, the stream passes through a wide marsh.

Moose lake is about two miles long and one mile wide and has low shores. (10). It is everywhere shallow and presents a dreary, desolate appearance. At the time of our visit scores of ducks were seen in the vicinity.

(10) Bur. Mines, Vol. 8, p. 179.

Driftwood River

Driftwood river leaves Moose lake from the north end. Here it is about fifty feet wide and quite deep. The first ten miles of the river is free from obstruction, beyond which it is filled with driftwood at many places. (11). The miscoscopic examination of a light-colored aphanitic rock, from the first outcrop on the river from Moose lake, proved interesting. It is a devitrified glass which still retains its perlitic texture. More will be said of this rock in Part III. The Driftwood river empties into the Black a short distance above where the latter joins the Abitibi.

Up Black River

The Black river was ascended for nine miles, and then inland trips were made westward and eastward. The westward trip was into the township of Taylor, the eastward into the township of Carr.

The first half mile from the river going westward reveals an undulating surface of clay soil covered with good spruce and poplar. At the end of this distance, a stream about twenty feet wide and running N. 30 degrees E. was crossed. Beyond this creek for half a mile, the region is quite level and consists of clay soil; the same is true as far west as the Driftwood, except that the dry clay areas are occasionally interrupted by short stretches of spruce swamp. In most places this area is well supplied with small streams.

The trip eastward from the river was through an area which had been overrun by fire a few years before. The surface is undulating, the soil clay. This area is well drained, and with very little difficulty could be made ready for cultivation. This applies to at least three miles back from the river, and conditions appeared similar for some distance farther eastward.

The first falls on the Black river is close to the boundary between the townships of Carr and Bowman. The drop of this fall is about twelve feet over a massive green dolerite. From a small bay-like part of the river straight west of the falls is a portage, the first of the portages on a route which leads to Fort Matachewan. The same route may be used as far as Separation lake in going to Temiskaming. From Separation lake one turns aside from the Matachewan route and follows a series of lakes and portages to the Blanche river and thence to Temiskaming.

(11) Bur. Mines, Vol. 8, pp. 179-180.

First Falls to Matachewan

As mentioned before, this route leaves the Black river by a portage from a small bay-like expansion below the first falls. About one hundred yards west from the river one comes upon McDougall's clearing. A few hundred yards to the north of this are some Indian wigwams, and a small patch of cleared ground. No one was occupying the wigwams or McDougall's house, but the fact that none of the furnishings had been removed indicated that they had not been permanently abandoned. McDougall's house is neatly built and is provided with stoves and other modern furniture, which give one the feeling that he is no longer in the land of the tent and the wigwam, but in some part much less remote from civilization. The clearing around the house was not under cultivation, but in the small patch of ground around the wigwams, fine potatoes were growing. It was here that Mr. Wilson of the Dominion Survey took a sample of soil, which on analysis proved to be supplied with all the elements of fertility (12).

From the clearing to the end of the portage, which runs a little west of south, is about one mile. The area passed over is undulating, the soil clay, and the timber white spruce, balsam and poplar of good size. The portage ends at a small lake, which is about twenty chains in length and has low, grassy shores.

A portage leaves this small lake from the southwest corner. It is only a little more than ten chains long and crosses a gravel ridge which resembles an esker. It leads to another lake which has low shores and beautifully clear water, and from which a small creek flows from the southwest corner. The trail from this lake is almost two miles in length, runs west of south, and leads to a small marshy creek. The first sixty chains passes over a rolling area of good clay soil covered with large spruce and poplar; the next twenty chains is rather low and wet; the remainder of the portage is a jackpine plain.

The small marshy creek at the end of the portage flows into a pond, on the west shore of which are many boulders, all of Laurentian and Huronian aspect. The drainage of the pond seems to be by seepage, since it has no outlet. The portage leaving the pond follows for a short distance the edge of a marsh, then it rises to a jackpine plain, over which it continues for more than forty chains to Troy lake. Troy lake is low and marsh and is surrounded by small jackpine. Drowned trees, at some distance out from the shore indicated that the water was higher than formerly. The lake is about forty chains long in an east and west direction and about twenty chains across. The portage from the lake is about twenty chains in length and ends in a small pond, from which a portage of about sixty chains, over a jackpine plain, leads to Cherry lake.

(12) Geo. Sur. Can., Sum. Rep. 1901, pp. 121-122.

Cherry and Grave Lakes

At the north end of Cherry lake is a large open space, which suggests that at one time there may have been an Indian settlement here. To the southward beyond the lake, hills rise conspicuously from the surrounding level area. Cherry lake is about sixty chains long and twenty chains wide. Its waters are clear, and its shores are low and clothed with spruce and jackpine.

The portage from this lake is more than one mile forty chains long, runs somewhat south of west, and leads to Grave lake. The first eighty chains is low and marshy, the remainder a jackpine area. Near the end of the portage is a ridge, from which there is a descent of about thirty feet to the level of the lake.

Grave lake is a pretty sheet of clear water surrounded by jackpine. It is crossed in a southerly direction, then a portage of one mile thirty chains, with one small intervening lake, reaches a pond just north of Bethea lake. This pond receives the waters of Bethea lake by a swiftly flowing stream, which from the pond probably flows to the Black river.

Bethea Lake

Bethea lake is larger than any of those thus far described on this route. It is irregular in outline and is over a mile in length in a direction northwest and southeast, and is half a mile in width. It has clear water and is very shallow in the northwest. The first rock outcrops from Black river were seen on the shores of this lake. On the east shore is a rocky bluff, which rises about one hundred and sixty feet (aneroid) above the level of the lake. This bluff consists of a somewhat schistose doleritic rock. Similar rock, but somewhat more massive, was seen on the south shore and also on the north shore to the west of the stream by which the lake was entered. The shores of the lake, where not rocky, are of sand and gravel.

From the northwest bay of the lake, a trip was made for about half a mile to the top of a high ridge of dolerite, which runs N. 50 degrees W. It is interesting to note that a pebble about three inches in diameter of banded hematite and jasper was found on this ridge. This is evidence that iron range lies to the north, but, owing to the scarcity of outcrops in that direction, due to the prevalence of drift, it is doubtful whether it be exposed.

A climb to the top of the rocky bluff on the east shore of the lake, enables one to get a good idea of the surrounding country. The general appearance of the region to the north, west and south is one of moderate relief, but in the directions N. 70 degrees W., S. 50 degrees W. and S. 10 degrees W. prominent ridges may be seen miles in the distance. As far as could be discerned, the timber is spruce, jackpine, poplar and white birch.

Continuing our course, we ascended, about half a mile, the small creek which enters the lake in the southeast. It is very crooked and flows through a wide marsh. At the head of the creek is a muddy lake, so shallow that we found it difficult to paddle in it. This lake, which we named Gowan lake, is over half a mile long and has low gravel shores. The route leaves the lake from a bay in the west.

From Gowan to Harold lake is two miles, and from Harold lake to Davis lake is one mile and twenty chains. The direction of both of these portage is about S. 20 degrees W. There is no change in the topography, the timber or the soil.

Dav.s Lake

Davis lake is a beautiful sheet of clear water about a mile in length and half a mile in width. On the northeast shore are two small outcrops of rock. The northerly one consists of a massive pyritous dolerite; the southerly one is a coarsely crystaline quartz syenite, in which there is a very small percentage of ferromagnesian constituents. These rocks are exposed only at the water's edge, and it is impossible, owing to the presence of drift, to ascertain which rock is the later. Distinct glacial striae running south were observed. Farther south is another low, glaciated outcrop of light-colored, phanerite rock. The striae here run S. 8 degrees E. The outlet of the lake is in the south end. It very quickly expands into a small lake from which it passes out as a shallow stream fifteen feet wide. The route does not follow this stream, but leaves the small lake by a portage, which, however, crosses the stream in less than half a mile. Where crossed the stream has a width of ten feet and is running S. 40 degrees W. Beyond the creek, the portage runs S. 15 degrees W. and at the end of about two miles twenty chains, Wataybeeg lake is reached. A marshy region lies to the south of the creek for about forty chains; this is followed by an area with a rolling topography, which suggests recessional material; the last mile is dry and level.

Wataybeeg Lake

Wataybeeg lake is one of the largest within the area examined. It consists of two quite distinct parts, the narrows joining them being situated about the middle of the west side of the northern part. The northern part is about three miles long in a northern and southern direction; its greatest width is about two miles. A long sandy point projects into the lake from the east. To the south of this point is a small rocky island, the rocks of which appear to grade from a hornblende albite syenite to a quartz albite syenite. These rocks possess rather unusual features which will be described in detail in Part III. On the east shore of the lake is a conspicuous bluff of sand; a similar bluff is situated on the shore to the north of the narrows. The southern part of the lake is over five miles long but has an average width of less than half a mile. About half way down its western side is a bay, at the entrance to which is a large island. Two streams from the west empty into the bay. The shores of both parts of the lake are fairly high and consist of sand and gravel; the only rock exposed is that on the small island referred to above. The timber around the lake is chiefly second growth, the whole region having been overrun by fire, apparently twenty or twenty-five years ago. The outlet of the lake is at the north just to the west of the portage from Davis lake. This river will be described later.

The route leaves Wataybeeg lake from the south end of the long narrow part. The trail to the succeeding lake, which is small, is about thirty chains in length and passes over a high, open, sandy area, which appears to extend for a considerable distance in all directions.

A Lake on the Divide

A portage of less than twenty chains from the small lake reaches Sunny lake, which is about one mile long and twenty chains wide. This lake has sandy shores and beautifully clear, sea-green water. It lies on the Height of Land and has no outlet.

The Height of Land portage leaves Sunny lake from the southwest corner. It is about fifty chains in length, runs S. 20 degrees W. and ends at a pond, about ten chains south of which is a small lake, whose waters flow southward. From this lake to Kenoja (or Kenozha) lake is about twenty chains.

Kenoja lake is more than half a mile long and about twenty chains wide. A creek flows out from the southwest corner. The route follows the creek for only a short distance, when a portage is taken to the right. An Indian named Baptiste informed us that the creek flows to the Blanche. The portage from the creek runs a little west of south for about fifty chains to another small creek, which flows northward. On the portage about ten chains from the latter creek, is an outcrop of massive granitoid rock. This creek was ascended for about half a mile to a small lake, on the shores of which are numerous granitic boulders. A portage of about fifty chains from the south end of this lake leads to Blackburn lake.

Blackburn lake is irregular in outline and its shores are rocky. The chief outcrops are hornblende schist, the dynamic action being very pronounced; on the east shore of the lake is a dike, the rocks of which grade fram a basalt near its margin to a more and more coarsely crystalline diabase as the distance from the margin is increased.

It may be said in general that from this lake southward along the route, the region becomes more rugged, the drift is thinner, and hence the rock outcrops are more frequent. It should also be added that from here on, some of the timber escaped the fire which, as mentioned above, swept over so large a part of the region.

The trail leaves Blackburn lake from a small bay in the southwest. It is rocky and about twenty chains in length, the exposures being hornblende schist with a strike nearly north and south. Along this portage is birch, balsam and spruce of fair size. This portage leads to Canoe lake, which is about half a mile long. Less than ten chains from the south end of Canoe lake is Tent lake, which is also about half a mile long. On the shores of both lakes are several exposures of altered eruptives.

Separation Lake

A portage of forty-five chains from Tent lake in a direction a little south of west ends at a fairly large body of water, which was named Separation lake, for there are two routes leading out of it, one to the Blanche river, the other to Fort Matachewan. The lake, where entered, consists of a long narrow bay running north and south. The route to Fort Matachewan leaves this bay near the northwest corner, and after a short portage Optic lake is reached. A further examination was made of Separation lake. Just south of the portage to Optic lake is a bluff of chloritic schist. Following the narrow bay to the southward, one passes an island, and rocky shores rise steeply on either side, the distance between the shores being only a few yards. Beyond this narrows the lake widens, and straight ahead is the portage which leads to the Blanche river. Turning westward around a point to the right of the narrows, one enters the main body of the lake, which contains several islands of greenish altered eruptives. Optic lake may also be reached from this part of the lake by following for less than ten chains the shallow stream which flows out to the north of these islands.

Optic, Bird and Turtle Lakes

Optic lake is about half a mile long, and on its shores are scattering white pine and spruce. The route follows the outlet in the northwest. It is very shallow and quickly expands into Bird lake, which is irregular in outline and runs in a southwesterly direction for more than half a mile. The rocks collected from this lake proved to be altered acid porphyry. The shores are covered with jackpine, birch and spruce; occasional white pine and red pine were also seen. The outlet is in the southwest bay, but where it leaves the lake, it is shallow and rapid, and hence Turtle lake is reached by a portage of less than twenty chains, which runs south over a well-timbered area.

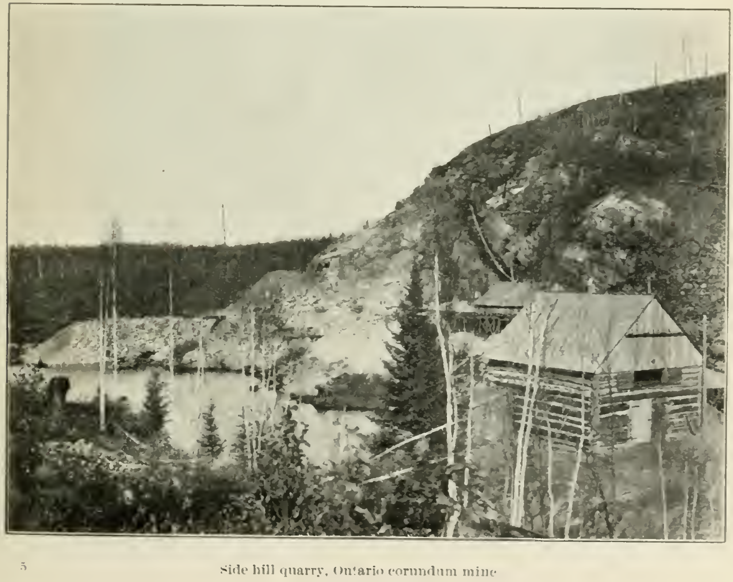
Turtle lake is also irregular, is more than a mile in length, and contains several rocky islands. The rocks are similar to those of Bird lake, but less altered and somewhat less acid. The outlet, which is called Musquataysee or Turtle river, leaves from the west shore, just to the north of where the Indian, Baptiste has a fair-sized clearing and two or three respectable looking buildings. This river, in less than fifty yards, empties into the north end of Baptiste lake, out of which it almost immediately flows again, the inlet and outlet being only a few yards apart.

Baptiste Lake

Baptiste has lived here for thirty years. He cultivates a few acres of land, on which potatoes, turnips and other vegetables are grown. The spot is very pretty and reminds one of the site of a Hudson Bay Company post. About ten chains south of the clearing is an outcrop of coarse-grained massive dolerite carrying iron pyrites.

From the clearing to Fort Matachewan there are two routes; one follows the Turtle river, which empties into the Montreal river just opposite the Mata-

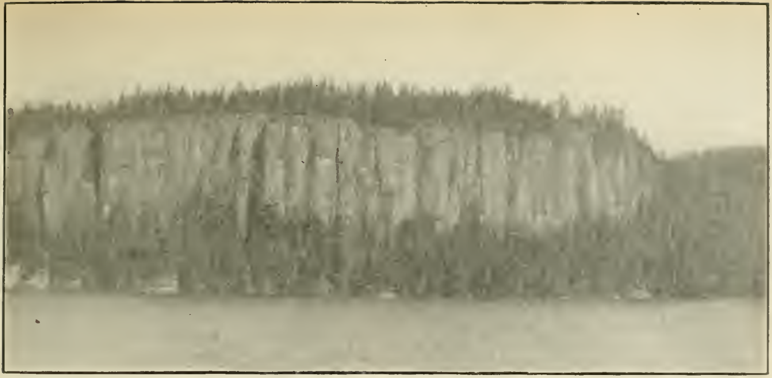
Mill at Ontario corundum mine, erected 1903.



Side hill quarry, Ontario corundum mine

Pit at Radnor iron mine. Grattan township.

Cobbing ore, Olden zinc mine.



Castellated trap cliffs ot Nipigon bay.

Radnor mine: Banded magnetite and silicious material in low grade portions of ore body.

chewan Falls about four miles above the Fort. The other is a lake and portage route and is the better of the two, for the Turtle river is said to be shallow and to have numerous rapids.

Baptiste lake, which is a series of expansions and contractions, is over one and one-half miles in length in a northerly and southerly direction; its greatest width is about one half mile. A portage leaves the south end and runs southwest for about twenty chains over a rather sandy plain to a small muddy lake. From this lake a portage of forty chains leads southward to Narrow lake, which is about one mile long. On the shores of Narrow lake are several outcrops of fine grained, chloritic rocks, which upon microscopic examination reveal their original igneous origin.

A portage from the south end of this lake leads to the Fort, which is situated on the east bank of the Montreal river. This portage winds around a high hill, the distance from the lake to the Fort being less than one mile. The Fort was in charge of Mr. Lafricain, who showed us several samples of iron pyrites and hematite, which he says he obtained in this region.

Route to Temiskaming

We next went back to Separation lake and followed the Temiskaming route for a short distance. As mentioned above, the portage leaves the lake straight south of the long narrow arm and in less than twenty chains a small lake is reached, the shores of which consist of altered eruptive rock. The surrounding timber is second growth. The route follows a creek, which enters in the southeast. A short distance from its mouth is a portage of about ten chains; it is on the west side and is due to a small fall and rapid over a ridge of altered dolerite. From the head of the portage the creek was followed for about half a mile in an eastern direction. It is crooked and flows through a marshy area. A short distance beyond a pond-like expansion in the creek, a small branch enters from the right. The portage leaves the left bank of this branch. The portage was followed for a mile and a half in an eastern direction when a small marshy lake was reached. The area passed over is sandy and is covered with small jackpine and spruce. Near the east end of the portage is an outcrop of quartz diorite, the plagioclase of which is considerably decomposed.

Wataybeeg Lake to Black River

Wataybeeg river flows out of the north end of Wataybeeg lake. Where it leaves the lake it is thirty feet wide and shallow. At the end of about sixty chains is a portage of less than ten chains to avoid a rapid over large boulders. Below the portage, the current is strong, and the river is so filled with large boulders that we found it necessary to let the canoe down by a line. A second portage of less than one hundred paces on the left hand side avoids a small falls over coarse-grained dolerite carrying iron pyrites. Below this portage are high banks of sand and gravel on both sides of the river, which has here a width of more than sixty feet, but is only about one foot in depth. Soon a creek was seen entering from the east. It is said by the Indians that a route beginning with this creek leads to Davis lake. One thing is certain that Wataybeeg river above this creek has been used considerably by the Indians, whereas below, we found that it had never been travelled. It was filled at scores of places with driftwood, around which it was necessary to cut portages. It was necessary also to cut portages around the falls and some of the rapids. This river should never be used, for only very short stretches of it are free from obstructions.

In the course of less than one mile from the creek referred to above, three lakes were seen, one on the right hand and two on the left; the second of the two on the left contains clear, green water. Below this lake is a short rapid over large boulders, and about sixty chains farther down is a fall of about five feet, due to a ridge of pyritous dolerite. An island is formed in the river on each side of which is a narrow gorge.

Falls on the Wataybeeg

About sixty chains farther down is a very pretty fall of thirty feet (aneroid). At the head of the fall the river narrows to about twelve feet then widens as its white waters plunge over the rocky ledges. Three types of rock were seen here, a massive, coarsely-crystalline, pyritous dolerite, a coarse-grained granite and a gray aphanitic rock in the form of a narrow dike in the granite. The timber from Wataybeeg lake to this point is spruce, jackpine and poplar; the soil is sandy.

About a hundred yards below the high fall, the river forms a chute with a drop of about fifteen feet; this was passed by a portage on the right hand side. Below this portage the soil is no longer sand but clay, and the timber is a better grade of spruce. The river is now free from falls or rapids for more than two miles, when there is a drop of four feet over a schistose rock containing much deep green hornblende.

A short distance below this fall nine feet of stratified clay, overlain by one foot of sand, is exposed in the bank; the area back from the river at this point is rather low and level and clothed with large spruce. Similar features were noted during the next two and one half miles down the river.

At the end of this distance an inland trip was made eastward. About four and one-half miles from the river, the northwest bay of Bethea lake was struck. The first half mile from the river is a level clay area followed by higher gravelly soil for about one-half mile, when there occurs a ridge which consists of two distinct types of rock, one a coarse crystalline dolerite, the other a light-colored granite; the line of contact is not well indicated. Beyond the ridge the region becomes swampy, this continues for about one mile twenty chains, when a dry jack-pine area is entered, which continues to and beyond Bethea lake.

A trip was also made to the west from the river. The first mile and a half is level to undulating and consists of clay soil. Beyond, the area becomes lower, the timber being chiefly dry tamarac.

Three miles farther down the river is a fall of about twenty feet, due to a ridge of pyritous quartz diorite schist. Below the fall rapids occur more or less continuously for three miles. In this distance the following outcrops of rock were observed:

1. A very fine-grained aphanitic rock, consisting chiefly of actinolite and chlorite.

2. A considerably decomposed quartz dolerite.

3. A dark aphanitic rock carrying iron pyrites, which proved to be an altered diorite.

4. A rather fine-grained rock with ophitic texture, composed chiefly of augite, plagioclase and quartz.

From these rapids to where the river joins the Black, the banks are low. The soil is clay and the timber, except for a short distance from the mouth, where there is a brule, is spruce, cedar and balsam. The Wataybeeg river joins the Black about thirteen miles from the Abitibi, or about three miles below the first falls on the Black.

Upper Black River

The Black river was ascended from the first falls to the Pike river, which was explored. It joins the Black from the east about one and one-half miles below the third falls. At the mouth this stream is thirty feet wide and has a good current. About half a mile up it becomes shallow and rapids begin. Farther up is a bluff of rock on the left, and just beyond is a fall of two feet. The rocks are altered andesites. Less than half a mile above this small fall the river becomes so shallow and swift and so filled with large boulders that it was impossible to float even a lightly loaded canoe. Being unable to use the river any longer, we made an inland trip eastward to Speight's north and south line.

The line was struck at 28 M. 50 chains. Pike river was twice crossed in making this trip. The area passed over is in part rolling and in part fairly level; the soil is clay, the timber spruce and balsam. Close to the line a rather low area covered with small spruce was entered; this low area appears to be quite extensive, stretching away to the east, north and south.

Having returned to the Black river, we continued our ascent to the third falls and made an inland trip to the west. The first twenty chains from the river is high, then comes a drop to a rather level, clay area, which continues for about sixty chains, when the soil becomes sandy. The sandy area is followed by a muskeg, which has a width of about twenty chains in an easterly and westerly direction, but which appears to extend for a considerable distance to the north and south. The surface of this swamp is of sphagnum moss. A pole, driven down for more than twelve feet, did not strike the rock. The upper nine feet consists of decomposed vegetable matter, below which is a fine blue clay free from grit. Beyond the muskeg for about eighty chains, the region is fairly level, the soil is clay, and the timber spruce and balsam.

From the third falls on the Black river, to where it is crossed by Speight's 1902 line, rock outcrops are quite numerous. They are altered, fine-grained volcanics and rather coarse-grained dolerites. Clay soil is revealed in the banks of the river throughout almost the whole distance. About two miles north of the crossing of the line, second growth timber begins. It is similar to that which was seen on a large part of the area between the Black river and Fort Matachewan. Wilson reports a similar area for some distance to the east (13).

Having completed our work we ascended the Black and White Clay rivers to the Height of Land and then followed the Blanche route to Tomstown, where steamer was taken to New Liskeard.

(13) Geo. Sur. Can., Sum. Rep. 1901, p. 117.

Part II: Topography and Resources

A Drift-Covered Area

Although exact determinations of level have not been made, it is probably safe to say that the area has a general elevation above the sea of about 1,000 feet. The relief is moderate, the greater part of the area being comparatively level or undulating, with here and there ridges, which stand out conspicuously above the surrounding country. The surface is to a great extent drift covered, in this respect differing very markedly from many parts of the area which lie to the south of the Height of Land north of Lake Superior and Lake Huron. Much of the drift is stratified and consists of clay, sand and gravel. These deposits are no doubt lacustrine, the lakes having been formed in Glacial times, in front of the ice, during its retreating stages. The limits of these lakes, at the different periods of their history, could be worked out only by detailed topographic study. There is no doubt however judging from the wide distribution and heights of these stratified deposits, that the lakes were of considerable extent. While the laminated clays were being laid down in the bottoms of these lakes, the sands and gravels were being deposited along the shores or near the margin of the ice sheet.

Drainage Systems

The chief lakes are Night Hawk, Frederick House and Wataybeeg. Besides these, there are numerous other smaller lakes, but their number is not as great as on many other areas of equal size in northern Ontario.

The waters of that part of the area which lies to the north of the Height of Land flow to the Abitibi and thence to James Bay. The largest of these rivers are the Black, the Frederick House, the Porcupine, the Redstone and the Night Hawk. The main branches of the Black are the Driftwood, the Shallow, the Wataybeeg and the Pike. The waters to the south of the Height of Land flow to the Blanche and to the Montreal rivers. All the rivers are very young, possessing V-shaped valleys, and having falls and rapids. The drainage is not well established, for many swamps exist.

Evidences of Glaciation

Where the rocks are exposed, they exhibit the grooves and striations due to glaciation. The surfaces of some of the islands in Night Hawk lake are good examples of roches moutonnées. The directions (magnetic) of striae were observed as follows:

Island in Porcupine Lake	S. 30 deg. W.
West shore of Night Hawk lake	S. 1[illegible] deg. E.
Near entrance to Night Hawk river	S. 16 deg. E.
Island in Frederick House lake	S. 5 deg. E.
Davis lake (northeast shore)	S.
Davis lake (southeast shore)	S. [illegible] deg. E.
Tent lake	S. [illegible] deg. E.
Wataybeeg river	S. 15 deg. E.
Black river (third portage)	S. 10 deg. E.
Pike river	S. 15 deg. E.

Where boulder clay is found, the boulders are quite local. This is well shown in a bluff containing many boulders on the south shore of Night Hawk lake. An examination of these boulders shows that there are very few limestones from the Devonian area, which lies to the north, but that almost all are similar to the rocks of the vicinity. Of course limestone easily disintegrates, and this might account, in part, for its scarcity.

Resources of the Region

The chief resource of the region is its soil, which over large areas is clay, analyses of which will be found in the report of Mr. Jarvis. It may be said that the districts best adapted for settlement are located in the northern part; to be more specific, north of the line which runs west from M 120 on Niven's meridian to the Mattagami river, and north of a line running east from the same point, namely M 120, to M 24 on Speight's north and south line of 1902. South of the line running east the soil is much more sandy than to the north, and since a large part of it has been overrun by fire, the timber is too small to be of value.

Much of the northern area has spruce, balsam, poplar and birch timber, the largest of which is found in the valleys of the rivers, especially in those of the Porcupine, Black, and Driftwood.

No minerals of economic importance were found. As was mentioned before, a pebble of banded jasper and hematite was picked up north of Bethea lake. Mr. Lafricain, of Fort Matachewan, has specimens of hematite, which he says were found in the vicinity.

Climate

No frosts occurred between June 14th and September 1st. Some of the temperatures from the record for the month of August are as follows, and show the highest and lowest points reached :

—	6 a.m.	12 a.m.	6 p.m.
Lowest temperature	35 deg. F. (on the 15th).	54 deg. F. (on the 12th).	48 deg. F. (on the 6th).
Highest temperature	58 deg. F. (on the 18th).	74 deg. F. (on the 2nd)	76 deg. F. (on the 4th).
Average temperature	47.6 deg. F.	62.18 deg. F.	61 deg. F.

It was noted from the condition of vegetation generally, and especially from the date of the ripening of berries, that the season was about two weeks later than in the vicinity of Toronto.

Requirements

Before this region can be of any practical value to Ontario, it must be made accessible. This can only be accomplished by the building of railways. If one may judge by the present activities in this direction, it is safe to predict that before many years many parts of northern Ontario, which are now inhabited only by the Indian. will be centres of agricultural and industrial activity.

Part III: Petrography

As already stated in this report, a large part of the area which was examined is covered with drift, hence the rock outcrops are not very frequent. In fact, the exposures are confined chiefly to the shores of lakes and rivers, and even here, they are so limited that in but few cases was it possible to trace in the field the relationships which the different rocks bear to one another. However, a good idea of the petrology of the region has been obtained from the microscopic study of about eighty rock specimens, which were collected from the various outcrops. Some of these were found to possess interesting and unusual features.

Many of the rocks are igneous, the primary constituents of which have not been greatly changed or the original textures materially altered. Some have been considerably metamorphosed, yet retain distinct evidence of an igneous origin. Others have been so profoundly metamorphosed that all traces of the original rock have been destroyed. Only one specimen, a slate, which occurs on a small island in Porcupine river near Night Hawk lake, suggests an aqueous origin.

Classes of Rocks

The rocks may be classed as dolerites, syenites, diorites, porphyries, volcanic tuff and schists. The schists, as here used, include those schistose rocks which have been so greatly metamorphosed that it is impossible to say whether they are of igneous or of sedimentary origin. It is worthy of note that nearly all the rocks of the above classes contain iron pyrites.

Dolerites

The dolerites, as the term is here used, are medium or coarse-grained phaneritic rocks, which consist chiefly of a plagioclase feldspar and augite, and subordinately of iron pyrites and magnetite; but one, and sometimes several of the following minerals may also be present : olivine, mica, hornblende, quartz, orthoclase and apatite. In texture the rocks vary from ophitic, that is the plagioclase feldspars are lath-shaped and are enclosed in the augite, as in the case of diabase, to panautomorphic, in which both the plagioclase and augite possess their proper crystal forms more or less perfectly. Many of these rocks are similar to those which are frequently described as gabbros, or, from hand specimens, as diorites.

The dolerites are the most widespread rocks of the area. Specimens were collected from the following localities :

1. The portage between Delbert and Jarvis lakes.
2. A point on the west shore of Night Hawk lake between the Porcupine and Redstone rivers.
3. Along the Driftwood river.
4. The shore of Bethea lake.
5. The east shore of Davis lake.
6. The southeast shore of Blackburn lake.
7. Between Baptiste and Turtle lakes.
8. South of Separation lake on the Temiskaming route.
9. Several places on the Wataybeeg river.
10. Between Wataybeeg river and Bethea lake.
11. Several places on the Black river.

Two specimens with crystals about two millimetres in diameter were collected quite close to each other, on the north side of a long point on the west shore of Night Hawk lake, between the Porcupine and Redstone rivers. They exhibit quite different features. One specimen contains large crystals of plagioclase and augite, both of which have fairly definite crystal outlines. The crystals of plagioclase are frequently bordered by orthoclase, and in some cases there is an intergrowth of the pyroxene and of what appears to be primary hornblende, the latter partly surrounding the former. There is also present a considerable amount of decomposed biotite, a little quartz, some calcite, large crystals of apatite and some chlorite. The other specimen consists of augite, a considerable amount of olivene, plagioclase, a small amount of mica and some magnetite. The texture is coarsely ophitic. The former of these two specimens has the following composition (14):

	Per cent.
SiO_2	51.50
Al_2O_3	18.81
Fe_2O_3	4.30
FeO	6.41
MgO	2.90
CaO	6.78
Na_2O	4.84
K_2O	1.76
TiO_2	.40
H_2O, CO_2,	2.41

From this analysis the norm was determined and the rock classified according to the quantitative system (15). The result was as follows:

Class II.—Dosalane.
Order V.—Germanare.
Rang III.—Andase.
Subrang IV.—Andose.

A specimen from the northeast shore of Davis lake is a dark phaneritic rock with ophitic texture. Besides the augite and plagioclase, there is some quartz, magnetite and a small amount of biotite. The augite is in part altered to chlorite.

A dark coarse-grained phaneritic rock, obtained just south of Baptiste's house, between Baptiste and Turtle lakes, shows very little decomposition. The minerals present, besides the augite and calcic plagioclase, are quartz, a small amount of hornblende and biotite, magnetite and acicular crystals of apatite. The texture is panautomorphic. A dark, coarse-grained phaneritic rock from an outcrop at the foot of the second portage on Wataybeeg river, contains a considerable amount of augite, partly altered to chlorite; the plagioclase crystals are quite distinctly automorphic. An interesting feature is the presence of small patches of most perfect graphic texture, due to the intergrowth of primary quartz and orthoclase.

A specimen from the head of the 35-foot fall on the Black river north of where Speight's 1902 line crosses the river is a green, aphanitic rock, considerably decomposed. It contains an altered orthorhombic pyroxene, a light-colored hornblende, which is probably actinolite, decomposed plagioclase, secondary quartz and a small amount of altered mica.

Several specimens consisting almost entirely of secondary minerals are probably altered dolerites.

(14) Analysis by Mr. A. G. Burrows, Provincial Assay Office, Belleville.

(15) Quantitative Classification of Igneous Rocks by Cross, Iddings, Pirsson and Washington.

Syenites

Perhaps the most interesting of all the rocks of the area were collected on a small island in Wataybeeg lake. Two quite distinct types were found, one of which has been called a hornblende-albite syenite, the other a quartz-albite syenite.

The hornblende-albite syenite is a medium-grained phanerite, the individual grains having a diameter of about one millimetre. This rock consists of about equal proportions of light-colored minerals and of the dark ferromagnesian minerals. The light-colored minerals are feldspars, no quartz being present. The feldspars have a pale pinkish color, pearly cleavage surface, and in patches they exhibit poikilitic effects. The ferromagnesian minerals are hornblende and biotite, the former predominating. In thin section, the prevailing texture is poikilitic; but certain parts present a somewhat graphic texture, due to the interlocking of the crystals; the only constituent, other than the accessory minerals, which approaches automorphism is the hornblende.

The feldspars consist of a plagioclase feldspar and microcline. The plagioclase feldspar was proven, by means of its index of refraction and angle of extinction, to be albite. The albite and the microcline assume several relationships; in some cases, the microcline is poikilitic in the albite; in some cases, the opposite is true, that is, the albite is poikilitic in the microcline; again, the two minerals are coarsely intergrown, in which case an approach to graphic texture is presented, but further examination shows that the two minerals have a parallel arrangement, and hence the texture is really coarsely microperthitic; the albite and the microcline appear to have grown contemporaneously.

The microcline usually shows poigsynthetic twinning, that is, lamellar twinning according to the albite and pericline laws.

The albite is also twinned, although many of the crystals are so cut that the striations are not apparent; the prevalent twinning is according to the albite law, but a few Carlsbad twins were also observed. The striations of the albite are very narrow and straight. Of the two feldspars, the albite has suffered the greater amount of decomposition, although both are comparatively fresh.

The hornblende usually occurs in irregular crystals, although automorphic forms in sections cut across the prisms also occur; in such cases the characteristic cleavage is quite perfect. The pleochroism is from a light-greenish brown to green.

The biotite occurs in irregular shaped plates. Its color is brown. The ferromagnesian minerals are poikilitic in the feldspars; both the biotite and the hornblende are somewhat altered.

The subordinate minerals are sphene, which occurs in orange-yellow irregular crystals, and apatite, which is quite abundant in well-formed prisms, some of which are colored by iron oxide. The secondary minerals are a fibrous light-colored hornblende, which is probably actinolite, a light-green chlorite and calcite.

An analysis of this rock by Mr. A. G. Burrows of Belleville, Ont., gave the following result :—

	Per cent.
SiO_2	56.62
Al_2O_3	16.33
Fe_2O_3	trace.
FeO	4.21
MgO	7.65
CaO	5.12
Na_2O	4.34
K_2O	2.68
TiO_2	.26
CO_2, H_2O, etc.	2.70

From this analysis the norm was determined and the rock classified as follows :—

Class II. Dosalane.
Order V. Germanare.
Rang III. Monzónase-Andase.
Subrang IV. Akerose-Andose.

Measurements were made of the minerals present in this rock and the mode determined (16).

The result was as follows:

	Per cent.
Albite	27.80
Microcline	17.54
Biotite	11.15
Hornblende	42.45
Apatite	.73
Titanite	.29

(16) Quant. Class. of Igneous Rocks, p. 204.

With these percentages an attempt was made to ascertain what must be the nature of the hornblende to correspond with the composition of this rock as determined by analysis. In this calculation the biotite was assumed to have the composition of the biotite in a quartz-monzonite from Walkerville, Butte, Montana (17).

It was found that the hornblende must be high in silica, high in alumina, high in magnesia, low in iron and low in potassium. A hornblende from Sanlupe was found to have such a composition (18).

Considering the hornblende to have the composition of the hornblende from Sanlupe the rock was classified from the mode. The result was as follows:

Class II. Dosalane.
Order V. Germanare.
Rang II. Monzonase.
Subrang III. Monzonose.

All the constituents agree fairly closely with the chemical analysis except the K_2O, which is too high.

The quartz-albite syenite is found associated with the hornblende albite syenite, the two types seeming to grade into each other. Magascopically, this rock differs considerably from the associated rock, in that it consists almost entirely of light-colored minerals, there being less than 5 per cent. of ferromagnesian constituents. This rock is also different in that it contains quartz, while mica is absent.

In thin section, the texture is seen to be similar to that of the hornblende-albite syenite. The feldspars are albite and microcline, which present the same characteristics as were described in the associated rock, but whereas in the hornblende-albite syenite there was less than twice as much albite as microcline, in this rock the albite is about six times as abundant as the microcline.

The quartz comprises about 13 per cent. of the rock. It is clear and has xenomorphic outlines. It is usually segregated in small patches.

The ferromagnesian mineral is hornblende, which has a rather deep-green color and constitutes about 5 per cent. of the rock. It shows the usual pleochroism, and in some crystals the characteristic cleavage is present.

The accessory minerals are sphene, apatite, zircon, and a small amount of magnetite.

This rock was also measured and the percentage weights determined.

This result was as follows :—

(17) Table XIV. Quant. Class. of Igneous Rocks.

(18) Dana: System of Mineralogy, page 395.

	Per cent.
Albite	69.86
Quartz	13.55
Microcline	11.91
Hornblende	4.26
Apatite	.03
Titanite	.29
Zircon	.06

From these percentages the approximate chemical composition was determined and the rock classified. The hornblende here was assumed to have the composition of the hornblende from Saulupe, as in the case of the hornblende-albite syenite.

The result was as follows :—

Class I.—Persalane.
Order IV.—Britannare.
Rang I.—Liparase.
Sub-rang IV.—Kellerudose.

Specimens, presenting features very similar to those of the quartz-albite syenite, were obtained from the following localities:—

1. The east shore of Davis lake.
2. The 30-foot fall on the Wataybeeg river.
3. Between Wataybeeg river and Bethea lake.

The rock from Davis lake is rather coarsely crystalline and has a small amount of both hornblende and biotite, the latter considerably altered ; quartz is present in an appreciable amount. The albite and microcline show beautiful poikilitic texture.

The rock from the 30-foot fall on the Wataybeeg river is somewhat more decomposed than the quartz syenite from Wataybeeg lake, the poikilitic texture is not quite so pronounced, and quartz is somewhat more abundant. Some of the hornblende shows twinning, and several of the crystals are quite distinctly automorphic. The secondary minerals are chlorite, sericite and epidote.

The rock from between Wataybeeg river and Bethea Lake presents no new features, except that some of the feldspars exhibit zonal weathering.

Diorites

Many of the rocks which in the field were thought to be diorites proved under the microscope to be dolerites. In fact, only one of the specimens collected has been called a diorite, and even this is not a normal rock of that class. It was obtained on the second portage from Separation lake on the Temiskaming route. It is a medium-grained phanerite, with apparently about equal amounts of ferromagnesian and light-colored minerals. The ferromagnesian constituent is hornblende, which varies in color from a yellowish-brown to a deep green; the light-colored minerals are plagioclase, microcline and quartz. The plagioclase is so decomposed that it was impossible to determine its kind ; the microcline exhibits the characteristic twinning and is more abundant than in a normal diorite. Iron pyrites is also present.

This rock resembles the hornblende-albite syenite from Wataybeeg lake, in that it has about equal amounts of ferromagnesian and light-colored minerals, and has two feldspars—a plagioclase and microcline; the hornblendes also of the two rocks are similar. It differs from the Wataybeeg specimen, in that it does not possess the distinctive poikilitic texture, has a considerable amount of quartz, and is free from mica.

A schistose rock, obtained on the Wataybeeg river, contains much deep-green hornblende, some decomposed plagioclase feldspar, a considerable amount of secondary quartz, iron pyrites and magnetite. This has been called a quartz diorite schist.

Porphyries

The word porphyry is here used in a broad sense, and includes rocks which contain phenocrysts of any kind and a ground mass. In many cases, these rocks have been so altered that the porphyritic texture is not detected in hand specimens, although it is quite evident in thin section. A few of the rocks are fine-grained and microporphyritic.

The rocks which megascopically exhibit the porphyritic texture were collected from the shores of Turtle and Bird lakes and from an outcrop at the third falls on the Black river. The Turtle lake specimens are porphyritic, aphanitic rocks, the phenocrysts being albite; the ground-mass of these rocks still retains its original flow structure, but has been entirely recrystallized, the secondary products being chlorite actinolite, epidote and quartz. The metamorphism seems to have been metasomatic rather than the result of dynamic agencies. The rocks from Bird lake are very similar to those of Turtle lake, but they have been more metamorphosed and are apparently more acid.

The rock from the third portage on the Black river is of a green color, and is distinctly porphyritic. The phenocrysts are plagioclase feldspar, which is considerably decomposed; the ferromagnesian minerals have been altered to chlorite. There is some evidence of the original flow structure; this is probably an altered andesite.

The porphyritic rocks which have been so altered that the phenocrysts are not observed megascopically are quite widespread ; some of the most interesting of these will be described.

A dark-green aphanitic specimen, obtained two miles north of Delbert lake, consists entirely of secondary minerals, of which serpentine is the most abundant; long, needle-like, light-colored crystals of actinolite are also present. There is distinct evidence of the outlines of original phenocrysts, between which a ground mass is strongly suggested. The nature of the secondary minerals suggests that the original rock was very basic.

About one mile south of the portage which leaves the south shore of Jarvis lake is a dark green, somewhat schistose, aphanitic rock, which in thin section is micro-crystalline to micro-crypto-crystalline. Although considerably decomposed, a few altered striated feldspars, which possess distinct outlines, are present; the original ground mass appears to have been fine-grained. The minerals, besides the feldspar, are pale-green chlorite, quartz which shows granulation, and a distinct amount of calcite with definite rhombic outlines. There is evidence of crushing in the zone of fracture.

An interesting type of rock occurs about one mile north of VIII. M. 50 chs., on Niven's 1898 base line. It is light-colored, aphanitic and schistose. Microscopically, it exhibits an eutaxitic texture. Lines of flowage are distinct. Metamorphism has effected a general parallelism of the grains at right angles to the original lines of flowage. The altered phenocrysts appear to have been striated plagioclase and quartz. The secondary minerals are a considerable amount of finely granular quartz, some sericite and a white opaque mineral, probably kaolin. This rock is no doubt an altered porphyry of acid composition.

At first the small fall on Pike river is a soft, greenish, non-schistose, aphanitic rock considerably decomposed. In thin section it consists of porphyritic crystals of plagioclase and a micro-crypto-crystalline ground-mass. There is still evidence of the original flow structure and of microlites; the chief secondary product is chlorite.

Micro-porphyritic rocks were collected from a small island in Frederick House lake, from Dundonald township, east of Frederick House lake, and at the fifth falls on the Black river. They are very fine-grained, aphanitic rocks, which, in thin sections, are seen to consist of numerous, small irregularly arranged crystals of plagioclase and a micro-crypto-crystalline ground mass. The rock from Dundonald township contains considerable quartz. These are no doubt altered andesites or dacites.

One of the most interesting of the undoubted surface lavas was obtained on Driftwood river, from the first outcrop below Moose lake. It is a devitrified glass. Megascopically, this rock is of a light-gray color, is rather fine-grained, aphanitic and has a dull lustre. Microscopically, the most striking feature is that the rock is divided by sets of more or less concentric fissures, which give it the globular structure characteristic of perlite. Examined under cross nicols, it is seen to be completely crystallized and to possess some features of peculiar interest. There are numerous patches, which have a radiating arrangement similar to that possessed by spherulites. These patches are found to have no definite relation to the perlitic cracks; in some cases they cross them, while in other cases they are entirely independent of them. They are distinctly a later development than the cracks. A study of the constituents of these patches shows them to be made up of a striated plagioclase feldspar and not intergrowths of feldspar and quartz. Phenocrysts of primary striated plagioclase and of quartz, with fairly definite outlines, are still present. The ground mass consists of fine-grained quartz and plagioclase, some well-formed crystals of calcite, and some pale-green chlorite.

Volcanic Tuff

Only one specimen of an undoubted volcanic tuff was found. It was obtained on the first portage west of Porcupine lake. It is massive, fine-grained and aphanitic. In thin section, the angular shapes and arrangements of the crystals stamp it as a pyroclastic. The chief minerals are striated plagioclase feldspar and quartz, the latter predominating; some chlorite is also present.

Schists

The schists are of various kinds, including chlorite schists, sericite schists, actinolite schists and hornblende schists.

A specimen of a chlorite schist from the first portage east of Mattagami river shows a considerable amount of pale-green chlorite, many light-colored, acicular crystals of actinolite, some quartz, and a light-colored, opaque mineral resembling leucoxene. The quartz has irregular outlines and exhibits undulatory extinction. The best example of a sericite schist was obtained on the southeast shore of Jarvis lake. It is micro-crystalline to micro-crypto-crystalline, and shearing action is very pronounced. The most prevalent mineral is light-colored, scaly muscovite;

quartz and crystals of calcite are also present. The actinolite and hornblende schists have no features of unusual interest.

Generally speaking, the rocks which show the most distinct schistose structure are located between the Mattagami river and Night Hawk lake and in the vicinity of Blackburn lake. The strike of these schists varies considerably. In the vicinity of Delbert lake the strike is approximately east and west; near IX. M. 35 chs. on Niven's 1898 base line it is N. 60 degrees W.; between Blackburn and Canoe lakes it is approximately north and south. The origin of these schists is uncertain, but the absence of undoubted sedimentary beds in the region, and the occurrence of many metamorphosed rocks the origin of which is distinctly igneous, strongly suggest that they are not of sedimentary origin, but are greatly altered and sheared basic and acid eruptives.

The question arises, "What is the age of the rocks which have been here described?" It is known that many are the result of extrusive and intrusive volcanic action. It is also known that many have been subjected to profound dynamic processes. But it has not been possible in the field, owing to the scarcity of outcrops, to determine the relationships of the various rocks to one another, nor to any formation whose age has been determined. Former workers in this field and in the adjacent fields have characterized similar rocks as Huronian, using that term in a rather broad sense to include all the rocks above the Laurentian and beneath the lowest fossiliferous strata (19). With our present knowledge of these rocks, a closer interpretation, as to their age, is not warranted.

Before closing, I wish to convey my sincere thanks to Prof. J. P. Iddings of the University of Chicago for assistance in connection with the rocks here described.

Agricultural Capabilities of Abitibi

By Tennyson D. Jarvis

On June 12th 1903 the writer received instructions from Mr. Thos. W. Gibson, Director of the Bureau of Mines, to join Mr. Geo. F. Kay at Sudbury in a geological, biological, and agricultural survey of the Abitibi region, Mr. Kay being geologist, and the writer biologist and agriculturist for the party. Accordingly, on June 16th the party, consisting of Mr. Kay, Mr. H. Davis, myself and two canoemen, took a freight train to Metagama, 80 miles west of Sudbury, on the main line of the Canadian Pacific Railway. After a night spent on the floor of Metagama station our party embarked in two canoes, one large, one carrying three men, and the bulk of the provisions, and the other carrying two men and some baggage. A two-day paddle up the Spanish river and some small lakes and portages brought us to the height of land.

On Saturday June 20th Fort Mattagami raised its flag in honor of our arrival. Mr. Miller, agent of the Hudson Bay Company there, entertained our party royally, showing us everything of interest at the fort, including his general store, the English church, sawmill, garden, cattle, chickens, etc. The soil at the fort, though very sandy, has been made to yield, by the use of farmyard manure, excellent potatoes, cabbages, turnips, beets, peas, beans and other vegetables, and some small fruits. However, the country we passed through between Metagama and Fort Mat-Mattagami is extremely rocky and not at all suited for farming,—though of value to the lumbermen, being wooded with black and white spruce, poplar and some white pine. Tisdale township, the first scene of our operations, was reached two days later.

I have divided the Abitibi region into nine districts; each district is briefly described, and a summary of the notes taken on the trees, soil, and surface of the country, of the principal water courses, portages and inland surveys is tabulated for each district. The trees are named in order of abundance.

Tisdale Township

The country in this township and neighborhood is very irregular. Some parts are low and swampy with large tracts of muskeg; then again there are numerous rocky ridges which are either bare or too stony for cultivation. The floor of the low land consists of sphagnum and other bog mosses, varying in depth from a few inches to several feet. The soil beneath this floor is mostly sand or gravel.

(19) The Huronian of the Moose River Basin, by W. A. Parks.

Porcupine Lake District

The land in this district is not so low and rocky as it is in Tisdale township. The soil for the most part is sandy, and the country as a whole will not make very good agricultural land. The timber around the lake is chiefly spruce, aspen, birch, larch and scattered clumps of balm of Gileads. Inland in the township of Whitney there is considerable muskeg consisting of small black spruce and larch.

ate vicinity of the river, consists of birch, spruce, aspen, balm of Gilead, black ash, all of which are of a good size, and the land thickly wooded.

Night Hawk Lake

This lake is dotted with islands, a few of which are rocky and bare of flora, while most of them are nicely wooded, giving the lake a picturesque appearance. The banks of this lake on the south and west shores are from 10

Area Traversed.	Trees.			Soil.	Surface of country.
	Kind.	Size.	Quantity.		
Portage leading to Tennyson lake.....	Spruce .... B. Pine .... Balsam .... B. of Gilead	Large...... Medium. " "	Fairly thick Scattered. " "	Clay loam near river bank; sandy over remainder of the portage.	High and dry, and then low and swampy.
Small portage between Tennyson and Jarvis lakes.	Balsam .... Aspen. .... Spruce.....	Large...... Medium. "	Fairly thick Scattered. "	Sandy	Dry and level.
Country surrounding Tennyson Lake..	B. Pine.... Spruce..... Birch. .... Aspen...... Larch......	Large...... " " " Medium.	Fairly thick " " Scattered. "	Sandy	Level country and rocky.
Country surrounding Jarvis lake	Spruce..... B. Pine .... Larch......	Large...... Medium. "	Fairly thick " Scattered.	Sandy	Level country and very rocky.
Inland trip 2½ miles north of Jarvis lake.	Spruce .... Larch. .... B. Pine .... Birch. .. . W. Cedar ..	Small...... " Medium. " "	Large area of muskeg. Rocky areas Scattered. "	Sandy soil below sphagnum moss.	Level, and very rocky in places.
Short portage ¼ mile long between Jarvis and Delbert lakes.	Spruce .... Birch. .... Balsam....	Medium.... " "	Fairly thick " Scattered.	Sandy	High and level.
Trip south to Niven's line from Delbert lake.	Spruce .... Aspen. .... W. Cedar ..	Large...... " "	Fairly thick " Large cedar swamp.	Sandy soil on way to Niven's line; clay soil on Niven's line and on return trip.	Level country, high and dry.
Portage from Delbert lake to Porcupine lake.	Spruce .... Aspen. .... Birch. .... Balsam....	Medium. " " "	Fairly thick Scattered. " "	Sandy soil near Delbert lake, and clay soil near Porcupine lake.	Fairly dry over first part of portage, low and swampy over latter part.

Porcupine River

The country surrounding the Porcupine river is mostly dry, and when cleared will make very good farming land. The soil tested on the banks and in the inland country is mostly clay loam, and is well covered with vegetable matter. For about three miles up the Porcupine river, on either side, there is a swampy tract of land covered chiefly by large larches, which are mostly dead or dying from the attacks of the larch saw-fly. From here on the timber, in the immedi-

to 35 feet high, and vary greatly in composition. Most of the banks are stratified clay deposits, but here and there are glacial deposits of sand and gravel which will be of great value to the settler in road-making. On the north and east shores the banks and surrounding country are very low.

There are many rivers running into Night Hawk lake. These rivers are broad and marshy, having low banks in the vicinity of the lake. In the marshes the yellow water-lily, buckbean, water plantain, beaver hay, rushes, etc., are most common.

In proximity to the lake are large areas of dead trees which have been killed by the water rising in the lake.

The higher land around the lake is well timbered. Here and there are large clumps of black ash and balm of Gilead: spruce, aspen, and birch are also common. On the south shore there is a grove of red pine, some of which will measure about 16 inches in diameter.

On 4th July we visited an Indian garden, which was located on one of the islands on Night Hawk lake. The potato stalks were about seven inches high, and had not been injured by frost. Onions, turnips, carrots and cabbages were all thriving, even with the little care that was bestowed upon them. Among the weeds noticed in the gardens were shepherd's purse, curled dock, lamb's quarters, broad-leaved plantain, lady's thumb, strawberry blight, horseweed, great willow herb and cow parsnip. These grew in great abundance, indicating a rich soil.

On our inland trips from the lake we noticed the surface of the country to be more undulating, and thus drier, a distance back from the lake. This inland country, with the exception of a few low areas near the lake, and occasional tracts of muskeg, will make splendid agricultural country.

Frederick House Lake

On July 11th our party left headquarters on Night Hawk lake and started for Frederick House river. The timber along this river is small, and not of much value to the lumbermen. The soil is clay or clay loam, and the surface of the country is more or less undulating, and thus well drained. This area will make a splendid agricultural district.

The trees around Frederick House lake are fairly abundant but not very large. Excluding a few large sand hills on the northwest side of the lake, the soil is mostly clay or clay loam. This lake, like Night Hawk, is very shallow and subject to sudden storms.

Long Portage District

This district is for the most part a high and dry sand plain, with occasional

Area traversed.	Trees.			Soil.	Surface of country
	Kind.	Size.	Quantity.		
Around Porcupine lake	Spruce	Large	Fairly thick	Clay and sand	Level country
	Birch	Medium	Scattered.		
	Aspen	"	"		
	B. of Gilead	"	"		
	Larch	Small	"		
Whitney township, inland 4 miles east from S. E. shore of Porcupine lake.	Spruce	Large	Fairly thick	Clay soil; gravel and sand area.	Some fair farm land; level country
	Cedar	Medium	Large.		
	Aspen	"	Scattered.		
	Muskeg	Small	Large area.		
	Balsam	Medium	Scattered.		

Area traversed.	Trees.			Soil.	Surface
	Kind.	Size.	Quantity.		
Porcupine river between Porcupine lake and Night Hawk lake.	Spruce	Large	Thick	Clay banks	Level country, when cleared will make good farming land
	Aspen	"	"		
	Birch	"	"		
	Larch	"	Scattered.		
	B. of Gilead	"	Small clumps.		
	Balsam	Medium	Scattered.		
	W. Pine	"	"		
	W. Cedar	"	"		
Hoyle township; 6 miles up Porcupine river; went west 2½ miles.	Spruce	Med'm to large	Fairly thick	Clay banks	Level land, inclined to be a little swampy in places.
	Aspen	Medium	Scattered.		
	Cedar	"	"		
	Larch	"	"		
	Balsam	"	"		
Hoyle township 8 miles up Porcupine; went east 3½ miles.	Spruce	Medium	Thick	Clay soil	Level land and a little wet in places
	Aspen	Large	Scattered.		
	Birch	"	"		

valleys of clay or clay loam. Large Banksian pine are the most common trees on the higher areas, while spruce, aspen and balsam form the bulk of the timber on the lower levels.

Moose Lake

After leaving the third long portage we arrived at a small unnamed lake, where we camped over night. In the morning we crossed this little lake and paddled up Driftwood creek leading out of this lake and flowing into Moose lake.

Driftwood creek is narrow and winding, and deep in many places. Alders, dogwood, and small willows are very thick on the banks, and choke the river here and there. There was good looking clay soil on several bank exposures. This creek or river traverses very level land and within a mile or so of Moose lake there are broad marshes on either side of the river. Ducks were numerous in these marshes and the young were just commencing to fly.

Moose lake is certainly well named. It is practically one large marsh. The yellow water lily, rushes, and sedges are thick over the whole lake and form the ideal feeding ground of the moose. On the banks on the opposite side of the Driftwood creek marsh the trees are chiefly spruce and aspen, with a few birches and a few clumps of balm of Gilead.

Driftwood river flows out of Moose lake into Black river. For the last 6 miles of travel in this river there were many log-jams which greatly impeded our progress.

The trees on either side the river all the way from Moose lake to Black river are abundant and large. At the entrance of the Driftwood river, and for a short distance up the river, there are close to the shore small groves of black ash, and several small clumps of balm of Gilead. The clay banks were from two to several feet high, and the general surface was rolling land, becoming more so as we neared Black river.

Area traversed.	Trees.			Soil.	Surface.
	Kind.	Size.	Quantity.		
Cody township: went up small river ¾ of a mile, and then about a mile into Cody township.	Spruce	Large	Fairly thick	Clay loam	Dry. Farming land
	Birch	"	Scattered.		
	Aspen	"	"		
	Balsam	Medium	"		
Redstone river, 9 miles up from the lake.	B. Ash	Medium	Many small clumps.	Clay loam	Level country.
	Spruce	"	Scattered.		
	Cedar	Large	Swamp.		
	B. of Gilead	Medium	Small clumps.		
	Aspen	"	Scattered.		
	Elm	"	"		
Carman township: left rapids 9 miles up Redstone river and went east towards Night Hawk lake 2¾ miles.	Spruce	Large	Scattered	Clay	Low and swampy over most of this area.
	Cedar	"	Thick in swamp		
	Balsam	Medium	Scattered.		
	Birch	"	"		
	Aspen	"	"		
Dance township: left rapids 9 miles up Redstone river, and went west 2¼ miles.	Spruce	Large	Thick	A few to several feet of sandy soil above clay bottom.	High and dry land. Good place for a pulp mill.
	Aspen	"	"		
	Balsam	"	Scattered.		
	W. Cedar	"	"		
	N. Pine	"	"		
Night Hawk river	Spruce	Medi'm to large	Thick	Clay banks	Level country.
	Aspen	Medium	"		
	Cedar	"	"		
	B. of Gilead	"	"		
	Balsam	"	Scattered.		
	Birch	"	"		
Thomas township. Went up Night Hawk river 9 miles, then crossed Thomas township back to lake 3½ miles.	Spruce	Large	Thick	Clay soil over most of this trip. One sand patch ¼ of a mile across.	Level country, most of it dry and fit for farm land.
	Balsam	Med'm to large	Scattered.		
	Birch	Small	Small area.		
	Aspen				
	Muskeg				
Dundonald township. Went east from Night Hawk lake into Dundonald township 3 miles.	Birch	Large	Scattered	Clay soil over most of area. About one mile of sandy soil covered with B. pine.	Most of this area will make good farm land.
	Spruce	"	Thick.		
	B. Pine	"			
	Aspen	"	Scattered.		
	B. of Gilead	"	"		

Black River

In the Black river district the land, from the Abitibi river to the White Clay river, is mostly rolling, and is thus well drained. From the evidence of many dead trees on either side of this river, for several miles up from its mouth, I should say that the country for several miles around is flooded during the spring season. The timber along the river consists of aspen, spruce, birch, balsam, balm of Gilead, white cedar, larch, and rarely black ash and white elm. Leaving out one large brule, a few thinly wooded areas, and a few Banksian Pine plains, the timber along the banks of Black river is large and of abundant habit.

The soil over the greater part of this area varies from light to heavy clay. Here and there are sand plains or ridges of sand and gravel.

Area traversed.	Trees. Kind.	Size.	Quantity.	Soil.	Surface.
Frederick House river.	Aspen	Small	Fairly thick	Clay or clay loam	Undulating; good farm land.
	Spruce	"	"		
	Larch	"	Scattered.		
	B. of Gilead	"	Small clumps.		
	Willow	"	Scattered.		
	Birch	"	"		
Matheson township, $3\frac{1}{2}$ miles in from Frederick House river.	Spruce	Medium	Fairly thick	Clay over most of area. Sand and gravel ridge about $\frac{3}{4}$ of a mile.	Undulating; good farm land.
	Birch	"	"		
	B. of Gilead	Large	"		
	Aspen	Medium	Scattered.		
	Cedar	"	"		
Frederick House lake.	Spruce	Med'm to large	Fairly thick	Stratified clay banks. Sand banks.	Undulating; good farm land.
	Birch	Large	"		
	Balsam	Medium	Scattered.		
	Aspen	"	"		
	B. of Gilead	Large	"		

Area traversed.	Trees. Kind.	Size.	Quantity.	Soil.	Surface.
Matheson township. Trip inland from Long portage about $2\frac{1}{2}$ miles.	Spruce	Large	Scattered	Very fine sand $\frac{3}{4}$ of a mile; $\frac{1}{4}$ mile clay muskeg rest of way.	High and dry. Swampy.
	Birch	"	"		
	Muskeg	Small	Large area, one mile from portage.		
1st long portage 2 miles long.	Banksian pine	Medium	Thick	Fine sand	High and dry.
German township $3\frac{1}{2}$ miles inland from long portage.	Banksian pine	Medium	Thick	Fine sand; clay for last $1\frac{1}{2}$ miles.	High and dry for first 2 miles, then low and swampy for $1\frac{1}{2}$ miles.
	Spruce	Large	Fairly thick.		
	W. pine	"	Scattered.		
2nd long portage 2 miles long.	Banksian pine	Large	Thick.	Sand	High and dry.
Trip from 3rd small lake to Night Hawk lake.	Spruce	Large	Thick	Sand for first half mile, clay over next 2 miles.	High and dry over most of this area.
	Aspen	"	"		
	Banksian pine	"	"		
	Birch	"	"		
	Muskeg	Medium	"		
3rd long portage $2\frac{1}{4}$ miles long.	Banksian pine	Large	Thick	......	$1\frac{1}{2}$ miles high and dry; last $\frac{1}{4}$ mile very low and swampy.
	Spruce	"	Scattered.		
	Birch	"	"		
	Aspen	"	"		
	Muskeg	Small	Thick.		

Timber of the Region

Following is a list of the forest trees, in order of their abundance:

Black Spruce, (Picea nigra); White Spruce, (Picea alba); Aspen Poplar, (Populus tremuloides); Paper Birch, (Betula papyrifera); Balsam, (Abies balsamea); Balm of Gilead, (Populus balsamifera candicans); Banksian or Jack

Pine, (Pinus banksiana); White Cedar, (Thuya occidentalis); Larch or Tamarac, (Larix americana); Black Ash, (Fraxinus sambucifolia); Norway or Red Pine, (Pinus resinosa); White Pine, (Pinus strobus); White Elm, (Ulmus americana); Soft Maple, (Acer dasycarpum).

Some of the smaller species of trees, in order of abundance, are :—

Mountain Maple, (Acer spicatum); Alder, (Alnus incana); Mountain Ash, (Pyrus americana); Shad-bush or June-berry, (Amelanchier canadensis); Wild Red Cherry, (Prunus pennsylvanica); Mountain Alder, (Alnus viridis); Willow sp., (Salix sp.).

On the level inland country black spruce is the most abundant. The trees measure from 10 to 24 inches in diameter. On the rocky areas and sand plains jack or Banksian pine forms about 90 per cent. of the trees. This tree measures from 10 to 24 inches in diameter. In the swampy areas white cedar and larch are most common. Cedar swamps are fairly numerous and the cedar trees measure from 15 to 30 inches in diameter. Most of the larch trees are dead or dying from the attacks of the larch saw-fly. On the banks of rivers and on the shores of the lakes, where the land is well-drained, white spruce, aspen, birch, balm of Gilead, and black ash are most abundant. Aspen measures from 10 to 18 inches in diameter. White spruce measures from 14 to 24 inches in diameter; balm of Gilead from 12 to 20 inches in diameter.

There are considerable areas of muskeg. In these areas the timber consists of small black spruce and larch, from 3 to 5 inches in diameter and of very little commercial value.

Birds of the Abitibi

At the season of our field work many of the birds were nesting and, therefore, it was not the best time to study them. Many Warblers were seen in the tree tops, but, having broken my field glasses on the way up I was unable to determine or even describe the species. A list of the birds noted is given below :

Canada Grouse, (Dendragapus canadensis); Ruffed Grouse, (Bonasa umbellus); American Goshawk, (Accipiter atricapillus; Screech Owl, (Megascops asio); Night Hawk, (Chordeiles virginianus); Phoebe, (Sayornis phoebe); Wood Pewee, (Contopus virens); Catbird, (Galeoscoptes carolinensis); Belted Kingfisher, (Ceryle aeyon); Downy Woodpecker, (Dryobates pubescens); Flicker, (Colaptes auratus); Hairy Woodpecker, (Dryobates villosus); Cliff Swallow, (Petrochelidon lunifrons), Cedar Waxwing, (Ampelis cedrorum); Northern Shrike, (Lanius borealis); Yellow Warbler, (Dendroica aestiva); Wilson's Thrush, (Turdus fuscescens); Robin, (Merula migratoria); Loon, (Urinator imber); American Herring Gull, (Larus argentatus smithsonianus), Chickadee, (Parus atricapillus); Rusty Blackbird, (Scolecophagus carolinus); Vesper Sparrow, (Poocaetes gramineus); Canada Jay, (Perisoreus canadensis); Crow, (Corvus americanus); Bronzed Grackle (Quiscalus quiscula aeneus); Purple Finch, (Carpodacus purpureus); House Sparrow, (Passer domesticus); White-throated Sparrow, (Zonotrichia albicollis); Chipping Sparrow, (Spizella socialis); Black Duck, (Anas obscura).

Area traversed.	Trees.			Soil.	Surface.
	Kind.	Size.	Quantity.		
Inland trip to Driftwood river from camping ground 9 miles up Black river.	Spruce	Medium	Thin	Clay soil	Rolling over most of this area. Good farm country.
	Aspen	Large	Scattered.		
	Balsam	"	"		
	B. of Gilead	"	"		
Black river	Aspen	Large	Thick	Chiefly clay	Rolling land. Good farm country.
	Spruce	"	"		
	Birch	"	Scattered.		
	Balsam	"	"		
	B. of Gilead	"	"		
	Banksian Pine	Medium	Thick in places		
	W. Cedar	"	Scattered.		
	Larch	"	"		
	Elm	"	"		
	Brule		Several square miles.		

Wild Animals

The following is list of the animals noted :—Moose, 31 ; Red Deer, 11 ; Black Bear, 4 ; Otter, 1 ; Beaver, 1 ; Muskrats, Hares, Red Squirrels and Chipmunks, numerous ; Garter Snake, 1 ; Toads, common ; Leeches, common.

Moose are the largest, and judging from the number seen on our survey and the abundance of tracks on the banks of the rivers and shores of the lakes, they are without doubt the most abundant of the larger animals. Their favorite haunts seemed to be along the marshy rivers running into Night Hawk lake and on the shores of Frederick House river, which flows out of it. The yellow water-lily rootstalk and marsh grasses seemed to form the bulk of their summer food.

The Red Deer are more timid than the Moose, and do not prove such easy prey to the hunters as the latter. They were found most abundantly around the little lakes in Long Portage district.

Black bear are not very common in this district, only four being seen on the whole trip. One of these was found on Molle lake and the other three on the Black river.

Thanks to the wise legislation in the protection of the beaver, this animal is becoming much more numerous and the danger of its extermination has been warded off for some time. Fresh beaver dams were very common on the smaller inland rivers. On a small unnamed river in Tisdale township, south of Tennyson, Delbert, and Jarvis lakes, there were fresh beaver dams every few yards.

At Fort Mattagami I obtained a list of the furs traded by the Indians at that place for the year ending May 1903. The following is the list : Ermine, 200 ; Bear, 50 ; Fisher, 15 ; Lynx, 15 ; Marten, 250 ; Mink, 200 ; Muskrat, 2,000 ; Wolf, 1 ; Otter, many.

The Indian hunting season extends from about the middle of September to about the middle of June. The Indians were just coming home from their winter's hunt the day we landed at Fort Mattagami on 21st June.

Fish

Perch, Whitefish, Pike, and Pickerel are the most common species found in the rivers and inland lakes of this region. Pickerel are very numerous in Porcupine lake, and Pike may be obtained in almost all of the waters.

Flies of the Abitibi

Throughout the whole trip we were constantly pestered by flies of various species. I shall endeavor to convey some idea of the habits of these tormentors and our experience with them.

The level wooded country of the Abitibi regions abounds in swamps, marshes and muskegs, which form ideal breeding places for mosquitoes. They proved to be the most troublesome pests which we encountered during our trip. They began to be very annoying soon after we took to our canoes at Metagama, and from that time until we reached Mattawa on our return there was no respite. It is impossible to convey an adequate idea of the suffering which we were obliged to endure from their attacks, and no application of oil or salve to our hands and faces seemed to have any effect in keeping them off.

Although they were very annoying at all times, they were probably most active on cloudy days and at a temperature ranging from 45 degrees to 70 degrees F. They were more numerous on land than on water, but we were nearly always accompanied by a swarm even when far from shore.

I was surprised that we did not occasionally meet with Indians in the woods. On inquiry I learned that they never hunt during the summer months when flies and mosquitoes are out, but congregate at the forts where they can protect themselves to some extent from the insects by building smudges, thus keeping the atmosphere constantly laden with smoke. Even dogs at Fort Mattagami have learned to creep close to the smudges for protection. Let it be remembered that while the hands and face were the special points of attack, the mosquitoes did not limit themselves to these exposed parts, but would even insert their probosces through our thick duck trousers and suck the blood to their hearts' content.

Black Flies

Next in importance to the mosquitoes may be mentioned the Black Flies (Simulium molestum). These are small black insects about one-eighth of an inch in length, with stout bodies and bulging thoraxes. The mouth parts are very curious, and Prof. J. B. Smith has ascertained that the females, which alone suck blood, possess, besides the usual sucking organs, genuine biting mandibles. Unlike the mosquitoes, they breed in rapidly flowing water. Although the bite of these flies is not poisonous, it is very severe, drawing blood freely. I frequently noticed the faces of my companions streaked with blood, the result of fly-bites. We experienced the greatest discomfort from these flies on bright warm days, and between 9 a.m. and 9 p.m. They did not trouble us much during the hours of darkness, but seemed to congregate on the walls of the tent in search of light. They were not attracted by lamp-light. While the bites of the black flies were very painful, we also suffered from their getting into our nostrils, our ears, and under our eyelids. We experienced much inconvenience, too, by their congregating in large numbers in soup, gravy, and other articles of diet. This vexed our jovial half-breed cook so much that he once remarked he would not mind cooking for us if he could only board somewhere else himself.

At one time the back of my neck was so lacerated by fly-bites that it became stiff and swollen, and I was unable to turn my head for several days. Heavy applications of carbolic salve to the face and hands seemed to prevent the attacks of these flies to some extent. I observed that they were troublesome not only to man but also to moose, deer, and dogs, and that they were more active in June and early July than later in the season.

Sand Flies

These flies are very small yellowish insects, with transparent, whitish-colored wings having somewhat darker spots. I found great difficulty in capturing specimens, as it was impossible to handle them without crushing them. By placing a green leaf on the back of my hand and allowing them to crawl on it, I succeeded in securing a number by folding the leaf and inserting it into a cyanide bottle.

The bites of these insignificant-looking insects are very poisonous, causing much swelling and a painful, burning sensation. Though the sand flies look insignificant they never allow one to be ignorant of their presence day or night. They adhere very closely to the skin; they crawl up under shirt sleeves and trouser legs; and keep the whole surface of the body in a state of constant irritation. Unlike the black flies they are attracted by lamplight or firelight, and are therefore very troublesome around the camp fire.

Deer flies (Chrysops) are large flies about half an inch in length. We found them very numerous in July, and experienced much discomfort from their attacks. The bite is not poisonous, but causes sharp, severe pain. They are not troublesome excepting on clear, hot days. These flies attack deer and moose as well as man.

Bull-dog tabanus (Tabanus affinis): This was the largest of the fly torments of the Abitibi. Like the deer fly, it was troublesome only on clear, hot days in June and July.

In conclusion I may say that although the various species of flies above described are exceedingly troublesome at the present time, it is altogether probable that as the country becomes cleared and drained and the soil cultivated, they will largely disappear and life will then be as tolerable in this region as in the older parts of the Province.

Injurious Insects

Larch Saw Fly (Nematus erichsonii): Nearly all of the larch or tamarac trees in this northern country have been destroyed by the larvae of this saw fly. During the early part of July the adult flies were seen floating down the Porcupine river, and a few days later the shore of Night Hawk lake was covered with them. Pupa-cases were found in masses beneath the surface of vegetation of all the trees examined in the district. The flies deposited their eggs about the first week in July and the eggs hatched about the 12th of July.

Spruce Gall Louse (Chermes abietis): The Gall Louse was very common on the black and white spruces. The spruces along the water seemed to suffer more than the inland trees, and the white spruce more than the black.

Birch Case-Bearer (Coleophora sp.): This insect was found feeding on the paper birch and alder. In some districts it was very common and destructive to the birch.

American Tent Caterpillar (Clisiocampa americana): Found about one hundred miles north of Metagama feeding on the leaves of the wild red cherry.

Pale Brown Byturus (Byturus unicolor): This pest was found throughout the district feeding on the leaves and buds of the wild raspberry.

Pine Borer (Monohammus confusor): A few specimens of this Borer were found and the work of the insect was noticed in a few places.

American Saw-Fly (Cimbex americana): The larvae of this insect were found in considerable numbers on the willow trees around Night Hawk lake.

Lace Bugs (Corythuca arcuata): Common on the birch and alder throughout the region.

Tomstown, on the Blanche river, a new centre in northern Ontario. The Government road runs directly west into Evanturel township.

Fort Mattagami.

Indian camping ground, Fort Mattagami.

Spittle Bugs (Aphrophora sp.) : Common on the red osier dog wood, spruces and many herbs.

Cabbage Butterfly (Pieris rapae) : The larvae of this insect were found in the Indian gardens around Night Hawk lake, feeding on turnips and cabbage. The adults were found throughout the region generally.

Clouded Sulphur (Eurymus philodice) : Adults were quite common around Night Hawk lake.

Cut Worms (Hadena sp.) : Very injurious in gardens at Fort Mattagami, and common in the Abitibi region.

Alder Blight (Schizoneura tessellata) : Alders were covered with this insect.

Yellow Swallow Tail (Papilio turnus) : These butterflies were found in the same places as the Banded Purple, and usually accompanied them.

Fall Canker Worm (Alsophila pometaria) : Found on the birch, aspen and many other shrubs throughout the district.

Polyphemus Moth (Telea polyphemus) : These were observed floating on the water, and flying around the river banks.

Locusts : Common in dry places, but most of them were in the nymph stage.

Tettix sp.: Common in wet places and along river banks.

Pine-cone Willow Gall (Cecidomyia

Day of month.	Abitibi. Max. temp. F.	Abitibi. Min. temp. F.	O. A. Coll. Max. temp. F.	O. A. Coll. Min. temp. F.	Abitibi.	O.A. Coll. Inches rain.
June.						
25	80	58	63	51	Heavy thunder storm	.42
26	68	56	66	47	Cloudy day	
27	82	59	76	47	Clear day	
28	70	54	75	49	Rained considerable in morning	
29	69	58	71	53	Clear day	
30	74	58	82	63	"	.07
July.						
1	71.5	55	82.5	61	Commenced to rain at 10 a.m. and rained all day	.21
2	73	36	84	67	Fine clear day	
3	71	38	81.5	58	Fine clear day and rained a little in evening	.01
4	73	49	72.5	61	Fine clear day	.76
5	79	53	72.5	60	"	.05
6	79.5	58	82	54	"	
7	84	68	83	57	Thunder shower in morning, rained very little	
8	81	68	83	57	Clear day	
9	84	57	88	67	Cloudy in afternoon	
10	78	59.5	90	71	Rained heavily during night	.09
11	74	44	90	62	Heavy thundershower to-day	.04
12	64	45	80.5	62	Showery all day	.02
13	61	45	80	48.5	"	
14	69	47	71	57	"	
15	69	49	65	43	Clear day	
16	69.5	51	66	49	"	
17	73	57	75	50	"	
18	64	49	77	60	Cloudy all day	
19	72	48	71	56	Cloudy all day, rained a little	
20	74	48	72	57	Cloudy all day	
21	72	46	76	54.5	Clear day, heavy thunder shower in evening	
22	80	53	77	57	Mostly clear all day	
23	82	48	71	56	A little cloudy	
24	64	47	83	58	Clear morning, showery all afternoon	
25	67	46	87	62	Showery all day	
26	70	46	87	77	Clear all day	

Scurfy Bark Louse (Chionaspis sp.) : Found on the alder at Frederick House lake.

Ash Colored Blister Beetle (Epicauta cinerea) : Found feeding on the wild vetch near Porcupine lake.

Black Blister Beetle (Epicauta Pennsylvanica) : Found feeding on golden rod.

Buttercup Oil-Beetle (Meloe angusticollis) : Found in grass.

Maple Borer (Dicerca divaricata) : The adult of this borer was found in the middle of July around Night Hawk lake.

Banded Purple (Basilarchia arthemis) : This butterfly was found in open places along river banks.

strobiloides) : Galls were found on the heart-leaved willow.

Birch Aphis (Aphis sp.) : Aphids in this country were very uncommon, but birch aphids were found in small numbers on nearly all birches.

Potato Beetles (Doryphora decemlineata) : A few potato beetles were found in the Indian gardens at Fort Mattagami.

Aspen Leaf Roller : This insect has caused considerable damage to aspens in this region.

Balm of Gilead Leaf-Gall : This was common on many trees around Frederick House lake.

Weather Observations

In the foregoing table I have given, for comparison, the notes taken at the Ontario Agricultural College, Guelph, on the temperature of the air and other data. The maximum reading of the temperature of the air was made between 1 and 2 in the afternoon, and the minimum reading between 4 and 5 in the morning.

Abitibi Soils

Some 27 samples of soils, typical of the various districts traversed, were collected, all of them being taken from below the immediate covering of vegetable matter on the surface. They were submitted to Prof. Reynolds of the Physical Department, Ontario Agricultural College, for a physical analysis. Messrs. Bracken, Kennedy and Tennant, O. A. C. students, are responsible for the results as given below :

Methods of Analysis

In the analysis of these soils they were treated in the following manner :

(1) They were first examined and described as they appeared to the naked eye, the differences in color and physical properties being particularly noticed.

(2) They were then placed under a microscope, where the color, size, and structure of the particles were particularly noticed; also the composition of the soil, e.g., quartz, feldspar, clay, organic matter, and cinder.

(3) Twenty grammes of each sample were then weighed out, and after being placed in a copper beaker, and covered with water, boiled for an hour and a half to separate completely all particles. The soil and water was then poured into a glass jar about fifteen inches in height and three inches in diameter, and allowed to stand for two minutes. At the end of this time the water was poured off down to within two inches of the soil. The jar was then filled with fresh water, and allowed to stand another two minutes, when it was again poured off in the same manner as before. When the water became clear it was poured off as before, and the moisture evaporated from the soil remaining. This was subsequently weighed and the character of the soil found by the percentage, in weight, of the particles greater than .001 inches, it being assumed that all particles of greater diameter would settle in water in two minutes. The soils were then placed in their respective classes by use of the following table :

Classification of Soils

Soil.	Amount greater than .001 in.	Amount less than .001 in.
Heavy clay......	0– 10 gms.	100–90 gms.
Clay	10– 25 "	90–75 "
Clay loam	25– 40 "	75–60 "
Loam...........	40– 60 "	60–40 "
Sandy loam	60– 75 "	40–25 "
Light sandy loam	75– 90 "	25–10 "
Sand	90–100 "	10– 0 "

The particles greater than .001 in. were then placed under the microscope and again observed.

During all these operations the aim was to get at the accurate composition of the soils.

The Samples Examined

Sample No. 1. Typical soil of Dance township: taken from near the river bank, a short distance from the rapids where we terminated our trip on the Redstone river.

Light in color and lumpy. When examined under the microscope sand is seen to be the predominant constituent. This sand is of a very fine character, and is evidently held in lumps by the vegetable matter and the clay. After a beaker analysis this soil proves to be a sandy loam, having 69.45 per cent. of sand and silt. After separating the sample into sand and slay, the humus remained about evenly distributed in each, and was in such fine particles as would readily be reduced to plant food. Judging from the analysis of this soil it should be of average fertility and of excellent texture.

Sample No. 2. A sample of subsoil collected about 200 yards from creek between Delbert and Porcupine lakes.

This soil is light gray in color. The soil grains adhere together in small hard lumps varying in size from 1 inch in diameter downwards. There is a very slight appearance of vegetable matter present. A mechanical separation showed that 21.3 per cent. of this sample is sand. Both the sand and clay have a slightly reddish tinge. This soil is therefore a clay lacking in humus and vegetable matter.

Sample No. 3. Soil taken a few yards inland from the junction of the Abitibi and Black rivers.

It is of a light gray color, with dark streaks running through it. A very adhesive soil, the sample being in a hard lump, indicating presence of much clay. On powdering a lump, considerable cinder and several little pieces of organic matter were found. A microscopical examination showed a little fine sand. After a beaker analysis this soil proves to be a clay loam, having 29.35 per cent. of the particles greater than .001 inches in diameter. On microscopical examination of these particles they prove to be mostly crystalline. Some are white in color, a considerable number light gray, and a few of yellowish tinge. They are all very small, and are apparently quartz and feldspar. This would be a very profitable soil with cultivation and the addition of humus.

Sample No. 4. Surface soil of Cody township.

This soil is dark in color and very lumpy. The lumps are very firm and difficult to break down. Looking at this soil with the naked eye, the sand, humus, and clay are in such small particles that the presence of humus would not be seen, except that it gives the whole a darker color than it would otherwise have. When examined under a microscope one finds the sample is composed of a white sand and clay mixed with very fine humus of a dark color. A beaker analysis proves this sample to be a sandy loam, containing 64.06 per cent. sand and silt. After the separation the humus seems about evenly distributed between the sand and clay.

Sample No. 5. A sample of soil in Cody township taken at Niven's line three-quarters of a mile up a stream which flows into Night Hawk lake.

This soil is of a gray color. The texture is very good. The soil grains are joined together in very small lumps. Some organic matter is present, consisting of broken roots and stems of plants. Under the microscope the soil grains appear principally in compound particles. The mechanical separation showed the presence of 43 per cent. of sand in the sample. The sand was quite dark in color ; the clay was a little lighter-colored. This soil is therefore a clay loam with a small portion of humus and vegetable matter mixed with it.

Sample No. 6. Typical soil of Dundonald township.

It is a very light gray in color, much resembling clay, but not baked, being in a very friable and porous condition. The size of grains ranges from that of dust to that of peas. It shows a little organic matter in a state of decay. On microscopical examination it shows presence of fine particles with a tendency to compound structure. It is gritty and seems to be a mixture of sand and clay. A beaker analysis proves it to be a clay loam, having 29.25 per cent. of particles greater than .001 inches. A microscopical examination of these proves the presence of white and black particles of a crystalline nature and brownish water-worn pebbles. The former are probably quartz and mica. These particles range in size from that of a pin point to a few the size of a clover seed. This appears to be a good soil and one which would be fairly easy to work and give good returns.

Sample No. 7.—Carman township subsoil pulled out by a ground-hog about half a mile from camping ground on Redstone river.

It is light in color. The sand is coarse and the humus scanty. Analysis shows this to be a light sandy loam, containing 76.06 per cent. of sand and silt. When the separation was made the clay portion apparently contained some coarse light vegetable remains, in such small proportions as to be of little importance.

Sample No. 8. A sample of soil collected in Whitney township.

This soil is dark gray in color. It is in a fine mellow condition. There are very few lumps in it and those present are quite small. There is a considerable quantity of undecayed vegetable matter present in the form of small pieces of wood and leaves. Under the microscope considerable quantities of vegetable matter can be seen ; some of it is in the form of humus, as indicated by the black color. There are compound particles and separate grains in about equal quantities. This would show that the soil is a loam with a large quantity of vegetable matter in it. A mechanical separation showed the presence of 69 per cent. of sand in the sample. Both the sand and the clay are quite dark in color. This proves to be a sandy loam with a considerable quantity of humus in it.

Sample No. 9. Soil taken a few yards inland from about 7 miles up the Black river.

This is in uneven clods of a light gray color. It has a gritty feeling. It is quite adhesive and shows very little organic matter. On microscopical examination it shows some very fine clear-cut particles of white sand, much brownish-gray gritty matter mixed with fine dust, presumably clay, and some dark specks of cinder. A beaker analysis shows this to be a clay loam. These particles are found on microscopical examination to be principally white crystalline pieces of quartz with a small proportion of feldspar or yellow particles.

Sample No. 10. Soil of German township.

This is of a dark color; coarse vegetable matter can be seen with the naked eye. Microscopically one finds this sample rich in fine humus, which acts on the sand, which is also very fine, causing it to form into hard lumps. This proves to be a sandy loam. It contains 66.75 per cent. sand and silt. In the separation the greater part of the humus remained in the residue along with the sand and silt, making this portion dark in color, while the clay was light in color, apparently containing but little humus.

Sample No. 11. Soil collected in Dance township from a delta deposit carried down by the river.

This soil is of a light gray color. There varying in size from a hen's egg down. are a large number of lumps present These lumps are very hard and difficult to break down. Under the miscroscope the soil grains appear to be in compound particles. There is very little appearance of separate soil grains and no noticeable quantities of humus. Apparently this soil is a heavy clay and lacks vegetable matter. A mechanical separation was made which showed the presence of 75 per cent. of sand. A slightly darkened color of the sand would indicate the presence of a slight amount of humus. This soil is clay loam.

Sample No. 12. Soil taken from Dance township.

This gives every appearance of a rich dark loam. It is made up partly of fine powder and partly of lumps about as large as a pea. It contains a large proportion of humus. Viewed under the miscroscope it is found to be composed of white quartz and a fine dark powder, probably decayed vegetable matter, in about equal proportions. After a beaker analysis a miscroscopical examination proves the presence of quartz and also shows a small proportion of feldspar. The particles of each are so small that they cannot be recognized by the naked eye. It proves to be a loam, having 51.57 per cent. greater than .001 inches in diameter. This soil has a first-class texture and is rich in humus.

Sample No. 13. Typical soil of Thomas township.

This sample was in a fine powdered state free from lumps. In color and texture it is not unlike the fine dust found on our clay roads. There is very little humus visible to the naked eye. On microscopical examination one finds that the chief constituent is clay mixed with a small amount of humus. The latter is of a light dry nature. On beaker analysis it shows 29.25 per cent. sand and silt. This would bring it under the clay loams approaching clay. In separating, the clay remained a long time in suspension in the water, and contained but little humus, while the residue, consisting of fine sand and some coarse light vegetable matter was, as stated in the analysis, present in small quantities. This soil might be easily improved by ridging in the fall to expose it to the frost, which would likely bring about coagulation, and increase its porosity.

Sample No. 14. A sample of vegetable matter collected in Carman township about two and one-half miles from the camping ground on Redstone river.

This soil is almost black in color. It is very loose and light in texture. Scarcely any lumps are present. There is a large amount of undecayed vegetable matter in it, consisting of broken bits of wood and roots. Under the miscroscope a considerable quantity of the soil grains has a separate grain structure. There is a large amount of black-colored particles present. This soil is apparently a sandy loam very rich in humus, and a separation was made which showed the presence of 59.2 per cent. of sand. The sand contained large quantities of wood and roots in small pieces. The clay was nearly black in color. This soil may be classed as a loamy vegetable soil.

Sample No. 15. Soil taken from near portage on Redstone river in Carman township.

In color it is a very light gray. It is found in irregular lumps varying in size from a fine powder to pieces the size of a large pea. It is rather gritty, otherwise giving every indication of being a strong clay. Under the microscope it shows a compound structure, and a very apparent absence of humus. The particles are all light colored and very small. A beaker analysis proves it to be a clay loam, 34 per cent. of the particles being greater than .001 inches in diameter. On microscopical examination this is seen to be composed of very small brownish particles of a gritty nature. This soil is deficient in humus, otherwise it is a good serviceable soil.

Sample No. 16. Soil taken from Whitney township, about 200 yards back from the east side of Porcupine lake.

In general appearance this is a light colored soil, lumpy and resembling a stiff clay and with very little humus. Miscroscopical examination shows a small amount of very fine humus, and the balance appears to be clay and fine silt. The analysis gives 38.95 per cent. sand, thus classifying this as a clay loam approaching loam. After the separation what little humus the soil possessed in a visible state was found in the residue. The residue was composed of very fine silt mixed with fine vegetable matter. Under the miscroscope considerable fine humus could be seen in the clay portion.

Sample No. 17. Soil collected from an island on Night Hawk lake.

This soil is a uniform light gray color. It is somewhat lumpy. The lumps vary in size from a hen's egg down. These lumps are a little difficult to break down. Under the microscope the soil grains all appear to be in compound particles. No separate grains can be noticed, neither is there any appearance of vegetable matter or humus in the soil. A mechanical separation showed the presence of about 17.7 per cent. of sand. Both sand and clay are a light gray color, which shows that there is no humus or vegetable matter in the soil. This soil is therefore a clay.

Sample No. 18. Another soil taken from Dance township.

This is apparently a sandy loam, the sand tending almost to the size of gravel. The particles range from the size of dust to that of pin heads. It is reddish brown in color and shows a little vegetable matter, quite porous and open. A microscopical examination shows white and red particles, each of definite outline, probably quartz and feldspar, with considerable reddish brown dust. It has clearly a separate grain structure. A beaker analysis proves it to be a sandy loam having 62.95 per cent. greater than .001 inches in diameter. On microscopical examination of this, pervious observations were confirmed, and a little cinder found.

Sample No. 19. Soil taken from Tisdale township on portage a few yards from river bank.

This sample looks quite different from any so far examined, being of a fine mucky nature, dark brown and free from lumps. Examining it with the microscope a small amount of fine sand and silt could be seen, but the bulk of the sample was vegetable matter. The clay soil was rich in fine humus thus accounting for the absence of lumps. The sand contained more than 75 per cent. coarse humus. A beaker analysis proves this to be a loam, containing 59.25 per cent. sand and silt.

Sample No. 20. Soil collected in Murphy township.

This soil is nearly black in color. The soil grains are collected in small hard lumps, which can only be broken down by considerable pressure. They almost seem like small pieces of stone. It has a very poor texture. There is also a very small quantity of vegetable matter in it. Under the microscope the soil grains seem to be cemented into lumps. They are quite dark in color. A mechanical separation showed 61.5 per cent. sand. Both clay and sand were almost black in color. This soil is therefore a sandy loam with a large amount of humus in it. The cementing of the soil grains into lumps is no doubt due to the humic acid in the soil. This acid seems to have great power in cementing sand grains into lumps.

Sample No. 21. Soil taken from an island on Night Hawk lake.

It is very dark in color and in a good physical condition, being loose and powdery. On microscopical examination it is found to consist mostly of brownish dust, with considerable quantities of white quartz and brownish feldspar particles. A little vegetable matter is present. A beaker analysis shows the presence of 19.5 per cent. sand. Therefore it is a clay. On microscopical examination a small proportion of white crystalline pieces are discernible, together with a larger proportion of brown water-worn particles and a little mica. This gives every indication of being a good soil.

Sample No. 22. First long portage—very fine sand.

In general appearance it is light gray and resembles quicksand, being very fine. Very little humus is present, and what there is appears as dry, separate particles. A beaker analysis gives 91.55 per cent. sand and silt. This would classify it as sand, approaching light sandy loam. After separating the sample into its clay and sand constituents, the sand portion was not very different from the whole soil. The small amount of clay that was present was darker in color than the whole soil, which was perhaps due to the presence of some humus.

Sample No. 23. Soil collected in Thomas township from glacial deposits one and a quarter miles inland from Night Hawk lake.

This soil is of a gray color. It is quite loose and friable. There is a large number of small stones in it and also some vegetable matter. Under the microscope the soil grains appear to be entirely separate from each other to a very great extent. There is a small quantity of black-colored soil grains. This soil is a mixture of sand and gravel with a small amount of undecayed vegetable matter and humus in it. The gravel would constitute nearly one-half the soil. A mechanical separation showed the presence of 81.7 per cent. of sand in this sample after the gravel had been removed.

Sample No. 24. Soil taken from Thomas township, a sample of the vegetable matter which covers most of the soil in this region.

This is a humus or peat soil. It is found in black lumps, with much organic matter in a partial state of decay. When some of the soil is powdered it feels gritty to the touch. When examined under the microscope a few white particles of sand are found. A beaker analysis shows besides a few white particles of quartz a considerable number of water-worn pebbles about one-half the size of pin head. They are not sufficiently numerous, however, to have any material effect on the character of the soil. When this organic matter is mixed with the white clay loam it should make a fairly rich soil.

Sample No. 25. Soil taken from Hoyle township at the portage on Porcupine river.

This soil is of good texture, having a few small lumps, due to the action of the clay and humus. The color is light gray. Under the microscope it appears to be well coagulated, and the humus which is in a fine state is in sufficient quantity to make the soil fairly rich. The sand portion contained a lot of humus and the sand particles were very small, resembling clay except that they did not adhere to each other. This would seem to be an excellent soil both in point of fertility and ease of working. A beaker analysis showed 6.10 per cent. sand and silt. We would therefore classify it as a sandy loam, approaching loam.

Sample No. 26. Soil collected in Matheson township, typical of a part of that district.

This soil is light gray in color. It is very loose and friable. The lumps are small, few in number, and easily broken down. There is a very small amount of vegetable matter in it. Under the microscope the soil grains appear in compound particles and as separate soil grains, in about equal proportion. This soil appears to be a loam lacking in vegetable matter. A mechanical separation showed the presence of 52.4 per cent. of sand. Both sand and clay were of a uniform light gray color. This soil is therefore a loam lacking greatly in vegetable matter and humus.

Sample No. 27. Soil obtained from near Porcupine river.

It shows many lumps of clay in which the cinder has been incorporated; also considerable cinder in the free state. It is black and gray in color, according as the cinder or clay predominates.

A microscopical examination only confirms the above. A beaker analysis proves this to be a clay loam, there being 36 per cent. of sand, silt, and cinder. But this can hardly be accepted, as a considerable part of that 36 per cent. was cinder and not sand. I would therefore call it a clay with a large amount of cinder.

Conclusions

Of these 27 samples of soils, according to our classification 4 are of clay; 8 of clay loam; 3 of loam; 8 of sandy loam; 2 of vegetable matter; 1 of sand; 1 of glacial deposit of sand and gravel.

We see a wide variation in these soils and therefore we would expect them to be fitted for a great variety of crops. These soils examined were taken from below the vegetable matter. When vegetable matter is mixed with them, they will make good rich soils suitable for agriculture.

Economic Resources of Moose River Basin

By James Mackintosh Bell

Lignite coal has long been known to exist in the Moose River basin of northern Ontario. Limonite and other iron ores and gypsum have also been briefly described in the same region. It was with the special object of deciding definitely whether the lignite occurred in workable quantities suitable for exportation or for future local use, and as far as possible studying the other economic mineral resources of the region, that a small expedition was sent by the Bureaw of Mines into New Ontario during the summer of 1903.

The party consisted, besides the writer, of an assistant —Dr. W. A. Parks of Toronto University—and of four voyageurs, Louis and Joseph Miron, Kenneth Spence, and "Joe" Kechiperach ; and I may here mention that one and all performed their duties in a most excellent manner during the long season. The party left Missanabie station on the Canadian Pacific Railway on the 18th of May, and arrived at Mattawa in returning on the 17th of September.

The Territory Explored

The country covered by the summer's explorations is roughly bounded on the south by the fiftieth parallel of north latitude, from Riverside Portage on the Missanabie river to near New Post on the Abitibi river. From New Post the boundary of our sheet strikes east-northeast to Kesagami lake. Thence northward it follows the Kesagami river to Hannah bay. Passing westward along the seashore, it ascends the Moose river some eighteen miles to the mouth of the Kwataboahegan, and this river it follows to a point some ninety miles up its course, whence it turns southwest to Wabiskagami river and Riverside portage.

The path to the starting point of our work at Coal brook, which enters the Missanabie from the east, lay by the Missanabie river. The water of the Missanabie was exceedingly high, and in consequence, as we were heavily laden, more portages had to be made than is customary, and our advance for this reason was so much delayed that it was the 6th of June before we reached Coal Brook, where it had been intended that our operations on the coal should begin. There we found that the water in Coal Brook was so high that all outcrops of lignite were hidden, and it was decided that that portion of our work should be left till the water subsided, and accordingly we continued our way northward. At the mouth of the Opazatika river the party was divided, Dr. Parks continuing northward to examine the deposits of lignite on the Kwataboahegan river, while I ascended the Opazatika some twenty-five miles to study the iron-bearing rocks which occur at that distance from the mouth of the stream.

The Opazatika River

As the Opazatika is an almost unknown river, I shall here diverge slightly from a general discussion to give a brief description of this large and important tributary of the Missanabie, which I myself ascended almost to its head waters in 1901. The river joins the Missanabie at a point some forty-five miles below Hell Gates, and about the same distance above the mouth of the Mattagami. The river is formed by the union of several streams entering Opazatika lake, an irregular sheet of water eight to ten miles long and two to three miles in width, which lies some six miles east of the Missanabie river at the entrance of the Cabanshee, or Brunswick lake portage. From Opazatika lake to its mouth the river has a length of a little over one hundred miles. In high water the Opazatika is an easy route towards Hudson Bay, but in midsummer the water is exceedingly low, especially in the lower part of the river. Moreover, the portages are poorly cut out, and towards the north not at all; only here and there slight traces of trails being seen. North of Opazatika lake are several small lake expansions, below which follow over fifteen miles of more or less broken water as far as Red fall. About fifteen miles below Red fall is Zadi lake, and for this distance the Opazatika flows with slight current. Zadi lake is a small shallow body of water, with an average width of about a mile, a length of about five miles, and a maximum depth of some twelve or fifteen feet at summer water level. It is separated from Neshin lake of almost similar dimensions by a short stretch of river on which occurs Philip's portage. Just below Neshin lake is the canyon of the Opazatika, from which point to the foot of Breakneck falls, a distance of about twenty miles, the course of the river is broken by numerous falls and rapids. Below the Breakneck falls the Opazatika enters the James Bay coastal plain, afterwards to be described, and flows with swift current to its junction with the Missanabie. The Breakneck falls are among the most remarkable physiographic features of the region, there being a straight drop of over sixty feet. The hydraulic importance of this fall will be more fully appreciated when it is mentioned that the volume of the river at its mouth where its width is some 293 feet is 4,276 cubic feet per second, as measured at the end of the month of June.

Returning from the small iron deposit of the Opazatika, a day was spent in examining the poor and unsatisfactory beds of lignite outcropping along the Missanabie above the Opazatika. This work completed, two weeks were occupied in carefully examining the beds of lignite occurring along the banks of the Soweska river, which is the larger and more southerly of two fair-sized streams which enter the Missanabie, about thirteen miles above the mouth of the Opazatika. The Soweska is a small swift-flowing river, about one hundred and fifty feet in width at its mouth, which takes its rise in the large muskegs and swamps thirty or forty miles to the west. It is navigable for light canoes in spring for about twenty-five miles from its mouth, but its lower course is much broken by small yet decided rapids.

The Wabiskagami

Returning to the Missanabie, we ascended the stream to the mouth of the Wabiskagami. The Wabiskagami joins the Missanabie about twenty-two miles below Hell Gates. It is the largest and most important stream, entering the Missanabie from the west between the Mattawishquaia and the Kwataboahegan. It rises in Wabiskagami lake, which is reached by a route of several long portages and small lakes that leaves the Missanabie river below the Skunk islands. Another route is said to be by the Pewabiska river; but the Indians avow that this stream is almost impassable save for the smallest canoes. Wabiskagami lake is reported to be a beautiful sheet of clear water ten to twelve miles long and three or four miles wide. It is to be regretted that we were unable this summer to visit it, but in descending the Missanabie I did not know of the route to the lake, and presuming it to lie approximately where marked on the existing maps of northern Ontario, I ascended the Wabiskagami river itself. We passed up this stream some sixty-five or seventy miles from its mouth, though in reality at the end of this distance by the river we were only about thirty miles in a direct line from the confluence of the river with the Missanabie.

The general upward trend of the river valley for this distance is some 10 degrees south of west, but the river is so crooked that there are numerous and continuous variations from this course in every direction. At the point where we turned back the valley of the river apparently bends much more to the south, and as far as can be judged from Indian stories, the lake is about twenty-five miles farther in that direction.

The Wabiskagami is a fine clear watered stream, carrying much more water than most of the coastal plain rivers during the summer. Though its current is always swift and often rapid, still its fair depth makes it a comparatively easy stream to navigate even in ascending, but only within the coastal plain, for within the old land area numerous short rapids break its course and make travelling slow and difficult. At its mouth the river is probably a hundred and seventy feet in width, wider in some of the shallower spaces above, but on the whole averaging much less. The Wabiskagami is physiographically an interesting river, and will be described in greater detail further on in this report.

On our return to the Missanabie we started the descent of that stream. In going down an astronomically checked survey of the river was made to locate as accurately as possible the various outcrops of lignite. A stop of some length was made at the gypsum deposits of the Moose river, and this interesting mineralogical occurrence carefully studied. A detailed map was made of the Moose river in the vicinity of the gypsum. We reached Moose factory on 4th July, and were soon afterwards joined by Dr. Parks, who had meanwhile been occupied up the Kwataboahegan river.

The Kwataboahegan rises in Moosonee lake and in the surrounding swamps and muskegs at about one hundred and twenty-five miles off to the west of the Moose river. Some half way down its course it is joined by the Agwasuk from the north and the Mituskwia from the south, both of which considerably augment its volume. It enters the Moose river by several mouths at Hancock rapids some twelve miles above Moose Factory. In the lower reaches of the river the Kwataboahegan is wide, shallow, and swift, but higher up the river is narrow, deeper, and less rapid, while some of the tributaries are merely stagnant streams meandering through the swamps and muskegs.

After a few days spent in re-outfitting at Moose Factory our party was again divided, Dr. Parks going up the Abitibi river to carry on explorations for lignite, while I went to examine Kesagami lake, which lies about half way between Moose Factory and Abitibi House on lake Abitibi, on the winter trail. It is the winter home of a large portion of the Moose Indians, who resort thither on account of the fishing; and is also occasionally visited by Indians from New Post, Abitibi House, and even from Rupert's House. The lake is drained by the Kesagami river, a large stream, which, uniting with the Kattawagami to from the West river, enters Hannah bay at the mouth of the Harricanaw. The Kesagami river is an exceedingly difficult river to navigate. On the coastal plain it is merely swift, but inside the old land area, fall after fall separates shallow stretches of boulder-filled rapids from each other. For this reason, when the Indians visit Kesagami lake in summer they usually go not by the Kesagami river but by the French river and one of its tributaries. This was the route we followed. The French river joins the Moose from the east nine miles above Moose Factory, and just at the head of tide water. The lower French river is wide and shallow, and its course interrupted by short stretches of rapids. The route leaves the main stream by the Nettogami river, which joins the French some twenty-five miles above its mouth. This stream is followed for about sixty-five miles as far as Agaskagou lake, whence a portage of a mile and a half leads to Kesagami lake.

The Nettogami River

The upward course of the valley of the Nettogami has a direction about south-southeast for forty-five miles, where it makes a sharp bend to the north for two miles to Nettogami lake or marsh, from which it again bends south-southeast as far as Agaskagou lake. The Nettogami throughout its course is shallow and rapid. For thirteen miles below Agaskagou lake as far as Fox rapids the river is easily ascended, the rapids being small and far apart, and the river fairly deep.

Below Fox rapids follow four miles of very swift water, as far as Wastabaskinan chute, which is a straight drop of four feet. A mile or so of rough water continues below the chute, at which point the river enters the marshy floor of a former lake, and meanders for several miles with a slack and even current. This marsh with numerous spots of open water dotting its surface, the Indians know as Nettogami lake, and in spring, it is, I am told, so thoroughly covered with water as to deserve to be dignified with the name of lake. Below Nettogami lake the river winds and bends for nine miles with exceedingly rough rapid water, and this stretch is usually passed by a portage about six miles in length, the distance being relieved by several small lakes about midway across the portage. Seven miles below the foot of the portage the river, always rapid, plunges over a cascade with a drop of about twelve feet, passed by Gilbert's portage on the west bank. Between Gilbert's portage and Kage-ga-te-chinook, a mile below, the Nettogami dashes and swirls in all directions between huge gneissic boulders. At Kage-ge-te-chinook the river drops about six feet. About one mile below this are the falls of Kawaskitoukik. Here the river is hemmed in to a width of twenty or thirty feet, and flows in a foaming cascade for almost a mile, having a total drop of about one hundred and ten feet, passed by a three-quarters of a mile portage on the east bank. Less than half a mile below Kawaskitoukik the river plunges over a cascade with a drop of fifteen feet, passed by a portage on the east side. A mile still lower down is Kabaquay-she-wish-iwan falls—a cascade of exquisite beauty with a drop of about thirty feet direct. After flowing calmly for a mile beyond these falls. the river again plunges some eighty feet in a roaring cascade passed by Axe Handle portage on the west side. Below Axe Handle portage slightly over a mile of rough water is followed by a series of chutes having a total drop of eighty feet passed by Ashian portage. Below Ashian portage the river continues rapid for some three miles to the foot of Pischew rapid, where it enters the coastal plain, and from this points to its mouth, a distance of twenty-one miles, though the river is always rapid and shallow, there is no serious impediment to navigation save at the point where it crosses an inlier of Pre-Cambrian rock within the coastal plain some nine miles above its mouth.

Returning to Moose Factory from Kesagami lake, a few days were spent in and around Moose Factory, when we porceeded up the Abitibi river and joined Dr. Parks who was occupied near the Blacksmith rapid. Here most of our time was spent in examining the lignite on the Abitibi itself, but in addition short trips were made up the Big and Little Cedar rivers to see if the lignite beds observed on the main river outcropped on these tributaries. A traverse was undertaken across country to Mattagami river to examine the occurrence of limonite at the Grand rapid, and still another to Gypsum mountain, which crosses the boundary line between Algoma and Nipissing at mile post 276. A careful, paced survey was carried up the Abitibi river from the mouth of Big Cedar creek to the foot of Coral portage in order to locate definitely the various deposits of lignite on the stream.

We left New Post on 31st August, and having a pleasant and successful trip out reached Mattawa, as has been said, on 17th September.

Stratigraphy

It is intended primarily that this report should deal with the economic geology of the region under discussion, but as an introduction to this phase of the subject, I wish to discuss briefly the general stratigraphy and physiography in order to elucidate the genesis of the various economic occurrences.

The geological succession of the rocks of the Moose river basin is as follows in ascending order :

Pre-Cambrian : Laurentian,
unconformity ?
Huronian,
unconformity.
Palaeozoic : Devonian,
unconformity.
Pleistocene : Glacial,
Post Glacial.

Pre-Cambrian rocks, so prominent throughout northern Canada, appear only in the southern and southeastern part of the region described, the rest of the area being overlaid by Palaeozoic and other still more recent formations. Exposures of rocks of all ages, especially the older ones, are poor and unsatisfactory throughout the area, and visible contacts are rare. However, in a few places the relations existing between the Pre-Cambrian and Palaeozoic are well shown. One of these contacts is on the Wabiskagami about twenty-five miles west of its mouth, and here the Devonian sediments lie uncomformably upon the upturned gneissic beds which strike north 20 degrees east and dip at an angle of 45 degrees to the south of east. This is the best contact which I have seen in the region, but the boundary between the two series is always shown physiographically on the various rivers, and it is chiefly from this knowledge that the boundary is delineated, as follows : Striking somewhat north of east from the Wabiskagami it crosses the Missanabie just above Bull bay, whence turning directly east it passes the Opazatika near the mouth of the Squasiche river. From the Opazatika the contact bends east-northeast and crosses the Mattagami below the foot of the Long portage. The sandstones, shales, etc., outcropping at Sextant portage on the Abitibi overlie unconformably a pre-Cambrian eruptive rock, but though this rock causes the rapid there occuring on the river, still it is probable that the true present boundary between the Pre-Cambrian and Palaeozoic lies a little farther south between the Sextant portage and the Otters. The contact crosses the Little Abitibi some ten miles south of the Bad river, whence it continues northeast, and traverses the Nettogami twenty-one miles above its mouth. Continuing northeast it crosses the Kattawagami about twenty-five miles south of Hannah bay, whence it strikes at first east, then slightly east of north to Rupert's bay. Inliers of Pre-Cambrian rocks appear on the Little Abitibi, the upper French and the Nettogami river.

Pre-Cambrian Gneisses

With the present state of knowledge it is exceedingly difficult to attempt any sub-division of the Pre-Cambrian, though doubtless, further careful work will show that this great series is capable of reduction. In general, however, the Pre-Cambrian consists chiefly of gneisses and schists, and to a less extent of slates, quartzites and iron sediments, as well as acid and basic eruptives. Apparently, gneiss occupies the lowermost part of the series with both an acid and a basic phase. Macroscopically, the acid phase is apparently a granite, showing every phase of metamorphism from that in which shearing is scarcely visible to that in which the rock is laminated into wide bands of the component minerals. The rock is for the most part coarse-grained, and consists chiefly of three minerals—quartz, orthoclase and biotite, with various accessory minerals. Garnetiferous gneiss is common, as is also hornblende gneiss, which, however, grades into the basic phase. Two types of the acid gneiss will be described microscopically—one from the Wabiskagami (1) and another from the Nettogami (2).

The Wabiskagami gneiss represents what may be described as a feldspathic phase of the Pre-Cambrian gneiss. It contains the original minerals—microcline, orthoclase, plagioclase, biotite, quartz, magnetite, and secondary chlorite, epidote, muscovite, hematite, and hydrous iron oxide.

Microcline is the chief mineral of the rock. It occurs in large tabular individuals showing strongly double cross striation. All of it is more or less decomposed, with a separation of hydrous iron and hematite, and the formation of secondary muscovite. Practically every individual is more or less strained, and some are mere cores surrounded by a mosaic of granulated feldspar, with which is associated some quarts. Magnetite is rather rarely included in the microcline and orthoclase. The latter gives rise to the same products of decomposition as microcline, and is always clouded. The plagioclase is a somewhat acid oligoclase, which is usually fairly fresh, but shows the effect of pressure. The biotite is strongly pleochroic, but is for the most part altered to irregular masses of dark green chlorite and a very little epidote. The chlorite, which is also pleochroic, includes idiomorphic grains of magnetite. Quartz is not a very common mineral, and that which is not shattered shows undulatory extinction.

The Nettogami gneiss is in many ways similar to the one just described, but it is much more silicious and less metamorphosed. The constituent minerals are quartz, orthoclase, microcline, microperthite, plagioclase, biotite and quartz. Orthoclase is the most frequently occurring mineral. It is in large individuals interlocking in allotriomorphic structure with the other component minerals. It is usually fairly fresh, but shows a slight alteration to muscovite. It exhibits a remarkable pale pinkish birefringence. Microcline is abundant, and exists under the same conditions as orthoclase. Microperthite is seen in a few large individuals. The plagioclase is a somewhat acid oligoclase. The oligoclase and microcline show bending and even fracture. Quartz is a common mineral, and is often surrounded by a narrow rim of hydrous iron oxide. It not rarely shows wavy extinction, and is sometimes granulated. Biotite is rare, but is found in long narrow automorphic plates within the feldspar.

The Wabiskagami gneiss is visibly foliated, while that from the Nettogami is apparently almost massive. In the former the effect of dynamic stress is a much more striking microscopical phenomenon than in the latter, but even in that it is by no means wanting.

An interesting point about both the Nettogami and Wabiskagami gneiss, both acid, is the rarity of ferro-magnesian minerals. There are intermediate phases between the acid gneisses and the true basic gneisses. In general the basic gneiss is much less common than the acid gneiss. In the field there is sometimes visible a gradual gradation between the two facies, or again there is a somewhat sharp change from the acid to the basic. The acid gneiss of the Nettogami bears no lithological resemblance to the basic gneiss from the same locality with which it is closely asociated. Apparently the two represent original acid and basic differentiations of the same magma.

The basic gneiss from the Nettogami consists chiefly of monoclinic amphibole and plagioclase, with a little quartz, titanite and apatite. The rock is remarkably fresh, and is apparently in great part recrystallized with the production of a roughly parallel structure. The plagioclase is labradorite of slight basicity (maximum extinction of 23 degrees in the zone normal to 010). It contains inclusions of apatite and hornblende. With the labradorite are associated a few small grains of quartz. The amphibole is a dark-green, pleochroic hornblende, mostly fresh and locally rendered poikilitic by inclusions of titanite. Dynamic metamorphism is exhibited not only by the parallelism existing between the individuals of labradorite and hornblende, but by the bent condition of the labradorite.

The acid and basic gneisses, with the granites and pegmatites which cut them, have been called Laurentian. In many

(1) From just above Palaeozoic boundary.

(2) From the Pre-Cambrian (here Laurentian) inlier.

ways they bear a strong lithological resemblance to Laurentian gneisses elsewhere, but as a rule they are not so pronouncedly laminated.

At many points throughout the region the gneisses are impregnated by a newer granite, often pegmatitic, but sometimes merely coarse-grained. This granitic material seems to have resulted from the refusion or possibly merely recrystallization of the gneisses. In places this more recent rock has entirely replaced the gneiss. Again, fragments of distinctly banded gneiss varying in width from a few inches to many feet are included in the irruptive rock. This impregnation of the gneiss is excellently shown on the Nettogami river. The strike of the foliation of the gneisses varies considerably, but in general it may be said to be east and west. The dip both north and south is for the most part at a higher angle than forty-five degrees.

Pre-Cambrian Schists

The green schists of the region have been generally considered younger than the gneisses, and have been called Huronian. Many of them, however, are merely basic phases of the latter. Some may be younger, and the fact that they are interstratified with true sedimentary quartzites evidently derived from the erosion of the acid gneisses seems to point to this conclusion. Much study will be necessary before the exact relations between the schists and gneisses can be discovered. Schists occur within the area which we examined on the Nettogami, and with quartzites on the Blue or New Post river and on the Little Abitibi river. The schists are as a rule much altered chloritic rocks consisting chiefly of altered feldspars and chlorites, but considerable variation occurs, and many of them have been recrystallized with the formation of many secondary minerals. A typical green schist is that from the upper Nettogami (3), which appears under the microscope as a much squeezed igneous rock.

In the hand specimen it is a fresh and almost entirely recrystallized highly foliated rock. Beneath the microscope the following minerals are identifiable: Green hornblende, biotite, quartz, epidote, zoisite and magnetite. The ferromagnesian minerals are much more prominent than the quartz, and are arranged in a sort of rough parallelism with it. Several rounded areas consisting of muscovite zoisite, and apparently much altered feldspar, seem to be the remnants of large individuals of feldspar. It is very probable that these areas represent original phenocrysts. The hornblende and biotite both strongly pleochroic, are often intergrown, or again a plate of biotite passes in longitudinal extension abruptly into one of hornblende.

(3) Specimens from Wastabaskinan.

The iron-bearing limestones found on the Opazatika river and subsequently described in greater detail, from their lithological resemblance to similar rocks in lake Superior, are tentatively considered as Huronian, but they may not be so, and their relations with the underlying granites and gneisses seem to oppose this conclusion. They seem to lie horizontally and apparently truncate the upturned gneissic beds. If this attitude is true bedding and not cleavage, then these rocks need not be connected in age with the quartzites and schists which are always distinctly plicated.

Greenstone Dikes and Bosses

The gneisses, quartzites and schists are cut by numerous greenstone dikes and bosses of varying petrographical composition. The greenstone dikes are wide and more continuous and prominent in outcrop than any other of the solid rocks in the region. I shall here describe several types of these rocks from thin sections under the microscope. Of these phases the most important are the coarse-grained gabbro facies, the diabase-dolorite facies, and the diabase-porphyrite facies.

The first is perhaps in general the most common, being often seen in the larger dikes and in most of the bosses. There are gradations from a typical augite gabbro through hypersthene gabbro to anorthosite. A splendid example of gabbro is the rock forming the wall of the southern part of the canyon of the Abitibi, and visible also at the Oil-Can fall just above. Macroscopically, the rock is dark grayish-green in color, apparently consisting in great part of feldspar, and distinctly coarse-grained and granitoid in texture.

Beneath the microscope the rock is seen to be composed of the original minerals, plagioclase feldspar, monoclinic pyroxene, biotite and olivine, with the secondary minerals epidote, muscovite, talc, serpentine and titanite. Plagioclase is by far the most important mineral. It occurs normally in broad tabular individuals showing polysynthetic twinning after the albite law. The plagioclase is evidently a labradorite giving maximum extinction angles in the zone normal to 010 of 34 degrees. The alteration of these basic feldspars resulted in the formation of zoisite, epidote, etc. They sometimes show wavy extinction, and their peripheries exhibit local granulations with the production of secondary quartz—both fruits of dynamic action.

Pyroxene is much less common than plagioclase, and occurs in large individuals in between the labradorite. It is very light dirty gray-green in color, very faintly pleochroic, and is probably a diopside or malacolite. It is often twinned. The mineral shows sometimes the double prismatic cleavage, but exhibits usually only one with numerous irregular cracks. It is occasionally rendered slightly poikilitic by inclusions of small plagioclases, quartz and magnetite. It is associated with a dark brown biotite and with titaniferous magnetite. The former occurs in medium-sized plates which are strongly pleochroic, and the latter in large irregular grains surrounded by rings of strongly doubly refracting titanite. The titaniferous magnetite includes a beautiful bluish-green isotropic mineral, which is apparently pleonaste. The olivine in frequent irregular grains is partially serpentinized. In general the rock is beautifully fresh, and has undergone a slight amount of strain.

The diabase-dolerite type (4) is also a commonly occurring rock limited chiefly to dikes. It is a medium-grained, almost black rock weathering rusty brown. Even in the field it shows the ophitic structure of diabase. In the thin section it is a beautifully fresh rock composed of the following minerals: original plagioclase, monoclinic pyroxene, olivine and magnetite; and secondly, serpentine and hydrous iron oxide. Plagioclase, pyroxene and olivine are about equally distributed in the rock. The plagioclase occurs usually in long laths typical of diabase, and holds in its interstices the irregular shaped pyroxene and olivine. A few however are large, wide and tabular, with their edges invaded by the ferromagnesian minerals. These look like altered phenocrysts. The plagioclases, which show occasional zonal structure in the large individuals, and polysynthetic twinning in the lath-shaped feldspars, are apparently labradorite of medium basicity.

The pyroxene is very light gray-green in color, shows distinctly the double cleavage, and is probably diopside. Both pyroxene and plagioclase are fresh, but olivine in large grains shows alteration along the cracks to serpentine.

(4) Example described is from Pischew rapid, Nettogami river.

This secondary mineral in transmitted light is usually light-green in color, but is occasionally stained a bright yellow ochre, with formation of iron oxide. The olivine is also sometimes similarly colored. Magnetite is abundant in irregular grains, in association with the pyroxene.

The diabase-porphyrite type of rock, (specimen from the foot of Kabaquayshewishiwan falls), unlike the last specimen described, is considerably decomposed. In the field it appears as a somewhat fine-grained rock, containing large very light-green, or practically white phenocrysts. Beneath the microscope the ground-mass is more prominent than the phenocrysts, and consists of an interlocking mat of monoclinic pyroxene and plagioclase feldspar. The phenocrysts are all of plagioclase feldspar, which is also the commonest mineral in the groundmass, occurring in long laths and interlocking in ophitic structure with the pyroxene. It is a fairly basic labradorite, showing a maximum extinction of at least 31 degrees in the zone normal to 010.

The pyroxene, which is light gray-green in color, and is often twinned, is apparently diopside. It is seldom fresh, and has undergone considerable paramorphic alteration to uralite. A few secondary idiomorphic grains of biotite have also resulted from the decay of original pyroxene. Magnetite is abundantly associated with the ferro-magnesian minerals.

This type differs from the last in containing a somewhat finer-grained ground-mass, and in the greater development of large phenocrysts which are merely incipient in the diabase-dolerite type.

The Palaeozoic Series

Stretching from the Archaean boundary northward underlying the flat coastal plan are the Palaeozoic rocks of the Moose Basin which, with the recent rocks above them, cover by far the greatest part of the region under discussion. The series consists of interstratified conformable conglomerates, sandstones, shales, limestones and gypsum beds for the most part lying almost horizontally, but in places folded into gentle synclines and anticlines. The series is unconformable with the intensely corrugated Pre-Cambrian rocks beneath them, and also with the glacial material above.

From fossils collected on the Mattagami and Abitibi by Dr. Robert Bell and others the beds have been classified as Devonian about the horizon of the Corniferous (5) ; but perhaps further study of the Palaeozoic rocks may show the presence of upper and lower formations. A collection of fossils was made this summer by Dr. Parks from the Kwataboahegan river, where fossiliferous limestones are splendidly exposed (6), and a few additional fossils were collected by us both on the several rivers which we ascended; and it is hoped that these may help to elucidate the age of the rocks.

On the Kwataboahegan, it has been said, limestones are well exposed and form the bed of the river for miles along its course. On the Moose river limestone causes the shallow rapids that so seriously impede navigation in a dry summer. On the Missanabie I know of no outcrops of Palaeozoic rocks, but the Wabiskagami near the Pre-Cambrian boundary shows exposures of ripple-marked sandstones and conglomerates as well as exposures of rusty sandstones and limestones. On the lower Opazatika there are no decisive outcrops. The Mattagami for miles along its course shows limestones freely appearing. On the Abitibi every rock of the series, with the exception of the gypsum beds, is seen, and there are frequent exposures all the way from the mouth to the Pre-Cambrian boundary below the Otters portage. On the Little Abitibi limestones appear frequently, and the Nettogami and French rivers are floored with the same rock almost throughout their entire course on the coastal plain. Limestone and sandstone appear on the Kattawagami and on the Harricanaw. These rocks also outcrop at Netiticie on the south coast of James Bay, and I am told on the west coast of the bay north of Moose Factory. Also they are apparently the fundamental rock beneath the western part of James Bay itself.

It is not probable that in general the Palaeozoic rocks are of great thickness, as shown by the several inliers of Pre-Cambrian rock within their boundaries, but the thickness possibly increases northward. The greatest known thickness is that shown in the outcrop just below the Sextant portage, and this appearance it will be of interest to describe somewhat in detail. The outcrop consists of sixty to seventy feet of intercalated blackish, reddish, and light-gray shales, with thin beds of dolomitic limestone and thick layers of coarse grits and sandstones. The lowest exposures are of slightly consolidated conglomeratic grits and sandstones, above which come the interstratified shales and thin calcareous layers.

The reddish shales predominate, and as the beds are mostly loose and poorly indurated, in weathering they break down and cover all the underlying rocks with a thick talus of red clay of a beautiful hematite red color, which from a distance with the bright green of the poplars in the background makes a very pleasing picture. Several large springs break through the higher strata at this point, and have cut deep ravines through the soft rocks. These gorges are unobstructed save for the larger pieces of rock which fill them and are added to from time to time as the rock disintegrates. The whole series points to rapid but intermittent elevation of the region with a deposition of beds of varying lithology.

Another interesting outcrop of Devonian rocks is that at the contact of the Devonan with the Pre-Cambrian on the Wabiskagami river. The outcrop shows well stratified grits, sandstones and limestones. The lowest exposures immediately above the plicated gneiss are coarse grits gradually becoming finer, and merging into arenaceous limestones which, with true limestone, form the main mass below the contact.

On the Nettogami at the mouth of the Kiashko river and again about one mile above it are cliffs of a re-cemented limestone breccia twenty to thirty feet in height, rising vertically from the river, or overhanging it, which are prominent features in this region of small relief. Some of the limestones lower down the Nettogami, just above the Laurentian inlier, and others seen on the Abitibi along the eastern shore at the Long rapid, consist of a mass of orbicular fragments of limestone, loosely held together, which with the slightest blow fall into small separated pebble-like fragments.

Pleistocene Geology

Overlying the Palaeozoic rocks are those of the Pleistocene period, which outcrop far more prominently than any others in the region and influence profoundly the geology and topography. The Pleistocene rocks may be sub-divided into Glacial and Post-Glacial, between which there is a slight unconformity.

(5) See Rep. Can. Geo. Survey, 1877. page 5 C.

(6) See "Devonian Fauna of Kwataboahegan River," by A. W. Parks, pp. —— of this Report.

Rocks of Glacial Age

The Glacial Age consists of at least two glacial epochs and one interglacial period, and it is very probable that further work in the drift will allow still greater subdivision. The rocks of the Glacial Age consist of hard clay conglomerates, less consolidated boulder clays, loose sand, blue clays, arenaceous shales, lignitic clay shales, and lignites—the last four composing the coal-bearing measures of the interglacial period.

The entire area is more or less covered by glacial drift, though the stratified interglacial rocks are not general in their occurrence, and not only are they practically limited to the region of the coastal plain, but they are by no means equally distributed throughout that area itself. They are found at intervals all along the Kwataboahegan river, along the Wabiskagami, from a short distance beyond the Pre-Cambrian boundary to its mouth; on the Missanabie from the foot of the Long portage northward; on the Abitibi below the Abitibi canyon; and on the Mattagami, Nettogami, and other streams farther east. As they are of economic importance owing to the lignites which they contain, their somewhat erratic distribution is marked on an accompanying map.

The greatest thickness observed of the stratified interglacial beds was on the Wabiskagami river, where sixty feet of lignitic shales were seen along the stream. This thickness is apparently local, and as a rule the lignite measures average only a few feet thick. The sediments seem to have been deposited in numerous shallow unconnected fresh-water basins, as judged by their distribution and lithology. The interglacial beds suffered tremendous corrasion from the ice of the second glacial epoch, which greatly diminished their thickness. The total thickness of the whole drift varies considerably, though in general it is thickest towards the south of the area and decreases gradually towards the sea; a maximum may be set at about one hundred and twenty-five feet towards the Pre-Cambrian boundary. Fossilized shells were found at one point on the Kwataboahegan by Dr. Parks in the interglacial sediments.

The stratified interglacial beds do not always lie horizontally, although this is their general attitude. On the Wabiskagami are wide shallow synclines and anticlines as well as more pronounced departures from horizontality. On the Abitibi at the Blacksmith rapid and at several other points elsewhere, the upturned interglacial beds are truncated by the deposits of the second glacial epoch. These irregularities are due to ice-shoving rather than orogenesis. It was observed that where there was the greatest thickness of coal-bearing measures, there was relatively, strangely enough, a smaller thickness of lignite.

Post-Glacial Rocks

Following glacial times the sea advanced once more over the Moose Basin, and the whole region as far south as the Pre-Cambrian boundary was beneath water. After marine sedimentation had continued for a comparatively short period of time, the sea departed northward—a regression which is still continuing. The shells contained within these clay marls and sand, which compose the Post-Glacial formation, are those of species still living in the shallow waters of James Bay, and of these may be mentioned Saxicava rugosa, Macoma calcarea (Tellina proxima), Tellina groenlandica, Mya truncata, Mya arenaria, Cardium islandicum, Pecten islandicum, Maconea fragilis, Fusus toxnatus, Natica clausa, and Rhynchonella psittacea.

The Post Glacial sediments are the most consolidated of the Pleistocene rocks. They often form steep wall-like cappings to the glacial drift, and do not disintegrate in the hand. Their greater induration is due to the cementing of the sand and silts by calcium carbonate derived from the dissolution of the numerous contained shells. Their distribution is practically that of the stratified drift, though the outcrops are much more general, the formation wedging out towards the Pre-Cambrian boundary and increasing in thickness northward. They are exposed everywhere within this area where erosion since their uplift has not removed them. Their maximum thickness is eleven feet on the Soweska, and possibly twelve or fifteen feet near Moose Factory, where only the upper part of the glacial drift appears. When first seen in descending the Missanabie river at Bull Bay the Post-Glacial rocks have an elevation of about three hundred feet above Hudson Bay.

Physiography

The main physiographic features of northern Ontario are the broad upland plain or plateau and the wide coastal plain, separated from each other by a fall line which traverses the numerous rivers. The broad upland plain or plateau is the drift-covered northern extension of the rocky Laurentian highland lying north of lake Superior, while the coastal plain is the landward continuation of the low shelving shores of the southern part of James Bay. The fall line is the line which joins the points at which the various rivers that drain the upland descend on to the coastal plain.

The Height of Land Plateau

A traveller across Canada by the Canadian Pacific railway will remember the indescribable dreariness, the apparently endless rocky hills and barren sand plains, denuded of timber by forest fires, which stretch away in either direction from the railway line as it passes north of Lake Superior. Naturally he will imagine that the country increases, or at any rate continues, in dreariness and desolation northward, but instead at less than fifty miles north of the railway the windswept hills disappear, and away from the numerous rivers stretches a vast north-sloping level plain covered with a luxuriant vegetation.

The interior is everywhere singularly level, so much so in fact that drainage is often poor and numerous swamps and muskegs result, especially in the northern portion. Almost no hills occur, and the few elevations which have been able to resist the long continued subaerial denudation are so exceptional as to be worthy of mention. Near the shores of Kapuskasing lake, Mount Horden rises to a height of two hundred feet above the lake, and faintly relieves the monotony of the landscape, but the slope to its summit is so gradual and the whole so drift-covered that I was unable to tell when I reached that point. The low hills around lake Opazatika have perhaps a relief of a hundred feet above the lake, and along the Abitibi river near New Post elevations rise somewhat more above the level of the nearest water. Solid rock hills appearing above the drift are almost never seen away from the lake and the river shores, but I am told by the Indians that a relatively high range of hills of this sort is crossed in travelling in winter from Moose Factory to lake Kesagami. Some years ago I crossed several low hills near the Palaeozoic boundary between the Opazatika and Mattagami rivers. It has been mentioned that these residuals of erosion, known as monadnocks, become more numerous southward, and the country on the lake Superior shore and for thirty miles north of it is high, rough and rocky. The same thing applies to a less extent to the eastern part of the province of Ontario, and the region just north of lake Abitibi is one of fairly uneven relief, while that south of it shows many monadnocks of considerable altitude.

This upland plateau, with its singular evenness of surface, intensified since glacial times by its regular mantle of drift, is a remarkable example of an elevated plain of erosion or peneplain. More advanced peneplaination on the one hand, and greater deposition of drift on the other, with possibly a slight differential uplift, have combined to make the smoothness of the surface greater towards its centre than at the periphery.

Lakes of Moose Basin

Lakes are common physical features in the rocky country to the south and east of the plateau, but in the flat country northward the few which exist are mere ponds of insignificant size. The largest lakes are marine-dammed basins which occur as expansions on the larger rivers and their main tributaries, while the smaller lakes in the interior away from the main channels of drainage are shallow, ice block holes which break the monotonous green of the forest. As typical examples of the former may be mentioned Opazatika lake and the various expansions of the Opazatika river lower down its course, while lake Mokaki, between the Opazatika and Kapuskasing, is one of the numerous ponds which dot the southern and middle interior of the upland.

Kesagami lake is one of the large lakes of Ontario. Its situation is near the edge of the northeastern extension of the coastal plain. It, with the numerous ponds which surround it, represents a specialized feature which departs somewhat from the regular rule of lake distribution, and will be discussed later in detail. All the lakes of the region are shallow and increase in shallowness

Coal exploration party : Missanabie River.

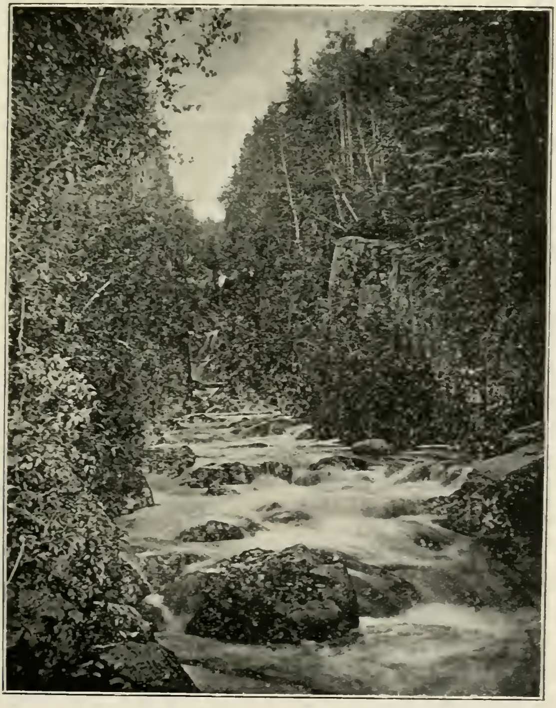
The upper Nettogami river, showing timber.

Couchiching falls, Abitibi river

Brecciated limestone cliffs, Nettogami river.

Peat island, lake Kesagami.

Pond Portage rapids, Missanabie river



Falls near mouth of New Post brook.

northward. Neshin lake and Zadi lake, of the Opazatika river, are with Wanzatika lake, the remnants of a much larger physical feature.

The River Systems

The Moose River Basin, of decidedly large extent, is one of the most prominent drainage areas of central Canada. Most of its various tributaries run independently and cross the fall line separately to unite on the plain below. The Moose has four main branches —the Missanabie, with its principal tributaries, the Pashoskoota, the Congking, the Albany branch, the Mattawishquaia, the Opazatika, and the Wabiskagami; the Mattagami with tributaries, the Poplar Rapids, the Ground Hog and Kapuskasing, the Abitibi, with its affluents, the Frederick House and the Little Abitibi, and lastly the French, with several joining streams of small importance.

On the plateau,the main streams traverse the country from south to north in roughly parallel lines, and flow now broken by rapids miles in length, again by short wild chutes and falls, or else steer their course placidly with slack water for many miles. This portion of all the rivers abounds in splendid sites for water power. On the Missanabie may be mentioned the falls of St. Peter, a chute of twenty feet, Thundering Water falls (drop 24 feet), Riverside Portage falls (drop 25 feet), Long portage falls (drop 140 feet), and many others. On the Opazatika I have already mentioned the splendid capacities of the Breakneck falls, and there are many others on this stream which are worthy of description. On the Mattagami, the Smoking Falls, with its almost straight drop of ninety feet and its deep canyon below, through which surges the great river, is but one of the many sites of hydraulic power on that river. On the Abitibi there is a splendid series of falls, chutes, and cascades, terminated by the Abitibi canyon.

In the upper part of the plateau the rivers flow slackly, with an occasional rapid or fall, but for the most part with no great continuous current, while in the lower part they dash with tremendous velocity and enter the coastal plain as roaring cascades. The middle stretches are a combination of the two phases. In the upper reaches of the river, as a rule no true shores exist, willows and alders growing right from the water's edge, with the land sloping gently away from it to the level of the plateau. Often. however, the rise takes place abruptly from the river or a very short distance back from it. Lower down the river the rise from the water's edge is as a rule more abrupt and decided.

The level of the plateau gradually slopes north. but with much more uniform descent than that of the rivers, so that often above a fall or rapid after a long stretch of calm water even the main river flows almost on the level of the plateau. Just below the higher falls the banks can be seen to rise steeply up the plateau on either side. Where the rock ridge which causes the fall, beneath the drift is wide, as in the case of the northern boundary of the plateau, and where the rivers have been able to wear back their channels for some distance, canyons have formed through which the waters dash and surge with great force. Long canyons are common in the lower parts of the river, while boulder rapids, or sharp chutes, or falls, prevail in the upper stretches. The best example of a canyon is that of the Abitibi. Here the stream having dashed for some four miles over a series of falls and chutes, debouches by a narrow entrance into a wide, deep basin, only to plunge at the opposite side in a cascade and run for two miles through the canyon. The height of the steep walls of the canyon is quite two hundred feet, and the bank rises away from the edge for fully a hundred feet more. An interesting fall is that on the Blue Water river or New Post brook just behind New Post. At this point the small stream enters the Abitibi with an almost vertical fall of ninety feet, flowing directly over the edge of the plateau in a veritable hanging valley.

It has been mentioned that the line which joins the points where the rivers descend from the plateau on to the coastal plain, is marked on each river by an abrupt descent. This demarcation is the fall line, where occurs as a rule the last decided drop between that place and the sea. On the rivers flowing directly north, across the edge of the plateau, the drop is great and sudden, as seen on the Missanabie, Abitibi, Opazatika and Mattagami, but east and west flowing rivers, running diagonally across the contact, have a more gradual but nevertheless decided descent. None of the numerous falls on the various rivers which mark the termination of the plateau, are directly at the junction of the Pre-Cambrian and Palaeozoic, but the rivers have cut back their valleys, and the falls are now some distance from the contact within the old land of the plateau.

The Coastal Plain

It is evident from the geology of the Moose Basin that the region north of the Pre-Cambrian area has undergone several oscillations in level, and that the present modern coastal plain is superimposed on the ancient coastal plain of Palaeozoic rocks, which must certainly have stood above sea level during the deposition of the glacial drift. The boundaries of this modern plain are somewhat uncertain, but coincide with that of the Post-Glacial sediments which represent it geologically, and in general with the southern boundary of the Palaeozoic already delineated.

The coastal plain of the Moose Basin is almost absolutely flat, but it has a gradual quaquaversal slope from the encircling Pre-Cambrian border to the centre on James bay. Down the slope of this coastal plain the various rivers flow with swift though even current, joining like the ribs of a fan near the mouth of the Moose river.

The plain has a height above the sea of perhaps three hundred feet at the edge of the old land, from which it gradually slopes to sea level.

The interior of the country towards the north near the sea is a vast muskeg covered with sphagnum, and broken occasionally by large lake-like swamps, and at wide intervals by a sand or gravel ridge rising a few feet above the general level and supporting a healthy growth of spruce and poplar in delightful contrast to the monotonous muskeg wooded with scrub spruce and tamarac.

The numerous shallow streams which thread their way across the top of the plain have narrow strips of dry land along their edges, proportionate to their size and the amount of drainage effect which they exert. The main streams, the Moose and the Abitibi, and to a less extent the others, are bordered by strips of heavily timbered land varying from several hundred yards to half a mile; while in the case of a stream the size of the Soweska (fifty yards wide), the strip is only one hundred and fifty yards wide, though much greater on the alluvial flats. The large swamps and occasional shallow lakes which exist particularly toward the north of the coastal plain, are water-filled depressions left by the retreating sea, with areas being rapidly invaded by the all powerful muskegs. Of such nature is the huge swamp in which the Soweska river and Little Kwataboahegan rise, and Moosonee lake is probably a less advanced stage of the same thing.

The interior of the southern part of the coastal plain is more inviting to the eye and drier than the northern part. In fact, ridges supporting a healthy timber growth are not uncommon. These occasional ridges elevated a few feet above the muskegs run approximately north and south, and often are brokenly continuous for miles, wedging in to the wider areas of dry land on the old land to the south. The most conspicuous and quite the highest of these ridges is the so-called Gypsum mountain, which crosses the Algoma-Nipissing boundary at Mile Post 276. The name is, at this point, not a good one, as the greatest elevation is scarcely twenty feet above the muskeg, and it is more correctly a low rise which runs for miles and supports a luxuriant growth of banksian pine. From a high tree in this locality I was able to see a considerable hill for this flat country off to the southeast, which seemed to be a continuation of the gypsum ridge. The altitude of the distant hill does not probably exceed two hundred feet, but in the monotonous level country which stretched to the horizon in all directions around me it stood out in relatively mountainous relief.

River Habits and Effects

In general the coastal plain is too recent a physical feature to be maturely dissected by its drainage channels. In fact, in this particular it is decidedly new. The principal rivers, the Missanabie, Mattagami, Abitibi, and French, which flow down the coastal plain, have remarkably straight courses for miles, being held in wide shallow valleys. At the southern limit of the plain the height of the valley wall is probably one hundred feet, and this gradually lowers in the direction of the sea. As a rule, both sides of the main river valleys rise directly or almost so from the level of the river, but in much of the upper part of the main streams the rivers swinging from side to side of the valley have produced on one side precipitous banks rising from the river level, and on the other alluvial flats—the beginning of a flood plain.

The smaller rivers, which traverse the slope of the coastal plain, show exceedingly crooked river channels which swing from side to side across the valley; narrow flood plains alternating with scarped banks on both sides of the stream. All the larger rivers have already cut their way through the post-glacial and glacial material, and are now running on or near the Palaeozoic strata, which in many places they have also deeply cut. The smaller streams, on the other hand, are cutting their channels through the glacial drift.

Beautiful examples of alternating spur and valley are seen all along these northern rivers where the numerous small streamlets descend from the level of the coastal plain to the river, making deep gorge-like valleys in the clay marls and boulder clays, separated by broad spurs from each other. The Missanabie, Abitibi and Mattagami, show in many places terraced valley sides along their courses. The numerous springs which enter the rivers flow from beneath the clay stratum, and do not increase the dissection of the plain. On the Wabiskagami river the narrow flood plain is surmounted by residuals of erosion of the coastal plain, thus showing the presence of two cycles of erosion, the last one being but a short time started. One of the most remarkable of these remnants occurs just below the edge of the old land. A hill of limestone overlaid by boulder clay one hundred feet high rises above the surrounding low limestone flat, and is separated from the main part of the plain by a narrow shallow pond or loop lake—the original course of the river.

Land slips are common all along the large rivers of the coastal plain, particularly on the French, and strips of the bank covered with trees a hundred yards or more in length and half as broad frequently give way and slide into the streams. These slides occur chiefly in the spring, and are probably caused by the unequal thawing of the slippery clays. During the months of June and July, also, it is a common sight to see streams of mud flowing down the banks into the river.

The rivers of the coastal plain flow with a swift but as a rule even current. In other words, they flow at grade save at the few points where the rivers have worn their channels through the recent strata and have exposed inequalities in the Palaeozoic rocks beneath, where the current is sufficiently accelerated to be termed rapid; or where river erosion has laid bare a portion of the underlying Pre-Cambrian, and a decided chute results. On the smaller streams the numerous boulder rapids are unimportant, and were the rivers not so shallow, would not be serious obstacles to navigation.

The Moose in midsummer often contains so little water that it is practically impassable for miles even with light canoes. In the summer of 1901 the lower Moose in the limestone shallows and rapids below the gypsum beds showed only small streamlets of water trickling here and there between the limestone shingle in a valley channel quite a mile in width. Of course, that was an exceptional season.

The rapid which occurs at the mouth of the Abitibi is due to the fact that that river, not nearly as powerful as the Moose, has been unable to cut down its channel as quickly as the latter, and in consequence a serious rapid occurs at the junction. Another rapid on the coastal plain is at the point where the Nettogami crosses the Laurentian inlier on that river, and a similar feature is the rapid at Sextant portage on the Abitibi.

In the high water of early spring, when the rivers often rise fifteen and twenty feet, all rapids are obliterated, the water covers the flood plains and invades the lower part of the coastal plain itself. The effect of this phenomenal rise of water with the immense amount of thick ice which it carries in its train, is to build up along the edge of the plain a steep ridge composed of clay and boulders, to grind to matchwood any trees along the bank which may come in its way, and to pack as hard as a pavement the gently sloping boulder-strewn banks of the river.

The shores of all the larger rivers on the coastal plain are bordered in low water by wide stretches of sand and silt (bank rims) covered with erratics of every size and description, but chiefly consisting of flat limestone shingle and rolled Pre-Cambrian cobbles and boulders. These bank rims are the shoreward equivalents of the bars which occur so frequently in mid-stream. Both bars and bank rims are in spring covered with water, but in late summer are often many feet above it, and are bright with a luxuriant growth of wild flowers and grasses. Near the confluence of the Kwataboahegan with the Moose, the bank rims extend out for three hundred yards at least from the true bank, and the bars of the lower Moose often show a surface a quarter of a mile wide above water in summer. By addition of alluvial material, and that brought by shore ice in spring, the bars grow into islands, and the outward edge of the bank rims into new banks, supporting a large growth of timber, and running parallel with the old and true bank from which it is separated by a shallow depression.

Lake Kesagami

Kesagami lake, quite the largest sheet of water in northern Ontario north of Lake Abitibi, is a most interesting physical feature. It is a shallow expanse of water in the heart of the muskeg country, with shores unprotected either by large forests or hills of magnitude, and exposed to the continual sweep of the storms from Hudson's Bay. It is of exceedingly irregular outline, but its main axis lies north and south. From its wide open northern portion three large deep bays—Opimicon, Muchimanitounuck, and Newnham bay, stretch off to the south, and three short bays off to the north. Kesagami river enters the most eastern of the large southern bays —Newnham bay—and flows out by the most eastern of the small northern bays.

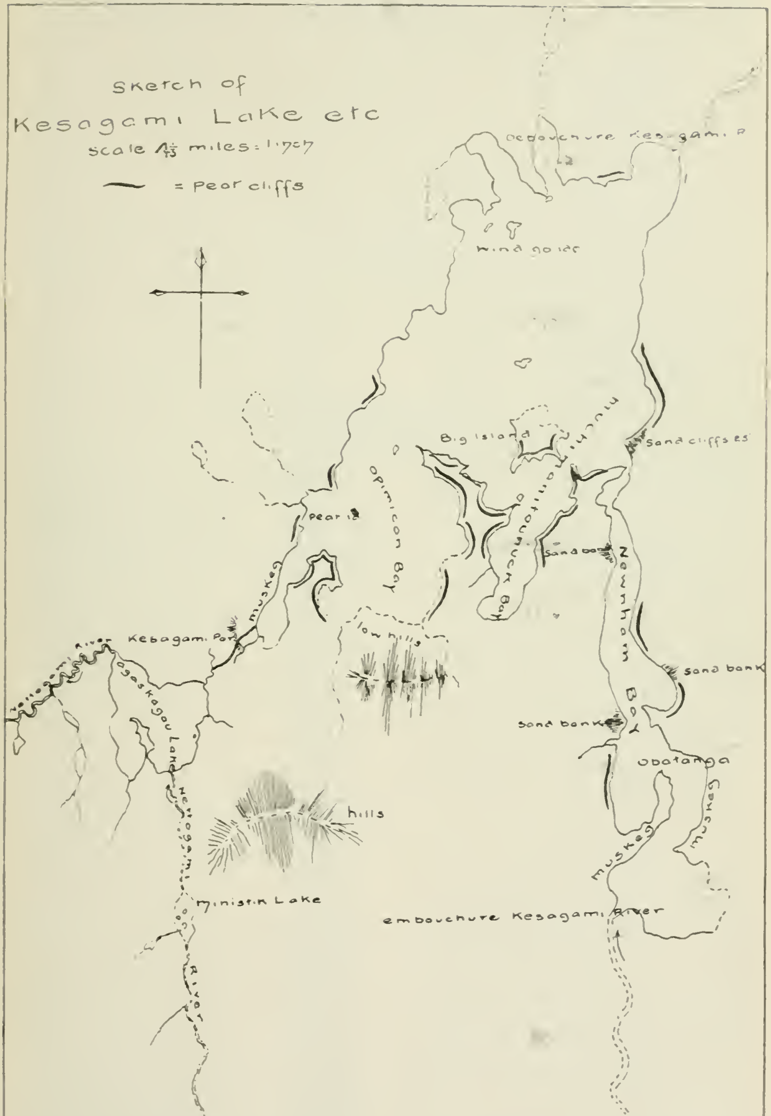
The greatest length of the lake from embouchure to debouchere is twenty-four miles and a half, and its maximum width through the northern end of Big island is some nine miles. The lake is not deep at any point. In the bay west of the outlet, the greatest depth is apparently nine feet five inches—six feet being the average. Between Peat island and the western mainland the greatest depth obtained was eight feet, and six feet was more common. Newnham bay is very shallow. Its average depth is not more than four feet, while in Muchimanitounuck one sounding showed nine feet three inches.

Cliffs of Peat

The most extraordinary feature about the lake is the fact that its shores are almost entirely surrounded by cliffs of peat which rise above the water sometimes only a few feet, but often twelve or fourteen feet in height. Not only are the shores of the mainland of this material, but those of the main islands are so as well. The dash of the waves on the soft, spongy material have worn away the banks to a marked degree, and they now present to the water front the most bizarre forms of overhanging cliffs, deep caves, caverns, thick columns, and pillars. From time to time huge sections of these cliffs fall off, and are soon worn to a black powder, which is kept washing up and down by the surf all along the shore. In some places the slightly carbonized tree trunks derived from the peat beds thickly cover the lake bottom near the shore.

The exposed points, such as that between Opimicon and Muchimanitounuck bays are long, narrow gravel spits from which all the peat has been removed, and many of the smaller points as well as a portion of the eastern coast south of the outlet of the river is heaped with large rolled galet. It was observed that there is a tendency for these narrow boulder and gravel points to be drawn out in fish-hook shape southward. The bays often show narrow sand beaches bordering the shore, but this seems as a rule to be material washed from the bottom of the lake and covering the base of the peat cliffs. At a few points the stratum beneath the peat is exposed, and in every instance, where seen, it was noticed to be composed of a hard, dense, almost boulderless bluish clay, evidently glacial. At a point on the western shore some six miles southwest of the outlet a bank of unassorted silt-like, pebbly clay outcrops. This bank is of small lateral extent, but is interesting as the only place on the eastern shore where anything other than peat or muskeg appears away from the immediate shore line. On the opposite side just north of the entrance to Newnham bay occur banks 25 to 30 feet high of fine-grained light-yellowish sand, with lensoid layers of fine gravels interstratified. The outcrop shows false and irregular horizontal bedding. The bank exposes an open cliff face to the lake front, which is being rapidly removed by the continual action of the water, and the sand falling down has given a wide beach ten to fifteen feet in width. Several sand cliffs of similar nature to the one just described occur along the shore of Newnham bay. The banks gradually decrease in thickness along the beach to the west and north, disappearing beneath the peat beds. They appear to be the remnants of glacial or post glacial beds which were afterwards raised and exposed to the action of the waves in a wide open body of water previous to the deposition of the peat.

At many localities along the shore of Kesagami lake the peat beds do not appear, but only the growing sphagnum, and at these places open muskegs stretch away to the horizon. I am told, however, that none of the country around Kesagami lake is ever flooded even in spring. Agaskagou lake, an expansion of the Nettogami, which lies just to the northwest of Kesagami, is an exceedingly shallow pond two miles wide by the same in length. It is in many ways similar in character to the larger lake, but in no part do peat cliffs appear around its shores. The wide hillock which is crossed by the portage trail from Agaskagou lake to Kesagami is similar in character to the sand banks of Kesagami lake it-


Sketch of
Kesagami Lake etc
= Pear cliffs
Big Island
Sand cliffs
Pear Is
Sand bank
Newnham Bay
low hills
hills
Minisis Lake
embouchure Kesagami River
muskeg
Obatanga
Sand banks

self. The extensive muskeg country all around Kesagami contains many small lakes and ponds within its borders. My Indian guide told me that rocky hills occur one day's travel (say thirty miles) south of Kesagami lake, and just to the south of Muchimanitounuck are low hillocks of sand, gravel, and perhaps solid granitic rock.

Kesagami lake and the numerous ponds which surround it seem to be the remnants of what was once a much larger body of water. For some time this body of water must have stood at a comparatively uniform level, allowing of the growth of sphagnum swamps all around its borders, and along the numerous shoals and islands. Then when the uplift of the region followed, the growth of sphagnum on the more open part of the lake exposed to the waves ceased, but continued in the smaller ponds and in the more protected parts. The dashing waves were able to wear away much of the thin beds of peat along the shore and cut back the beds as cliffs. Hence has resulted the present form of Kesagami.

Economic Geology

It has been already mentioned in the beginning of the report that the main object of our summer's trip was the study of the economic mineral resources of the Moose basin. While it has been found that the region is entirely lacking in vein deposits of metallic minerals, as it is natural to expect, especially in an undisturbed region like the coastal plain, yet the bedded deposits of limonite, lignite, gypsum, and kaolin have, I think, proved to be of greater extent and value than at first anticipated.

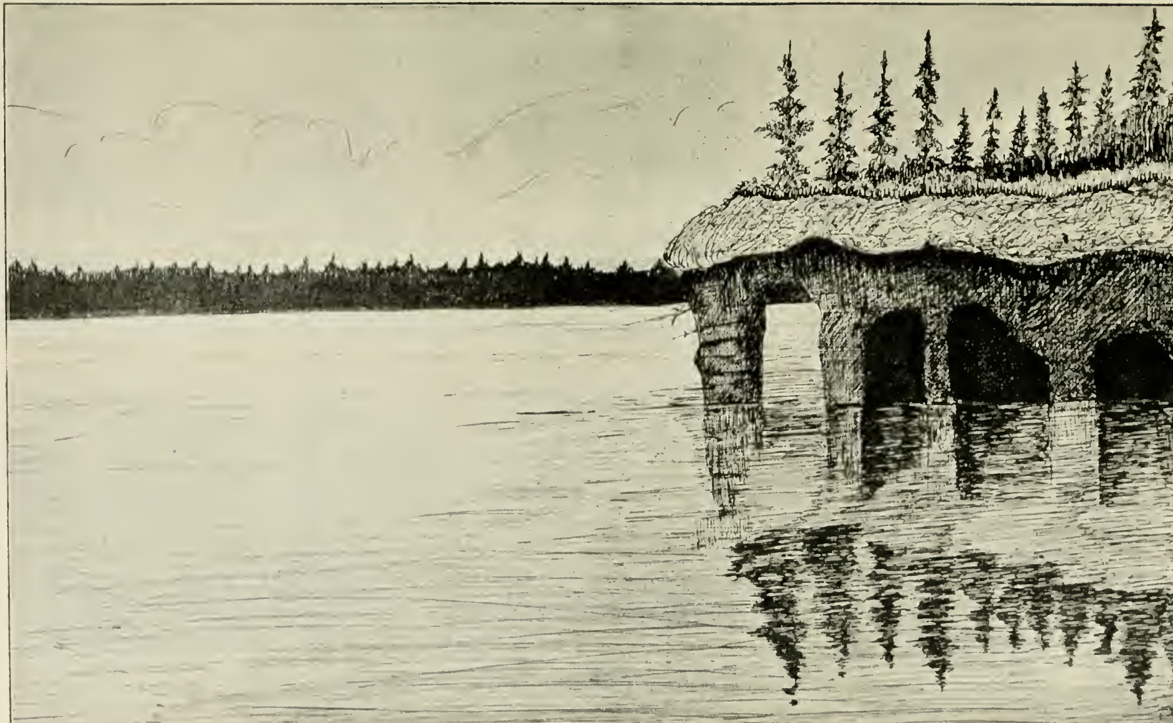
Iron Carbonates

The Opazatika iron-bearing limestones cross that river about 25 miles above its mouth, and form a deposit of scientfiic interest, and of possibly economic value. The exact nature of the body is difficult to understand, owing to the broken and generally unsatisfactory condition of the rocks and of their small visible lateral extent, but apparently it is a bed of more or less ferruginous, magnesian limestone, appearing on both sides of the river at and just below the crest of the second rapid above the Breakneck falls.

The iron-bearing rocks are exposed for some 225 yards continuously on the east bank of the stream, and appear as several isolated outcrops on the opposite side for a somewhat shorter distance. Besides the main exposure on the eastern bank there occurs a regular heap of large pieces of carbonate, which are apparently in place at a point some 250 yards south of the prominent outcrop, but the high state of the water, covering much of the carbonate beneath water, made it impossible to make sure of this point. Back from the bank of the river no outcrops of solid rock appear, but I think it lies at no great distance beneath the glacial drift. The inconspicuous exposures on the western bank and the upper, doubtful outcrop on the opposite side, are almost hidden by the large number of loose boulders, which have been washed from the overlying beds of boulder clay and hard pan. The main outcrop of carbonate on the eastern shore rises above the water as a low cliff seven to eleven feet in height depending on the level of the river. The carbonates are here overlain by a rusty layer of the products of their own disintegration.

Lithologically these iron-bearing rocks of the Opazatika iron range consist of poorly ferruginous magnesian limestone, of richly ferruginous limestone, and of silicious limonite or Gothite. The fresher specimens of limestone are light yellowish pink in color, but most of the outcrop by the oxidization of the iron carbonate always contained with the other carbonates, is colored a deep ochre or dark red. In texture the rock is, as a rule, soft, dense and fine-grained, containing numerous geodes of quartz crystal and veinlets of specular hematite. It is sometimes botryoidal and even stalagmitic.

Under the microscope a fairly fresh specimen of ferruginous limestone is seen to consist of a mosaic of grains of carbonate more or less oxidized with the formation of hydrous iron oxides, and containing a few areas of chalcedonic silica. The amount of iron carbonate contained in the limestone is variable from place to place, but it sometimes contains so much of this material that it might almost be spoken of as a somewhat oxidized siderite. Again, in places the rock has been greatly silicified, by the dissolution of the calcium and magnesium carbonate, by the action of waters containing carbon dioxide, and with the deposition of silica in their place. Its iron carbonate has been entirely oxidized to hydrous iron oxide, and has been added to by the infiltration of further iron oxide formed by the oxidation of superior iron carbonate in ferruginous limestone, now entirely re-



The Peat Cliffs of lake Kesagami, with pillars.

Drawing by J. M. Bell.

moved by the glacial erosion and by other means. These enriched masses occur at intervals throughout the beds, but apparently are more frequent towards the centre of the deposit and at lower horizons. It was observed that the carbonates immediately overlying the inferior gneiss were richly ferruginous. At the outcrop the iron-bearing rocks are never sufficiently rich to be termed iron ore, but workable bodies of this valuable material may exist at short distances in the interior or beneath the surface along the river. The following analyses represent chemically the character of the Opazatika iron-bearing rocks.

	Loss, CO_2 etc.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	S	P	MnO_2	H_2O	SO_3
Silicious hydrous hematite.....	6.40	53.14	1.10	34.84	1.95	1.14	.15	.028	.66	..	..
Purely ferruginous limestone..	44.40	1.00	.56	4.42	29.36	19.56	..	..	..	.31	.23
Pure siderite	37.9	..	..	62.1							

The carbonates apparently lie in horizontal attitude, though as no decided bedding planes were observed, this separation of the rock may be cleavage. The rock is so much shattered that a slight blow of the hammer causes a large piece to break into small angular bits, and at points along the bank these fragments are simply held in place by a thick paste of red hydrous iron oxide. As the bottom of the carbonate beds is not exposed, it is impossible to estimate the thickness, but this would not seem to be considerable because at several points small fragments of a coarse pegmatite were found enclosed in the ferruginous material.

Apparently the carbonates have resulted from the direct precipitation from a sea water rich in iron magnesia and lime on the surface of the upturned gneissic beds cut by dikes of pegmatite. The feldspars of these underlying crystallines have been in part replaced metasomatically, leaving remnants unattacked towards the bottom of the deposit.

No fossils are found within the beds, and their age is in consequence a matter of conjecture, but from their lithological resemblance to the iron-bearing calcareous, magnesian rocks of the Mesabi range on lake Superior they have tentatively been classed as Huronian, though as a matter of fact they may be more correctly correlated with the ferruginous carbonates of the Devonian of the coastal plain.

It is rather difficult to estimate the extent of the iron-bearing rocks, but if we realize that it is at least 250 yards long and probably 500 along the river, that its width is certainly not less than that of the stream at the point (about 75 yards), and that a minimum thickness may be set at fifteen feet and is possibly greater, it will appear to be a fair-sized bed and one in which workable bodies of iron ore may possibly be found. As the carbonate contained no magnetite, we could not trace its continuation towards the interior of the country by the usual methods of magnetic surveying.

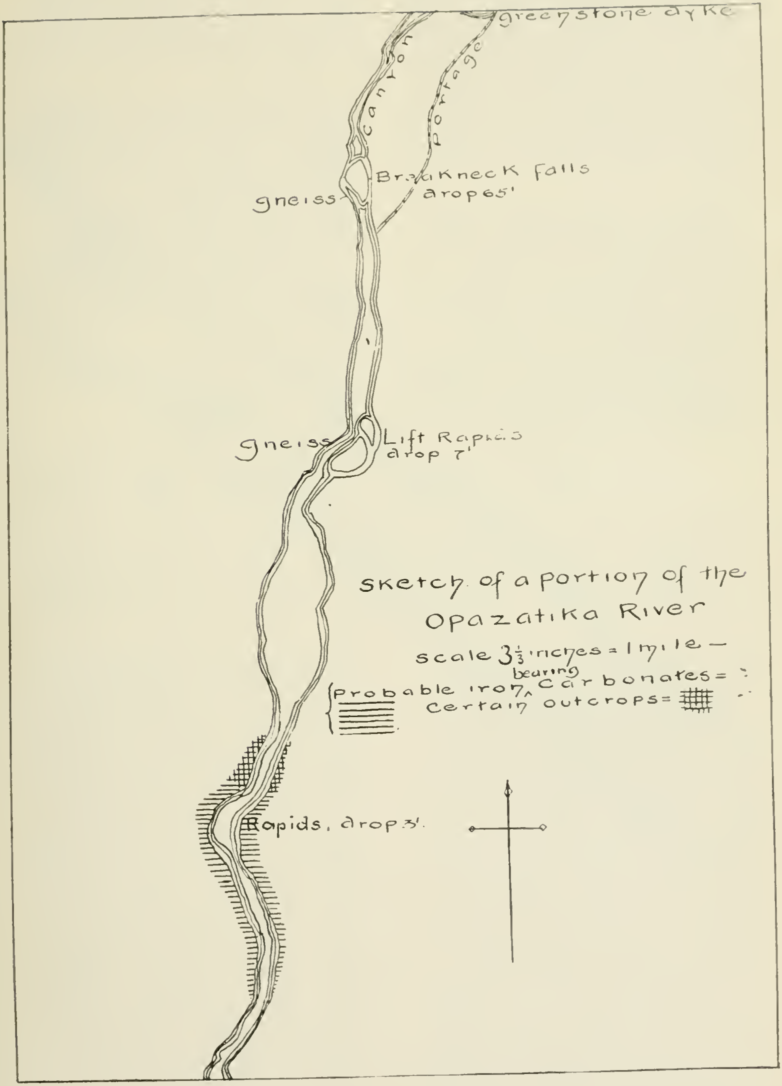
L monite on Mattagami

On the Mattagami River, about 25 miles above its junction with the Missanabie, and some 16 or 18 miles below the foot of the Long portage and just north of the Grand rapid, there occurs a large deposit of limonite. The mass of ore appears on both sides of the river, which has here a width of about 400 yards, and in low water it can be seen in the bed of the stream. The deposit was discovered by Dr. Robert Bell, and described briefly by him in the reports of the Canadian Geological Survey (6).

The largest exposure of ore is on the northern side of the river, where it appears at frequent intervals along the bank for 1,166 feet, while on the opposite bank it outcrops almost continuously for 327 feet. The greatest observed thickness is shown on the southern bank, where it ascends at least 15 feet and perhaps 19 feet above the level of the river, depending on whether the overlying four feet of loose limonite is or is not in place. The greatest width of any single outcrop is seen on the northern bank, where a 45-foot surface of ore is exposed. The limonite occurs at the base of cliffs of limestone lying almost horizontally 30 to 40 feet high overlain by fine-grained boulder clays and silt. Its continuation toward the interior is hidden by these overlying rocks, and its appearance at the foot of the cliffs often obscured by the talus resulting therefrom.

All the limestone overlying the ore contains iron carbonate; the lower part, or that in close proximity to the ore, being often decidedly ferruginous. The mass of the ore has resulted in part

(6) Rep. Can. Geo. Survey, 1875, page 321.


greenstone dyke
Canyon
Portage
Breakneck Falls
drop 65'
gneiss
Lift Rapids
drop 7'
gneiss
Sketch of a portion of the
Opazatika River
scale $3\frac{1}{3}$ inches = 1 mile —
Probable iron bearing Carbonates =
Certain outcrops =
Rapids, drop 3'.

from the direct oxidation of the siderite in this iron-bearing limestone and in part by the replacement of calcareous and other impurities contained within the iron carbonate of the limestone by hydrous iron oxide, deposited either as siderite and subsequently oxidized, or directly as hydrous iron oxide in cavities. This ferruginous material is brought in solution as carbonate by waters containing carbon dioxide, and is doubtless leached from the wide area of siderite-bearing limestone above the ore stratum.

The other smaller part of the deposit has been formed in a slightly different way—namely, by the direct deposition of hydrous iron oxide in the cavities in the loose talus of limestone and boulder clay at the foot of the cliff. Doubtless this has also been in part a process of replacement of the iron-bearing limestones and other soluble rocks contained in the debris by hydrous iron oxide. This enrichment is still proceeding by the oxidization at the surface of the waters of iron-bearing limestone is approximately Corniferous (Devonian), and the ore is hence of later date than that epoch. Some of it is undoubtedly post-glacial, as seen by the glacial material which it contains, and a small portion is certainly modern.

In texture the ore is sometimes soft and spongy, often botryoidal and reniform, again dense, hard, and resembling hematite. In color it is rusty yellow, brownish, purplish, or even bluish-black. Lithologically, for the most part, the ore is an exceedingly pure and high-grade limonite or brown hematite, excellently suited for the manufacture of steel and commercially fit for any use to which the best of iron ores are adapted. The following are the results of the analyses of several specimens and enclosing rock :—

(1) Of the limestones containing very little iron.

(2) Of the more richly ferruginous limestone.

(3) Of the breccia ore.

(4) Of the pure ore.

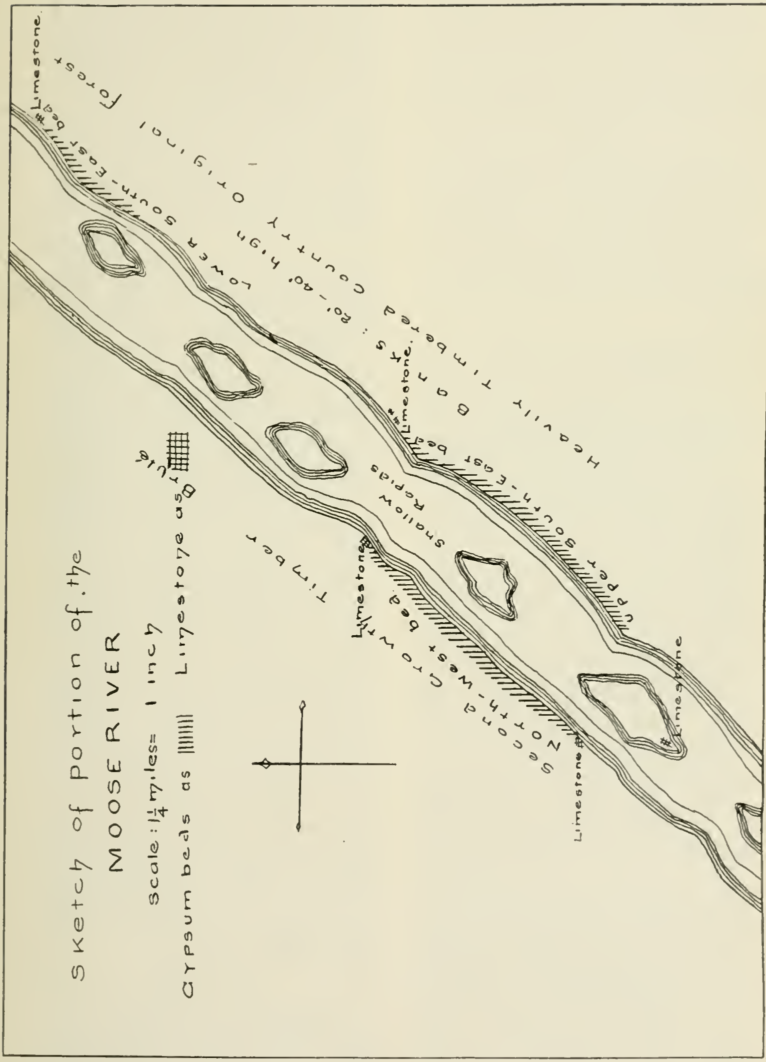
	SiO_2	Al_2O_3	Fe_2O_3	CaO.	MgO.	CO_2	H_2O.	SO_3	Organic	S.	P.	MnO_2
1	.56	.20	1.03	48.43	5.32	43.93	.18	.58	.39	....	....	....
	.38	.26	1.76	53.80	.82	43.00	.18	.30	....	....	....	....
2	3.42	1.38	2.48	32.32	16.18	43.03	.20	.21	....	....	....	....
3	9.44	.70	68.95	.76	.27	13.93	....	....	....	.10	.22	5.44
	21.56	2.52	48.97	3.32	1.39	15.73	....	....	....	.08	.11	5.66
4	2.90	.40	81.82	.75	....	12.88	....	....	....	.09	.08	1.58

the numerous chalybeate springs which flow from beneath the limestone and enter the river at this point. Much of the ore along the river bank on both sides is not a solid limonite, but is more correctly a very rich limonite breccia or conglomerate containing unreplaced bits of limestone and pebbles of quartz and other rocks as well as small masses of clay. The upward limit of the ore is exceedingly irregular; sometimes rich limonite is seen standing in vertical contact with limestone which contains little or no iron carbonate, or again there is a more gradual transition from limonite through partly oxidized carbonates, to limestone quite unchanged. In general there is a tendency towards greater enrichment along the jointing planes.

The Mattagami river at the point where the ore body appears runs apparently in a very shallow syncline towards the centre of which the beds have a slight dip from either side. The middle of the trough was doubtless a locus of extensive deposition of ore previous to its being the bed of the river. The age of the ore is somewhat uncertain. The

In the mass of the ore there is a considerable amount of unoxidized carbonate, as well as other impurities in the breccia ore. At a favorable point on the south shore a shot was fired in the limonite, and a fragment over three feet deep blown away. Little or no deterioration in its quality could be observed at this depth. On the north side the ore, covered by a talus of limestone fragments and boulder clay, is at the surface cut off to the west by a high cliff of limestone and to the east it disappears beneath the debris. On the south side the ore is lost both to the east and west beneath the loose talus material. The remarkably abrupt contact of the ore body with the sideritic limestone to the west on the north side, has led me to the conclusion that by far the greatest part of the ore has been brought by circulating waters, and is not so much due to the direct oxidation of the carbonate in situ.

When it is remembered that most of the ore is of high grade, that the area exposed is large, that the actual ore body may prove to be much


Sketch of portion of the
MOOSE RIVER
Scale: 1¼ miles = 1 inch
Gypsum beds as
Limestone as
Timber
Shallow Rapids
Second North-West Crown bed
Upper South-East bed
Lower South-East bed
Heavily Timbered Country : 20'-40' high Banks
Original Forest
Limestone
Limestone bed
Limestone
Limestone
Limestone
Limestone

larger when the overlying mantle of drift has been removed, and that finally, it exists in an easily workable position, the value of the deposit will be readily appreciated.

Mr. Borron mentions(7) a deposit of limonite similar to that of the Grand rapid as appearing on the Oba river, and is of the opinion that there are many similar ore bodies within the Moose Basin. The limestones outcropping on the Wabiskagami river just below the Pre-Cambrian boundary, were in places observed by the writer to be so ferruginous as almost to deserve the name of impure iron ore. Chalybeate springs are frequently seen throughout the entire coastal plain along the various rivers from the Albany to the Harricanaw, and may show the wide extension of this iron-bearing horizon of limestone.

Gypsum on the Moose

On the Moose river, starting about twelve miles below the mouth of the Mattagami river, are the gypsum beds known to the natives of the country as the "white rocks." These were briefly described by Dr. Bell in the publications of the Canadian Geological Survey (8), and were afterwards mentioned by Mr. Borron (9).

The beds are found on both sides of the river, although they are not seen on the numerous large islands of mid-stream. There are two separate groups of gypsum beds. The upper extends along the northwest side of the river for two miles and a half, and along the opposite side for about two miles and three-quarters, while the lower is as far as known, limited to the southeast side where it starts some three or four miles below the foot of the upper bed and continues for about one mile.

The gypsum beds of the Moose are an important part of the topography of the Moose Basin, and appear as a series of low cliffs facing the river front. The thickest and purest beds are shown by the upper exposures on the northwest side. The beds are overlain by limestone bearing crinoidal fossils, although it only apears at the end of the beds and in the shallow synclines shown on the cliff face. The truncated anticlinal folds of gypsum, with the limestone in the flat-lying synclinals, are overlaid by a varying thickness of a breccia of gypsum, limestone and clay. Above this beds of boulder clay and clay marl, which are sometimes gypsiferous, fill up the inequalities and produce a bank of even crest line. The breccia overlying the gypsum and limestone varies considerably in character. Above the gypsum it is practically all a gypsum breccia, while above the limestone it is wanting, or is mixed with limestone and decidedly thinner; its place being taken by glacial or more recent material.

Approaching the gypsum bed from the southwest along the river, limestone is exposed about one-quarter of a mile above the gypsum for 150 yards, and it is evident from the disturbed and deformed character of the outcrop that the gypsum, which is the cause of the local warping, underlies it at no great distance. A talus of shattered limestone continues from the limestone in situ to the first apearance of the gypsum. This limestone is a dense, fine-grained, light-grayish rock, evidently containing considerable iron carbonate, which oxidizing in places gives the limestone locally the rusty appearance of an iron ore. Encrustations of iron pyrites and geodes with scalenohedrons of calcite also occur. Springs of clear water and others with ferrous carbonate, which oxidizes at the surface, enter the river at this point.

From its first apearance to the point at which it finally disappears below the overlying limestone the gypsum shows many changes in its thickness above the water; sometimes in the anticlines rising to a considerable height, again in the synclines almost or entirely disappearing. The average thickness of the gypsum bed is about 10 feet, although it is often less, and has a maximum in 16 feet above the water level. In quality it is sometimes a grayish, pinkish, greenish, or even snow-white, saccharoidal gypsum; again it is a coarsely crystalline, brownish, and whitish-gray gypsum; often it is a laminated, whitish saccharoidal gypsum with stellate-shaped spots of brown selenite; and lastly, it is a clear, transparent selenite. The lower beds are generally purer than the upper, and there is a tendency towards the more finely crystalline varieties with depth. The overlying breccia is thoroughly indurated, but its value is diminished, if not ruined, by the mixture with limestone, clay, and other impurities. Selenite is in this breccia a variety commonly seen.

Extent of Beds

A description of the beds at several points along their course will give some idea of their general character. Measurements are made from the first appearance of gypsum.

At 50 yards the gypsum rises from the limestone shingle two feet back from

(7) Report on the Basin of the Moose River, p. 72.

(8) Rep. Geo. Sur. Can., 1875, page 321.

(9) Report on Basin of Moose River, p. 61.

the river shore to a height of eight feet two inches, and is overlaid by 15 1-2 feet of many-pebbled boulder clay containing numerous large pieces of gypsum just above the solid material. In quality the gypsum is chiefly grayish, saccharoidal gypsum with some selenite.

From 165 to 275 yards, banks of mixed grayish and brownish finely crystalline gypsum rise eleven feet above the water, and disappear beneath the sands and boulders of the river bottom at two feet below the water.

At 500 yards, nine feet three inches of saccharoidal brownish gypsum rise from the water's edge, and are overlaid by twelve feet four inches of roughly stratified drab and lighter-colored sandy marl.

From 600 to 975 yards no outcrops of gypsum occur, and the trough is filled by interglacial lignitic clay, from which issue springs of dirty water coated with some oily material, which smells not unlike petroleum.

At 975 yards limestone with a decided sharp tilt up-stream appears, and just beyond the gypsum again outcrops.

At 1,000 yards whitish saccharoidal gypsum with some rusty crystalline selenite rises ten feet four inches above the water, and is overlaid by two feet of gypsum breccia, above which are deposited twelve feet six inches of limestone bearing boulder clays and clay marl.

At 1,100 yards to 1,225 yards gypsum is absent, but a syncline of drab-colored, much broken porous limestone appears, in which trough the lignitic measures again show up.

At 2,095 yards ten feet of beautiful white gypsum rise from the water, overlaid by six feet of brecciated gypsum, above which is 13 feet of boulder clay and marl clay, sufficiently indurated to stand alone. The gypsum retains this great thickness for almost 1,000 yards.

At 3,050 yards fifteen feet of fine whitish, saccharoidal gypsum is overlaid by fifteen feet of clay marl. From this point on the quality of the gypsum deteriorates, and the thickness of the brecciated upper portion of limestone and gypsum increase relatively to the purer lower portion.

The cliffs of gypsum presented to the water front are often bizarre and grotesque; sometimes appearing as a series of snow white columns divided by deep caves and caverns; again shelving gradually in a series of overlapping conchoidal sheets from the base of the overlying marl to the river edge. The interior of the country is pitted in all directions with deep, steep-edged holes, sometimes round like a chimney, sometimes oval shaped, separated by low, rounded hillocks or by flat, abruptly-rising mounds. The holes are due to the sagging of the overlying beds of drift into spaces produced by the dissolution of the underlying gypsum, since the deposition of the drift and the hillocks indicate partly the retention of the original position held by the bed, and partly perhaps further swelling of the gypsum, due to greater hydration.

There can be no doubt that the gypsum bed has resulted from the hydration of anhydrite. Ample evidence of this fact is shown in the corrugated, distorted, and deformed nature of the limestone beds which overlie the gypsum, as compared with the slight departures from horizontality everywhere throughout the Palaeozoic basin of James Bay, save where gypsum is found.

The character of the upper gypsum beds on the southeast side does not differ materially from that of the opposite side, though in general the quality is not so good, and the amount of brecciated gypsum predominates over the unbroken material. The beds appear almost continually along the river, and like those of the other side of the stream are overlaid by broken limestone and gypsum, and by a varying thickness of boulder clay and marl. The cliffs are more cavernous and indented than on the northwest side. The general topography away from the bank resembles that on the opposite side. The gypsum beds, though generally massive, show at several points on this side, the anticlinal swelling of the upper beds especially, and the consequent fracturing of the overlying limestone.

The best part of the gypsum bed is from 1,400 to 2,100 yards from the southwest end of the outcrop, where ten to twelve feet of whitish, saccharoidal gypsum rises from the water, and is covered by three to six feet of clay, mixed limestone and gypsum breccia, and by six to ten feet of boulder clay and marly clay.

The lower gypsum beds on the southeast side are composed almost entirely of grayish crystalline gypsum with spots of brownish selenite, which apparently contain considerable impurity. They are not so remarkably caverned and pillared as the upper cliffs, and occur usually as sloping banks a few feet back from the summer water level. The maximum thickness is about thirteen feet, which is attained towards the southern part of the exposure from which it thins and wedges out towards the north.

Gypsum Mountain

In the midst of an immense wet, swampy muskeg, with only a scant growth of stunted spruce and tamarac, a most remarkable feature is Gypsum mountain, with its high land wooded with a large and healthy growth of Banksian pine, spruce, poplar and birch. A mountain in the true physiographical sense Gypsum mountain is not, as it stands only a few feet above the muskeg; but in contrast to the low, almost interminable muskeg around it, it stands out with a relief almost deserving that title.

Approaching the mountain from the south, along the Algoma-Nipissing boundary line, the gypsum first becomes apparent some 1,325 yards south of Mile Post 276 as a low gentle rise from the muskeg, and soon the surface shows the same hummocky, uneven character as observed in the interior near the Moose river beds. The width of the bed along the line is some 2,300 yards. At right angles to the line westward the beds extend about 350 yards, when dipping below the muskeg they disappear from view, but the high, aspen-covered land farther to the west may indicate their continuation. East-southeast from the line the gypsum beds were traced three-quarters of a mile, where they showed no sign of giving out; in fact, had increased in thickness, and it is very probable that they extend brokenly, if not continuously, in a general southeasterly direction across the head waters of the French river, where gypsum was seen by Dr. Parks in 1898.

The surface of the land within the limits of the gypsum is exceedingly rough and uneven, and the topography is often strange and fantastic. The rugosity increases towards the middle, where the deep holes and intervening elevations present a labyrinth of wonderful natural bridges, snow-white pillars, majestic columns and deep narrow caverns. Here and there the larger holes are basins filled with water of sparkling transparency from which threads of water flow to feed a fairly large creek that winds through a maze of caves and tunnels to the east of the boundary line. These clear-watered natural reservoirs, with their surrounding cliffs and floors of shining white gypsum and with the high Banksian pines above, reflected in the marvellously clear water, give a scene of exquisite beauty. The ponds are often twenty to thirty feet in depth, and are at most twenty-five or thirty yards across. It is probable that limestone overlies the gypsum of Gypsum mountain, as it does on the Moose river, but it was not seen in place, although many large angular fragments were observed. Gypsum mountain was possibly a shoal during the deposition of the Post Glacial sediments of the Moose Basin. At its highest point are numerous large boulders, with sand containing Pleistocene sea shells.

The gypsum of Gypsum mountain is for the most part of excellent quality. It is more uniform in texture than that of the Moose river, and consists almost entirely of whitish saccharoidal, sometimes slightly grayish rusty crystalline gypsum. The thickness of the bed is probably great. Cliffs twenty feet high were frequenty seen, and the downward extension of the bed may greatly increase this thickness. The general attitude of the beds is horizontal, but their mode of formation has corrugated them into innumerable small anticlines and synclines.

Other Gypsum Deposits

Unfortunately we were unable this summer to visit the gypsum of the French river, and I can here only repeat without further elaboration, the result of Dr. Parks' brief investigation in 1898. The beds are situated at the junction of the Kawukekamastuk and Wakwayowkastik rivers, at about eight miles southeast of Gypsum mountain, and in the direct line of the continuation of those beds. The exposure rises from twelve to fifteen feet above the water, and appears along the river for approximately twenty chains. In quality it consists of both grayish and whitish crystalline gypsum, much intermixed with streaks of pure selenite. The bed is very probably a continuation of that of Gypsum mountain.

A deposit of gypsum appears on the Harricanaw river on the western side of and near the head of Gordon island. The deposit is only of interest scientifically, as it is too small to be of any economic value. Overlying a horizontal limestone, sometimes exceedingly porous and dark in color, again more compact and lighter in color, is a bed of hard, dark crimson clay. Within this clay are small patches of beautiful red crystalline selenite, and in the lower part of the stratum, just above the limestone, are a number of small layers of satin-spar gypsum, none of which exceed four inches in thickness. The hard red clay extends along the river for about half a mile, and has a maximum thickness of perhaps ten feet. Reddish clay, similar to that in which the gypsum occurs, is also exposed opposite the foot of Gordon island, on the mainland.

Following are analyses of two samples of gypsum, made by Mr. A. G. Burrows, Provincial Assayer, Belleville. They are from the upper beds of the Moose river, and represent respectively the pure white saccharoidal gypsum, and the light brownish crystalline variety.

Constituent.	Sample No. 1.	Sample No. 2.
Water	21.35	21.01
Silica	None.	Trace.
Ferric oxide and Alumina	Trace.	Trace.
Lime	32.80	32.90
Magnesia	.70	None.
Sulphuric acid, SO_3	44.98	45.98

Shales and Clays

Dr. Robert Bell remarks in the Report of the Geological Survey of Canada for 1877-78. "On the Abitibi River, which was explored by one of my assistants in connection with the work of the season, bituminous limestones and carbonaceous shales were found, belonging to the Devonian formation, and which have a strong resemblance to the petroleum-bearing strata of the same age in the Athabasca-Mackenzie valley. These rocks occur all along the Abitibi between twenty-nine and thirty-nine miles from its mouth, and in one place the limestone contains a little free petroleum."

While in the Moose River Basin this summer these carbonaceous shales, spoken of by Dr. Bell, were investigated by Dr. Parks and myself, but we were unable to find anything indicative of petroleum. There is a faint odor resembling that of petroleum on breaking a fresh piece of shale, and a rather frequent appearance of a bluish-red scum on the surface of standing pools, which is commonly supposed to be due to petroleum, but which is much more probably due to the oxidation of iron pyrites, the odor being that of sulphurous acid, and the scum hydrous iron oxide.

The shales are however interesting in that they are the Devonian equivalents of the carbonaceous clays of the inter-glacial period. They consist of soft, dark-gray, often rusty and sometimes carbonaceous shales, interstratified with light gray green shales, also occasionally rusty.

In general the rocks show both cleavage and bedding, which are usually parallel, and dip at low angles to the horizon; but in some places there are pronounced local variations from horizontality, and the shales at times are much deformed and shattered. These more marked irregularities are often apparently due to ice pressure during the Glacial age. The shales, fine in grain and remarkably uniform in texture, show main joints running in a southeasterly direction, besides irregular, circular and conchoidal jointing. The shales in weathering break down, and form soft, plastic dark and light-gray clays, which are indistinguishable from those of glacial origin.

They first appear on the shore of the Abitibi at the foot of the Long rapid, and outcrop at frequent intervals for about four miles. The most prominent exposure is that which appears on the eastern shore, just above the head of Plum Pudding island, and which continues along the river as a series of high cliffs for rather over half a mile. These have a maximum height of thirty-seven feet, of which the lower twelve feet above the water are composed of soft grayish shales with lenticular, orbicular, calcareous concretions, and the upper twenty-five feet are of black and rusty carbonaceous shales. The beds dip up stream and inland at an angle of twenty-five degrees. The river at this point probably runs on the eroded crest of a low anticline.

The great clay banks which appear so prominently in the coastal plain region may contain numerous deposits of clay suitable for making fire bricks, pottery and possibly even china. Doubtless, also, the sands with which they occur may be of economic value in the manufacture of glass.

The chief requisite for a fire clay is, I believe, that it should contain as small an amount of fusible material as possible—the less the better, and four per cent. is about the limit.

Beneath the lignite on the Abitibi, Soweska and elsewhere occurs a beautiful, fine plastic clay, generally light gray-green in color, but sometimes stained dark brown, or almost black, by carbonaceous material. These clays are uniform in texture, paint-like in appearance, and are free apparently from sand and grit. They occur widely spread, but are best shown at the deposit of lignite on the Blacksmith Rapids (10). I had thought that these clays might be used for fire clay, if not for pottery, but apparently they contain too much fusible material for the former, and are in reality better suited for the latter purpose. Potter's clay is a fusible variety, usually containing some oxide of iron and carbonate of lime; the latter ingredients

(10) See Borron's Report on the Basin of the Moose River, 1890, p. 72.

causing it to effervesce slightly with acid, and the former giving it, after burning, a red or yellow color. It will be interesting to compare the analyses of several clays from the Moose Basin with those used at large pottery establishments at various points.

quartz sand mixed with pure white kaolin.

The analysis of clay from the Wabiskagami is that of a representative sample—a mixture really of the pur white clay with the ocherous material and with the white quartz sand. It may be compared with several kaolinic clays.

Locality.	SiO_2.	Al_2O_3.	Fe_2O_3	CaO.	MgO.	K_2O.	Na_2O.	SO_3.	H_2O+C
Blacksmith rapids, Abitibi river...	62.76	18.47	3.18	.88	.91	2.98	.29	.10	11.04
" "	55.56	21.87	7.171	.241	.60	Tr.	3.00	3.47	6.82
(11) Stevens Pottery, Baldwin, Ga	46.07	21.72	15.75	.25	.67	.48	....	......	.34
(11) Uhles Pottery, Evansville, Ind	59.50	26.22	.80	.362	.76	2.96	....	......	....
(11) Stoneware clay, Woodbridge, N.J	67.84	21.83	1.57	.28	.24	2.24	....	......	6.70
(12) Fire clay	69.33	23.62	.561	.49	Tr.	....	....	......	....

Kaolinic Clay

Of the deposits of clay in the Moose Basin none are more interesting than the unstratified beds of kaolinic material which it is believed are sufficiently pure to be used for the manufacture of fine china. Mr. Borron describes at length a deposit of kaolin, or china clay (13) on the east bank of the Missanabie river, about five miles below Coal brook, which he considers to be of great economic importance. At the time of our visit we were unable to examine the deposit, owing to the high water, but it is doubtless a parallel of an interesting body discovered this year by our party on the Wabiskagami river eight miles above its mouth. The deposit lies on the right, or southern, bank of the stream, along which it is traceable for about four hundred feet, rising above the summer level to a height of at least ten feet. It is overlaid by a talus of soft boulder clay, which in places entirely obscures the underlying material. The kaolinic clay is soft, plastic, and unctuous, generally almost white in color, but sometimes stained deep hematite red or yellow ochre by impregnation of iron oxide. Much of it is remarkably free from sand, but other parts contain lenses and small pocket-like areas composed of grains of clear glassy

It will be seen that the kaolinic clays from the Wabiskagami contain considerably more silica than either pure kaolin or the commoner china clays, but the quartz grains are mostly in large fragments which could be easily removed by suspension in water, as is the mode of obtaining Cornish clays from the disintegrated granite, leaving a remarkably pure material, save perhaps for the large amount of ferric oxide. When dried, the Wabiskagami clay is hard and dense, but is easily powdered. The powder is fine and white, and contains large grains of quartz easily separable from it.

The kaolinic clay from the Wabiskagami, with its remarkable freedom from all impurities save iron oxide, and with often even this lacking, is undoubtedly a valuable deposit. It is apparently the product of the decomposition of a granite containing little ferro-magnesian mineral, and probably highly feldspathic, such as binary granite or aplite. This material is ice-transported and unstratified. It was doubtless deposited either in the condition of rock flour or more probably as large fragments of disintegrated rock mixed with finer ground material of the same rock species.

Material.	SiO_2.	Al_2O_3	Fe_2O_3.	CAO.	MgO.	Alk.	SO_3	H_2O+C
Wabiskagami clay..................	53.78	29.58	5.09	.44	Tr.	Tr.	.08	11.
(14) Pure Kaolin.........................	46.5	39.5	....	....	....	....	....	14.
(15) Cornish China Clay	53.16	45.61	.31	.41	.51	....	....	....
(15) Meissen China.......................	57.70	36.80	.30	Tr.	5.20	....	....	....

(11) See 16th Annual Report of U. S. Geol. Survey, Mineral Resources, Non-Metallic Products, pp. 94 and 95.

(12) From Knapp's Chemical Technology, Appleton's Cyclopedia.

(13) Borron's Report on the Moose River Basin, p. 71.

(14) Dana's Mineralogy, 1902.

(15) Knapp's Chemical Technology, Appleton's Cyclopedia.

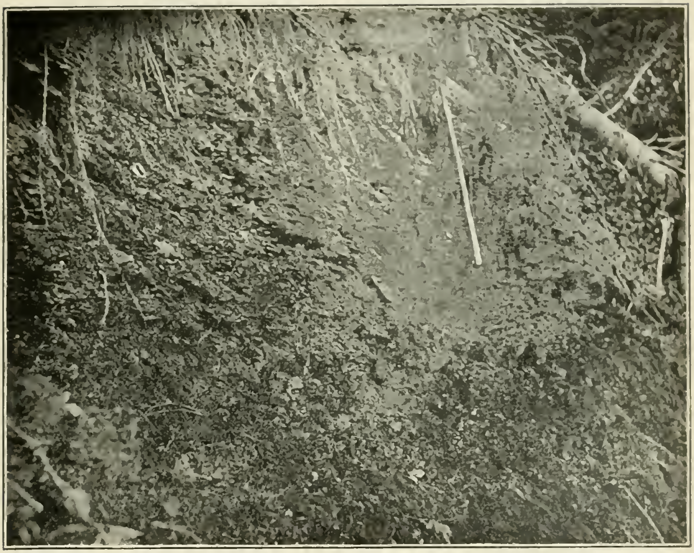
Gypsum beds, Moose river.

Gypsum beds, Moose river, showing cavernous structure.

7

Gypsum cliffs, Moose river.

Devonian shales etc. below Sextant portage, Abitibi river.



Near view lignite, Soweska river.

The upper Soweska river.

Fourth lignite seam, upper Soweska river.

Lignite on Soweska river, showing test pit in seam.

Deposits of Lignite

Lignite, or brown coal, may be described as a fuel about half way in the state of carbonization, between peat on the one hand and bituminous coal on the other. The term is a loose one, and includes materials of wide divergence in chemical composition, in texture, and even in mode of occurrence. The "braun kohl" of Saxony and Brandenburg is so soft that it is dug in the fields with spades, and piled in great stacks to dry, when it is said to form a valuable fuel. On the other hand, the lignites of the western states and those of Alberta and Manitoba are generally black in color, comparatively highly carbonized, and so much consolidated that they have to be broken with a pick. The lignites of the Moose Basin are, considering their recent age, in a remarkably advanced state of carbonization. Some of them may be compared with the tertiary lignites of the Souris valley, Manitoba and of Lethbridge, Alberta, but others are typical brown coals, and resemble the German material.

Dr. Robert Bell was the first to describe the occurrence of lignite in northern Ontario (16), but his investigations were limited to Coal Brook and the Missanabie river. Mr. Borron carried on explorations for lignite in 1885, but also chiefly on Coal brook on the Missanabie (17). Dr. Parks mentions the occurrence of lignite on the Abitibi river at the Blacksmith rapid (18).

As already mentioned, the lignites of northern Ontario are of Glacial age, occurring in stratified beds of clay-shales. The coal measures, as these inter-Glacial beds may be called, occur extensively throughout the whole region. Their distribution has been given in the general discussion. They by no means always carry beds of lignite, but in general they are always more or less carbonaceous. It is noteworthy that the localities at which the greatest thickness of inter-Glacial clays occur are the most barren of lignite. On the Wabiskagami, for instance, where the coal measures are well exposed for miles along the course of the stream, practically no lignite beds are visible, although many very thin seams are interstratified with the hard, very evenly bedded clays. On the Nettogami river, just above the Kiashko river, thick beds of black clay shales, very regularly disposed, rise from the river with almost cliff-like precipitance. From a distance the beds look as if composed chiefly of lignite, but investigation showed the color was due not to thick strata of this material, but to a great many very thin seams of a rather peaty lignite intercalated with the thicker beds of clay and arenaceous shales. The Glacial age of the coal measures was determined at numerous points by the occurrence of boulder clay containing striated pebbles both above and below them. It is very probable that the lignite beds are not all of the same period, and that they belong more correctly to several rather than to one inter-Glacial period, but I know of no direct evidence in favor of this hypothesis. There is a great difference in the state of carbonization of the beds, but this is due apparently not so much to difference in age as to the amount of deformation which the beds have undergone. When undisturbed they retain a distinct peaty character, but where folded they are often highly carbonized. It is impossible to connect with each other the isolated and often widely separated coal seams of the inter-Glacial coal measures. In general there is a marked similarity in their mode of occurrence and in the beds which overlie and underlie them.

Beds on the Missanabie

Owing to the high water on our way down the Missanabie, we were unable to examine the deposit of lignite on Coal creek, and I had not time to return to it later in the season. However, as the occurrence had been carefully studied by Mr. Borron, and described by him (19) I did not think its investigation as important as that of the several little-known deposits occurring elsewhere.

A small deposit of lignite occurs on the Missanabie on the southeast side, some nineteen miles below Coal brook, and about two miles and three-quarters above Cedar island. The seam is exposed in a steep bank of till, which rises from the river at an angle of sixty-five degrees for the first 100 feet, and at a much flatter angle for 40 or 50 feet more. The vertical height of the hill is about 75 feet above the summer water level. The bed has a maximum thickness of thirty-four inches, of which the upper eighteen inches is impure and mixed with clay, and the lower sixteen inches of fair quality and quite uniform in texture, being made up chiefly of slightly carbonized moss, sticks and rushes. The bed is traceable for only a few yards, where it either thins out or is lost in the heavy talus from the bank above. It is underlain in des-

(16) Rep. Geo. Sur. Can. 1875-77.
(17) Report on the Basin of the Moose River, p. 62.
(18) Rep. Bur. Mines, Vol. 8, p. 188.
(19) Report on the Basin of the Moose River, p. 65.

cending order by one foot of stratified sandy clay, ten feet of unassorted sand and small pebbles, thirty feet of sand merging into yellowish boulder clay, thirteen feet of sand with numerous small pebbles, sixteen inches of stratified fine-grained yellowish clay, seven feet of mixed sand and boulder clay, and thirteen feet or more of a hard dense clay conglomerate, containing numerous quartz grains and pebbles. Above the lignite lies about thirty-five feet of boulder clay and blue clay merging probably upward into post-glacial marine strata.

Another small seam of lignite is visible on the southern bank of the river, almost opposite the mouth of a large stream which enters the Missanabie about one-half mile below the mouth of the Soweska. This bed is traceable for at least 600 feet, though it is often obscured by heavy talus of clay and boulder clay, and its termination to east and west is completely hidden. The vegetable nature of this lignite is very apparent, and it may more correctly be called a peat. The seam, which has a maximum thickness of about three feet six inches, is made up of thick laminae of moss and sticks divided by thin layers of silt. This is evidently the same lignite bed as already described by Dr. Robert Bell, who gives the following section (20): "Immediately beneath the lignite is a layer one foot thick of irregularly mingled clay and spots of impure lignite. Next below this are forty feet of unstratified drift, full of small pebbles, under which are a few feet of stratified sand and gravel. Resting upon the lignite are five feet of hard, lead-colored clay with seams and spots of a yellow color, and layers of red gray, drab and buff. Above all, and forming the top of the bank sixty feet high, are ten feet of hard, drab clay, with striated pebbles and small boulders, and holding rather large valves of Saxicava rugosa, Macoma calcarea (Tellina proxima), and Mya truncata."

During the wet spring weather on the Missanabie, streams of soft, sticky clay are continually flowing from the wet upper beds of glacial clays, undermining the more consolidated post-glacial, and causing it to break away. The lignite bed just described, and its enclosing stratum, were with difficulty studied, owing to the great amount of this material which covers it, and it is quite probable that the seam which I saw may be only the inland continuation of that seen by Dr. Bell, much having been removed by erosion.

(20) Rep. Geo. Sur. Can., 1877, p. 4C.

Traces of shaly lignite appear on the southern bank of the stream at a few feet above the summer water level, about four miles below the last described seam or at about six miles above the mouth of the Opazatika. The appearance is unimportant, the lignite consisting of mere podlike lenses in the stratified clays.

The lignite which outcrops just below Big rapids on the Missanabie on the northwestern bank of the stream shows up at intervals for 350 feet. It appears at nine feet above the summer level of the river, and at eighteen feet below the level of the bank above. The lignite itself, though often imperfectly mineralized, is nevertheless of good quality, and consists almost entirely of somewhat carbonized wood. It is not in a true seam, but is instead a bed of lignite fragments and sand, probably re-assorted material broken up by the last glacier and worked over by the action of post-glacial waves. In my examination I found no point at which the thickness of the bed exceeded one foot, though Mr. Borron intimates a greater thickness and possibly the thickest part has been removed by the decay of the bank (21). The lignite is overlaid by gravel and sand, and underlaid first by a thin stratum of sand, and then by hard clay conglomerate.

The pieces of lignite are often large, but when exposed to the air, they tend to break up into smaller bits. However, when obtained even a short distance away from the outcrop, the lignite is apparently more adhesive, and can be kept for weeks (22) without falling to pieces. It breaks with a conchoidal fracture, the fresh surface showing the compact texture and rather brilliant lustre of jet. The analysis of lignite from the Big rapid shows it to be of good quality. It is unfortunate that it should occur in such small quantity.

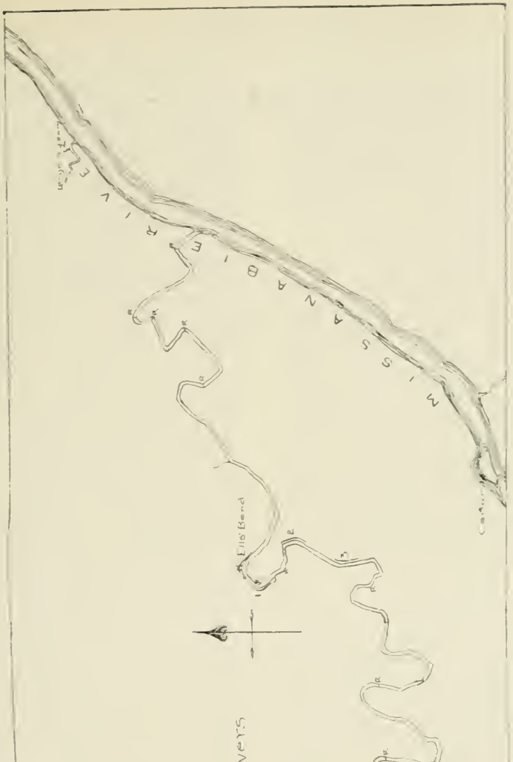
Peaty lignite occurs in the interglacial beds already mentioned as overlying the gypsum of the Moose river. The quality is fair. but in quantity these are mere pockets.

On the Opazatika

Several seams of impure lignite occur on the lower Opazatika River, the most important being at two and a half miles, at three miles, and at three miles and three-quarters above the mouth. The lowest outcrop shows two small seams in a bank of stratified clay and boulder clay about twenty feet in

(21) See Borron's Report on the Moose River Basin, 1890, p. 63.

(22) A sample was kept for five months intact, at the end of which it suddenly broke up and fell apart.


Sketch of portions of the
Lower Missanabie and Soweska Rivers
location of lignite beds
lignite
Ells' Bend
MISSANABIE RIVE

height on the western side of the river. The seams are about three feet apart. The lowest is of fairly pure but very mossy lignite. The seam is only a few inches thick, and is overlaid and underlaid by blue clay. The upper seam is an exceedingly compact argillaceous brown lignite, also narrow and unimportant.

The second bed on the western side of the river shows lignite of rather better quality than the first. It is composed chiefly of moss and rushes, not much carbonized, which break off in long strips sixteen inches long. The seam is some nine inches thick, and is traceable for 225 feet along the bank, and reappears again about one hundred yards still farther up stream.

The third outcrop shows a lignite bed about twelve inches thick, of rather poor quality, underlaid by blue clay and overlain by rusty clay and sand. The seam extends along the bank for about 300 feet. All the lignite beds on the Opazatika and Missanabie lie practically horizontally, the small departures from this attitude being scarcely observable.

The Soweska Seams

The Soweska river shows the greatest amount of lignite outcropping along its banks of any of the streams so far examined in the Moose Basin, there being eight distinct points at which it occurs within a distance of four miles. Of these the lower three are practically one seam; while the other five, although they may be one seam, are so widely separated from each other that they cannot be so connected. The seam lowest down the river starts about three miles from the Missanabie in a straight line, or some five miles following the bends of the river. In was at this point, Ells' bend, that most of our work was done.

The seam first appears on the left or northern bank of the stream, at the point where the bank rises from the low level of the flood plain to that of the elevated plain above, and is continuous all around the convex side of Ells' bend, a distance of about 1,000 feet east and west, and rather over 900 feet north and south. The seam does not appear on the concave side of the stream, this being a low flood plain below its level.

In the next bend the second appearance of the lignite shows up on the opposite or right hand side of the river, the concave side being a flood plain which cuts off the southward continuation of the first appearance. This second showing of lignite is traceable for 650 feet along the bank, when it is cut off, owing to the sloping of the bank, but reappears some 700 feet farther south, where cut banks again are visible on the right hand side of the stream. This third outcrop of lignite is visible for but 250 feet, when it is buried beneath a heavy talus of clay and sand.

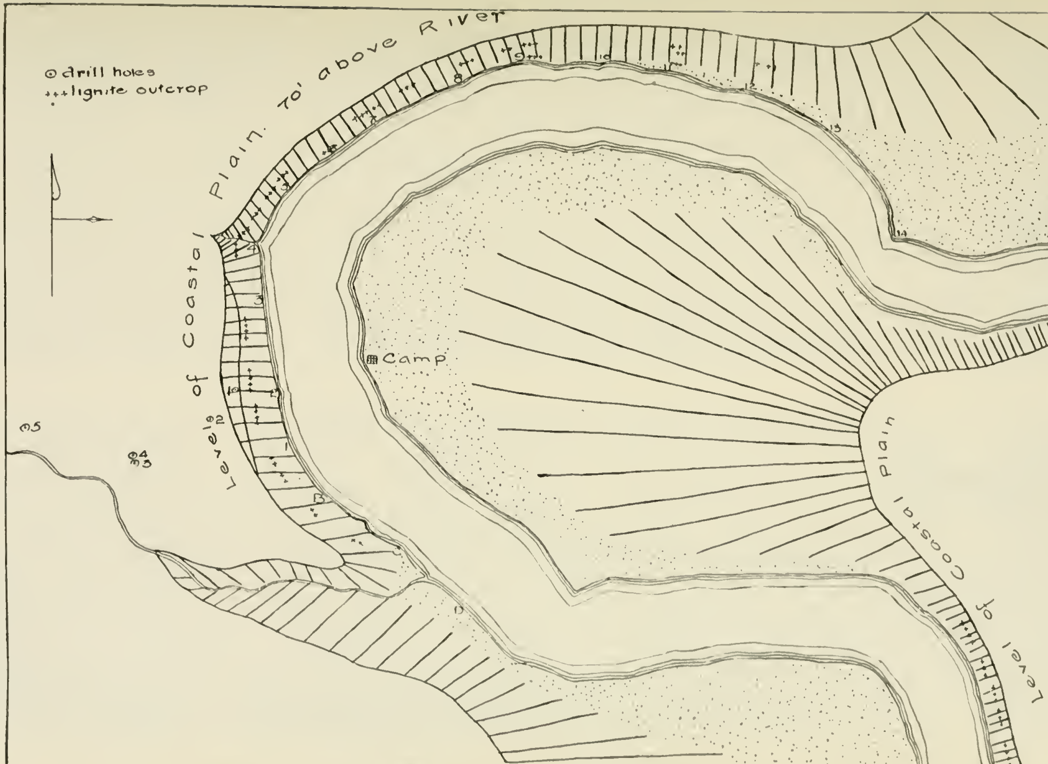
These three appearances of lignite all belong apparently to one and the same seam, which has thus a total north and south extension of at least three-quarters of a mile, and a minimum width east and west of one-quarter of a mile, as shown partly by the exposures along the bends of the river, and partly by the records of holes drilled with a long articulated auger in the interior away from the bank of the stream.

There is a great irregularity in the thickness of the seam. It has a maximum of about five feet, averages over three feet, and thins out almost to zero at the northern end of the seam at the third appearance. Where it first shows up in the northeast of Ells' bend, it has a thickness of three feet nine inches, and is composed of brownish and blackish layers of rather argillaceous material. The seam is about forty feet above the summer water level, is overlaid by boulder clay and post-glacial stratified beds, and underlaid by hard blue clay merging into dense clay conglomerate.

One hundred and eighty-five feet farther west, the seam lies 38 feet up the bank, and has increased to four feet two inches in thickness, but much of it is still argillaceous (opposite 11 on diagram). Two hundred and fifty feet beyond (or fifty feet west of 9), the seam has diminished to two feet three inches in thickness of which quite one foot is of good quality and the rest is fair. Two hundred feet more to the west (opposite 7 on the diagram) the lignite is four feet two inches thick, of which three feet five inches is of good quality. Two hundred feet still farther westward is a three-foot outcrop of splendid lignite (opposite 5). Three hundred and seventy-five feet to the south of the last, the outcrop is about five feet thick, composed as follows :

1 ft. 6 in. Poor, argillaceous lignite.
6 in. Superior lignite.
2 ft. Argillaceous lignite.
1 ft. Good lignite.
2 in. Argillaceous lignite.

At this point the lignite is overlaid by a few inches of stratified grayish clay, above which lies twenty-five feet of yellowish, weathering blue clay with occasional pebbles, some of which are striated. This is surmounted by four feet of post-glacial argillaceous sand containing numerous marine shells. Beneath the lignite lie 38 feet of blue clay with numerous boulders, merging



Ells' Bend, Soweska river; location of lignite deposits. Scale, 260 feet—1 inch.

in depth to a hard arenaceous clay conglomerate grit.

Near the point where the seam disappears beneath the sloping bank on the south side of Ells' bend, it has a thickness of three feet four inches measured from above as follows :

.9 ft. Argillaceous lignite.
.4 ft. Blue clay.
.3 ft. Fair lignite.
1.8 ft. Rather argillaceous lignite.

Where the lignite bed reappears at the second place of occurrence on the other side of the river, it has diminished in thickness to a little over two feet, the seam occurring in a high, steep bank forty feet above the level of the river, underlaid by yellow weathering arenaceous clay with pebbles, and the clay conglomerate. It is overlaid by fourteen feet of clay containing few boulders, and four feet of post-glacial marl-like silt. The seam, which is about half of good lignite and half of argillaceous material, retains the average width of somewhat less than two feet throughout its outcrop. It is of the same quality and thickness as at the third point of appearance on the next bend above.

When we reached Ells' bend the seam was by no means exposed all along the cut face of the bank; in fact, in comparatively few places did it outcrop prominently, and was for the most part hidden by talus. However, we proved its continuity by cuts in the bank, made at frequent intervals. To make certain of the extension of the seam inland, five bore-holes were sunk by an articulated auger (as shown on the accompanying map).

As the most inland of the holes passed through an increasing rather than diminishing thickness of coal, at a point four hundred feet from the edge of the bank, I considered it unnecessary to continue investigations further.

Drilling at Ells' Bend

In drilling we were much inconvenienced by the quicksand nature of the stratum at the bottom of the post-glacial silt, etc., which filled into the narrow drill holes as fast as the auger could be removed, and we found it necessary to put a hole three feet wide down from the surface to the top of the boulder clay, the edges of which were surrounded by timbers kept in place by nails and willow hoops. Another inconvenience was the occurrence of the small pebbles in the clay overlying the lignite, which were continually sticking in the auger and stopping its progress. In fact, in several holes we were obliged to desist for this reason, and we were never able to drill in the hard, boulder-filled stratum beneath the lignite. We found it unnecessary to erect triangles to haul out the auger, the high aspens growing along the bank of the Soweska making an excellent substitute.

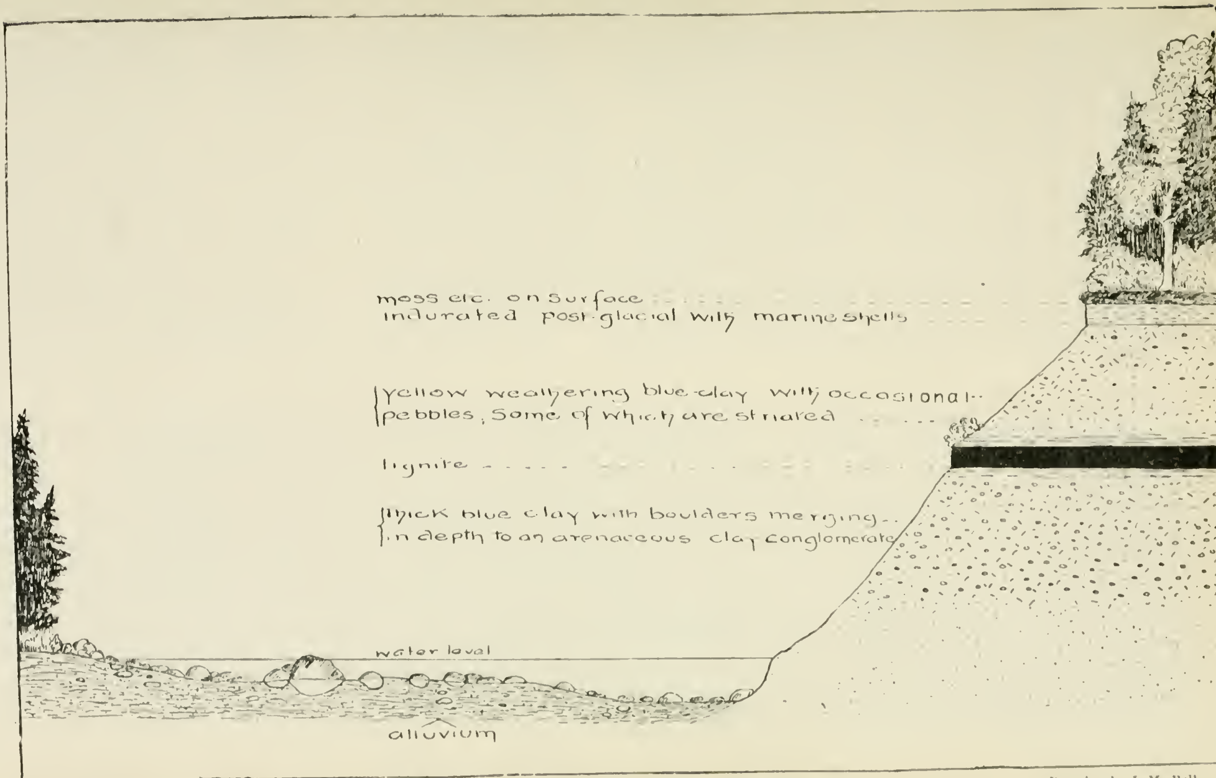
The quality of the Ells' bend lignite is for the most part fairly good. It is not very highly carbonized, but it is very much better as a fuel than its analysis or even appearance would warrant. While we were camped on the Soweska we used it almost entirely as fuel, and it proved most satisfactory. When taken from the seam in large pieces, it is almost black and of a dull, earthy aspect, this appearance being due to the large quantity of free water which it contains. When dried, though it adheres well and does not break apart, it is much lighter in color and less coal-like in aspect. Even when put into the fire wet, it burned easily, emitting a strong bituminous smell, and left apparently a comparatively small amount of ash. Even the argillaceous varieties burned freely, though of course with a proportionately larger quantity of ash.

It is my opinion that the relatively high percentage of ash in much of the Soweska lignite is within certain limitations not so serious a detriment to its value as it would be in the case of other coals containing a greater amount of fixed carbon. It has been observed that the lignites with a very small proportion of ash, as at the Big rapids of the Missanabie. exhibit a tendency to crumble, while the Soweska lignites with a much higher percentage of ash retain their coherency, and apparently burn quite as well.

The lignite of Ells' bend is almost entirely formed from moss, though at a few points along the seam many small sticks occur between the layers. These sticks are but slightly carbonized, though squeezed almost flat parallel to the bedding planes. The lignites lie practically in undisturbed horizontal positions; though there may be a very slight dip down stream.

It is hardly probable that the lignite of the Soweska is worth transporting to distant markets in southern Ontario, but there is no doubt that it will be eminently valuable as a fuel for the people who will undoubtedly inhabit the fertile valleys of the rivers which form the Moose Basin.

The fourth point where the lignite ocurs on the Soweska lies almost two miles and a quarter southwest of Ells' bend. The seam outcrops for about 240 feet in a bank some 60 feet high. The



Cross section of Soweska river at Ells' Bend. Scale 34 feet = 1 inch.

Drawing by J. M. Bell.

maximum thickness is about two feet five inches. The quality is for the most part poor, being decidedly argillaceous. The bed is overlain in ascending order by six feet of sand, over ten feet of boulder clay, and eleven feet of stratified marl which is decidedly consolidated and stands out in an overhanging cliff above the bank below. Beneath the lignite lies the usual clay conglomerate.

The fifth point of occurrence of lignite is rather over a mile west of the last described. Here a seam, mostly of good lignite, but with some decidedly argillaceous material appears for a little over 300 feet. The seam, which has a thickness of two feet six inches, is overlain by a boulder clay and marl-like silt, and underlain by yellow, weathering sand.

Numbers six is probably a continuation of number five. It appears on the opposite side of the river in the next bend of the stream above. The bed which varies in thickness from three feet three inches to four feet two inches, is exposed about half-way up a bank sixty feet high, at intervals for 125 feet, being lost at either end in a talus of thick, soft, aqueous clay which rendered investigation both dangerous and difficult. The lignite is very impure, being mixed with sand, clay and gravel. It is overlain by unassorted clay and by stratified silt, and underlain by three to five feet of stratified soft, sandy grit, bearing striated boulders, beneath which is the widespread hard clay conglomerate.

Number seven is brokenly continuous for 670 feet; and where it first appears is exposed about half-way up a bank 55 feet high. It varies in thickness from three feet to over five feet. Almost half-way along its course, where it has a thickness of five feet, two inches—the upper two feet being good lignite, and the lower three feet two inches sand mixed—it is overlain by 15 feet or more of boulder clay, and 10 feet or less of post-glacial stratified silt, containing numerous shells. Beneath the lignite lies two feet of stratified sand with thin layers of lignite, followed by hard clay conglomerate. Where the lignite is cut off to the west by the slope of the bank, it is directly overlain by reassorted silt. At this point the following section was made, measuring from the top of the bank :

0 ft. to 7 ft. Marl-like silt.

7 ft. to 10 ft. Lignite, more or less impure.

10 ft. to 14 ft. 6 in. Bedded sand with a little gravel becoming coarser.

14 ft. 6 in. to 17 ft. 6 in. Rusty, fine gravel, coarser in descent,

17 ft. 6 in. to 20 ft. 9 in. Fine-grained sand.

21 ft. to 25 ft. Gravel, talus-covered.

25 ft. to 37 ft. Clay conglomerate, talus-covered.

The sands underlying the lignite are often exceedingly rusty, and at one point a layer some two inches thick is so much so that it might almost be termed an iron ore.

A short distance above number seven on the opposite side of the river, number eight appears. It is a narrow seam, only eight inches thick, of very woody lignite, some fifteen feet above the summer water level. It does not increase in thickness, and runs out within 300 feet.

It is quite probable that when further exploration has been carried out along the Soweska, lignite will be found at many more points than shown by my map, as it was quite impossible to examine all the banks in a detailed way, and much lignite may be concealed beneath the heavy coating of talus which covers all but the steepest banks. At present the widespread occurrence of the lignite, in decided seams continuous for comparatively long distances, is a very encouraging feature, even if in places the quality is disappointing.

On the Kwataboahegan

The deposits of argillaceous lignite on the Kwataboahegan River were examined by Dr. Parks, who reported nothing of economic value. The lowermost deposit occurs on the north bank some 60 miles above the mouth of the river. The seam, which has a maximum width of two feet six inches, outcrops almost continuously along the edge of the river for 450 feet in a bank 40 feet high. Though compact and hard, it is never pure, and is for the most part mixed with clay. Above it lies above 25 feet of hard, blue clay, surmounted by six feet of shell-bearing post-glacial material. Below the seam is a hard stony clay, containing many shells. This is of great scientific interest, as it is the only point in the Moose Basin where interglacial shells are known to occur.

About half a mile above this point on the opposite side of the river, appears a lignite bed which is probably a continuation of the one just described. The whole is argillaceous, and the upper part is mixed with blue clay. It is overlain by bluish clay, and underlain by hard, stony gray clay. For a mile and a half up the river from this second exposure, or for about two miles from the foot of the first outcrop of lignite, traces of coal are observable as narrow black streaks on the face of cut-banks. These streaks appear to occupy a fairly decided position in the bank, though in places it is evident that the material which they contain has been reassorted. There is no doubt that a discontinuous bed of impure lignite exists at this horizon with a slight dip down stream, being about three feet above the level of the river at the northwestern point of exposure and only a few inches above at its lowest appearance.

About one mile above this first series of exposures, traces of lignite again show up along the river bank, and are visible at intervals for some two miles. The seams are never continuous, but are apparently mere broken lenses and scattered bits of lignite interstratified with blue clay and hard-pan. Dr. Parks thinks these may represent the remnants of the westward continuation of the first series of seams described. He considers that the blue clay above the lignite, and the gray clay beneath it, are more or less constant, the lignite being slightly unconformable with the latter, while in places the lower levels of the blue clay are interstratified with the lignite. This condition is identical with what was observed on the Soweska. The blue clay is in places replaced in part by sand, and merges upwards into gray boulder clay. The blue clay varies in thickness from a few inches to twenty or thirty feet, while the gray clay in some places reaches a thickness of fifty feet, forming the conspicuous element in the clay banks of the region. The lignite itself is both arenaceous and argillaceous. It consists of thin layers of indurated moss, with partings of clay or sand. It burned with considerable difficulty in the camp fire, leaving a large residuum of clay or sand.

On the Abitibi

Inter-Glacial coal measures are exposed at intervals all along the Abitibi from the top of the Long rapids to the mouth of Big Cedar creek, but in comparatively few places are these at all likely to be productive of coal. Drilling operations were conducted at four points—first, at a point about three-quarters of a mile below Little Cedar creek; second, on both sides of the Abitibi at the Blacksmith rapid; thirdly, just at the foot of the Long rapids; and fourth, at a point about one mile and a quarter above the foot of the Long rapids; and at only one of these points, viz., at the Blacksmith rapid, can our operations be said to have met with success.

At three-quarters of a mile below Little Cedar creek, the work was started. Though true lignite is not exposed in the shore at this point, still, as there is considerable thickness of more or less lignitic clay, it was thought that lignite might lie beneath the surface in the interior, and accordingly Dr. Parks, who conducted the drilling operations on the Abitibi, decided to put down a few holes away from the river bank here. Five holes in all were sunk, and though several passed through stratified lignitic clay the hope that true lignite would be found was not realized. The lignitic clay is apparently interstratified with a fine blue clay which underlies gray boulder clay. In places it lies horizontally, but again is deformed, probably either by ice pressure or by subsequent landslips.

East Side Blacksmith Rapid

Lignite appears on both sides of the Abitibi river at the Blacksmith rapid. A prominent outcrop occurs on the east bank about one-quarter of a mile below the foot of the rapid, and at about three feet above the water and twelve feet back from it. At this point along the shore the lignite has a longitudinal extension of only twenty-two feet ten inches, though the thickness of the bed is ten feet seven inches. It is not correctly speaking, a pocket, but is a remnant of what was probably once a thick and extensive bed, most of which has been removed by succeeding glacial corrasion. The original bed of peat, probably very little consolidated, was shoved by the advancing ice sheet into a series of close tight folds which were afterwards overridden by the ice, much of the peat ground to powder, and partly, at least, carried away. In what is left the beds are folded into a steep anticline, the crest having been truncated; while northwards for 280 feet are frequent outcrops of dark brown boulder clay containing fragments of lignite, and colored by the powder which resulted from it.

The northern limit of the anticlinal lignite remnant is much thicker than the opposite limb, the latter thinning to a few feet just beyond the crest and dying out altogether within a very short distance. The northern limb, which dips at first at an angle of seventy or eighty degrees, gradually approaches horizontality, and at fifteen feet from the crest of the anticline has diminished to two feet in thickness. The strike of the upturned bed is S. 65 deg. E., and I see no reason why the lignite should not continue into the interior in that direction, but ice shoving differs so markedly at different points that all of the seam may have been removed, or on the other hand the present extension of the beds may be much greater The lignite is overlain at its outcrop on the river by three to five feet of consolidated boulder clay resembling hard pan, filled with huge cobbles, and this our auger could never penetrate, so that out of five drill holes sunk in wide pits with great difficulty in the interior, none with certainty even reached the horizon of the lignite. Above the boulder clay lies six feet of post-glacial re-assorted gravel and sand. Beneath the lignite is a hard brownish clay, mixed with a light pea-green clay. At the crest of the anticline a deep pit was sunk in the lignite, and from its bottom a drill hole carried down in the coal to see how deep the tilted beds extended, but after passing nine feet five inches of lignite, all our efforts could not force the auger further, so hard was the lignitic material.

The thickness of the boulder clay above the coal is variable, and at 67 feet north from the crest of the anticline of lignite, its upper surface has descended much lower in the bank than at the lignite anticline. A section at this point showed from the base up as follows : seven feet of rusty weathering unstratified boulder clay; two feet interstratified soft and indurated coarse and fine sandy gravels with some very rusty layers; two feet eight inches interstratified thin layers of sand and rusty, very slightly carbonaceous clay, (the latter predominating), having stratification. with a slight tilt of the beds inland ; two feet of grayish rusty weathering hard clay, becoming darker in descent, and assuming stratification; four feet seven inches marly silt-like material, containing a few large and many small boulders, and a few small shells.

Quality of the Lignite

The quality of the lignite is excellent. In its small exposure it is remarkably pure and unmixed with either sand or clay. It consists in part of moss-formed material, and in part of trunks and roots of trees, both of which are as a rule well carbonized—though in places the mineralization is not complete in the centre of the larger trunks. Some of the roots still retain their original position with reference to the beds. The moss-formed lignite is jet black in color, though its vegetable origin is apparent. The woody lignite is not always so dark in color as the moss-formed, but when broken, after a short exposure to the air, it often shows a beautiful brilliant lustre. For the most part the lignite of both kinds is coherent, but part of the mossy material, especially that around the larger trunks, which are sometimes six or eight inches in diameter, is loose, friable, and poorly consolidated. Small concretions of iron pyrites are not uncommon in this soft material.

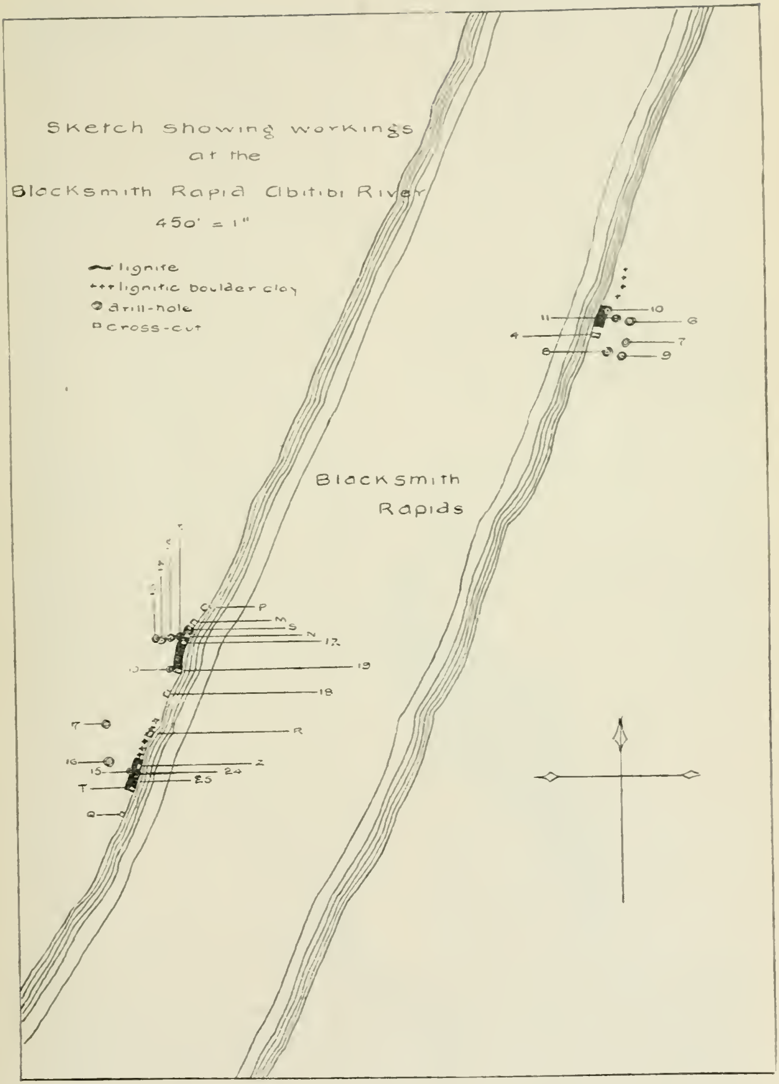
This coal would make a good fuel for all practical purposes. It burns freely in the open air, leaving a very small residue. If it extends inland, as there is reason to hope, then there will be a quantity of good coal for the future settlers in the region.

West Side Blacksmith Rapid

Prior to the commencement of operations on the west side of the river at the Blacksmith rapid, lignite outcropped only in a few spots along the talus-covered bank, but abundant test pits and open cuts showed the existence of a considerable body of the coal on this side of the stream. The lowermost lignite occurring was exposed by a cut at the foot of the rapids, and from this point the lignite was found by frequent open cuts to extend up stream for 160 feet at least (from open cut "S" to cut XIX.) A great deal of lignite in pieces and streaks was shown by a cut at 100 feet north (from cut "S"). Southwards (from open cut XIX) the boulder clays are barren of any signs of lignite and quite light-gray in color for 128.2 feet. Then they become pronouncedly lignitic and a hard, dense, almost black clay filled with pebbles and fragments of lignite, appears along the river for 176.7 feet, where it passes into true lignite. The lignite continues for 46 feet 5 inches, when it dips rapidly below the overlying boulder clay, and disappears.

All efforts to drill any distance down from the surface in the interior were fruitless. Six holes in all were tried, but none were successful in reaching what was supposed to be the level of the seam. All of these holes had to be dug out with picks and shovels for a depth of six or eight feet down to pass the pebbly alluvium and quicksand of the Post-Glacial, and this part timbered. Then, when drilling did get started on the boulder clay, it was always sure to be stopped by a stone before any depth had been attained.

On the river bank itself wherever true lignite was exposed, we had comparatively little trouble in drilling to find the thickness of the coal, etc., but in the boulder clays, especially in the hard black lignitic clay, it was absolutely impossible; in fact, a short distance below the surface even the pick made very little impression on this material. In


Sketch showing workings
at the
Blacksmith Rapid Abitibi River
450' = 1"
lignite
lignitic boulder clay
drill-hole
cross-cut
Blacksmith
Rapids

working on it, it gave the impression of having the consistency of hard, black India rubber. Test pits were sunk in it at intervals, but with a depth of a few feet no increase in the quantity of lignite was observed.

The thickness of lignite at various points is interesting. At a point two feet from the water's edge on open-cut XIV., a bore hole showed a thickness of three feet of coal, underlain by a grayish, smooth, plastic clay. At 21 feet from the water the thickness of lignite in the same open-cut is nine feet. At this point the lignite lies 5 feet below the brink of the bank, at the water's edge 15 feet felow and at 34 feet 4 inches in from the water, at 7 feet below the top of the bank; so that there must be a sharp rise in the upper surface of the coal from the water to the first drill hole and then a gradual slope inland. This may represent a thinning of the coal seam inland at this particular point, or it may be merely a local corrugation. Very probably much of the seam close to the river has been removed by fluviatile erosion.

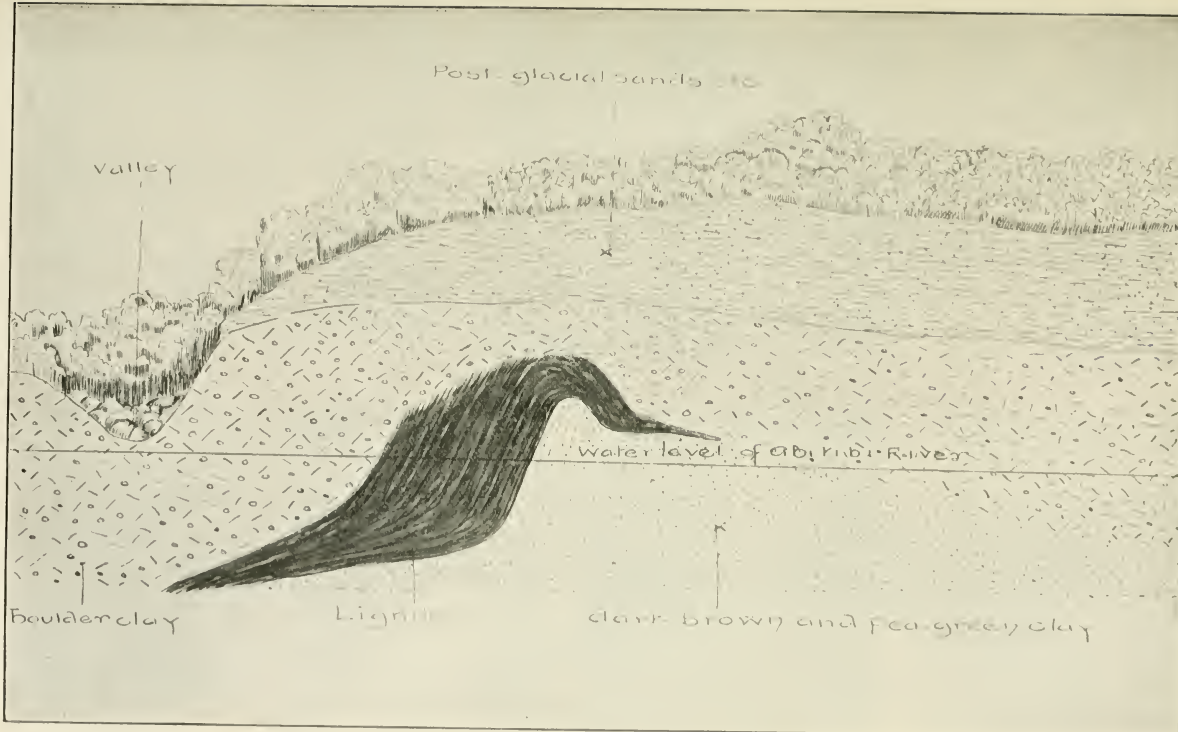
At the top of open cut XIX a drill hole was sunk ten feet in lignite containing a very little clay, and at this depth the auger stuck, owing to the caving in of the walls of the hole. This hole was sunk at a point ten feet above the water level, and about 15 feet back from it. Another was lowered just in front, at the water level, which traversed ten feet of blue lignitic clay and then one foot of lignite. On entering the lignite bed, a flow of water was tapped which flowed for some weeks laden with lignite. Beneath the lignite is a hard boulder clay. It is very probable that the clay overlying the lignite is re-assorted alluvium, and not glacial material.

On the southern exposure of lignite on cross-cut XV, which was run N. 60 degrees W. from the river bank, at a point 31 feet from the water, a drill hole was sunk which passed through 18 feet of lignite, 10 feet 2 inches being below the river level. Beneath the lignite lies a somewhat lignitic clay; above it 9 feet 10 inches of sand, silt, etc., measured from top of bank down as follows: 3 feet sand and silt, 2 feet of gravel with marine shells, 4 feet 10 inches of boulder clay. Hole XVI, which was sunk 100 feet inland from this point, reached with great difficulty a depth of 16 feet. This passed through a little lignitic material between 14 and 15 feet, but did not enter the main mass of lignite, if indeed it exists. It is quite possible that the lignite lies lower than 16 feet from the surface, as a decided slope inland of the surface of the lignite is observable at the outer outcrop. Another drill hole was sunk just above the water level, at a few feet back from the river, and right in line with hole XV. This hole passed through first one foot of loose river gravel, and then 13 feet of lignite, beneath which lay the usual tough blue clay. Evidently the lower surface of the lignite slopes towards the centre of the river at this point. There is also a gradual slope of the bottom of the bed to the south, since a drill hole (XXV) 14 feet 3 inches south of XV showed 13 feet 6 inches of coal below the water level.

The quality of coal on the west side of the Abitibi is in general inferior to that on the opposite side. It consists of a loose, incoherent, black lignitic powder, highly carbonized, through which are scattered with variable frequency angular fragments of woody lignite often six or seven inches long by three or four inches thick, and as many wide. The powdered material is chiefly moss-formed lignite, though part of it is broken up woody lignite. Apparently the lignite becomes less friable in depth. In places there is a little loose clay mixed with it, especially in the upper part, and it contains a little iron pyrites. There is never any stratification, and the whole might almost be spoken of as an uncemented lignite breccia.

I do not think it probable that the two deposits of lignite on the west side of the river are the opposite limits of a syncline, and it seems to me much more likely that they are the remains of a thick seam of lignite which was first corrugated by the shoving of the ice, and afterwards shattered, powdered, and probably deposited in holes in the underlying plastic clay. If this is the case the two deposits are quite distinct and separate. This theory accounts for the inequality of its thickness, for the lignitic boulder clay lying between the two lignite deposits, and also for the extraordinary nature of the lignite itself, which has the carbonization of superior lignite with the lack of homogeneity of peat.

It was most unfortunate that none of our drill holes penetrated to the supposed horizon of the lignite in the interior, to ascertain definitely whether or not the coal existed. For my own part I think it does, there being no apparent reason why a total outcrop of lignite of over two hundred feet, with always a considerable thickness and a maximum at twenty feet, should suddenly die out away from the river bank. Of course glacial corrasion has been most unequal and irregular, and it is possible that all the lignite in the in-



Section showing lignite bed, east side Blacksmith rapid, Abitibi river.

terior has been removed, but the opposite is equally likely to be true. This can only be proved by the sinking of numerous shafts to the depth of twenty or thirty feet. At any rate, there is in situ and in view a considerable quantity of lignite (at least 1,600 tons), which is not an unimportant resource of the region.

Several drill holes were lowered on the west bank of the river below the Long rapids on an extensive outcrop of carbonaceous clay, in the hope that lignite would be struck in these coal-bearing measures with depth, but the hope was not realized.

Other Deposits

About one and one-quarter miles above the foot of Long rapids, a small seam of rather argillaceous lignite was discovered by Dr. Parks on the west side of the river. The seam lies about 38 feet above the summer river level, and some 77 feet back from it. It has a maximum thickness of 3 feet 6 inches, is overlain by sandy clay, and underlain by interstratified beds of fine sand, fine bluish clay, and coarse gravelly sand resting on Devonian shales. The seam is a mere lens, dying out within a few feet in either direction. A drill hole sunk one hundred feet back from the bank at this point failed to reach the level of the lignite, owing to the numerous boulders in the overlying boulder clay.

From Indian report I have learned that considerable lignite outcrops along the Kesagami river, but I was unable to visit the locality. It is very probable that when the numerous streams which enter the Missanabie from the west, between the Soweska and Kwataboahegan, have been explored, a great deal of lignite will be discovered. These streams flow through that section of the country most likely to be productive of coal deposits of economic value. Of the largest of these streams may be mentioned the Atagwaigon and Ash, which could easily be ascended at the time of high water.

Peat Bogs of Coastal Plain

At first glance the great muskegs of Northern Ontario, with their almost interminable extent of sphagnum and their miserable scrub spruces and tamaracs, seem absolutely valueless, but as a matter of fact, they may before very long be a really valuable asset. The moss extends downward into peat, and there is every stage of carbonization from that which is still green and growing to that which, were it not for its lack of homogeneity, would be called lignite. The extent of these peat bogs is enormous. They cover thousands of squares miles, and in fact clothe practically the entire region of the coastal plain, except on the mere borders of the rivers. No detailed investigations have been made of the thickness of these peat bogs, but they vary from a few inches to probably 25 or 30 feet. On the smaller rivers, beds of peat are often seen along the river bank above the drift. Several were observed on the Soweska, and on the Kwataboahegan, where a thickness of from six to ten feet is commonly exposed.

It is, however, on Kesagami lake that the most interesting sections of peat appear. This remarkable body of water is almost entirely surrounded by beds of peat, which appear topographically as low cliffs rising abruptly from the water front, and often caverned and pillared in a most grotesque and extraordinary manner. The peat, which has a maximum thickness of quite twelve feet, and averages about seven, is underlain by hard gray boulder clay, and overlain by growing sphagnum moss. Above the underlying clay it is black in color, and grades upwards through brown-black to brown, and light-brown. A great many sticks, branches and trunks of trees are interstratified, and these vary with the moss-formed peat in the state of carbonization, decreasing from the bottom up. The peat is almost always pure, though along the face of the cliffs some silt has been washed by the waves into the less coherent portions, and deteriorates the quality at the outcrop, but of course this defect is local

On page 175 is a table showing the composition of lignites from various parts of the world, including some from northern Ontario, also samples of peat from Kwataboahegan river and lake Kesagami.

A specimen of lignite from Moose river, obtained by Dr. Bell in 1875, analyzed as follows:

	Slow coking.	Fast coking
Fixed carbon	45.82	44.03
Volatile combustible matter	39.60	41.39
Ash	2.84	2.84
Water	11.74	11.74
Ratio of volatile to fixed combustible	1:1.16	1:1.06

Climate

The climate of the Moose Basin has been so often described that I need hardly mention it here. In general there is little or no variety north of the height of land as far as Moose Factory. The snow usually melts during the last two weeks in April, and the ice leaves the rivers about the same time. Vegetation is delayed, and it is the end of May before the leaves appear on the deciduous trees. June, July, August, and the early part of September are warm, sometimes excessively hot, and with a plenteous supply of rain. The latter part of September, October, and much of November are chilly and rainy, with occasional flurries of snow, but with much fine autumn weather. By the end of November winter has begun, and lasts until the beginning of April. This season is bright and delightful, and though exceedingly cold, yet the air is so bracing, especially in the interior, that I doubt if its severity is felt as much as in more southern latitudes. Apparently, however, the seasons are subject to great variety. For instance, the summer of 1901 was very hot and dry, hardly any rain falling from the end of May until the middle of September, when torrents of rain deluged the country for the two following months. Last summer, 1903, was damp and with scarcely any really hot weather, while the autumn was partly fine and partly rainy. Light summer frosts have been known to occur in the Moose Basin, but are not common. All the hardier vegetables and even Indian corn and tomatoes are grown at New Post on the Abitibi. Cereals, with the exception of barley and oats, have scarcely been tried, but I see no reason climatically why they should not thrive as well as around Sault Ste. Marie. The bishop of Moosoree has in his garden at Moose Factory some small apple trees and plum trees which, though they have not borne, are apparently growing well.

Locality.	Water	Ash.	Volatile.	Fixed carbon.	Remarks.
Golden City, Colo., 56 ft. below surface	13.43	3.85	37.15	45.57	Gray ash.
Carbon, Wyoming.........	6.80	8.00	35.48	39.72	Light gray ash, nearly white.
Monte Diablo, Cal........	3.28	4.70	47.05	44.90	
Germany	......	4.60	52.50	42.90	Drill brownish black, powder same. Compact ash, brick color.
Minerve Land.	......	10.00	57.40	32.60	Compact brilliant, black color, irregular fracture. Powder brownish black: yields coke.
Big Rapid, Missanabie....	20.06	2.95	40.12	36.87	Woody lignite. Ash greenish yellow.
Abitibi, Blacksmith rapid.	16.46	7.28	39.66	36.58	Moss lignite. Black, ash yellowish green.
Soweska river (23).........	12.25	25.34	42.96	19.45	Lignite. Black and fairly good. Ash greenish yellow.
"	7.56	10.88	57.38	24.18	Woody lignite.
"	13.92	31.04	39.00	16.04	Argillaceous lignite. Ash yellowish.
Abitibi, Blacksmith rapid.	10.34	32.67	33.67	23.32	Conglomerate lignite. Ash reddish brown.
Kwataboahegan river	11.39	36.22	38.20	13.59	Argillaceous lignite. Greenish ash.
1½ miles above foot of Long rapid Abitibi	8.17	57.64	27.50	6.87	Lignite. Yellowish ash.
Peat, Kwataboahegan R..	13.56	4.73	59.80	21.91	
Peat, L. Kesagami	14.38	16.80	47.55	21.27	

(23) The high ash in the case of the Soweska lignites is probably in part due to the fact that the specimens for analysis were taken from the outcrop, into which much impurity had filtrated along the stratification planes.

Soil

The soil of the great central interior on the old land plateau is excellently suited for agriculture. It is a rich clay loam of great fertility. Where tried for vegetables, as at New Post, it is wonderfully productive. I have walked for miles across country, passing over only this splendid soil. It is unfortunate under these circumstances that so much of this region, especially the northern part, is swampy, because with such singular uniformity of surface draining, when the country is opened up, may be difficult. Towards the south of the upland there are not nearly so many areas of swamp; in fact, no more than one should expect to find in any new and unopened region, or as existed in southern Ontario prior to the clearing of the forest, and the character of the soil on the whole is much better. In general, the width of the clay belt is about ninety miles where it crosses the Missanabie, and about sixty miles on the Abitibi.

It has been mentioned that by far the greatest part of the coastal plain region is covered with muskegs, and is in its present condition unfit for agriculture; but the alluvial flats of the various rivers which are not flooded in spring, the numerous islands, and finally river bank strips of land varying in width from a few yards on the small streams to one-quarter or one-half a mile along the large rivers, are quite suited for farming. It is apparently mainly a question of drainage. The impervious clay substratum does not allow a free movement of water in so level a region, especially as with clay and boulders packed up along the edge of the bank there is a slight slope towards the interior rather than towards the river, especially near the sea. However, I observed in the southern part of the plain, where the forests had been recently burned off, and with it the muskeg moss, that the underlying soil was laid bare and was in these places quite or nearly dry, or merely moist, for miles, and where the moss had been entirely removed was supporting a rich growth of wild grass. This was especially observable on the completely timber-stripped area on the Opazatika near Scott's island, and in the land passed over in a trip made across country from the foot of the Long rapids of the Abitibi to the Grand rapid on the Mattagami. I therefore believe that much of the land, particularly the southern part where the sphagnum growth is light, can by burning off the moss be made suitable for farming. The northern part, with its treeless muskegs and with moss of great depth, seems a more difficult problem. The land around the upper Nettogami river beyond the Pre-Cambrian boundary and around lake Kesagami itself is nowhere good. Where not peat bog, muskeg or tamarac swamp, it is too sandy or gravelly to be of any value agriculturally.

The southern shores of James bay from Moose Factory to the Ontario-Quebec boundary line are bordered by wide plains but slightly elevated above the level of high tide, covered in summer with a luxuriant growth of wild grass and flowers, which at the end of the season is quite four feet in height. Formerly the home of hundreds of caribou, it would with the opening of the country become immediately suitable for the grazing ground of domestic cattle.

Forest Trees

The forest trees of northern Ontario are: White spruce (Picea (24) alba), Black spruce (Picea (24) nigra), Balsam (Picea (24) balsamea), Tamarac (Larix americana), Banksian pine (Pinus banksiana), Cedar (Thuya occidentalis), Aspen poplar (Populus tremuloides), White birch Petula papyracea), as well as White pine (Pinus strobus), Red pine (Pinus resinosa), Swamp elm (Almus americana), and Black ash (Traxinus sambucifolia), which are found sparingly towards the southern part of the area. Among the common shrubs may be mentioned several species of Falix Mountain maple (Acer pennsylvanicum), White alder (Alnus incana), Green alder (Alnus viridis), Red cherry (Prunus pennsylvanica), Choke cherry (Prunus virginiana), Mountain ash (Pyrus americana), Service berry (Amplauchier canadensis), Hazel (Corylus americana), Juniper (Juniperus communis), and Hawthorn (Crataegus coccinea), towards the south.

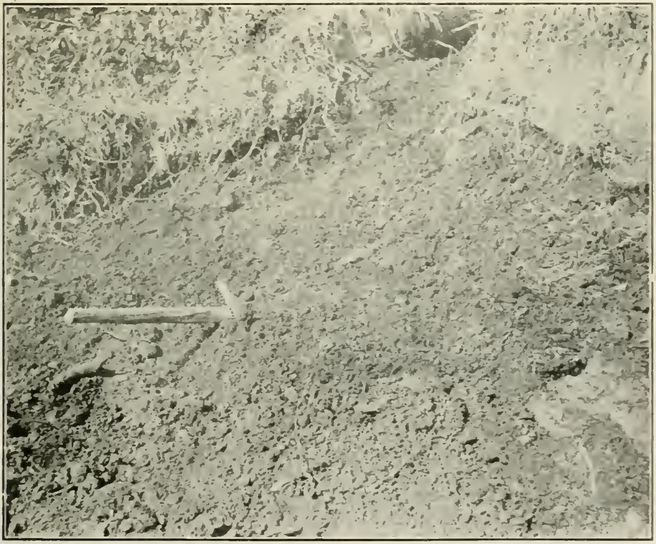
The distribution of these various trees and shrubs is important, as showing the capabilities of the region from a climatic standpoint. Some years ago I saw a fine grove of swamp elm growing on the Kapuskasing, 70 miles below the lake of the same name, and this year I observed some on the Skunk islands of the Missanabie, as well as near the mouth of the Blue Water river below New Post. White and red pine grow on the Abitibi as far north as Iroquois falls, and I saw a lonely white pine down the Kapuskasing some thirty miles south of the White Spruce river. These points may, I think, be said to mark the northern limit of growth of these particular species.

In the dry land throughout the country white spruce, the two poplars, balsam, and birch are the principal forest trees, and these grow with a luxuriance and, when allowed, to so healthy a size that there is no doubt of the good character of the soil. In the muskegs and swamp land is a stunted growth of black spruce and tamarac, though even on the edge of the muskeg the black spruce is quite large enough for pulp wood, while the tamarac in the more southern swamps of the region, though now mostly killed by the larch saw-fly, was once of large size. Cedar grows commonly along the river edge, and Banksian pine at the few points where solid rock is exposed or where the soil is sandy. The latter is a beautiful tree which often attains a circumference of four or five feet. Large cedar occasionally have a circumference of ten feet; though the soundest specimens and those of greatest and straightest height are of much smaller horizontal dimensions. Spruce has a maximum circumference of seven feet or a little more. Aspen and cottonwood are a little smaller, and birch seldom if ever exceeds four feet.

Often for miles along the river and stretching for miles into the interior in the more southern part we have this splendid forest, but in general by far the greatest part of the country is wooded with second growth and not by original forest, from the midst of which stand out sometimes single individuals and often large tracts of the forest of bygone days. The timber along the Missanabie and Opazatika is almost entirely of second growth, that along the

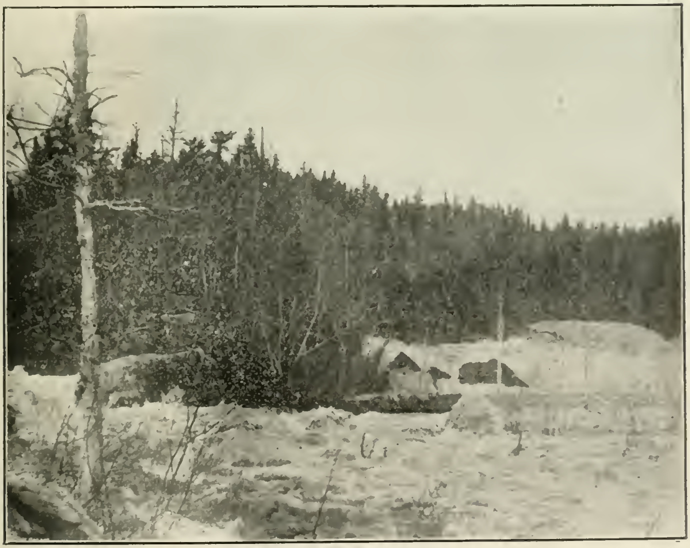
(24) Abies.

Drift in lignite, east side Abitibi river. Lignite in foreground.



Opened lignite seam, west side Blacksmith rapid, Abitibi river.

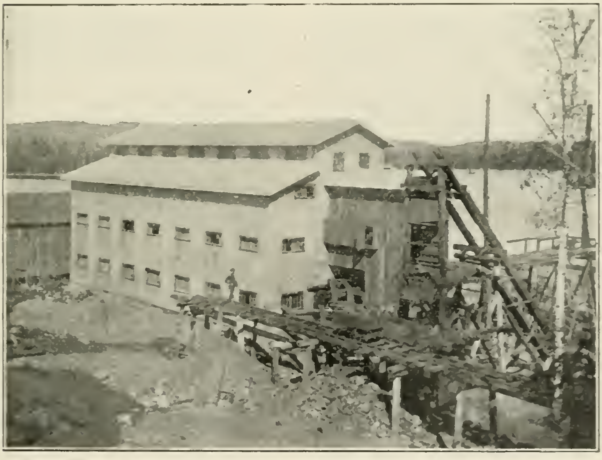
Grand or Breakneck falls, Opazatika river.



Thundering Water falls, Missanabie river.

Ojibway Indian "en costume."

Indian villagers of lake Abitibi.



Black Donald graphite mine and works, 1903.

Kapuskasing and Ground Hog is better, while that along the Abitibi is the best of all, and in the upper reaches of this stream, the river is bordered for miles by excellent timber. On the coastal plain the timber on the main Moose and Abitibi is chiefly second-growth, with here and there patches of good timber, but the Kwataboahegan is edged for miles of its course by a superior forest growth, and the same thing applies to the Kattawagami, or eastern branch of the West river.

The Ravages of Fire

It is unfortunate that so much of the timber of the north has been destroyed by recent fires. During the dry summer of 1901, a conflagration swept the whole country from the Kabinagami as far east at the Little Abitibi, and another even more terrific in its fury devastated the region southeastward from lake Kesagami almost as far as Grand Lake Victoria, on the upper Ottawa. On the Missanabie from the Skunk islands to the mouth of the Soweska there is scarcely a green tree standing, the few remaining patches standing out as oases in a desert of blackened rampikes. The burned area extends on the Opazatika from below the foot of Skunk island to the Opazatika canyon, though fortunately more clumps of green have escaped the fire. On the Mattagami there is a clean sweep from the Grand rapids almost all the way to the mouth of the White Spruce river, which joins the Kapuskasing about 30 miles above its confluence with the Mattagami. In 1901 before the fire had passed over the country I journeyed down the Kapuskasing and Mattagami, and made frequent observations on the magnificent forest which then extended along both these rivers, and which stretched away in virgin fertility from the river banks. This summer an Indian from the White Spruce told me of the terrible destruction which the fire had wrought. The force of the fire had somewhat abated by the time the Abitibi river was reached, and, though great stretches of the country from New Post northward have been deprived of timber, there is still much fine forest along the lower reaches of the river. I do not know exactly how far west the fire spread, but in our trip up the Wabiskagami our course lay for 30 miles in a more or less westerly direction, and for that distance we passed through a wilderness of blackened tree trunks.

The loss from these forest fires is enormous. When it is realized that this one fire devastated an area of at least 3,000 square miles and destroyed as well hundreds of moose, bear, caribou, and innumerable small animals, it will be realized in a slight degree how great has been the destruction. Let one travel for miles, be it overland or by water, through these blackened deserts, without seeing or hearing a living thing, let him listen in midsummer to the sighing of the wind through these leafless rampikes, and he will realize the sadness of the Indian lament that he must now leave his hunting grounds and go elsewhere, far to the eastward or westward, to seek new spots where the game yet lives. I was in the country during that terrible fire of 1901, and I shall always remember the days we passed in semi-darkness, hourly expecting to have to take to the water to save our lives. Fortunately we were beyond its path to the east, but other members of my party were not so fortunate, losing all their clothes and equipment, and one old Indian died from the effects. It has been said that most of these fires have been started by lightning. Some may have been, but most of them are ignited not by the Indians, although they are unfortunately far too careless, but by occasional white tourists who find their way down the various rivers every year to the Bay, and who do not realize the awful danger of a fire once started in the great spruce forests of the north. It may be suggested that these great forest fires have the advantage of destroying the moss on the muskegs and making these lands fit for agriculture, but the damage done far outbalances the gain in this way, and it will be ample time to clear the drier muskegs when the country is opened up.

The flora of the Moose Basin is not especially distinctive. It is that which prevails from the Gulf of St. Lawrence to the edge of the prairies of Manitoba, and many of the commonest species are found also in southern Ontario. During the months of June and July the wide banks of the streams are turned into veritable gardens with cyprepedrum rubrum, rosa blanda, lilium tigridum, anemone alba, and many other species, and until late in September various species of solidago and aster brighten the valley with color. Many a northern pond is beautified by its pond lilies and patomagetons, and even the desolation of the brules is relieved by a marvellous growth of blue and red fireweed. The ferns of the north are also beautiful, and many a narrow valley is for the short summer turned into a tropical paradise by the luxuriance of their foliage. Osmunda regalis is the commonest and most showy, but there are many other species.

Northern Scenery

The scenery of northern Ontario is often beautiful, and though occasionally monotonous and lacking diversity, it is nevertheless a region well worthy a visit from lovers of the beautiful. High up on the upland plain the numerous lakes with their rough, rocky shores casting sombre shadows in the dark waters; their deep bays; their many tree-girt islands, separated by narrow channels; and their long, gravelly points, all remind one of the charms of the Thousand Islands of the St. Lawrence. Lower down on the various streams the change from the long sweep of still water to a wild dashing rapid, cascade, or fall, is often charming. The grandest and wildest scenery occurs in the last few miles of the streams on the upland plain at the point where they descend rapidly towards the coastal plain. The rapids passed by Riverside portage on the Missanabie are a magnificent sight. Here the river is hemmed in to a width of a few yards, and dashes with tremendous velocity between high walls of gneiss. Half way down the cascade an extraordinary columnar pillar sixty or seventy feet in height rises from the water, and around this the water seethes and boils with terrific force. From time immemorial the Indians have known this strange place as Conjuror's House.

The Breakneck falls, with their straight drop of 60 feet; the deep, rusty-walled cauldron below; the beautiful tree-covered island dividing the falls in two; and the wild canyon which continues below the falls make a splendid bit of scenery. The view from the ridge along the Abitibi canyon is one long to be remembered. Two hundred feet below foam in fury the waters of the great stream, here dashing over a ledge in a steep, sharp fall, there surging through a whirlpool, or again seething against one or other side of the dark cliffs which border it. In the brilliant sunshine these rocks appear various shades of gold, purple and red, while in the sombre shade they seem of an inky blackness. Lower down the canyon towards the north where the precipitous walls in places give way to more gradual slopes, the dark gorge is relieved by the splendor of the northern forest, while off to the south the deep canyon is lost in the tree-covered hills which stretch away to the horizon.

The lower Moose, with its low monotonous shores, and its many flat bars and islands, presents nothing especially attractive to the eye, but there is something inexpressibly majestic about the great sweeps and bends of a mighty river, with the banks merging and disappearing in the distance at the sky line.

Wild Animals

Every year a few sportsmen are attracted to those great, lonely wilds, and seek rest and quiet from the strenuous life of our busy southern cities in these ideal pleasure grounds. In a few years, more and more will take advantage of the delightful scenery and good hunting of the region, and these will be but the fore-runners of hundreds who will come in the future, as our urban population grows.

Moose were exceedingly plentiful during the summer. Formerly this giant of the forest was never seen around Moose Factory, but this season we saw several within a few miles of the post. One was seen by my men near lake Kesagami, and the Indian who was my guide told me that this was the first he had ever known to visit that part of the country. Caribou do not seem to be so abundant, and none were seen during the summer. Red deer are not uncommon as far north as New Post. Bear occur commonly, especially in the upper part of the coastal plain, where they find excellent food in numerous berries on the new brules. All fur-bearing animals apparently are decreasing, and the fire of 1901 made terrible inroads into their numbers. We saw occasional marten, mink and otter, but not a single beaver, notwithstanding the fact that many of our side trips during the summer were made into unfrequented lakes and streams admirably suited to be the home of this interesting animal; though at several points we saw signs of him in fresh cuttings.

Aboriginal Inhabitants

I am told that the number of Indians in the Moose basin is rapidly diminishing. This is due in part to the large annual emigration southward to the Canadian Pacific railway, and also to the terrible decimation of the tribe of late by tuberculosis and measles. The latter disease swept off quite one-fifth of the population of Moose Factory during the summer of 1902, and this summer during my short stay in the region the mortality from tuberculosis was really tragic. In fact, the present condition of the Moose Indian is most deplorable. The Hudson's Bay Company has much diminished in grandeur of late, and the chief depot formerly at Moose has been removed to Charlton island, so that the Indians who formerly found work in unloading the ship at

Moose Factory, and in charging the various vessels which carried the outfit of other posts have been deprived of this employment. Moreover, many of the Scotch servants of the company have been discharged and have gone to the railway with their families, so that the supply of cattle formerly kept at the Factory has been greatly lessened. This removes another means of livelihood from the natives—that of cutting fodder for the cattle. Then again, their natural means of livelihood is no longer productive. The supply of fur-bearing animals in the region is undoubtedly small, and though moose is increasing, still this animal is in numbers far too few to supply the Cree Indians with meat during the long winter—a lack which a comparatively large number of muskrat, hare, and partridge by no means fills. Of late it has become more and more necessary to depend on the imported provisions of the company, and without the wherewithal to obtain these their long winters are passed in a state of semi-starvation, in which condition they are a ready prey to disease. Many of them have taken to living around the Hudson Bay post at Moose Factory, even dwelling in houses in winter—a procedure absolutely fatal to them in that they do not understand the first principles of ventilation, and the change from the fresh air that circulates freely through their wigwams to a hot and stuffy, dark, dirty room is disastrous. As compared with the well dressed, well-fed, healthy Ojibways of Lake Abitibi, New Post, or New Brunswick House, they are a miserable, squalid, poorly clad, and sickly people, quite unlike one's idea of the noble red man. Yet in spite of their condition they are a charming, simple, imaginative, and at times grateful people; and I do think some serious efforts ought to be made to alleviate their distressing condition. Though not by nature specially industrious, still at the same time they are not lazy, and as a rule if they have work to do they do it to the best of their ability. The advent of a free trader to Moose Factory a year ago gave work to most of them, but I do not think that it was of a kind likely to prove of lasting interest to them, and rival trading does not improve the morale of the Indian.

Every effort is being made to ameliorate the state of the Crees by the Bishop of Moosonee and Mrs. Newnham, but the path of these benefactors is not an easy one, and they receive little or no support from outside. Mrs. Newnham has herself built a well equipped though small hospital, well cared for by Miss Johnson, a deaconess and carefully trained nurse. When I was at Moose Factory this summer, I saw several Indians leave the hospital cured of their various complaints, and others well taken care of during their last few hours of life. During the epidemic of measles a year ago the presence of the hospital with its willing workers doubtless saved almost the complete annihilation of the tribe.

The condition of the Ojibway, who occasionally hunts as far north as lake Kesagami, is infinitely better than that of his northern Swampy Cree neighbor. In the first place, he has had less of the evil, and to the Indian deadly, contact with white men. His hunting grounds are wider and better stocked, and he gets a better market for his furs. On our return journey in the autumn we fell in with a band of Ojibways on lake Abitibi, and I was really surprised at their opulence. They were well and neatly dressed, and abundantly supplied with food for the winter. Moreover, they were apparently an intelligent, self-reliant, and independent people, in delightful contrast to the importunate Crees.

It is with pleasure that I acknowledge my indebtedness for the many courtesies extended to me and to my party during the past summer by the various officers and servants of the Hudson's Bay Company, and by the missionaries of the Church of England in northern Ontario. Especially do I wish to thank the Bishop of Moosonee and Mrs. Newnham, whose kindness to us, as well as to all strangers who have found their way to the shores of James Bay, turned that far away outpost of civilization into a veritable haven of rest.

Devonian Fauna of Kwataboahegan River

By William Arthur Parks

The fossiliferous rocks deposited on the northern flanks of the great Archaean axis of Ontario occupy a vast area to the south and west of James Bay. They reach from the border of the old land to the waters of the sea and are responsible for many of the physiographic features of the coastal plain. To their presence must be ascribed the character of the Moose river from Moose Factory almost to the long portage, as well as for that of all the tributaries of the Moose, the Albany and the other streams of the coastal plain. Little has been done to determine the exact horizon of these rocks, but it seems probable that a fringe of Silurian deposits lies on the flank of the upland, at least in places, while the major portion of the Palaeozoic area is composed of rocks of an age comparable with the Upper Helderberg.

The writer has at various times had an opportunity to examine the series as presented on the Abitibi, the Moose, the French, the Kwataboahegan and other streams of the Moose system. Generally speaking, the assemblage of fossils at these different points is practically similar, but far too little work has been done to enable us to say that but one horizon of Devonian rocks is exposed in the basin of the Moose river. It is in no wise the purpose of the present paper to attempt to classify the deposits of the Palaeozoic in this region, but merely to add to the available information concerning the series as a whole. More particularly it is desired to describe the fossils of the Kwataboahegan river, a tributary entering the Moose on the north side about 12 miles above Moose Factory.

The following notes are the result of a little desultory collecting while engaged on work in connection with the recent expedition to investigate the coal of the Hudson's Bay slope. The rocks on the Kwataboahegan teem with fossils and form a rich hunting ground for the palaeontologist. While it is thought that the accompanying list is much more complete than any previously obtained, it must be admitted that but a small percentage of the forms actually occurring are recorded.

The strata exposed on the Kwataboahegan present limestones of a yellowish brown color, literally filled with organic remains, mostly in the form of casts. The general appearance of this rock is strikingly like that of the Guelph limestone and dolomite of southern Ontario. A grayish limestone is also seen, but the stratigraphical relations of the two series remains to be worked out. The gray rock is poorer in the remains of molluscs, but is far more prolific in corals and brachiopods than the soft yellow variety. This latter rock is much better exposed on the Kwataboahegan than elsewhere in the Moose basin, exactly comparable rocks not being observed by the writer on either the Abitibi or the French river. As above stated, the conditions of last summer's work did not admit of any attempt to differentiate strata. The following lists must be regarded therefore as simply indicative of the general fauna of the Devonian as exposed on the Kwataboahegan river. It is to be hoped that at no distant date an opportunity will arise to carry out in detail the interesting work of comparing the Palaeozoic strata to the north with those to the south of the Archaean protaxis.

In the summer of 1902 Mr. W. J. Wilson made a small collection of fossils from the rocks of the Kwataboahegan, a list of which appears in the Report of the Geological Survey of Canada for 1902. All the species collected by Mr. Wilson were observed with the exception of Gomphoceras beta. Although from time to time occasional fossils have been recorded from the Moose basin by Dr. Bell and others, so far as the writer is aware, the work of Mr. Wilson furnishes the only record from the Kwataboahegan. Gomphoceras beta is therefore added to the list of species seen last summer. The unidentified forms of Mr. Wilson's collection are not considered.

Anthozoa

Great numbers of corals are to be seen in both the yellow and the gray limestone, particularly the latter. The corals, more especially the rugose varieties, resist the action of the weather better than the enclosing rock, and are therefore found free along the shore of the stream. The following species were obtained:

Favosites basaltica, Gold.
Favosites hemispherica, M.-E. and H.
Favosites turbinata, Bill.
Favosites winchelli, Rom.
Favosites gibsoni, sp. nov.
Alveolites squamosus, Bill.
Alveolites vallorum, Meek.?, indet.
Syringopora nobilis, Bill.
Syringopora nobilis, Bill.
Syringopora perelegans, Bill.
Syringopora hisingeri, Bill.
Diphyphyllum, arundinaceum, Bill.
Diphyphyllum simcoense, Bill.
Phillipsaster gigas, Owen.
Phillipsaster verneuli, M-E and H.
Acrophyllum oneidaense, Bill. (doubtful).
Streptelasma prolificum, Bill.
Zaphrentis gigantea, Lesueur.
Crepidophyllum archaici, Bill.
Cyathophyllum exiguum, Bill.
Cyathophyllum halli, M-E and H.
Cladopora cryptodens, Bill.

As far as possible the revision of the Canadian corals by Lawrence M. Lambe was followed in identifying the above species (1). Rominger's species, Favosites winchelli, is however, retained (2).

Favosites gibsoni
sp. nov.

On the Kwataboahegan river a single specimen of a remarkable favositoid coral was obtained for which the above name is proposed. The corallum forms an almost circular stock with a diameter of six centimetres. The specimen obtained is 17 cm. long and is sharply broken at both ends. In this length of 17 cm. there is no perceptible tapering of the corallum, so that it is a fair conclusion that the coral attained a considerable length, possibly several feet. The corallites are disposed so symmetrically around a central axis that we are forced to ascribe an erect position to the living colony. Whether the corallum branched, as in most of this type of favositoid corals, it is impossible to say; the specimen shows no evidence of this manner of growth, but it would be premature to say that it did not exist. The corallites arise by intermural gemmation at the axis of the colony, and grow upwards three centimetres, in which distance they diverge from the axis three-quarters of a centimetre. Here they turn abruptly outwards, and continue to the surface in a direction strictly at right angles to the central line of the corallum. The corallites are practically equal in size, the largest being slightly under a millimetre in diameter. They are strictly polygonal, in most cases hexagonal, in shape, and are closely apposed, there being no trace of interstitial tissue. The intermural pores occur in the sides of the corallites and are of comparatively large size, one quarter of a millimetre in diameter, and separated from each other by double that distance. The large size of the pores and their considerable frequency necessarily occasions accidental confluence across several corallites, so that the weathered surface shows small veriform depressions where this has occurred. The tabulae are somewhat flexuous and in many cases incomplete (squamulae): about five occur in the distance of one millimetre. It will be seen therefore that the irregularity of the tabulae will be interfered with by the intermural pores, giving rise, in vertical sections, to zooidal chambers connected by large channels, which in some cases are seen to cross several corallites. Septa appear to be entirely absent.

A most remarkable feature of this coral is the concentric lines of growth, appearing most distinctly on the cross fracture which has been subjected to weathering. The first of these lines appears at a distance of one centimetre from the centre; about ten rings are to be seen from this point in a similar distance outward, being more closely crowded as the periphery is approached. A photograph of the weathered end is reproduced in Pl. II., Fig. 2, and a sketch in Pl. VII., Fig. 1. The weathered effect is seen to arise from the fact that the wall matter is more soluble than the infiltered calcite filling the cavities. This will account for the radial, tube-like appearance. The concentric rings are seen to owe their original to a differential weathering in the walls of the corallites, due to a difference in texture ob-

(1) Contributions to Canadian Pa'aeontology: Vol. IV., Pts. I & II.

(2) Geol. Sur. Michigan, 1873-1876 (Lower Peninsula).

taining at the same time in all the corallites of the colony, thus giving rise to uniform concentric rings. On a polished surface the resistant portions appear as clear lines across all the corallites, while the more readily weathered parts are represented by alternating milk-white portions. As the clear portions withstand the action of the weather while the rest of the wall is disintegrated, it follows that the unaltered part will appear as a ring embracing all the corallites and surrounding the axis of the corallum. The reason for the hardening of all the corallites at the same level is no doubt to be sought in the different activity of the organism in the different seasons. Thin sections show excellently this difference in growth; the clear portions appear as such, while the white parts appear dark under the microscope, no doubt owing to a less dense structure and the inclusion of air. Further, distinct lines of growth can be made out. It appears that the substance of the wall of the corallite was deposited in layers with a greater or less slant towards the centre of the tube. In summer the growth was rapid and the slant steep as shown in the dark parts of the section, while in winter the growth was slow and the inclination of the lines of growth much less pronounced, as shown in the clear portions of the section.

Stromatoporoidea

The only Favosites that at all resembles this species is F. cariosus, Davis, figured but not described in the Fossil Corals of Kentucky. The corallites are however, much larger and lack the lines of growth characteristic of our species. The corallum seems to be smaller, but without any description of Davis' form it is impossible, even hazardous, to make comparisons. (Plate I., Figs. 1-5; plate II., Fig. 2: plate VII., Figs. 1-2).

This interesting class of organism occurs in great abundance throughout the region, and in many cases the specimens are preserved with such perfection as to render their identification possible. The determination of species of Stromatoporoids is always attended with great difficulties, first, because it is practically impossible to obtain all the material desirable for the presentation of the various features; second, because the preservation is in many cases imperfect; and third, because the specific differentiation depends on point of minute structure showing such gradual differences that it is almost impossible to draw the dividing line.

In the following notes the writer has attempted to identify with known species as many forms as possible, and to create new species only where the characters of the specimen are different from some emphasized point in the description of known species. He is prepared to admit however that on the one hand all the species might be considered new, or on the other hand, by the neglecting of certain characters they might all be ascribed to previously described types. There is little doubt that the surface character of stromatoporoids alters with age. Deep sections show that the inflection of the laminae into monticules is acquired in later life. Unless a surface peculiarity is persistent from the younger to the oldest laminae, it can have no specific value. Certain surface characteristics as granulation, etc., may by thus persistent but mamelons, etc., are not. In the lack of any recognized system in this matter the writer has preferred to put stress on the minute differences of structure, but has been forced to regard surface character when that character has been used by authors to define their species.

Syringostroma restigouchense Spencer

A specimen was obtained agreeing in a general way with Spencer's species from the Silurian of New Brunswick. The form of the coenosteum is the same, and the nature of the surface, with its astrorhizal markings almost identical. In vertical section, however, a considerable difference is observable : the pillars are less stout and less uniform in size, while the concentric elements are thinner and more sharply defined. On the whole, however, there is no more difference than is to be expected in the same species at a slightly higher horizon.

Syringostroma aurora sp. nov.

This species forms an extensive somewhat flexuous coenosteum attaining a thickness of two inches or possibly more. The surface is minutely granular and has well marked astrorhizal systems about 15 mm. apart. The astrorhizal canals are distinct but extremely delicate, and the different systems seem to anastomose. In vertical section the resemblance to S. nodulatum is pronounced, but only five vertical pillars occur in a distance of two mm., while Nicholson gives six or seven as thus occurring. Further the very points which distinguish S. nodulatum from S. restigouchense are lacking in S. aurora. In the latter species there are no mamelons which is the chief character of S.

nodulatum, and the astrorhizal systems instead of being less developed are much more extensive. Had not Prof. Nicholson emphasized these points of difference as characteristic of S. nodulatum there would be no difficulty in considering the species identical; as it is we must regard S. nodulatum and S. aurora as the products of the evolution of S. restigouchense in two different geographical regions. The presence of mamelons is doubtless a character acquired by age: deep vertical sections show a constant increase outward in the bending of the laminae into these structures. Plate II., Fig. 4. and plate III., Figs. 1 and 2.

Syringostroma densum
Nich.

A specimen referable to this species was collected. Like nearly all the examples from our region. however. certain points of difference are observable. more particularly in the nature of the astrorhizal systems. the centres of which are 15 mm. apart. while in a specimen of S. densum in the collection of Byron E. Walker. Esq.. they occur at a distance of five mm. In our specimen the surface is minutely granular, precisely like that of Stromatoporella turberculata. Nich. The surface is not described by Nicholson. but Mr. Walker's specimen shows no granulation of this nature.

Clathrodictyon laxum
Nich.

This specimen conforms very closely to the description of the type.

Actinostroma moosensis
sp. nov.

This specimen very closely resembles A. stellulatum. Nich.. but as the European variety has not hitherto been reported in America. and as the present specimen differs in some distinct details. it is thought better to establish a new species.

The coenosteum is apparently massive and doubtless attains considerable dimensions. fragments being obtained several inches in diameter and from one to two inches thick. The laminae are distinct. and disposed in concentric layers from one-fifth to one-sixth of a millimeter apart. Considerable crumpling is observable in the laminae particularly where they bend upwards to form the mamelons. This surface character seems to be more strongly marked than in A. stellulatum. as a constant and distinct mamelons about four mm. apart cover the whole surface of the coenosteum as well as the surface which may be produced by fission along the laminae. Distinct astrorhizal systems are present situated from each other a distance of from 12 to 15 mm. The astrorhizal canals are well marked, and continue their course for the most part independent of the mamelons. The systems are superimposed and are easily seen in vertical section. As our specimen more closely resembles the second type of the species A. stellulatum, described by Nicholson in his Monograph. it will be observed that certain differences occur. as in his species the mamelons are from five to six mm. apart and correspond with the astrorhizal systems. In all the types described in a stellulatum the maximum distance apart of the astrorhizae is 8 mm. while the present example 12 mm. is the minimum and an extreme of 20 mm. has been observed. Further. the astrorhizal systems are well developed with numerous and long canals. sufficiently extensive to anastomose despite the considerable distance between the astrorhizal centres. In vertical section. the laminae are seen to be very distinct. continuing their course quite independent of the vertical pillars. These elements are about one-fourth of a millimetre apart, and appear to be of equal strength to the laminae. As they are much more slender than in most species of Actinostroma. one is inclined at first sight to think he is dealing with a Clathrodictyon. because it is manifestly impossible to cut a section parallel to more than a few of the pillars. The round cut ends of the astrorhizal canals are distinctly seen in vertical sections. Tangential sections show the ends of the vertical pillars. and the hexactinellid structure characteristic of Actinostroma, and owing to the distinct eminences of the mamelons the section shows concentric rings with centres a variable distance apart. (Plate III.. Figs. 3 and 4.)

Through the kindness of Prof. J. M. Clark. State Paleontologist. Albany. N. Y.. the writer was enabled to compare this specimen with one from Hackberry, eight miles above Rockford. Iowa. This specimen was unnamed. but is essentially similar in external characters to that under review. He has also had the privilege of comparing the specimen with samples of A. stellulatum in the collection of Byron E. Walker. Esq.. Toronto. A small fragment of what is probably a variety of the same species was also obtained. The microscopic structure is identical. but there are no visible astrorhizae and the mamelons are much closer together.

Professor Nicholson remarks that Actinostroma tyrrelli, Nich., is the representative in America of A. stellulatum; from his description it would appear that the three species are much alike, and that A. stellulatum occupies, in respect to the development of mamelons and astrorhizal systems, a position intermediate between A tyrrelli and A moosensis of the northern Palaeozoic areas of Canada.

By comparing the type specimens of Stromatopora solidula and S. expansa in the museum at Albany with our species, it is seen that the form is that of S. expansa, while the structure is closer to S. solidula. An unnamed specimen from Hackberry near Rockford, Iowa, which I take to be S. expansa, Hall and Whitfield, exactly corresponds to the present species in all external appearances. Sections, however, show some striking differences. The vertical pillars in A. moosensis are much farther apart and less continuous through the laminae, it being almost impossible to prepare a section in which a pillar can be traced through more than two interlaminar spaces. The laminae themselves are somewhat more closely apposed in A. expansa.

The two species, A. expansa and A. moosensis, are so much alike in external appearance that it has been thought advisable to reproduce the vertical and tangential sections of both in order to compare them under the came conditions. (Plate III., Figs 3 and 4—Actinostroma moosensis, Kwataboahegan river. Plate III., Figs. 5 and 6—Actinostroma expansa, near Rockwood, Iowa. Plate II., Fig. 3—Actinostroma moosensis).

Clathrodictyon problematicum
sp. nov.

It is with some diffidence that a new species is founded on the specimen about to be described, as but one fragment is available and that is almost destitute of surface characters. The same or a closely related species occurs at Le Roy, N. Y., a section of which I was enabled to compare although the specimen itself was not available.

The concentric laminae are very irregular in direction, but are quite well marked and are distant from each other about a third of a millimetre. The vertical pillars appear in no case to pass through the laminae, and in vertical section vary in distance from each other from a quarter of a millimetre to more than one millimetre. The pillars do not seem to arise from inflections of the laminae, but are quite independent, in fact the laminae are much more persistent than in typical Clathrodictyon. The surface appears to be without mamelons but is slightly undulating and most minutely granulated. Astrorhizae were not observed. In cross section, owing to the flexuous nature of the laminae, the cut edges of these structures are observable as well as occasional round dots representing the vertical pillars. No information is obtainable regarding the general shape and mode of growth of the coenosteum. The mass of the stromatoporoid is traversed by caunopore tubes about two-thirds of a millimetre in diameter, terminating on the surface two mm. apart. The species is very closely allied to Stromatoporella selwyni, Nich. In vertical section the resemblance is exact in the size of the visicles, the only difference being in the slightly less inflected nature of the laminae at the points of departure of the radial pillars. In tangential section however there is a marked difference, as none of the perforated tubercules of S. selwyni are present to give the circular cross section figured by Nicholson. An artificial surface produced by fission in C. problematicum shows a granulated surface, but the little tubercules are only about one-fifth of a millimetre apart, whereas in S. selwyni the distance of separation is one-half millimetre. Further the eminences are much larger in S. selwyni, and the greater ones are perforated, a characteristic not observed in C. problematicum. The tendency at the present time is to regard the presence of caunopore tubes as of no diagnostic value.

As Nicholson regards the perforated granules to represent the terminations of the zooidal tubes which he makes the main means of differentiation of the genus Stromatoporella, it is apparent that our species, in which these elements are entirely lacking cannot belong to this genus. The only other established genus at all capable of receiving it is the genus Clathrodictyon, and it is accordingly placed here but with the limitation already commented upon. (Plate IV., Figs. 5 and 6).

Stromatopora tubulifera
sp. nov.

One small fragment only was obtained of the species to which the above name is provisionally given. The general form of the coenosteum seems to be of the same nature as Stromatopora concentrica. No mamelons or surface indications of astrorhizal systems were observed. A polished vertical section suggests Syringostroma densum, Nich., but a very close examination shows the lack of closely applied concentric laminae and the continuation of minute clear vertical lines, representing the zooidal tubes, for as much as two-thirds of a millimetre. This condition is never seen in Syringostroma densum, nor are the occasional large pillars of that species visible in our example. In thin vertical sections the resemblance is entirely lost, and the typical structure of the genus Stromatopora is at once seen. The latilaminae are apparent as well defined lines a variable distance apart, the average being about one millimetre. Concentric elements between these lines are barely distinguishable, and the radical pillars are apparently absent. A distinct radial structure is however seen, owing to the excellent development of the zooidal tubes. These structures extend from latilamina to latilamina with a slightly flexuous course, about 15 appearing in the horizontal distance of one millimetre in the case of thick sections; in very thin sections about half that number occur separated by about their own width of infiltered matter. In transverse section the zooidal tubes appear as distinct rings, by no means constant in their distance of separation, but averaging from a fourth to a sixth of a millimetre apart. The zooidal tubes show distinct tabulae and in the better preserved portions of the specimen are seen to present these structure to the number of 16 in a millimetre. Although the surface of the specimen is too ill preserved to show any astrorhizae, it is likely that such structures were well developed as numerous large round holes are to be seen in vertical section particularly immediately above the latilaminae. (Plate IV., Fig. 1, 2, 3 and 4.)

Echinodermata

Of this class of organisms nothing was observed except numerous indeterminable crinoidal columns.

Polyzoa

Great numbers of polyzoa were observed, nearly all being examples of the family Fenestellidae. Most of these fossils are in a very poor state of preservation, and but few were collected. The identification of the Polyzoa even when in good condition is a labor of time. Among those obtained, one much resembles Polypora perangulata, Hall, and another has a less striking resemblance to Polypora shumardi, Prout. The latter specimen has its fenestrules closer together horizontally and farther apart vertically than in P. shumardi.

Cyclotrypa borealis

sp. nov.

One small specimen was obtained of a species of Cyclotrypa closely related to C. communis, Ulrich, and even more nearly to C. collina (3). But as both of these species are ascribed to the Hamilton formation, and as the present example differs in some details, it is thought advisable to establish a new species as above. Zoarium, flat, discoidal, probably incrusting, epitheca unknown. Total width of the specimen about five centimetres, with a thickness of five or six millimetres. These figures do not necessarily express the total size of the zoarium, as but a portion is accessible. Surface, gently undulating; monticules very slightly raised, about 12 millimetres apart. Zooecia circular from .2 to .3 millimetres in diameter. Between the monticules they are separated by about half their own diameter. The zooecia on the monticules are the largest and are separated from each other by correspondingly great distances. Zooecial tubes, circular and thin walled. Lunaria apparently absent. Mesopores angular, forming rings around the tubes: size of the mesopores variable, some being as large as the zooecia while others are about one-fourth that size. An average of nine mesopores surround each tube. Commonly only one or two mesopores occur between the neighboring zooecia, but as many as six were observed. Acanthopores apparently absent. Vertical sections show the zooecial tubes to possess diaphragms at intervals of about one-fourth of a millimetre, while the mesopores are more frequently crossed by horizontal divisions which are crowded towards the periphery and show a tendency to coalesce into continuous plates.

The species is closely related to Cyclotrypa (Fistulipora) collina, Ulrich, but may be distinguished by the much greater distance apart of the monticules. The minute structure seems to be almost identical, and although an epitheca was not observed, the vertical section shows a distinct structural line where the zoarium rests on the substratum. (Plate II., Figs. 1 and 2).

Brachiopoda

The fauna of the series is not particularly strong in this class of organisms. The soft yellow rock shows very few brachiopods, but the gray limestone is much richer. Species were iden-

(3) Geol. Sur. Illinois, Vol. VIII., pp. 476-478.

tified as follows, all from the gray limestones :

Stropheodonta pattersoni, Hall.
Stropheodonta inequistriata, Conrad.
Stropheodonta demissa, Conrad.
Stropheodonta perplana, Conrad.
Stropheodonta concava, Hall?
Strophonella ampla, Hall.
Spirifer duodenarius, Hall.
Spirifer arenosus, Conrad.
Spirifer euryteines, Owen, cf. fornaculus, Hall. ?
Spirifer divaricatus, Hall.
Spirifer fimbriatus, Hall (Reticularia fimbriata).
Spirifer murchisoni, Castelnau.
Spirifer varicosus, Hall.
Leptostrophia, cf. magnifica, Hall.
Camarotoechia tethys, Bill.
Rhipidomella livia, Bill.
Atrypa reticularis, Linn.
Chonetes cf. lineata, Hall, cf. yandellana, Hall (Wings lost.)
Chonetes antiopia, Bill.
Chonetes cf. logani var. aurora, Nor. & Pratt. (very doubtful).
Meristella nasuta, Conrad.
Amphigenia elongata, Vanuxem (imperfect cast only).
Grypidula galeata, Dalman.
Athyris spiriferoides, Eaton. (rare).

Atrypa reticularis is by far the most common form, and occurs in great numbers and with some diversity of ornamentation; it is common in the yellow rock as well as in the gray limestone.

In addition to the species enumerated above many casts of small forms, belonging to the Rhynchonellidae were observed.

Gasteropoda

The number of univalves existing in the seas of the period must have been enormous. The yellow rock is literally filled with the traces of these organisms. In no case however is the shell preserved, so that the identification of species becomes a very uncertain matter. Casts of the interior are common, but only occasionally is the impression of the exterior preserved. The external and internal casts of species of Loxonema or Murchisonia are among the commonest fossils of the area. While the imperfect state of preservation makes the identification of individual specimens difficult, the occasional finding of external casts with the ornamentation preserved, shows that diligent search would result in the establishment of many new species. While many of the species of gasteropods are common to both this area and the exposures of Upper Helderberg rocks in southern Ontario and the State of New York, some few features are significant. Particularly noticeable is the fact that some forms such as Pleurotomaria delicatula or P. camera and P. adjutor, which Hall regards as very rare in the rocks of New York, are among the commonest of the small gasteropods of the area to the north. The great numbers of Platyostoma lineata are worthy of note. In the following list the forms identified from internal casts only are so indicated. It is apparent that the authenticity of such forms is always open to question.

Loxonema robusta
Hall

Numerous internal casts and imperfect impressions of the exterior. The characteristic markings of Loxonema were not observed. As this form is so common, a photographic reproduction of a large internal cast and of the gutta percha impression of a smaller external impression is shown in Plate V, Fig. 2.

Loxonema subattenuata
Hall

The same remarks as for L. robusta apply to this species.

Ca lonema bellat la
Hall

Very numerous impressions of the exterior of this form are excellently preserved, and show types in which the whorls are flattened, and also types in which they are well rounded with distinct sutures. Numerous internal casts are also found, the identification of which is very doubtful. Some, in which the sutures are suppressed and the whorls flattened, are in all probability referable to this species, while others are more likely representative of some species of Pleurotomaria or Holopea. (Vide postea). The different shapes of this species as figured in Hall's work Pal. N.Y. Vol. V., Pt. II., Plate XIV., are all represented here.

Euomphalus decewi
Bill

Several indistinct casts of the interior, and an impression of the exterior are representative of this species which appears to have been quite numerous.

Euomphalus

Cf. laxus, cf. clymeniodes; fragmentary casts, very doubtful.

Euomphalus
sp.

Very poor fragmentary cast of the interior.

Platyostoma lineata
Conrad

Very numerous; great numbers of casts, one showing a portion of the shell with the external markings. This species seems to have been attacked, in many cases, by a most remarkable parasite, which incrusts the whole surface, giving at first the impression of an external shell which has adhered to the enclosing rock and resisted the disintegrating forces long after the inner shell had succumbed. Microscopic sections indicate that this is not the case, but that the shell is covered with a strange and undescribed parasite. This organism is now under study and a report on its structure and probable affinities will appear shortly.

Murchisonia desiderata
Hall

Both internal and external casts. The external impressions of the revolving band are very indistinct, but it seems to lie a little lower on the whorl. The specimens appear to be a little more slender and delicate than Hall's species.

Strophostylus unicus
Hall

Two imperfect casts are provisionally referred to this species, but there is a strong probability that they are undescribed species.

Holopea
sp

Three internal casts apparently not belonging to any species mentioned in this report. Somewhat resembles Pleurotomaria itys, Hall, from the Hamilton formation, but can not well be ascribed to that species. On the mere external casts it would be unjustifiable to found a new species. A photograph is therefore given of the three specimens in Plate V., Fig. 1.

Murchisonia
sp. indet.

A cast of a species with the revolving band midway on the whorls and therefore distinct from M. desiderata.

Pleurotomaria delicatula

Var camera, var nov. Shell depressed, trochiform; spire slightly elevated. apex minute. About five whorls appear, rapidly enlarging to the peristome. Aperture unknown. Shell wider than high. Surface marked by strong striae curving gently backwards from the suture to the revolving band. Four striae occur in the space of one millimetre. Revolving band distinct with fine striae showing curves directed backward. Striae of the revolving band twice as frequent as on the whorls. Revolving carinae absent. Answers very closely to Hall's description of Pleurotomaria delicatula. As this species is very rare in the rocks of New York State Hall's description is meagre. Our species seems to differ in certain points. The revolving band is situated above the centre of the whorl, so that a view from above shows distinctly the carinae of the band. The striae also are as distinct below the band as above, even more pronounced; this feature is directly opposed to Hall's description of P. delicatula (4).

Pleurotomaria adjutor
Hall

Many good casts of the small variety of this gasteropod were obtained. While there is no doubt of its identity, some slight differences are to be noted. The shell is always small, about half the size of the variety figured by Hall. The revolving band is proportionately wider and the striae are not multiplied as they are in Hall's figure. The carinae are fully as well marked as the crests of the revolving band and the lower carina is as distinct as the upper. This variety might be known as Pleurotomaria adjutor, var minima.

Bellerophon pelops
Hall

Very numerous internal casts probably referable to this species.

An external cast resembling B pelops but the peristome is not inflexed at the notch, and the revolving band is elevated and extends only a short way up the shell.

Although the Gasteropoda are so well represented. for the reasons already stated their identification is uncertain. Nevertheless, it is certain that sufficient time would yield external impressions for the identification of all the species. The occurrence of Pleurotomaria adju-

(4) Palaeontology of New York, Vol. V., Pt. II., Plate XIX., Figs. 18 and 19.

tor in considerable numbers (it is doubtles the most prolific of the small gasteropods) is very interesting as Professor Hall comments on its rarity in the rocks of the State of New York.

Scaphopoda

The remains of these organisms are very numerous, but in no case was any trace of the shell preserved. Internal casts abound, but the exterior markings are not well preserved. The abundance of these forms is very characteristic of the area.

Coleolus tenuicinctum
Hall

Numerous fragmentary impressions of the exterior closely corresponding to Hall's figures.

Coleolus tenuistriatus
sp. nov.

External impressions numerous. Best preserved and type specimen is four centimetres long, with a width at the mouth of five millimetres. Shells distinctly curved. Delicate oblique striae passing from the left towards the mouth of the shell. (Plate VI., Fig. 9).

Coleolus
sp.

A much larger specimen, with the striae running from an imaginary longitudinal line with a slight obliquity towards the mouth. Greatest diameter eight millimetres. The whole shell could not be less than ten centimetres long. The annulations are more pronounced than in the type specimen of C. tenuistriatus, but they are of the same general character, and may be merely the result of the larger size of the individual. (Plate VI., Fig. 8).

(Zittel places these forms under the Pteropoda, but lacking definite information, Hall's systematic arrangement is retained.)

Lamellibranchiata

As in the case of the Gasteropoda the remains of bivalves are common but ill-preserved. Without the expenditure of considerable time in the field it is impossible to do justice to this class of creatures. In the following notes no attempt will be made to establish new species, as the material is much too fragmentary, but the writer is of the opinion that a large number of new species of lamellibranchs will eventually be found in this field.

Conocardium cuneus

Var. trigonale. Hall. Very numerous and the best preserved of the lamellibranchs.

Goniophora
sp. indet.

The internal cast of a strongly angulated variety somewhat resembling G., perangulata, Hall, and even more like some of the European forms. A photographic reproduction of this cast is seen in Plate V., Fig. 3.

Modiomorpha
sp. indet.

Several imperfect casts. Do not correspond to any of Hall's figures. Compare Glossites patulus, Hall. Pal., N.Y., Vol. V., Pt. II., page 501, Plate XCVI., Fig. 15. Compare also the outline of Modiomorpha tumida, Whiteaves Contributions to Canadian Palaeontology, Vol. I., page 296, Plate XXXVIII., Fig. 10. (Plate V., Fig. 4).

Megambonia
sp. indet

Slightly resembles M. cardiformis, Hall.

Cypricardinia

Probably C. indenta, Hall. Pal. N.Y., Vol. V., Pt. II. Page 485, Plate LXXIX.

Mytilarca
sp.

Very poor specimen, possibly M. ponderosa. Hall.

Avicula textilis
var. arenaria

A good sample of this handsome form was obtained on the Abitibi river. Not seen on the Kwataboahegan.

Lyriopecten dardanus
Hall

Two good examples.

Cephalopoda

Like the other molluscs the cephalopods have left numerous remains in the rocks of the period. The shell is not preserved and identification is difficult. The following were noted.

Orthoceras thoas
Hall

Orthoceras pelops
Hall

Specimen badly worn. Identification very doubtful. Rather larger than any of Hall's figures.

Orthoceras luxum
Hall

Orthoceras
sp. indet.

Possibly O. procerus, Hall, but the specimen is so badly preserved that identification is impossible.

Orthoceras
sp.

This specimen consists of a small portion of the septate region, which shows a close resemblence to O. jaculum, Hall, in the size of the shell and the distance apart of the septa. That it is not identical is seen in the fact that the siphuncle is very small and central and the cross section of the shell is slightly elliptical, too little of the specimen is preserved to justify the founding of a new species. Compare also O. stylus, Hall, Pal. N.Y. Vol. V., Pt. II., Page 253. (Plate VI. Fig. 4).

Orthoceras extremum
sp. nov.

Shell straight. Though but a small fragment is preserved it appears to contract gradually towards the apex. The apical angle would probably be about 10 degrees. Transverse section elliptical. The third septum is 15 millimetres by 10 millimetres. As scarcely any evidence of crushing is apparent these figures express the degree of ellipticity, but possibly a little allowance should be made. Three air chambers are shown with a depth of two and a half millimetres each. The convexity of the septa is slight. Chamber of habitation comparatively large, extent unknown. siphuncle small and remarkably excentric. Surface unknown. Resembles O. inopatum, Hall, but is distinguished by its elliptical outline and the extremely excentric position of the siphuncle.. A small fragment, possibly of this species, shows a portion of the shell which is marked by minute annulations on the exterior. (Plate VI. Fig. 7).

Orthoceras algomense
sp. nov.

Shell probably straight, tapering very abruptly. If the angle shown by the chamber of habitation and the upper part of the septate region is continued to the initial point, the apical angle would be 18 to 20 degrees. Extremity unknown. Cross section sub-elliptical. At the fifth septum the greater diameter of the ellipse is 43 millimetres and the lesser 25 millimetres. The side of the ellipse in which the siphuncle is situated is much more convex than the opposite portion. Septa 7 millimetres apart near the chamber of habitation, but gradually approach one another towards the apex. The above described fifth septum has a convexity of six millimetres. Siphuncle is six millimetres from the more convex side of the shell. The chamber of habitation is 5 centimetres long in the specimen, but is not all preserved, the aperture being entirely gone. The characteristic points are the unusual cross section and the rapid tapering of the shell. The septate portion of another and larger specimen was obtained in which septa are separate from one another a distance of from five to six millimetres. No trace of the shell is preserved, but it appears to have been quite smooth. A sketch of the specimen and a view of the fifth septum to show the peculiar outline and the position of the siphuncle are given in Plate VI. Figs. 1 and 3.

Orthoceras pulcher
sp. nov.

The above species is founded on a rather fragmentary specimen, but one sufficiently preserved to exhibit distinctive characters that separate it from any known species of American Orthoceratids. It approaches nearer to O. crotalum, Hall, than any other species, and may be distinguished from Hall's species by the more undulating nature of the annulations and the greater distance between the crests. The specimen is somewhat crushed, so that it is impossible to give an outline of the cross ection, but it is probably somewhat elliptical. The chamber of habitation is 50 millimetres long and the width at the last septum is 32 millimetres in the greater diagonal and twenty millimetres in the less. The septa are three millimetres apart. The annulations of the body chamber are distinct and present a series of convexities and concavities, the former of a sharper degree of curvature. The two uppermost crests are fifteen millimetres apart; the second and third crests are separated by thirteen millimetres; the third and fourth by twelve, and the fourth and fifth by ten millimetres. If the rate of decrease in size is uniform with that presented by the chamber of habitation the apical angle must be about twelve degrees. The outer shell is entirely unknown. In addition to the annulation the inside of the shell must have been pitted, as the cast shows small monticules distant from each other from one to three millimetres. Owing to the crushed condition of the specimen the convexity of the septa cannot be given. (Plate VI. Fig. 2).

Gomphoceras beta
Hall

Collected by Mr. Wilson.

Hercoceras auriculum
sp. nov.

Two internal casts, showing the chamber of habitation and a few of the septa. Chambers of habitation at least three centimetres long, with a width of two centimetres at the aperture. Contracts rapidly towards the apex, which is unknown. Shell sharply bent, and exhibiting on its lateral margins distinct nodes distant from each other about six millimetres. First six chamber three milimetres thick. Septate portion seems to contract very rapidly towards the apex and the thickness of the air chamber is considerably less towards the concave side of the shell. Sinus not observed. The siphuncle is in all probability excentric and situated close to the convex side of the shell. (This is seen in a third specimen which is doubtfully referred to this species). These specimens are much too imperfect for the proper description of a new type, but they are very distinctive in the character of the nodes. The distance of the field of occurence alone justifies the formation of a new species. This species resembles Gyroceras (Halloceras) paucinodum, Hall, and Trochoceras biton, Hall, more than any other described species of Helderberg age. The shell, however, seems to contract more rapidly than in G. paucinodum, and as two specimens were found of about the same size it is a fair assumption that they were adults, in which case Hercoceras auriculum is a much smaller cephalopod than Hall's species. The characteristic flat ventral surface of G. paucinodum is absent in the present species, the outline of which is not far from circular.

The specimen differs from Trochoceras biton in the stronger nature of the plications and in the sharper curvature of the shell. Hall's figure and description of T. biton are too meagre for a close comparison, but it appears that his species is considerably larger than H. auriculum. (Plate VI., Fig. 5 and 6).

Trilobita

The remains of trilobites are numerous and exceptionally well preserved in comparison with the other classes of organisms. In nearly every case a portion of the test has been preserved in excellent condition, so that the minute tuberculations of the crust and the facettes of the eyes are distinguishable. In the rough rock where the mollusca and brachiopods are to be seen only by casts, milk-white fragments are observed on close examination to represent portions of the tests of trilobites.

Calymene platys
Green

This species seems to be the most prolific in the region, eight specimens, representing the different parts of the crust being found. The average specimen is large, measuring six or seven centimetres by ten centimetres. One buckler shows parts of the crust with the minutely tuberculated surface intact.

Dalmanites anchiops
Green

Pygidia only of this species were collected. Some of these pygidia retain the caudal spine and are doubtless referable to the above species; others are devoid of the spine, the absence of which doe not seem to be due to fracture. These are, in all probability, identical with the following.

Dalmanites stemmatus
Clarke

This species has been recently described by Prof. Clarke in The Oriskany Fauna of Becraft Mountain, Page 15, Plate 1.

Phacops cristata
Hall

One small buckler and several pygidia, in all probability referable to this species.

Proetus
sp.

A single pygidium of a species of Proetus was found which has some minor points of difference from any described form. It would be very unwise to found a new species on such fragmentary material, but a description of the pygidium follows. Semi-elliptical, wider than long, width to length about seven to five. Axis distinctly convex with ten annulations. Surface of annulations of the axis minutely tuberculated. Pleurae gently convex from the furrow to a well-marked marginal sulcus. Annulations of the pleurae twice the number of those of the axis. Furrow between each pair of annulations slightly greater than between the two annnulations springing from the single axal annulation. A single line of tubercles on each annulation of the pleurae. Annulations cease at the sulcus. Sulcus relatively broader than in other species of Proetus, regularly convex, and marked on its distal border by a narrow, thickened ridge. The posterior point is unfortunately lost, but there is evidence that the margin was inflexed at the extremity of the pygidium.

Resembles P. conradi. but differs in the greater width of the non-annulated border, and in the fact that the double tuberculated annulations of the pleurae continue to the axis without coalescing. Also differs in the marginal ridge. Differs entirely from the common species, P. crassimarginatus, in the character of the annulations (Plate VIII., Fig. 1).

Conclusions

While the number of species mentioned in this paper would form but a small percentage of the forms occurring in the rocks exposed on the Kwataboahegan river, they are nevertheless sufficient to reveal the age of the series, which is unquestionably to be referred to the Devonian. It would also appear that the organisms denote an age comparable with the bottom of the Upper Helderberg. In some cases the assemblage would denote the Oriskany. While generally comparable with the above cited formations, certain differences are to be noticed, as already mentioned in this paper. By an exact comparison of the fauna of the northern with that of the southern rocks many questions as to the migration of species in Devonian times would be settled. Some of the minor differences which bear on this point have been referred to, but it is obvious that close investigation, and a comparatively complete collection is necessary to unable us to speak with decision in this matter.

Oil and gas are known to occur in the rocks of this age in southern Ontario, and there is no reason to doubt that similar valuable deposits may be met with north of the Height of Land. The rocks are very rich in organic remains, as may been seen by a reference to Plate VIII, Fig 2. The decay of such enormous numbers of organisms must have given rise to large quantities of petroleum. Whether this product is entirely dissipated remains for future exploration to reveal. Great beds of gypsum are associated with the limestones at various points in the region. The relationship of these deposits also remains to be worked out.

In closing this paper the writer must request the indulgence of the reader for many fragmentary notes. Many undetermined species are referred to, which, in a more accessible region, would be dismissed without comment. At this distance from their place of occurrence, however. it was thought advisable to refer, even if as to some of them in an uncertain manner, to nearly all the specimens collected.

In the preparation of this report the writer is deeply indebted to Professor John M. Clarke, the accomplished palaeontologist of the State of New York, for valuable advice and for the privilege of comparing type specimens in the Museum at Albany. His acknowledgments are also due to Bryon E. Walker, Esq., Toronto, for the loan of specimens for comparison and for the use of his extensive palaeontological library.

The Northern Nickel Range

By A. P. Coleman

In accordance with the instructions of Mr. T. W. Gibson, Director of the Bureau of Mines of Ontario, my main field work last summer was devoted to mapping the northern nickel range, which had not hitherto been worked out geologically, though much of its extent was known roughly by the work of prospectors. Mr. M. T. Culbert, who had been my assistant the previous year was reappointed, and from his energy and experience in the work rendered excellent service. He continued in the field for some weeks after my summer's work was over in order to complete the investigation of some points in connection with the northern iron range, and at the northeast end of the northern nickel range where it connects with the southern range.

As usual we received much aid and hospitality from mine owners, managers and prospectors, for which thanks are due. The maps and reports of the Geological Survey of Canada were of great assistance in our work, though prepared long before the relationships of the nickel-bearing eruptive were known. For the more detailed work which we carried on township maps provided by the Crown Lands Department were made use of, and in portions of the range maps of mining locations furnished mainly by Messrs. Demorest and Sylvester, engineers of Sudbury, were employed. The township maps were found to be variable in accuracy, some being excellent, but others not so good.

As the literature on the Sudbury Mining District was mentioned somewhat fully in our last report it will be unnecessary to go over the ground again(1).

Topography of the Range

The topography of the northern nickel range differs materially from that of the southern range as described last year. In general the contact of both of the inner (southeastern) and outer (northwestern) sides of the nickel-bearing eruptive with the adjoining rocks is found to lie in a series of rugged hills having very steep slopes, often with vertical walls, and so arranged that to follow the boundary requires a great deal of rough travel; while the basic edge (outer or southeastern) of the main southern nickel range is generally low and often very uniform in level. However, this had one advantage since the hillsides afforded excellent rock exposures, so that the boundary could usually be fixed with certainty. While the boundary is commonly on hilly ground, none of the summits rise very high above the general level, the relief seldom exceeding 200 or 300 feet.

Except at the southwestern and eastern ends of the northern range, where the eruptive curves down to meet the southern range, there is comparatively little drift encountered, much less than in the previous summer's work; and in general the drift consists of gravel and sand plains rather than clay flats. On the whole the northern range seems to be at a greater elevation than the southern, probably because the range is narrower, allowing the resistant rocks on each side to approach nearer together, and also because the easily weathered basic edge is usually much less developed than it is on the southern range.

The region is very poorly provided with canoeable waters, though there are a few fair-sized bodies of water along the range, such as Windy lake, Moose lake, Trout lake and Joe's lake; but in general the canoe was of little service. There is also a great scarcity of wagon roads, and those that do exist, being largely winter roads made by the lumbermen, are very rough and often mucky. With the exception of the road northeast of Onaping, built by owners

(1) Bur. Mines, 1903, pp. 235-6.

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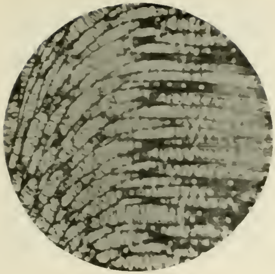

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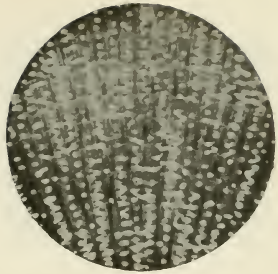

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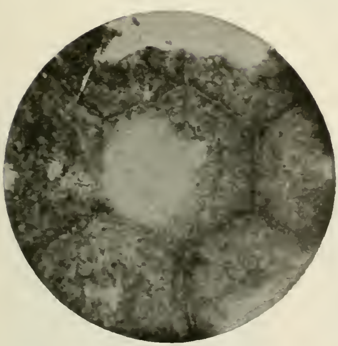

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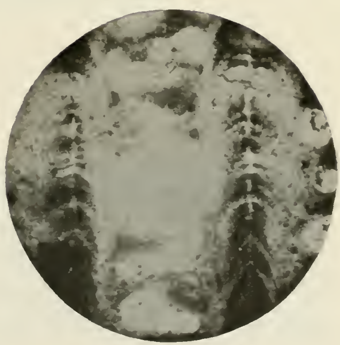

PLATE I.

Fig. 1: FAVOSITES GIBSONI *sp. nov.* Page 181. Vertical radial section, to show the tabulæ and the manner in which the corallites spring from the axis of the corallum. Enlarged three times.

Fig. 2: Horizontal section to illustrate the intermural pores and the walls of the corallites. Enlarged three times.

Fig. 3: The same enlarged six times. Owing to the imperfection of the photograph this figure is repeated in a pen and ink sketch, Plate VII, Fig. 2.

Fig. 4: Tangential section to show the polygonal shape of the corallites and the absence of septa. Enlarged 25 times.

Fig. 5: Horizontal section showing the lines of growth in the walls of the corallites. Enlarged 30 times.

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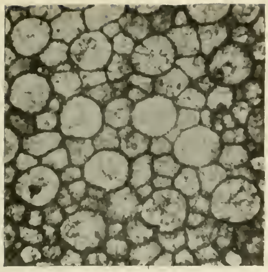

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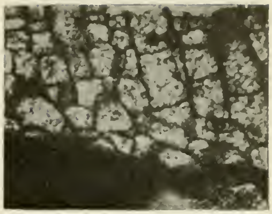

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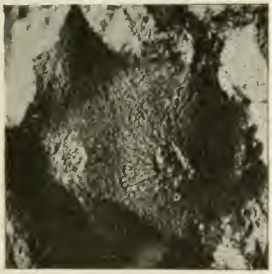

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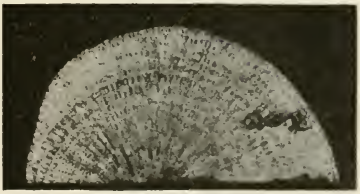

PLATE II.

Fig. 1: CYCLOTRYPA BOREALIS, *sp. nov.* Page 185. Tangential section, enlarged about 25 times.
Fig. 2: Ditto. Vertical section, enlarged about 25 times.
Fig. 3: ACTINOSTROMA MOOSENSIS, *sp. nov.*, Page 183. Photograph of surface. Natural size.
Fig. 4: SYRINGOSTROMA AURORA, *sp, nov.* Page 182. Photograph of surface to show the flat mamelons and the long, fine astrorhizal canals. Natural size.
Fig. 5: FAVOSITES GIBSONI, *sp. nov.* Page 181. Photograph of weathered end. Natural size. See also pen and ink sketch, Plate VII, Fig. I.

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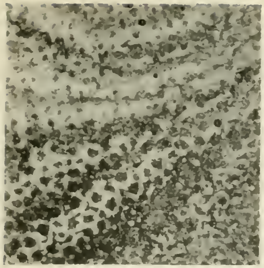

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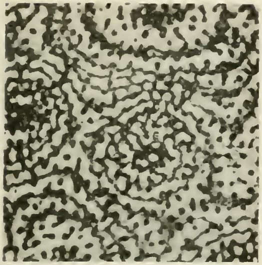

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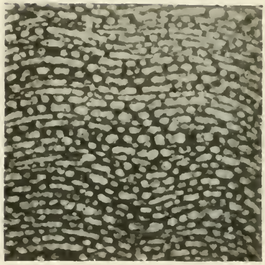

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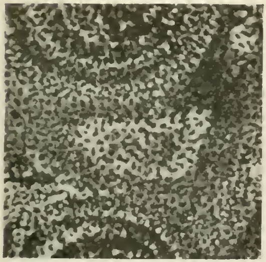

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PLATE III.

Fig. 1: SYRINGOSTROMA AURORA. *sp. nov.* Page 182. Tangential section, Fig. 2: Ditto. Vertical section.

Fig. 3: ACTINOSTROMA MOOSENSIS. *sp. nov.* Page 183. Tangential section. Fig. 4: Ditto. Vertical section.

Fig. 5: ACTINOSTROMA EXPANSA. *Hall.* Page 184. Tangential section. Fig. 6: Ditto. Vertical section.

All figures enlarged six times.

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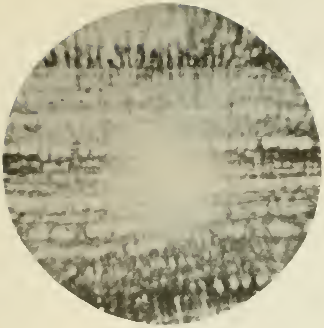

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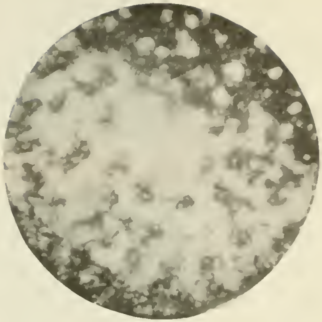

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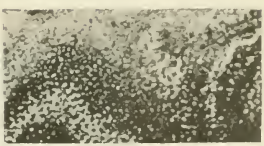

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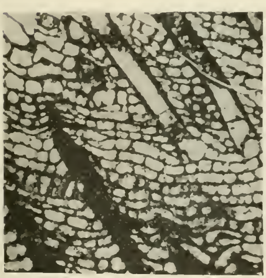

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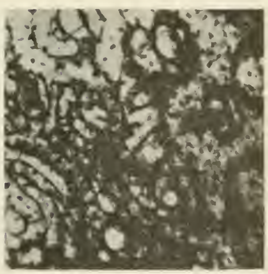

PLATE IV.

STROMATOPORA TUBULIFERA. Page 184. Fig. 1: Vertical section, enlarged 33 times. Fig. 2: Tangential section, enlarged 33 times. Fig. 3: Vertical section, enlarged 6 times. Fig. 4: Tangential section, enlarged 6 times.

CLATHRODICTYON PROBLEMATICUM, *sp. nov.* Page 184. Fig. 5: Vertical section, enlarged 6 times. Fig. 6: Tangential section, enlarged 6 times.

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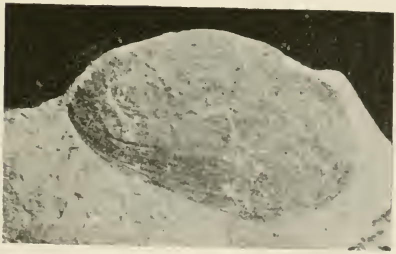

PLATE V.

Fig. 1 : HOLOPEA, *sp.* Page 187, Front, apical and umbilical views of different specimens.
Fig. 2 : LOXONEMA ROBUSTA, *Hall.* Page 186. View of internal cast of a large specimen and of the gutta percha impression of the exterior of a smaller one.
Fig. 3 : GONIOPHORA, *sp.* Page 188. Photograph of internal cast showing the great angularity of the shell.
Fig. 4 : MODIOMORPHA, *sp.* Page 188. Photograph of the cast of the exterior.
All figures of the natural size.

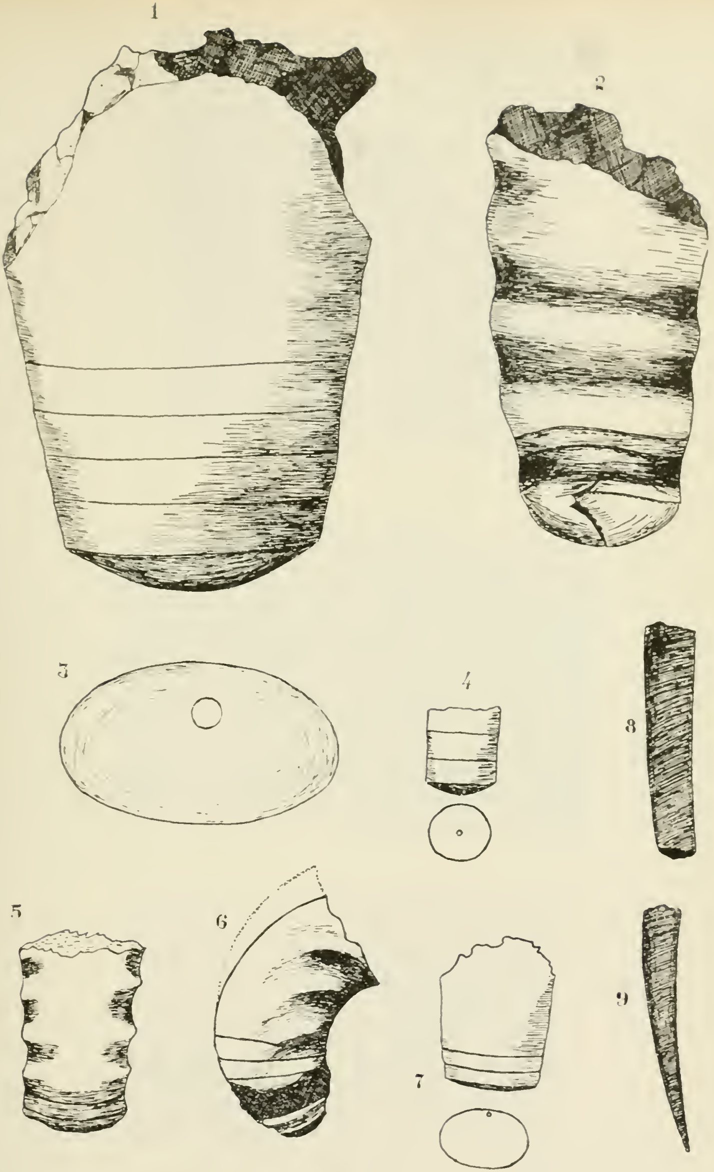

PLATE VI.

Fig. 1 : ORTHOCERAS ALGOMENSE, *sp. nov.* Page 189. View of chamber of habitation and the upper septa of the type specimen. Fig. 3.—Ditto. Fifth septum, showing the outline and position of the siphuncle.

Fig. 2 : ORTHOCERAS PULCHER, *sp. nov.* Page 189. Front view of the type specimen.

Fig. 5 : HERCOCERAS AURICULUM, *sp. nov.* Page 190. Chamber of habitation of the smaller specimen. Fig. 6 :—Ditto. Side view of the larger specimen showing the nodes and the degree of curvature. The dotted line indicates the probable outline of the ventral side.

Fig. 4 : ORTHOCERAS, *sp.* Page 189. Portion of the septate region and outline of septum with siphuncle.

Fig. 7 : ORTHOCERAS EXTREMUM, *sp. nov.* Page 189. Front view of type specimen and outline of septum.

Fig. 8 : COLEOLUS TENUISTRATUS, *sp. nov.* Page 188. Large coarsely striated example. Fig. 9 : Ditto. Apical portion of smaller form.

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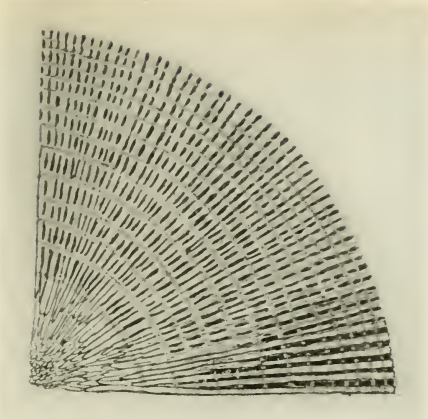

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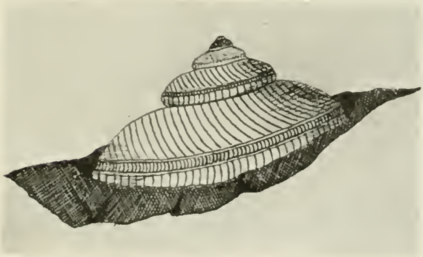

PLATE VII.

Fig. 1: FAVOSITES GIBSONI, *sp. nov.* Page 181. Pen and ink sketch of the weathered cross fracture, enlarged twice. Fig. 2: Ditto. Sketch of a portion of a horizontal section, showing the tabulæ, intermural pores and lines of growth. The intermittent activity of the organism is well shown in the continuity of the light and the dark portions across several several corallites. Enlarged about 20 times.

Fig. 3: PLEUROTOMARIA DELICATULA, var. CAMERA, *var. nov.* Page 187. Sketch of the best pre. served specimen, enlarged 6 times.

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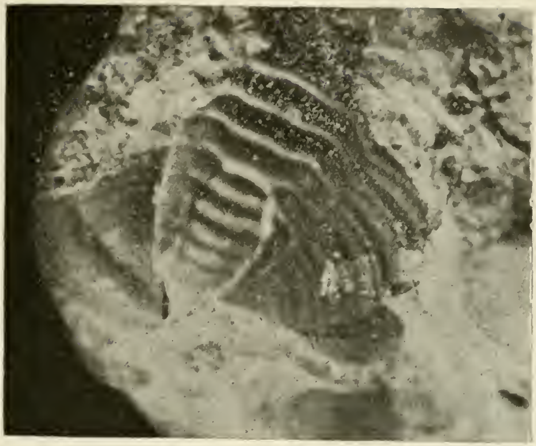

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PLATE VIII.

Fig. 1: PROETUS, *sp.* Page 191. Pygidium enlarged 5 times. (The photograph does not show the thickened margin.)

Fig. 2: YELLOW LIMESTONE FROM KWATABOAHEGAN RIVER. Page 180. Photograph of a fragment reduced one-half, to show the highly fossiliferous nature of the rock. The surface of this specimen shows:—Orthoceras luxum, Orthoceras procerus (?) Coleolus tenuistriatus, C. tenuicinctum, Pleurotomaria adjutor, Modiomorpha sp., Platyostoma lineata, Bellerophon sp., Euomphalus sp., Athyris spiriferoides, Cypricardinia indenta (?) Atrypa reticularis.

of mining locations in Levack township for the purpose of developing their properties, none of these roads follow the edge of the nickel-bearing eruptive, and so give little aid in tracing it. On this account most of the work of the summer had to be done by tramping, often for a distance of several m through the bush, from points that could be reached by wagons. As the pine had been cut in many places, the township lines are often almost obliterated, and walking along them, bad enough originally from the precipitous nature of the country, has become very slow and difficult. There are however some tracts of splendid pine still uncut, as in the township of Trill, where lines are easier to follow. Fire has not swept the northern range to the same extent as the southern, so that for the most part the cutting and blazing of the lines is much more distinct, and less time is lost in looking for lines. The older surveys however are largely grown up with small trees, especially where fire has run, and in such places one is often at fault.

While each edge of the northern nickel range tends to be rugged and hilly, the space between is generally not quite so rough, and the same is true of the Laurentian country to the north and northwest. Toward the southeast after a very precipitous row of hills formed of the indurated tuffs bordering the acid edge is passed, the relief becomes much less marked, and there are sand or gravel plains or clay flats through which the Vermilion river and its tributaries meander, often in a quite extravagant way. The underlying rock in this part of the district, when exposed, is black slate, which is much softer and more easily weathered than the tuffs beneath or the overlying sandstones, the latter often rising as low ridges still farther to the south.

Large tracts of the low ground through which the river winds are of good soil, now being rapidly taken up by settlers, mostly French Canadians, though some old country English families are settling here also. The townships in which our work was done are however almost devoid of good land, owing to their rugged rocky character.

Our survey covered parts of Drury, Trill, Cascaden, Dowling, Levack, Morgan, Foy, Bowell and Lumsden, Wisner and Hanmer, Norman and Capreol townships, the series beginning at the southwest and sweeping in a gentle curve to the northeast and north, a southward bend beginning however in Norman township. Both the basic and acid edges of the nickel-bearing eruptive were mapped, though more care was put on the basic edge where ore bodies might be expected to occur. Our aim was to fix the boundary wherever it was crossed by a township line, i.e., at about every half mile, and in most cases there deposits and swamps concealed the con were satisfactory outcrops, though drift deposits and swamps concealed the contact in a few places, especially in Cascaden and Trill townships. In no case were the drift-covered gaps longer than two miles except in the broad sand plains south of Capreol, where the outline of the eruptive is still uncertain.

Distances were determined by pacing tact in a few places, chiefly in Cascaden from corner posts or other fixed points, and the position of the contact was usually determined with a probable error of less than 100 yards. In the more important parts where mining or stripping of ore bodies had been done the basic edge was followed continuously when not drift-covered. For work in such places the dial compass had to be used on account of the strong local attraction. In the accompanying map of the Northern Nickel Range the boundaries of the eruptive band are given in solid lines where observed in the field, intervening spaces being dotted. Ore deposits or large gossan areas are marked with – The basic edge of the eruptive is colored brown and the acid edge red, the two colors blending in the middle.

Stratigraphical Relationships

While our special purpose was the mapping of the nickel-bearing eruptive throughout its whole extent northwest and north of the main or southern nickel range, so as to close up gaps and if possible connect the two ranges geographically, it was necessary also to make a study of the adjacent rocks in order to determine the exact boundary of the eruptive. It was found, as foretold in last year's report, that the two ranges join at the ends, making a continuous belt of eruptive rock enclosing a rudely oval, or rather boat-shaped area of sediments, classed by Dr. Bell in the earliest survey as probably Cambrian in age. The only possible gap in the belt is in the townships of Maclennan and Falconbridge, where extensive lake deposits form plains of sand and gravel, leaving very few outcrops. Assuming that the hidden parts resemble those that are exposed, there is little doubt that the belt of nickel-bearing rock is unbroken, and that the northern range is connected at both ends with the better known southern one.

Along with this goes the further probability that the whole mass of eruptive rock is sheet-like, forming a basin or short synclinal trough, as suggested in a diagram given in last year's Report; so that the enclosed sedimentary rocks appear to rest upon the eruptive sheet. Along three-quarters of the inner margin of the nickel-bearing rock it is in eruptive contact with the base of the sedimentary series just mentioned ; but a band of Huronian rocks of an older type intervenes between the two in Rayside, Snider, Creighton and perhaps Fairbank townships north of the main nickel range. The relationships here have not been finally worked out.

The outer or basic edge of the belt is also in eruptive contact with the rocks beneath, which, as far as the northern range is concerned, consist entirely of what is generally mapped as Laurentian, granitoid gneisses with basic schistose bands, the "basal complex" of some American geologists. On the south side, as shown in last year's Report and also by Dr. Barlow (2), the relationship is much less simple, quartzites, graywackes and various green schists and

(2) Geol. Sur. Can., Sum. Rep. 1902, p. 263.

eruptives generally called Huronion, making the boundary in many places, and granites or granitoid gneisses of somewhat doubtful age forming the boundary in others.

In general we may say that the synclinal sheet of nickel-bearing eruptive rests on undoubted Archaean rocks, Laurentian on the north and Huronian with various eruptives as well as probable Laurention on the south, its contact on both surfaces being of an eruptive character, so that it may be called a laccolithic sheet on a gigantic scale.

It had long been known that the northern nickel range splits up near the centre of Bowell township, one branch running slightly north of west into Foy, and another southwest to Morgan township ; but the real relationship was doubtful. Our mapping of the boundaries has shown that the basic edge of the eruptive follows the last mentioned direction, and that the extension into Foy is a narrow dike-like offset or apophysis, the only extensive projection from the eruptive yet discovered in the northern range.

The Range in Detail

The Southwest Corner

Fairbank lake, in the township of the same name, is almost entirely enclosed in the nickel-bearing eruptive, and gives good exposures of the rock on various points and islands. To the southwest about a mile and a half from the lake is the old Chicago mine, at one time called the Inez mine, with a fair wagon road leading three or four miles south to Worthington on the "Soo" Railway. The mine, which was worked partly as an open cut and partly from a shaft reaching a depth of 160 feet, is on a short offset to the south of the basic edge of the norite. The ore was apparently found in small pockets enclosed in very mixed rock, greenstone, green schist, porphyrite and a white rock almost free enough from green minerals to be called anorthosite. Two or three roast beds may be seen, and the roasted ore seems to have been smelted to matte and shipped to the railway by a curious single rail tramway in cars hanging beneath the rail. The tramway was worked by horses, but is now in ruins.

There are several buildings at the mine, as well as houses for the manager and miners a quarter of a mile to the north, but few of the buildings are now occupied, though two or three French-Canadian settlers have taken up farms in the neighborhood. Near the manager's house the norite leans up against Huronian rocks, and is here medium-grained and speckled gray in color, not so dark as in most parts of the basic edge farther east. The road to Fairbank lake, after passing a somewhat sulphurous spring and a farm house, turns north, and then east to the southwest bay, the ground being mostly low and swampy, though outcrops of similar but coarser speckled gray rock occur along the trail about 600 paces from the lake. As one goes north by canoe the rock on the shore of the lake becomes somewhat reddened where weathered, but remains rather gray on fresh surfaces, while on the north shore close to the tuffs which form hills between Fairbank and Vermilion lakes, the eruptive becomes dark-green and fine-grained, sometimes having an almost schistose cleavage. None of the outcrops toward the acid edge look like granite, though thin sections prove that the rock contains some quartz, and probably also orthoclase. This dark-green fine-grained phase of the acid edge of the nickel-bearing eruptive was found only at the southwestern end of the range.

The actual contact of the eruptive with the tuffs was not observed owing to the amount of drift and the density of the woods on the divide between the two lakes.

Sultana Nickel Mine

The wagon road from Worthington to the Chicago mine has been continued three miles northwest to the Sultana nickel mine in lots 7 and 8 in the sixth concession of Drury township, and lot 8, in the first concession of Trill ; and as the basic edge of the norite is not visible on the road, though rock crops out at several points, it probably runs somewhat parallel to the road, but farther to the northeast.

On lot 6, in the sixth concession of Drury, on what is called the Sultana east mine, gossan shows on a hillside with more or less are extending along its flank, which at first runs northeast and then turns east. Strippings of ore and test pits occur all along the boundary for about 150 yards. To the southwest the hill sinks into swampy ground, and neither ore nor norite was found in that direction.

Following the township line west of these outcrops, except for one hill of gray norite, the whole distance of at least half a mile to the Sultana mine proper, runs through swamp. At the Sultana a steep hill rises toward the southwest, much as at Sultana east, and a large number of test pits and outcrops show that the ore leans up against the wall of rock on this side of the valley also. On the flat beneath the hill camps for eating and sleeping, and offices, etc., have been put up, occupied at the time of our visit by Mr. Vasey and a party of men engaged in exploring the property with a diamond drill for the Lake Superior Power Company.

The strippings and other workings follow the foot of the hill in a direction about 10 degrees west of north for about a quarter of a mile (22 1-2 chains) from the cornerpost between lots 7 and 8 in Trill, so that the actual workings are in lot 8 of Trill; but one or two small outcrops occur on the hillside at a distance of 9 or 10 chains south of the cornerpost also. Part of the deposit is therefore in Drury, and the known extent of the ore is three-tenths of a mile. It is probable that careful search would disclose ore still farther to the south along the edge of the hill, but the bush is thick and no other hints of gossan were found.

Most of the ore to the north of the camp is along the lower flanks of the hill, but an offset runs 9 chains to the west a little north of the cornerpost, and two large strippings at this point show ore at the hill top 117 feet above the flat at the bottom.

There are three shafts, respectively 13, 19 and 22 1-2 chains to the north of the cornerpost, and beyond the last shaft the hill turns off to the west, and no more ore is to be seen. The deepest shaft is said to be down 110 or 120 feet; and there is a considerable quantity of ore on the dumps. A drill hole sunk a little to the east of the last shaft showed 36 feet of clay and sand, then norite followed by some ore, and finally greenstone with more or less ore. The dip of the rock surface between the shaft and the drill hole is about 40 degrees to the east.

In general the ore in this locality seems to lie in depressions of the hill as if it had settled into the lowest places. As the rocky hills bounding the swampy valley to the east and west seem to be converging toward the south, it is not unlikely that ore may be found beneath the swamp or drift in that direction, but up to the present none has been reported ; nor is it known if an offset runs southwards into Drury township.

The rocks forming the hill west of the gossan are not Laurentian, as suggested on the maps, but are more like Huronian, since they include green schist and diorite, with irregular patches of what appears to be norite penetrating them and showing on the flank of the hill toward the low ground. Much of the hill has the look of crush conglomerate.

The norite north of the Sultana is greatly mixed with older rocks, especially a flesh-colored arkose, and for half a mile in that direction, if it were not for the finding of the basic edge near the mine and the acid edge still farther north, one would be in doubt as to the relationship. It appears that there was a great amount of crushing and faulting of the older rocks with the eruptive toward this narrow southwest end of the great boat-shaped trough; but the thickly wooded surface prevents a very complete study of the geology. Just west of the Sultana mine the boundary of the norite is hard to trace, but about a mile to the northwest it is clearly seen again not far from a wagon road, now fallen into ruin and grown up with bushes, on the way to the Trillabelle or Gillespie mine; and from this northward to the third concession the road follows the contact, and ore may be seen at various places against a wall of hills like that at the previous localities.

Trillabelle Mine

In the third concession on the line between lots 10 and 11 of Trill there is a fairly well beaten trail or portage running east and west connecting with a canoe route eastwards to Fairbank and Vermilion lakes; and here just to the west of the old wagon road granite of a Laurentian aspect rises as a rocky hill above the swamp so usual at the basic edge of the nickel-bearing eruptive. Next to this, going north, is a dark-green rock containing some boulders, evidently a Huronian conglomerate or breccia, and against it ore is to be seen. Half a mile farther north the wagon road ends at the mine called by our guide the Gillespie, but in the Bureau of Mines report the Trillabelle (3) where a considerable amount of work was done many years ago.

Here and 170 paces beyond are a few foundations of stone, remains of a hoisting plant and various log houses; and ore or gossan against the hill which rises to the west. The rock observed is mainly greenstone with boulders suggesting a crush conglomerate, though a gray fine-grained rock near the northern pits may be norite. The dip of the rock face against which the ore lies at the points previously mentioned is from 35 degrees to 45 degrees to the east.

Half a mile north morainic hills conceal the bed rock and the next outcrop observed is probably the basic eruptive edge. the rocks higher up the hill to the west being bouldery greenstones like those mentioned before.

For a distance of 550 paces east of the line between lots 10 and 11 and near the middle of the fourth concession the rocks observed are a somewhat recrystallized arkose, evidently Huronian, and beyond this only bouldery drift is seen for 200 paces, probably covering the basic edge of the nickel-bearing eruptive, which here rises from under the drift.

The acid edge of the eruptive at this southwest corner is best studied from a chain of small lakes. Beginning at Fairbank lake a fair portage leads west to Cameron lake, mostly over drift. though the acid edge is only a little way to the north and shows on the north shore of the latter lake near its outlet. From Cameron lake a very poor trail leads west to a small unnamed lake lying across the boundary between the tuffs and the eruptive. The hills rising 270 feet (by aneroid) above this lake are about the highest in the region, and from the top one commands a wide view. They consist of the hardened sediments against the acid phase of the eruptive and present a greater variety of rocks than usual, including conglomerate, with large granite boulders, coarse white quartzite, dark-gray chert, a flesh-colored felsitic-looking rock and hardened gray chert; all brecciated and intermixed.

(3) Bur. Mines, 1894, p. 248.

The sharp ridge of mixed rocks runs northeast to Ross lake, which lies astride the boundary, and the acid edge on the shore is a fine-grained gray rock with considerable quartz, unlike the edge on Fairbank lake.

Windy Lake Region

Rounding the sharp bend which the nickel-bearing eruptive makes in Trill the outer contact runs north and northeast toward the west end of Windy lake, through difficult country largely swampy and drift-covered, so that for about two and a half miles the boundary has not been fixed, though it is known that Laurentian rocks crop out near Armstrong lake and that the boundary is to the east of this. The acid edge is unusually dark-green in color like that on Fairbank lake, and runs northeast from Ross lake to lot 3 on the Cascaden town line.

The nickel-bearing eruptive runs diagonally across Cascaden and Dowling townships and is most easily studied along the Canadian Pacific railway and on the shores of Windy lake. On the line between Trill and Cascaden the eruptive reaches a narrow arm of water running southward from a small lake, and extends northeast along another arm which forms the boundary against the Laurentian, here consisting of gneiss and greenstone. Without a canoe it was found impossible to cross to a location taken up years ago on the north shore of the small lake, where there may be an outcrop of ore. The rest of the margin in this township is most easily reached from Windy lake and then by a canoe route running southwest from it.

From the southwest bay of Windy lake a good trail runs 760 paces to a pond. 315 paces to another pond, and finally, after a little more than half a mile of trail in all, reaches a lake of considerable size. The trail runs over drift deposits including a moraine; the ponds are without outlets, suggesting kettles; and the unnamed lake appears to be mainly or wholly within the Laurentian.

On Windy lake itself the northwest shore, where not drift-covered is Laurentian also, of the usual kind in the region, consisting of reddish or grayish bands with darker gray layers of finer grained schist. The islands off shore and the large peninsula projecting from that shore are of norite. On the peninsula the boundary is largely hidden by morainic and esker ridges, but it is distinctly seen on the shore of the southwest bay. The rest of the shores of this beautiful lake are of norite or the intermediate rock between the basic and acid phases.

Much the best section of the nickel-bearing eruptive is provided by the railway cuttings to the west and east of the little station Onaping; and a number of rock specimens from these cuttings have been described by Prof. Walker(4.)

Beginning on the northwest near Windy Lake station, which is some distance west of the lake, Laurentian granite and gneiss with darker schistose inclusions is found until the shore of the lake is reached, when gray dioritic-looking norite is found, the actual contact however being hidden by drift. The rock remains the same in appearance for 100 yards, but soon changes to a reddish syenitic phase of fine or coarse grain, which continues to Onaping station, and is followed toward the southeast by greenish-gray rock having a peculiar ophitic-looking structure. The color and general appearance of the eruptive at the ends of this section are much alike, but the intervening phase of flesh-red syenite-looking rock is very different.

The acid edge of the eruptive rises as very steep hills to a height of 300 feet above the station, and the railway is forced to follow the valley of Onaping river in a sharp curve in order to cross the range of hills. The southeast side of these hills consists of hardened sediments, at first a gray, fine-grained graywacke conglomerate with pebbles and a few boulders of quartzite and granite, and sometimes also of gray chert, extending along the railway for about 1,000 feet; and followed by characteristic black vitrophyre tuff, often crowded with small fragments of gray material.

At another point on the acid edge, about half a mile south of Windy lake, a coarse Laurentian-looking conglomerate comes next to the eruptive, with many large pebbles or boulders of gneiss or granite embedded in it. This is succeeded by the graywacke conglomerate and finally the tuff, and similar relations are found to the southwest, where a Huronian conglomerate with granite pebbles and boulders comes next to the acid edge of the nickel-bearing eruptive.

(4) Quar. Jour. Geol. Soc., Vol. liii (1897), pp. 56-59.

The Levack Ore Deposits

To the northeast of Windy lake the basic edge may be traced, with some interruptions from gravel plains, to Onaping river; but no gossan or ore was observed between the Gillespie mine in Trill and the Onaping river in Levack township. The old mining road from Onaping to the Levack ore deposits is now in very bad condition from the heavy teaming of the lumbermen operating in the region, and also from flooding, due to their dams on the lakes intended to sweep down the logs in the somewhat shallow river and its tributary creeks. A diamond drill plant was taken along this road to the Strathcona mine during the past summer for the Lake Superior Power Company, but the difficulties met in transporting the heavy machinery were very great. The road leads along the river from the station for about 2 1-2 miles, largely over gravel plains, then crosses a bridge and follows the valley of a tributary toward the northeast, keeping along the foot of a range of Laurentian hills just at the margin of the norite. The actual margin is often occupied by small, narrow lakes, as though the norite had decayed more rapidly than the granite; and at several points where the norite still rises above the general level it is now weathering extraordinarily fast. The best instance is near the dam at the mouth of the creek draining Moose lake into the Onaping, where the spheroidal weathering is of a very characteristic kind. The rock, which is gray and coarse-grained, is irregularly fissured into blocks from 2 or 3 to 20 feet across. The weathering takes place along the fissures, leaving mound-shaped surfaces with channels between; and may go so far as to leave rounded blocks resembling drift boulders resting on the decayed surface, with material like fine gravel beneath the block representing the products of decay. In many cases the actual margin of the norite is not to be seen, but Laurentian rock rises to the northwest out of a lake or swamp and norite to the southeast.

About four miles from Onaping along the road just mentioned thick beds of gossan lying against the Laurentian attract attention at the Tough and Stobie property and test pits show that some ore underlies it, though no norite is to be seen. The Laurentian is of the kind usual in the region, granite running into gneiss and greatly mixed with fine-grained greenstone; and the ore, which consists of pyrrhotite, with a little chalcopyrite, sinks beneath the surface of the muskeg through which the creek winds.

Less than half a mile farther along the road there is another outcrop of gossan and ore like the first one, but with a lower hill of Laurentian on the northwest and a small lake on the other side. A little beyond this lake there is a gap in the Laurentian hills, suggesting an offset, and it is said that an ore body has been found some distance out in the granite, but we found no trail to it, and left it unvisited. Beyond this apparent offset there is another marginal lake, and then the route passes through low hills to what was once called the Levack mine, in lots 1 and 2 in the fourth concession at the end of the wagon road, about nine miles from Onaping.

Here two properties, the Strathcona and the Stobie No. 3, or Big Levack mine, have been opened up by stripping and test pits, and have been surveyed magnetically as shown by the systematically arranged survey pegs.

Strathcona Mine

Mr. Ernst A. Sjostedt, who examined the Strathcona property last summer report on it as follows:

"The mineral zone runs diagonally N. E. and S.W. across the north half of lot 3 and south half of lot 4 in the fourth concession of Levack township, and is bounded to the northwest by a range of syenitic granite, with which it forms a direct contact, and to the southeast by a wide range of norite, which usually forms one side of the mineralized zone throughout the Sudbury district. The largest body of ore is shown at the northeast end of lot 3, although the line of magnetic attraction is practically continuous across both lots, and ore is shown at various points on lot 4 as well. Near the northeast end of lot 3 the principal prospecting work has been done, a space of 3 or 4 acres having been cleared of timber and underbrush, and in places the formation stripped, exposing the capping and gossan, which generally reaches a depth of 2 to 8 feet. Part of the ore body is here shown up by a great number of cuts and pits, also by two shafts, of which No. 1 shaft is 45 feet deep, being 8 feet through barren cap rock, then through 25 feet of good mixed ore, then through 12 feet of solid pyrrhotite, and a 10-foot hole having been drilled in the bottom of the shaft, showing clean ore the entire distance. No. 2 shaft (250 feet north of shaft No. 1) is 30 feet deep, 6 feet being in cap rock and 24 in solid pyrrhotite.

"Pit A (320 feet north of shaft No. 1), and pit D (40 feet north of pit A) show ore within 2 feet of the surface, and trench C, along a low hill-side about midway between pit A and shaft No. 2, shows a face of ore 50 feet long, in the centre of which a pit was sunk through 12 feet of solid ore.

"From the data furnished by the above mentioned pits and shafts, covering an area about 600 feet in length and width, the amount of ore in sight on lot 3 is some 60,000 tons, but this includes an area of less than a tenth of the ground covered by equally promising surface indications, consequently there is every reason to expect a much larger body. The ore exists mainly in solid masses within a zone of 200 to 600 feet wide, and some 1,400 feet long. On page 199 are a number of analyses of samples taken from the above mentioned workings, which will show the character of the ore."

The Big Levack mine just to the east of the Strathcona presents a very irregular margin of gossan and ore spread over Laurentian hill-slopes and sinking to the southeast under muskeg with a dip of about 20 degrees in some places, but steeper in others. Some norite is present mixed with the ore; most of it however, and probably also of the ore has been weathered away, but may perhaps be found beneath the swamp.

The second set of mines seems much more extensive than those nearer Onaping. Beyond the Big Levack mine the nickel-bearing eruptive bends off to the east in swampy ground with small lakes and only one small patch of gossan was observed on its border.

Moose Lake Region

The acid edge of the nickel-bearing eruptive in Levack and the northeastern part of Dowling is best studied from Moose lake, which spreads out irregularly over a length of three miles along this margin. Moose lake may be reached by a road running northeast from Larchwod to Joe Seemo's farm on the banks of Onaping river near its junction with the Vermilion; and then by a trail leading through the woods to a bay on the line between Levack and Dowling townships. From the river to a pond with no outlet near the bay only drift is to be seen on the portage, but the acid phase of the eruptive here shows itself, and practically the whole of Moose lake is enclosed in it. The outlet of the lake into the stream mentioned before as joining Onaping river two miles north of the station is over the eruptive, and the same rock is found at various points on the lake and on the next small lake to the northeast, generally called Trout lake, and another to the east of it.

The acid edge runs northeast and southwest as a range of hills often with sharp minor ridges, sloping to the southeast and precipitous to the northwest, resulting perhaps from faulting during the sinking of the basin, or possibly representing a main direction of joints. All the survey lines cross these ridges diagonally. The contact of the nickel-bearing eruptive, with the tuffs to the southeast is often drift-covered, and on this edge as well as on the basic edge there is frequently a valley or narrow lake in this position. The sedimentary rocks to the southeast also form sharp ridges parallel to the eruptive ridges, and occasionally a narrow hill consists of the acid edge of the eruptive on one side and on the other of the tuffs.

The best exposure of the contact between the acid edge and the sediments found in the region occurs on the shore of a pond a little east of the end of the portage from the south to Moose lake. This body of water, unlike most others, cuts across the strike, and near its outlet into Moose lake the edge of the nickel-bearing eruptive shows a reddish-gray medium-grained rock, followed to the southeast by coarse flesh-red granite or gneiss, possibly a pegmatite dike. Then comes rock much like the first mentioned, succeeded by conglomerate with a fine-grained gray crystalline base and granitic-looking pebbles, lasting for about 120 feet, doubtless the basal beds of the sedimentary series. Beyond this is coarse white quartzite for about 70 feet, and then conglomerate again for about 200 feet, after which there is a curious breccia of paler and darker chert with some pebbles and boulders of granite for 1,000 feet, evidently the same as had been found along the railway southeast of Onaping beneath the vitrophyre tuffs.

Morgan Township

The basic edge of the eruptive crosses a small lake just east of the Levack mine and enters Morgan township on the fourth concession line, then turns a little north of east to Island river, which follows the edge for more than a mile and turns northeast once more to the fifth concession, and finally passes into Bowell township from the northeast corner of Morgan township. The boundary may be reached partly from Trout lake and partly from a lumber road leading over sand and gravel plains from Chelmsford to a camp near the junction of Island and Sand Cherry rivers. Travel in the region is, however, very troublesome from fallen timber and the unusually rugged and precipitous hills along the contact. The best exposures seen are near the lumber camp, where a steep hillside rises above Island river, having the nickel-bearing eruptive on its southern face pushing projections into the Laurentian rocks forming the summit. The former rock is not very gray, sometimes even rather reddish-looking, and of variable texture, coarse-grained and fine-grained parts running into one another, the finer grained material sometimes cementing blocks of Laurentian rock into a breccia. The Laurentian, which strikes east and west with a vertical dip, has the usual characters and consists of coarse gneiss with bands of gray-green finer grained material, the whole sheared in places into what looks like felsite. Near the edge it is greatly broken as if by the action of the eruptive mass to the south. No ore or gossan was found from the west edge of the township to lot 1 in the sixth concession, almost at

Sample from	Sampler.	Insol.	Fe.	Cu.	Ni.
Shaft No. 1 8 ft. from bottom	D. C. Schuler			.57	2.78
" piece from dump	E. A. Sjostedt			1.35	3.55
" 2, from dump	D. C. Schuler			.70	3.85
" 25 feet depth	"	5.03		2.11	3.54
" piece from dump	E. A. Sjostedt			.14	4.65
Pit A, surface	D. C. Schuler			.67	2.24
" B, surface	"			5.47	2.02
" B, bottom	"	6.10		1.54	3.37
" C surface	"			.33	2.40
" C trench	"	3.40		1.24	3.27
" C, 13 ft. pit	"			.28	2.72
" D, low ground	"	4.00	50.4	.30	3.21
Diamond drill hole, near A, 26 ft.	A. B. Wilmott			.65	3.80
" " 40 "	"			.58	2.60
Shafts, all over dumps	R. H. Aiken	5.01	54.3	2.23	3.15
Near norite wall	"			1.49	1.68
"	"			2.43	1.70
Average		4.71	52.3	1.31	2.97
Samples taken by Messrs. Cohen & Bradley, experts for J. R. DeLemar, N.Y				1.99	2.67
Total average				1.70	2.82

the northeast corner, and prospectors have taken up no locations between the two points. Near a small lake where the four townships, Foy, Morgan, Lumsden and Bowell, meet there are two locations with two or three patches of gossan, on which very little work has been done.

The southern or acid edge of the eruptive in this township has the usual characters, and is in contact at various points with the basal conglomerate so often found below the tuffs. The eruptive band is at its narrowest about the middle of Morgan township, having at one place a width of only a mile, and there seems less variation in character between the basic edge and the central and southern parts of the band than it is customary to find in other parts of the nickel range. Perhaps this fact should be brought into connection with the absence of ore referred to above. The thickness of the molten eruptive may have been insufficient to provide any large quantity of sulphides by gravitational segregation.

In Powell Township

In Bowell township the northern nickel range has long been known through the work of prospectors, and a row of locations has been taken up beginning at the southwest corner and running quite across the township, passing in the third concession into the next township, Wisner. About at the centre of the row of locations a long offset branches toward the west, extending out of Bowell into Foy and ending almost exactly in the middle of the latter township; and the whole of this offset is included in mining locations also, so that there has been more interest shown in ore deposits of this township than in any other on the northern range.

The locations are best reached by colonization and lumber roads from Azilda (Rayside) to Trout lake (a larger body of water than the one of the same name in Morgan township). Crossing Trout lake by canoe a trail leads inland from its northern bay and branches toward the southwest, west and northeast. A part of this trail which was cut out for the use of packhorses during the development of some of the properties is still in good condition, but toward the ends in each direction the path is rough and hard to follow, especially where the timber has been cut and fire has run.

Beginning at the southwest corner of the township the basic edge of the nickel-bearing eruptive is found a little north of the corner post of location WD 251, and in a general way the trail follows the edge, except where hills or swamps turn it aside, or where morainic ridges hide the contact. Gossan shows against the steep slope of the Laurentian toward the northeast corner of the location, and there is a swampy pond below, with hills of norite to the southeast. Near the west end of WD 241 an outcrop of gossan and a test pit along the trail indicate the boundary, and more gossan is seen toward the east side of the location, then drift hides the contact until WD 231 is reached where three similar small outcrops of gossan and ore occur against the Laurentian.

In WD 238 a small offset projects northward from the edge running into a narrow valley in location WD 37, where there are strippings showing gossan. The valley is enclosed by steep and bare Laurentian hills. A small lake in locations WD 242 and 239 appears to represent the boundary, and Roland lake a little to the northeast occupies the same position, having Laurentian on the north and norite on the south.

In a general way there is a valley running along the southeast edge of the Laurentian, which rises as a very rugged range of hills to a height of from 200 to 270 feet, with patches of ore along its foot. Southwest of the valley, which is often occupied by a narrow lake or muskeg, gray hills of norite rise to about the same height as the Laurentian.

In WD 35 the offset running to the Ross mine in Foy leaves the edge of the main range. In WD 36 near its northwest corner and probably extending into the previous location there is a promising outcrop of gossan and ore at the edge of the granite, but east of this to Trout lake no ore was observed.

Offset to Ross Mine

The longest offset on the whole circumference of the nickel-bearing eruptive extends for six miles nearly westwards from WD 35 to WR 5, reaching what is called the Ross mine, in the exact centre of the township of Foy. The path is at first good, but before the west boundary of Bowell township is reached fire and fallen timber and the debris left by the lumbermen injure it greatly, and beyond this care is needed in following it even in green timber, since it has scarcely been used for a number of years and the blazes are growing dim.

Just after turning off from the main range there is a considerable showing of ore on a hillside, and the adjoining rock consists largely of white plagioclase crystals so crowded together as to appear like anorthosite. Small seams of magnetite occur in this rock as well as sulphides. To the northwest in WD 150 a wide expanse of gossan is exposed by stripping and numerous test pits extending nearly to Nickel lake, where there is a log house occupied during the development work. Turning west the band narrows greatly and fine-grained norite penetrates between blocks of coarse-grained norite, of a gray gneissoid, rock, of greenstone, and of a white rock with porphyritic feldspars. the whole rusty or gossan-covered. The adjoining Laurentian is coarse red granite, an unusual variety in the region. On the shore of the next lake to the west a similar mixture of rocks is seen, and some gossan rises above the water.

From this point to the neighborhood of Ross mine little ore or gossan was seen, although the band of norite, narrowing and widening, seems to be continuous or nearly so the whole way; but somewhat similar outcrops of gray rock rising through drift-covered ground leave some doubt as to the relationships. Evidently the early prospectors considered the whole length to belong to the nickel range, or they would be have taken up locations along it. The greatest width of the offset, so far as observed, is in WD 234, where the rock seems to extend for about 500 feet, but usually it is much narrower, in one case apparently only 20 feet.

Our exploration of the locations just east of the Ross mine was greatly hindered by the work of a colony of beavers which had recently built a dam backing up the water for half a mile or more in various directions into the flat wooded land along the creek. WR 5, the original Ross mine location, includes two outcrops of ore and gossan standing as usual against a hill side of Laurentian, and dipping under the muskeg borders of a small lake; but the amount of ore to be seen is not large. Most of the Laurentian encountered along this offset is coarse-grained and flesh-colored, but some masses of gray-green rock, in general appearance not unlike the norite, are enclosed in it.

South Edge of Eruptive

The acid edge of the eruptive crosses from Morgan township into Lumsden in the fifth concession, and is fairly well exposed near the north shore of a small unnamed lake just north of the concession line in lot 9, as a gray rock weathering reddish. The neighboring sediments to the south look like quartzite with pebbles and merge into the tuffs, and these rocks continue to the northeast as a range of high hills, sinking however where Nelson river makes its way through. Along this valley gravel plains and morainic ridges conceal the rock. On the line between lots 6 and 7 to the south of a small lake crossing the concession line between Lumsden and Bowell the acid edge forms a hard gray-green rock, or some other eruptive appears to intervene between it and the sediments; but on the town line in lot 5 and also in lot 4 we find the usual relationships, the granitic-looking acid edge seeming to blend with a greatly metamorphosed coarse conglomerate. In places, if it were not for the coarser grain and different texture of the included pebbles and boulders, the matrix of the conglomerate could not be distinguished from the eruptive, and great care was necessary not to overrun the contact between the two rocks.

In location WD 252 at the southwest bay of Trout lake there is once more a fine-grained dark-green rock between the eruptive and the tuffs, in places very much like a basic eruptive rock itself, but in others charged with a few pebbles of granite, and having the characters of "slate conglomerate." In this marginal rock there are veins containing quartz with zinc blende, galena and a little copper pyrites, and at one point a shaft has been sunk to open up the ore. The quartz formed quite large crystals before the sulphides were deposited, and on breaking the ore the six-sided cross sections of the prisms are well marked. No very large amount of ore was to be seen, and the deposit does not seem to be of great importance so far as the present development work goes.

There is a small opening near a blacksmith shop a little east of the east bay of Trout lake, also on similar dark-green eruptive-looking rock, but even less ore is to be seen here than in WD 252, These small ore-bearing veins are found in the adjoining sediments or in greenstones connected with them and not in the nickel-bearing eruptive itself, but the eruption of the latter may have some connection with the formation of the deposits.

A very good section of the contact of the acid edge with the sediments is exposed on a small peninsula projecting from the south shore of Trout lake where the lumber road reaches the water. Two or three islets to the north show the nickel-bearing eruptive in its usual phase along the southeast edge, while the peninsula ends in a conglomerate having apparently two kinds of matrix, fine-grained green material containing epidote and quartz and rather coarse reddish or grayish quartzite, both including many small and large pebbles of granular quartzite and of granite. Irregular projections of the acid edge granite penetrate the conglomerate for 100 yards or more. Next to the southeast is a narrow range of precipitous hills of hard splintery cherty-looking brecciated rock, then comes a breccia of a less cherty kind with, however, a few granite boulders, probably the base of the tuffs. The section described is about 1,200 feet in length. Still farther to the southwest are the usual tuffs, less flinty and unaffected by the neighborhood of the eruptive.

Wisner Township

The basic edge of the eruptive runs almost due east from the northern side of lot 12 in the third concession to lot 4 in the township of Wisner, and then bends to the southeast toward Vermilion river and Norman township. The portion up to lot 4 has been surveyed as locations, but prospectors seem to have found no ore along the rest of it. This part of the nickel range is best reached by lumber road to Frenchman's lake and then by a canoe route to Joe's or Marion lake which crosses the nickel-bearing eruptive diagonally. The two Frenchman's lakes are in the sedimentary rocks, the south end being enclosed in the soft black slaty variety of the tuffs, but morainic materials hide the bed rock as one crosses to Joe's lake.

The basic margin of the nickel-bearing eruptive has the usual characters north of Joe's lake, the boundary to the north being Laurentian and a swampy valley running at its foot with low hills of norite to the south. Not much gossan or ore is to be seen in the locations across this township, though considerable showings occur on WD 16 and WR 14 near the head of the lake.

The acid edge is very well shown on Joe's lake, which it crosses near the south shore, and the bare surface of the rock near a small lake to the southwest gives an uninterrupted section across the boundary. The edge of the eruptive is granitic-looking and seems to blend into a conglomerate with a fine-grained crystalline ground-mass which might be taken for granite containing small and large boulders of granite, often with vague edges. This conglomerate is penetrated by indistinctly bounded projections from the eruptive and seems to have been greatly recrystallized in consequence of its presence. About 360 feet to the south the conglomerate has a ground-mass suggesting arkose or quartzite with a few pebbles of granite, and this dips beneath the small lake.

A parallel section on the shore of Joe's lake shows a similar conglomerate followed by breccia-like tuffs at a distance of 400 feet south of the acid edge, but with a few feet of a fine-grained green-gray rock without pebbles between.

The eastern side of Wisner township is most easily reached from the Vermilion river near Dawson, and a canoe route leads across from the second Frenchman's lake to this point. The rock showing between the two lakes is mainly tuffs, but half a mile west of Dawson a large dike of diabase rises beside the trail, perhaps the continuation of a dike found by Mr. Culbert on Onwatin lake about two miles southeast. Near Dawson gravel plains and muskegs cover the rock along Vermilion river, but the norite forming the northern edge of the eruptive is found rising as hills a mile west of the upper end of Bronson lake, near a small lake at the corner of lots 3 and 4 in the fourth concession of Wisner township. At the boundary the norite leans against a Laurentian hill, but no ore or gossan was to be seen; and similar relationships are found to the northeast towards Vermilion river, but gravel terraces hide the rock nearer the river.

Near the head of Bass lake, the next expansion of Vermilion river south of Bronson lake, the acid edge shows itself with the usual metamorphosed conglomerate to the south, here having a width of 800 feet before the tuffs are encountered.

Norman and Capreol

The boundaries of the nickel-bearing eruptive in these townships were mainly fixed by my assistant, Mr. Culbert, and the following account is given in his own words:

"The northern nickel range makes a sharp turn in the township of Norman, its outcrop there assuming a southward direction. In the northern concessions of Capreol township another change in direction is found, the strike being northwest and southeast to Massey creek as far as it was followed. The line of outcrop of the basic edge, owing to its comparatively rapid weathering, determines the position of a narrow valley from the Whistle property to Massey creek. This valley widens in many places, often containing lakes which conform to the strike of the eruptive. Examples are lakes Selwyn, Waddell, Ella and Clear.

"The basic phase along this part of its outcrop resembles the norite of the northern range, being a light mottled gray and is comparatively narrow. Darker phases occur in spots and resemble the rock at the Blezard mine, but the few small patches found near Moose lake are easily overlooked. Many peculiar contact varieties are found such as the poikilitic kind near the Blue lake ore deposit, which to the eye appears quite coarsely granular, but is found under the microscope to consist of large aggregates of feldspar optically continuous with inclusions of bi-silicates. The transition to the micrographic phase takes place within a short distance, and the total width of outcrop of the eruptive is a minimum in the townships of Norman and Capreol, being but little over a mile as a rule. The micropegmatite is of the usual flesh-colored rather coarse-grained variety found in the northern range and corresponds in mineralogical composition.

"On the east side the eruptive is in contact with Laurentian granite and gneiss. The granite is pinkish-red, with abundant quartz and few of the dark minerals in places where the acid magma has not incorporated inclusions and masses of earlier rocks. In many parts hornblende porphyrites and green schists occur, often running out in basic bands into the acid material and forming gneiss, or again occurring as immense blocks or large masses of considerable area which the action of the erupted material failed to shatter. A large mass of this kind occurs half a mile south of Moose lake near the small marsh on the road to Blue lake.

"The acid phase to the west comes in contact with the usual conglomerate, highly indurated with well-rounded pebbles and boulders of granite, greenstone, schist and quartzite. On passing westward this rock becomes softer and tufaceous, with no large boulders showing.

"A large diabase dike of great width, in some places a few hundred paces, was found in the valley of Massey creek on the boundary of Capreol and Maclennan townships in the third concession. It also outcrops on lot 5 in the fourth concession of Capreol on the shore of the small lake on the line between lots 5 and 6. This is probably the same dike that crosses lake Onwatin and which apears on lot 8 in the second concession of Wisner near the southwest post, the outcrops all being in a nearly straight line. The rock has a distinct green color due to a considerable content of olivine.

"Wherever the contact between the norite and the Laurentian appears on the surface indications of ore are found, either in thin patches of gossan or outcrops of ore bodies. Sulphide particles can be found on the contact wherever the rock is tested, and the red gossan product is present along its entire length in the townships near lake Wahnapitae. The more important outcrops of ore occur near Blue lake and south of it near the small Moose lake. On the shore of Blue lake the diamond drill has proved the existence of a body of ore, strongly magnetic and of some size. The outcrop near Moose lake shows a band of ore following the contact and varying in width from two to six feet of fairly good sulphides. In the test pits this ore appears rather lean, being mixed with some of the mother magma, but the proposition looks promising, having in view the improvement of transportation facilities. Further north, strong local attractions are found on the north end of Ella lake near the west side of WR 2, but no test pits have been opened to prove the existence of an ore body. The east side of Clear lake near the shore shows a few test pits with ore and a considerable extent of gossan.

"Leaving the Whistle property going westward the contact is found forty paces north of the northwest corner post of lot 7 in the fourth concession of Norman. The ground succeeding is low and drift-covered for nearly a mile, with no outcrops of the basic edge till near the line between lots 9 and 10, where the contact shows with a test pit and gossan 210 paces south of the northwest corner post of lot 9 in the fourth concession. To the west this outcrop is followed to low ground again with gravel deposits, but the norite outcrops south of the northwest corner post of lot 10 in the fourth concession at 410 paces. On following the uncut line half a mile to the west between lots 11 and 12 north from the post at the south boundary of the fourth concession a small test pit in a body of ore was encountered at 1940 paces. The Laurentian here contains good-sized bands of green hornblende schist like that which accompanies the Hutton magnetic ore deposits. The Laurentian was also found 1010 paces north of where the boundary of Wisner and Norman crosses the Vermilion river in concession four."

The acid edge of the eruptive was traced last summer southward through Norman and Capreol to the sand and gravel plains which hide the bed rock in Garson township: and the relationship of the eruptive to the overlying sediments was the same as has been described in other townships. A good exposure of the contact is seen on the road north from Dawson toward Moose mountain where, as one advances, the tuffs take on the character of conglomerate, and then of boulder conglomerate with a felsitic ground-mass before the edge of the eruptive is reached. In general, the ridges of tuffs and conglomerate, as well as of the eruptive, run north and south at this eastern end of the range, evidently conforming here as everywhere else to the direction of the line of contact, showing a close relation between the dips and strikes of the overlying sediments and the line of outcrop of the basin-shaped eruptive sheet.

No ore deposits are known on the acid edge at this end of the nickel belt, but a so-called nickel mine was found not long ago at the east end of Onwatin lake in black slate. Two openings made here show only iron pyrites.

Acid Edge of South Range

The norite edge of the southern nickel range has attracted great attention because of its ore deposits. but very little work has yet been done in the way of tracing the acid edge. As far as time would permit characteristic sections across the southern range were examined for the sake of comparison with the northern range, the sections chosen being near Whitson (or Blezard) lake and between Murray mine and Azilda, both of which were examined years ago by Dr. T. L. Walker (5).

The section examined near Whitson lake followed the road toward the northeastern settlements, along which there are numerous outcrops of rock. instead of the shores of the lake itself where Dr. Walker had worked. The basic edge at Blezard mine is of the typical sort for the southern range, consisting of dark-gray norite with bluish quartz and some plates of biotite; unlike the paler gray rock common on the basic edge of the northern range, where bluish quartz and biotite are not conspicuous. A wide swamp intervenes between the outcrops near Blezard mine and the hills to the north. where rock once more appears; and the character of the rock is still that of norite, though coarser in texture and paler in color than at the mine. After a short interruption of pale flesh-colored, fine-grained rock, either a dike of granite or a mass of metamorphosed quartzite, a coarse flesh-colored to gray variety of the eruptive is again encountered, either a syenite or diorite in appearance. A sharp hill of reddish gneissoid rock rises just beyond this, possibly another band of later granite, though it is sheared into a distinct gneiss. Next comes a dark flesh-colored variety of the eruptive, suggesting syenite, but proving under the microscope to consist mainly of pegmatite with much quartz. Coming down to lower ground near the northwest end of Whitson lake a darker gray rock, sometimes gneissoid, represents the acid edge of the eruptive and stands in contact with the sediments.

At the edge there is a narrow band of conglomerate containing pebbles and boulders of quartzite, granite, and perhaps other rocks, with some green chlorite schist, partly as matrix and partly without pebbles. There has been a good deal of crushing along the margin of the eruptive, and the relationships are not always clear, but the strike is about 60 degrees with a dip of 35 degrees to 55 degrees to the southeast, as if the eruptive had overturned the edge of the sediments. Beyond the contact tuffs of the usual kind are found at various points along the road.

Except for the granite or gneiss interruptions in the eruptive and the narrowness of the band of conglomerate between it and the tuffs, the relationship is like that found in various places on the northern range.

As the eruptive with its varieties along the railway between Murray mine and Azilda has been described in some detail by Prof. Walker (6), little need be said of it here, except that it conforms to the types found near Blezard and is penetrated by irregular dikes and masses of flesh-colored granite.

The acid edge is found half a mile east of Azilda station, where a road turns north, and has the appearance of reddish syenite greatly broken and sheared, as exposed on a cliff to the east of the level farm land. Some lower points consist of gray gneissoid rock with much mica, probably the extreme edge of the eruptive, but passing wthout any marked break into what is probably rearranged quartzite or arkose, evidently sedimentary. The latter rock crops out at various points on the road to the north; and a less modified arkose stands out of the clay flat as a sharp hill nearly a mile northwest of Azilda. Beneath the arkose is chloritic slate or schist with some flattened boulders, striking N. 15 degrees to 30 degrees E. and dipping about 20 degrees toward the east.

At the northeast end of Whitewater lake the acid edge takes the form of a somewhat reddish-gray, distinctly gneissoid rock, but the adjoining sediments are hidden under swamp and clay. A

(5) Quar. Jour. Geol. Soc., Vol. LIII. (1897), pp. 47-56.

(6) Ibid, pp. 47-54.

promontory on the north side of the lake two miles west shows none of the eruptive, but must approach closely to the edge. Here schist conglomerate rises out of the water having a strike of about 40 degrees east of north and a dip of 35 degrees to 45 degrees to the southeast. It includes many boulders of arkose or quartzite and perhaps also granite in a matrix of chloritic or biotitic schist. Less than a quarter of a mile to the north is a hill of characteristic tuffs containing many angular pebbles of other rocks, and the point on the north shore of Whitewater lake may represent a basal conglomerate of the tuffs, like that so often found at the edge of the northern range. A curious feature of the schistose margin of the sediments at all three localities is the dip to the southeast. This may however, represent only the schistose structure, resulting from squeezing at right angles to this direction; and the real strike and dip may be quite different.

In general, it may be said that the acid edge of the eruptive is more broken by dikes of granite, etc., on the southern than on the northern edge, and the adjacent sediments have been more profoundly acted on, resulting in the production of schists. The regular boulder conglomerate found at the northern edge appears to be thinner and less constant along the southern edge.

Basin of the Eruptive

In connection with the study of the nickel-bearing eruptive numerous observations were made of the rocks within its boat-shaped synclinal basin; and the results may be brought together here. These rocks have attracted attention since the nickel region began to be studied geologically because of their unlikeness to the ordinary Huronian rocks of northern Ontario. Dr. Bell in his 1890 report (7) gives brief descriptions of the rocks; and Prof. Walker mentions them also in the paper previously referred to. Numerous references have been made to them in reports of the Bureau of Mines (8), but no detailed study has been made of them, so far as can be found in published accounts. Dr. Bell's map divides the rocks of the basin into "dark argillaceous and gritty sandstones with shaly bands, possibly Lower Cambrian," and "black silicious volcanic breccia with black slate in some parts"; and in his report he comments on the unchanged character of the upper sandstones, which he clearly considers much later in age than the Huronian rocks around.

Dr. Barlow however in 1902 (9) regards these rocks as belonging to the same system with the Huronian slates and quartzites.

Nature of the Sediments

Our study of the rocks occupying the basin shows that in most places along the northern range the next rock to the acid edge of the nickel-bearing eruptive is a coarse conglomerate of granite boulders up to several inches or a foot or two in diameter, cemented by finer grained granitic or gneissic looking material, perhaps a metamorphosed arkose. Next to this may come a thin band of white quartzite or arkose; then a gray quartzitic or cherty rock with many fragments of dark-gray or white chert and sometimes pebbles of quartzite and granite.

Tuffs

Beyond the different phases of conglomerate, which may have a width of 1,500 feet or less, comes the vitrophyre tuff which has attracted so much attention, and dark gray or black rock on fresh surfaces, but weathering brown or pale-gray or almost white. On fresh or not too much weathered surfaces the rock is seen to be largely a breccia of angular fragments of dark or pale-gray materials in a compact black basis. Thin sections show that the fragments consist often of chalcedony or of serpentine. Occasionally pebbles or large rounded blocks of chert, quartzite or granite are imbedded in the breccia, showing that at least some ordinary detrital materials joined the rain of volcanic ash and lapilli which is supposed to have fallen into the sea when the rock was formed. Undoubtedly, however, most of the constituents of this curious rock have come from explosive volcanic eruptions on a very large scale.

The boundary between the tuffs and the conglomerate beneath is not usually sharp, but the transition takes place more rapidly in some places than in others.

The width of the tuffs was not determined by us in many cases, but in two instances we found them at least a mile and a half wide, and were not sure even then that we had covered the full width. Although they were almost certainly deposited in water, marks of stratification were not observed with sufficient

(7) Geol. Sur. Can., 1890, Rep. F., p. 11 and pp. 22-24.

(8) Rep. 1903, p. 291, etc.

(9) Summary Rep. Geol. Sur. Can., 1902, pp. 255-6.

clearness to determine strike and dip, but the direction of the sharp ridges in which the rock now stands is always parallel to the edge of the nickel-bearing eruptive. As the dip is not known, the thickness cannot be reckoned with any certainty.

Slates

The hard variety of tuffs which forms sharp hills and precipices seems to pass gradually into a softer, slaty variety with a well-marked cleavage. In this the fragments are flattened, giving a spotty look to the cleavage surfaces, and none of the cherty or chalcedonic material is present. This again passes into ordinary black slate with a good cleavage across the planes of sedimentation as shown by a slight banding. As the slates are the softest of the sediments they have undergone more destruction than the other rocks, and so are often drift-covered when the tuffs and sandstones rise as ranges of hills. Specimens of the slate have been proved to contain 6.8 per cent. of carbon, and they should probably be considered as ordinary muddy sediments originally charged with organic matter. This rock is so poorly exposed that in many places one can only infer its presence under the sheet of drift along the rivers.

Sandstones

The sandstones or arkoses, sometimes spoken of as graywackes, form the uppermost rocks of the basin, and are widely exposed, since they are more resistant than the slate and stand up often as sharp ridges rising 50 or 100 feet above the plain. These rocks are rather dark-gray and vary in texture from very fine-grained material, almost slate, to coarse arkoses, in which there are rounded fragments of quartz and feldspar as large as a pea, or rarely small pebbles. In a general way, they are very uniform over the central tract of the syncline, but have at any given point considerable variety. Occasionally black bands of slate occur in the sandstone, bringing out distinctly the stratification, but more often the direction of the bedding is obscure, though the general course of the ridges may be supposed to represent it. Occasionally in the finer grained varieties there is a distinct cleavage, which must not be confused with stratification.

The points at which the sandstones can be most easily studied are Larchwood toward the northwest side of the syncline, and Chelmsford toward the southeast side, both stations on the Canadian Pacific railway.

At Larchwood the banks of Vermilion river and the hilly country to the north and west of the village give excellent outcrops. To the north there are several parallel ridges of the rock striking 45 degrees to 50 degrees, and having a dip of 20 to 30 degrees to the southeast. The ridges are steep toward the northwest and slope about as the rock dips. Quartz grains, a little mica, and small pebbles show on weathered surfaces; and finer grained parts, greenish-gray in color and banded lighter and darker, are sometimes greatly crumpled. A mile west of Larchwood along the railway, where the ridges trend 35 degrees, the dip as shown by slaty layers is only 10 degrees to the southeast, but a slaty cleavage has a strike of 55 degrees and a nearly vertical attitude. Some large angular fragments of fine slaty or compact texture are enclosed in the arkose, one mass having diameters of five by seven feet, but the slaty cleavage runs through both.

Large oval concretions of impure carbonate of lime are common in certain beds, weathering more rapidly than the surrounding rock and so forming slight depressions. In appearance on fresh surfaces the concretions do not seem to differ much from the rest. About a mile and a half west of Larchwood the sandstones are covered with stratified sand, and the next rock exposed, near Phelan about two and a half or three miles beyond, is vitrophyre tuff.

Going east from Larchwood, the rock is well exposed at the falls of the Vermilion near the railway bridge, where the river, running southwest, has cut a small canyon between ridges and then suddenly turns off to the southeast across the ridges. The strike is here 55 degrees or 60 degrees and some black slaty layers dip 45 degrees to the southeast. Two miles to the east the sandstone strikes 70 degrees, and dips 30 degrees to the northwest, while an indistinct cleavage is about vertical. Four miles east the bedding seems to be nearly horizontal, as shown by slaty layers, but rather high and sharp ridges rise above the clay plain about parallel to the imperfect slaty cleavage; which at Chelmsford, six miles to the east, has a strike of 60 degrees. Concretions are prominent features again at Chelmsford, and a stone quarry west of the village gives good exposures of the rock, but the stratification seems too uncertain and irregular to settle a general direction of dip.

About two miles northwest of Chelmsford a quite high and continuous ridge of sandstone rises above the flat clay land with a strike of 35 degrees or 40 degrees, but with a cleavage running 60 degrees. Here too there are some concretions and slaty layers, in places coarser and finer materials showing contortion or swirling forms.

It may be said in a general way that the sandstones have the synclinal attitude, dipping southeast on the northwest side and northwest on the opposite side; but there is much irregularity in the arrangement, accompanied by a good deal of faulting and much squeezing and twisting of the slaty layers.

About four miles northwest of Chelmsford diabase penetrates the sandstone near its junction with the black slate, the only instance of the kind observed in these rocks, though large dikes of diabase occur in the slates and tuffs near the northeast end of the basin.

The data are not sufficient to estimate the thickness of the three main sediments of the syncline, the tuffs, slates and sandstones; but the total must represent several thousand feet, since the basin is ten miles wide between Whitewater lake and the inner edge of the eruptive sheet in Morgan township, and the dips run from 10 degrees to 45 degrees. If the average width of 8 miles is taken, and a dip of 30 degrees is assumed, the total thickness of the sediments will be over 10,000 feet, probably not at all an over-estimate. There may of course be more or less reduplication of strata by faulting, though evidence of faulting on a large scale has not been observed; but on the other hand the loss of thickness by erosion, which must have been very great in formations so old and so long exposed, may more than counterbalance it.

The River Systems

The relation of the rivers to the three main varieties of sedimentary rocks in the basin was noticed by Dr. Bell in the course of his survey (10), and deserves notice here. The Vermilion river, which is the most important, between Wisner and Norman townships, comes almost due south, with a nearly straight course between banks of slightly auriferous gravel, passing through a wide gap in the tuff ridges, and swinging southeast to Onwatin lake in the black slate. Up to this it has been a swift river with numerous rapids, but from Onwatin lake toward the southwest it changes its habit, flowing in a very meandering channel with gentle current between banks of clay and silt in the drift deposits overlying the slate among the northwestern edge of the sandstones. Near the northwest corner of Balfour township it is joined by another large stream, the Onaping, which after tumbling as violent falls and rapids over the tuffs turns northeast along the slates until it meets the Vermilion.

After the junction the Vermilion turns into the sandstones and passes through a series of rapids at Larchwood, then resumes its course southwest of Vermilion lake, which counterbalances Onwatin lake at the other end of the syncline, as noted by Dr. Bell, and flows out eastward once more along the band of slate; then doubles to the southwest, and finally escapes to the south across the tuffs and nickel-bearing eruptive near the boundary of Creighton and Fairbank townships. At its second sharp bend southwest it is joined by another considerable tributary, Whitson creek, coming from the northeast and following for miles the strike of the band of slate. The three most important streams of the district, when they escape from the tumult of their descent through the other rocks, wind gently in broad curves as soon as they reach the soft slates, and keep to the strike of the slate as long as possible.

As Dr Bell points out, there are many tributary streams pouring into the Vermilion and Onaping from the north, mostly with very rapid courses through rocky channels, but no tributaries of any magnitude join them in the flat lowlands of the interior of the syncline. The control of the watercourses by the ancient rocky structure of the country is very strikingly brought out in this region, as will be seen from the example just given.

(10) Geol. Sur. Can., 1890-91, p. 18F.

Petrographical and Stratigraphical Notes

Nickel-bearing Erupt ve

The nickel-bearing eruptive has already been studied at a few points in a somewhat detailed way, especially by Profesor Walker (11), and Dr. Barlow (12); but the rock is so important in its geological and also its economic relationships that a much more complete study is desirable. Professor Walker first recognized that the band of basic rock associated with the nickel ores of the region passed into a micropegmatitic rock and became much more acid on the edge opposite to the ore bodies, a section from the Murray mine to Rayside (now Azilda) being taken up in detail to bring this out, and another section from Blezard mine along the shores of Whitson (or Blezard) lake supplementing it. He also made the important fact clear that in the Windy lake region fifteen miles to the west of the Murray mine section, the arrangement is reversed, the basic edge being on the northwest side of the band, and the acid edge on the southeast. A series of analyses of rock specimens from the Blezard mine and Whitson lake brought out very clearly the chemical change in the eruptive on passing from the outer to the inner edge (13), the silica contents of the basic edge amounting to only 49.90 per cent., while two analyses from near the opposite edge showed 69.27 and 67.76 per cent. respectively.

In my last report on the Sudbury region the nickel-bearing eruptive was briefly described. Dr. Walker's views being confirmed, and the suggestion was made that the two bands of nickel-bearing eruptive joined at the ends, as a continuous belt, and that it probably formed an immense laccolithic sheet of synclinal form, with tuffs and ordinary sediments enclosed within it (14). The past summer's work has made this conclusion practically certain by connecting up the northern with the southern nickel range and actually following the eruptive belt from point to point, except where drift-covered, through the whole northern part of the area.

The edges of the boat-shaped eruptive sheet are everywhere in eruptive contact with the rocks above and below along the northern side, and probably also on the southern side except where later granites have come up between its basic edge and the rocks below.

Although the outcrop is continuous, its width varies greatly, being four miles or a little more along some parts of the southern range, as near the Creighton mine, but scarcely one mile in width at one point on the northern range near the northeast corner of Morgan township; and in general the southern side of the band averages wider than the northern. With the narrowing of the band as a rule the number and importance of the ore deposits along the basic edge diminishes, until, as in Morgan township, there may be miles of the edge without ore deposits or even a stain of gossan. The appearance of the rock in these narrowest parts is paler gray and less basic than at wider parts, so that in Dr. Bell's original map of the region they are not separated as bands of greenstone. Apparently, the differentiation of the magma was not carried so far where the thickness is less, or else the thickness is less because we are approaching the feather edge of the great sheet of rock, and the basic parts did not extend so far but might be found by sinking to a sufficient depth a mile or two in from the edge.

In Dr. Barlow's account of these rocks, which he groups under the convenient field term, greenstone, three varieties are distinguished, norite, diorite and amphibolite; the norite being the original form, and the other two representing a less and a more advanced stage of alteration. The norite is described as passing into micropegmatite and finally into a usually gneissoid rock, gray with paler phenocrysts, weathering flesh-colored, and consisting mainly of quartz and an acid plagioclase about which radiating pegmatite occurs, with some orthoclase and biotite or less often hornblende (15). His excellent a count corresponds well with my own results for the southern range near the best known ore deposits; but the sections made in the northern range and in the southwest end of the southern range, near the bend connecting it with the northern range, show rocks and relationships differing in important ways from those described by Walker and Barlow.

A few of these sections will be taken up with more or less detail, beginning at the southwest corner of the area.

(11) Quar. Jour. Geol. Soc., Vol. liii. (1897)

(12) Geol. Sur. Can., Summary Rep., 1902. pp. 256-260.

(13) Quar. Jour. Geol. Soc., liii., p. 56.

(14) Bur. Mines, 1903, pp. 276-7.

(15) Geol. Sur. Can., Sum. Rep., 1902. pp. 259 and 60.

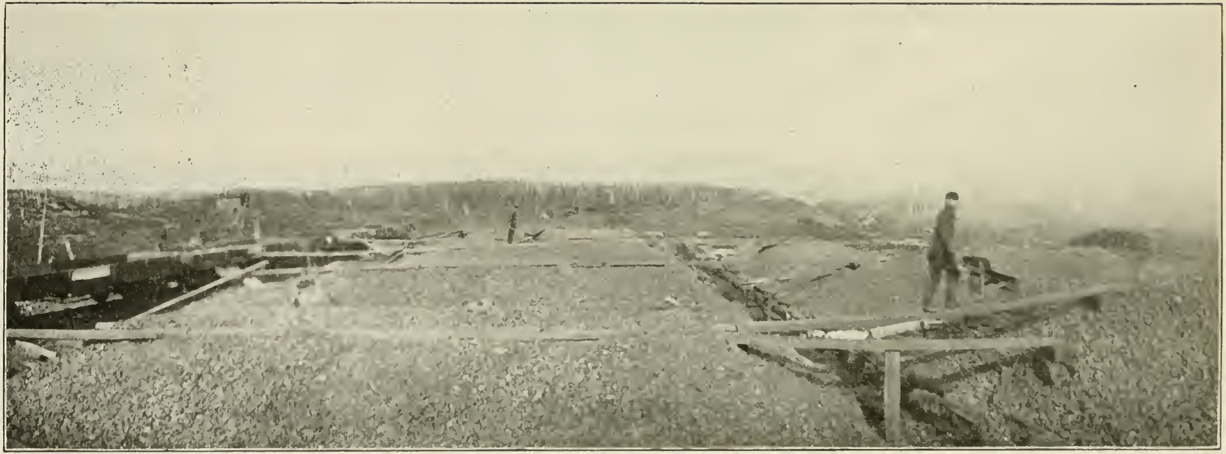
Nickel Eruptive, Windy lake.

Weathering of Nickel Eruptive; mouth of Moose Creek

Strathcona nickel mine.

Big Levack nickel mine.

North Star nickel mine, October 1903.



No. 3 or new roast yard, Canadian Copper Company.

Sultana Mine—Fairbank Lake

The nickel-bearing eruptive is fairly well exposed for a width of about three miles and a half between Sultana mine and the north end of Fairbank lake in the townships of Drury and Fairbank, though drift deposits cover much of the section southwest of the lake. Near the Chicago mine, but a quarter of a mile to the north, the basic edge of the eruptive shows against rocks having the appearance of Huronian schists and eruptives. It is here a rather dark gray dioritic-looking rock of medium grain, quite different in appearance from the very dark, almost black, variety seen near Murray mine, not only as to color but in the lack of the blue quartz blebs, and the large scales of biotite so characteristic farther east.

A thin section might easily be taken for one of diorite, since it consists mainly of plagioclase and hornblende with smaller amounts of quartz and biotite and possibly some orthoclase. However, the hornblende is clearly secondary in most cases, and one mass of it encloses some hypersthene. The plagioclase tends to form elongated strips or broad plates slightly suggesting the ophitic structure, and the small amount of quartz is interstitial with a hint of pegmatitic intergrowth. The lighter gray color of the rock as compared with examples farther east is at least partly due to the absence of the minute brown particles darkening the plagioclase in the latter case.

A paler gray rock 600 paces south of Fairbank lake on the trail from the Chicago mine, about half a mile from the previous outcrop, differs little from the rock just described except in the presence of a considerable amount of micropegmatite around the well-shaped elongated crystals of plagioclase.

On the southwest bay of Fairbank lake a dark green schistose rock, taken at first for a hornblende schist included in the eruptive, is probably a sheared representative of the last rock, consisting now of quartz, orthoclase, plagioclase and green hornblende crushed and rolled out, some larger feldspars occurring as rounded grains enclosed in "mortar" of quartz and smaller particles of feldspar.

Two points on the west shore of Fairbank lake consist of somewhat schistose greenish-gray rock flecked with flesh-colored feldspars, containing, as seen under the microscope, large feldspar masses, mainly orthoclase, and an acid plagioclase, so far as their weathered condition permits a determination, with crushed quartz and feldspar between, and a large amount of a mineral like epidote, not in small scattered crystals, but as considerable areas made up of several individuals, crowded together. This mineral has in part a faint dichroism, pale-green and gray, and a small extinction angle, and should probably be referred to epidote, though it resembles the woehlerite determined by Professor Walker in the Onaping nickel-bearing eruptive.

At the north end of the northwest bay of Fairbank lake east of the portage from Vermilion lake, near the edge of the eruptive against the tuffs, the rock is once more dark gray-green, very slightly specked with a flesh-colored mineral. It is very fine-grained and sometimes slightly schistose. Thin sections show that it is less sheared and crushed than the rocks to the south, and contains in spite of its dark-green color a large amount of quartz and feldspar in the form of exceedingly fine micropegmatite, as usual radiating from plagioclase crystals. There is probably some orthoclase, and hornblende occurs, though chlorite is the chief dark-colored mineral, giving the tone to the rock. An analysis given later shows that it is rather basic granite or a grano-diorite.

The inner edge of the eruptive at Fairbank has the appearance of being less acid in character than in most places, perhaps because adjacent portions of the tuffs have been dissolved in them. Shearing or squeezing has been a very marked factor in the region, especially toward the middle of the eruptive band, and has given opportunities for weathering to an unusual degree, accompanied by the formation of chlorite, masking the real color. The analysis of this rock, made by Mr. Ardagh, shows 68.95 per cent. of silica, so that it is not so basic as its dark-green color would suggest.

No complete section has been examined at the extreme southwest end of the basin, though specimens were collected near the Sultana mine and in the township of Trill to the north near Ross lake. Where the northern and southern ranges converge there seems to have been a good deal of faulting so that the eruptive is confusedly mixed with metamorphosed sediments, such as arkose, the mixture a quarter of a mile north of the Sultana being breccia-like. The norite rising as a hill to the east of the Sultana camp is much like the weathered edge described near the Chicago mine; but a little north of the Sultana the rock is of a different type, consisting of masses of hornblende with a little biotite enclosing white areas of plagioclase made up of many small crystals crowded together. These crystals are oval or short prismatic, and are sometimes untwinned, sometimes divided into halves, and sometimes of more complicated twinning; the extinction angles suggesting varieties from andesine to labradorite. The origin of this structure is not clear, but similar sections have been got from near Joe's lake in Wisner township and near Murray mine.

The acid edge varies in appearance. On Ross lake and another small lake to the north it is medium to coarse in grain and grayish flesh-colored, consisting chiefly of quartz, plagioclase and a little orthoclase, the quartz belonging mainly to the micropegmatitic outgrowths round sharp-edged plagioclases, but some forming clear separate blebs. A little hornblende and chlorite darken the color of the rock.

Specimens collected half a mile northeast of Ross lake, of a dark green-gray color with feldspar strips suggesting the ophitic structure, were at first taken for a dike or boss of a different rock; but thin sections prove to contain much micropegmatite so fine in texture as to be visible only with fairly high powers of the microscope. This may surround long slender, clear-cut plagioclase crystals or may form radiating masses with a rude black cross in polarized light, without any apparent nucleus.

Onaping-Windy Lake

The best section for the study of the northern side of the nickel-bearing eruptive is undoubtedly that along the Canadian Pacific railway between Phelan and Windy lake sidings, where numerous small rock cuttings expose the tuffs with their underlying conglomerate, the acid edge of the eruptive, its basic edge, and the Laurentian gneisses beyond. Taken at right angles to the strike of the belt of eruptive rock its width is nearly three miles. Rocks collected at different points on the section have been studied and described by Prof. Walker, (16), but it is worth while to refer to this section more in detail.

Going eastwards along the railway from Windy lake siding Laurentian is seen for a quarter of a mile, when drift and an esker ridge cover the rock for a distance. At the northwest end of Windy lake gray, dioritic-looking norite crops out, rather coarse and speckled in appearance, consisting, as seen under the microscope, mainly of plagioclase, hypersthene and augite, with a little quartz, biotite, and hornblende, many prisms of apatite and some magnetite. The plagioclase, which is clear and colorless and makes up about half of the rock, has extinction angles corresponding to andesine or labradorite, and is generally hypidiomorphic; while the hypersthene is idiomorphic. This mineral presents some anomalies, since some crystals showing the usual pleochroism, red, brown, pale brownish green and pale yellowish, have parallel extinction, while others extinguish at various angles up to 28 degrees. Diallage, brown and fibrous-looking, non-pleochroic, and with an extinction angle of about 45 degrees occurs in small quantities also; the small amount of hornblende present forms margins about the minerals just mentioned; and the brown biotite is present only in trifling quantities.

A specimen from a cutting a hundred yards east is coarser grained and not quite so fresh, but does not differ greatly in composition. An analysis of this rock given later, shows 56.89 per cent. of silica, considerably more than Professor Walker found in norite from Blezard mine on the southern range.

Fifty yards farther east coarse red syenitic-looking rock begins and lasts to Onaping station, showing in various cuttings. Thin sections prove however that the rock contains a large amount of quartz mostly pegmatitically intergrown with feldspar, but partly as fairly large clear spaces, so that it is too acid for syenite, and an analysis given later confirms this by showing 68.48 per cent. of silica. The feldspars are very badly weathered, but the well formed crystals making the starting point for micropegmatite seem to be all plagioclase, though the analysis proves that potash and soda are present in about equal amounts, (K_2O 3.36, Na_2O 3.72), so that the feldspar in the pegmatite must be chiefly orthoclase. The dark minerals include secondary looking hornblende and the mineral resembling epidote named by Professor Walker woehlerite. The last specimen collected to the west of Onaping station has extraordinarily slender prisms of feldspar, which strike the eye immediately on fresh surfaces.

To the east of the station the appearance of the rock changes and it becomes greenish gray and finer grained; though the microscope shows little difference except the presence of more hornblende. An analysis proves that this rock is less acid than the red variety west of Onaping, since it contains only 61.93 per cent. of silica.

At the margin of the eruptive against the basal conglomerate beneath the tuffs, it becomes finer grained, though still green and dioritic-looking; and thin sections show short, stout crystals and

(16) Q. J. Geol. Soc., Vol. liii., pp. 56-59.

little micropegmatite, the quartz, which is present in considerable amount, being mostly granular.

Sections to the Northeast

Two miles north of Onaping at the outlet of Moose creek into Onaping river there is an interesting slope of gray rather coarse-grained nortie, rapidly weathering into boulder-like forms, the loose sandy and gravelly debris sometimes still supporting the round boulders of less decayed rock. Thin sections show the typical nortie of the nickel range, consisting of a small amount of quartz, partly pegmatitic, much labradorite, a little apparent orthoclase, and a large amount of pleochroic augite very like hypersthene, but seemingly monoclinic with various extinction angles. Secondary hornblende and a small amount of biotite and magnetite complete the dark minerals. The plagioclase is largely idiomorphic and is sometimes partly enclosed by the augite, which also tends to idiomorphy, so that the order of succession is plagioclase, augite, quartz and pegmatite, the plagioclase and augite overlapping.

A rock found at the basic edge of the nickel-bearing eruptive a little east of the Big Levack mine on the eastern side of Levack township is very similar, except that the pyroxenes are almost completely changed to dull-green fibrous hornblende, and that biotite is present in larger quantities.

A specimen from about a mile and a half southeast of the last locality nearer the acid than the basic edge is coarse-grained and flesh-red in color, and consists as shown by the microscope mainly of micropegmatite and a little hornblende and biotite.

At the acid edge of the eruptive near the shore of the southwest bay of Moose lake the rock is fine-grained and flesh-colored with greenish patches. The freshest specimen is made up of plagioclase in well formed crystals (oligoclase to andesine) to the extent of one-half, the spaces being filled principally with quartz of a granular look and seldom showing pegmatitic structure. The dark minerals are chlorite filling interstices, and biotite, the latter in very small amounts. Close to this phase of the eruptive are rather coarse rocks also flesh-colored spotted with green, which in the field were collected as the altered edge of the basal conglomerate which underlies the tuffs. Thin sections however show very little difference in composition or character from the rock described above. One of the hand specimens contains a few black fragments of some other rock, and has a patch of coarse red feldspar mixed with quartz, which seems to have been deposited in a cavity of the rock. In the field the vague forms of pebbles and boulders resembling granite can be seen, and it is probable that the ground-mass of the conglomerate has been so long exposed to the heat and circulating solutions of the acid edge of the eruptive as to become completely recrystallized into quartz and feldspar.

In the eruptive itself near the acid edge and also in the metamorphosed conglomerate there are small vugs or enclosures surrounded with very red feldspar and enclosing hornblende and epidote. The space is sometimes completely filled and sometimes partly vacant.

Specimens taken from the basic and acid edges of the eruptive at about its narrowest point, in the northeast corner of Morgan township show little difference to the eye, though the one from the acid edge has a faint tinge of flesh-color which is lacking in the other. Thin sections show considerable differences however. One from the basic edge contains mainly feldspar with micropegmatite radiating from it, augite, hornblende and chlorite, the feldspar being largely plagioclase not far from andesine in optical characters, but with some untwinned crystals, probably of orthoclase, and one peculiar crystal, unstriated but containing irregular patches of plagioclase having low extinction angles from twin planes. Micropegmatite running into areas of unmixed quartz makes about a fourth of the section. The augite, partly very fresh, is nearly colorless and not appreciably pleochroic. The rock has not the usual character of the basic edge, being without hypersthene (or pleochroic pyroxene) or biotite among dark minerals, and containing a good deal more than the usual proportion of micropegmatite and orthoclase. One might almost hold that the true basic edge is absent at this narrow portion of the eruptive, and that the rock just described belongs rather to the intermediate facies between the basic and acid edges.

A thin section from the opposite or southeast side of the band consists mainly of very fine, often plumy, micropegmatite, sometimes arranged round broad crystals of andesine, sometimes about a narrow strip or about no apparent nucleus. This makes up at least two-thirds of the rock, while plagioclase and a crystal or two of orthoclase with hornblende and a small amount of the supposed woehlerite make up the rest.

Near Trout lake in Bowell township and Joe's lake in Wisner, sections across the eruptive are much like those already described and need not be taken up in detail.

Character of the Eruptive

We may sum up the general character of the nickel-bearing eruptive of the northern range by stating that the basic edge is paler in color and contains more silica than in the southern range, the difference being partly due to the absence of dusty-brown coloring in the plagioclases; but that it also consists essentially of plagioclase having the composition of labradorite with hypersthene or an augite very like hypersthene as to pleochroism, hornblende, usually secondary, and a little biotite. Among the pale minerals must be included small amounts of orthoclase and quartz, the latter seldom inclined to be micropegmatitic. This rather acid norite passes gradually into a reddish syenitic-looking rock, really a micropegmatitic granite or grano-diorite often containing a mineral resembling epidote possibly woehlerite, hornblende, and sometimes a little biotite, but seldom any of the pyroxenes. At the southeast edge of the eruptive the rock is usually greenish-gray in color and a little more basic, but otherwise like the central portions. The feldspars are apt to be lath-shaped. Occasionally the edge becomes quite basic and dark-green in color, still containing much micropegmatite but of a very minute and feathery kind; and this variety appears to occur where the acid edge comes in contact with tuffs, with little or no granite conglomerate between.

Where the eruptive band is very narrow there is less change in character in passing from the basic to the acid side, the most basic rock, norite, being largely wanting, as well as gossan or ore deposits.

Results of Rock Analyses

In order to check the results of microscopic work on the rocks forming the nickel-bearing eruptive, four analyses have been made by Mr. E. G. R. Ardagh, one of the chemists of the School of Science, and the results will now be compared with those of Professor Walker from the Whitson lake region on the southern range. Three of the rocks chosen for analysis come from outcrops along the Canadian Pacific railway near Onaping, where the exposures are good and the materials fairly fresh; the fourth is from the acid edge on the north shore of Fairbank lake, where the dark gray-green color led to doubts as to the real character of the rock. Specimen No. 1 is from near the basic edge west of Onaping, No. 2 from the middle of the eruptive, where the rock is flesh-colored, and No. 3 from the greenish-gray acid edge. For comparison Professor Walker's analyses of specimens from near Whitson lake are given in Nos. 5 to 9, No. 5 being from the basic edge and No. 9 from the acid edge, the others being distributed between the two edges in the order given :

—	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.
SiO_2	56.89	68.48	61.93	68.95	49.90	51.52	64.85	69.27	67.76
Al_2O_3	19.39	12.70	13.03	12.74	16.32	19.77	11.44	12.56	14.00
Fe_2O_3	.38	2.41	.56	.46	....	.47	2.94	2,89	....
FeO	7.11	4.50	8.00	5.15	13.54	6.77	6.02	4.51	5.18
MgO	2.11	.74	1.76	1.57	6.22	6.49	1.60	0.91	1.00
CaO	8.11	1.41	4.02	1.72	6.58	8.16	3.49	1.44	4.28
Na_2O	3.31	3.72	3.18	3.80	1.82	2.66	3.92	3.12	5.22
K_2O	1.04	3.36	2.80	3.28	2.25	0.70	3.02	3.05	1.19
H_2O	1.35	1.13	1.95	1.50	.76	1.68	.78	.76	1.01
TiO_2	.43	.61	.84	.43	1.47	1.39	....	.78	.46
P_2O_5	.11	.20	.32	.20	.17	.10	.24	.06	.19
MnO	.30	.05	.18	.13	trace	trace	trace	trace	trace
NiO	....	....	trace	trace	....	....	....	....	....
S	....	....	.19	....	....	....	....	....	....
Total	100.53	99.31	98.76	99.93	99.03	99.71	98.30	99.35	100.29
Specific gravity	2.834	2.673	2.757	2.694	3.026	2.832	2.788	2.724	2.709

It will be seen from a comparison of Prof. Walker's analyses with Mr. Ardagh's that his examples from the basic edge are distinctly more basic than the specimen from Onaping, Nos. 5 and 6 having seven and five per cent. less silica respectively. However, the very large amount of iron oxide (13.54 per cent.) in No. 5 suggests an abnormal quantity of magnetite, so that the specimen may be less acid than the average. The difference in the amount of silica corresponds to the appearance of the two rocks, the one from Blezard mine (No. 5) being much darker in color than the example from Onaping (No. 1). The most acid specimen from

Onaping (No. 2) and also No. 4 from Fairbank lake correspond very well with Dr. Walker's No. 8; but No. 3, on the extreme edge at Onaping is distinctly more basic than his No. 9.

In the Onaping analysis the rock from the basic edge contains, as one would expect, much more lime, magnesia and alumina than the most acid phase, and much less potash and silica.

Working out the percentages of minerals represented by the analyses from Onaping and Fairbank lake by the tables of Cross, Iddings, Pirsson and Washington we have the following results :

Mineral.	No. 1.	No. 2.	No. 3.	No. 4.
Quartz	6.42	27.78	17.16	24.84
Orthoclase	6.12	20.02	16.68	19.46
Albite..	31.96	31.44	27.25	31.96
Anorthite	32.80	6.1[illegible]	12.51	7.51
Hypersthene....	14.38	7.08	15.13	12.61
Diopside	5.33	....	7.28	....

In reality of course the orthoclase would contain some of the albite material and the rest of the albite with the anorthite would be combined as labradorite in No. 1, and as oligoclase in the others. As hypersthene does not occur in the more acid phases of the eruptive, but is replaced by hornblende, biotite, etc., probably some of the alumina, lime and potash with all the magnesia and much of the ferrous oxide really belong to these minerals.

In the new system of classification No. 1 is hessose; No. 2 toscanose; No. 3 is nameless, but comes in Sub-rang 2 of Rang 3 in austrare; while No. 4 is dacose close to adamellose. In reality the classification obscures the relations between No. 2 and No. 4, which, instead of being far apart, are near enough to have been chips from the same rock, so close do they come together in percentages of chemical constituents.

Effects of Eruptive

The basic edge of the eruptive seems to have had little metamorphic action on the adjoining underlying rock, usually Laurentian gneiss with bands of green schist, perhaps because these rocks were already completely crystalline and little pervious to solutions. Where offsets, like that in Foy, project into the Laurentian, there is much brecciation, and a confused mixture of rocks results cemented by fine-grained norite, but otherwise apparently not greatly changed by the presence of the eruptive.

At the acid edge the effect on the overlying rock was much more profound. In most cases this rock is a coarse conglomerate consisting of granite pebbles or boulders enclosed in a granitic or gneissoid ground-mass, so that the eruptive seems to merge into the sedimentary rock, which can only be distinguished from it by the presence of the boulders. Near the edge even these become indistinct. The apophyses of the eruptive are not dike-like but vague and irregular, and we must suppose very slow cooling with the circulation of water strongly charged with silica and silicates in solution. The metamorphosis of the conglomerate gradually diminishes, and at 1,000 or 1,500 feet the tuffs are encountered, somewhat hardened but otherwise little changed.

The acid edge of the eruptive is not nickel-bearing, though iron pyrites may occur in it; and in the adjoining sediments, especially if penetrated by gabbro or greenstone, small vein deposits containing zinc blende and galena occur.

Other Eruptive Rocks

In addition to the nickel-bearing eruptive a number of specimens of other eruptives were collected along the nickel range or within the sediments enclosed by it. Those which have been studied in thin sections are all of a basic character, and most of them occur as dikes, the most important being an olivine diabase found at various points in Capreol and Wisner, cutting the tuffs and slates. It differs little from diabase dikes described in last year's Report, and the same may be said of a mass of diabase found in sandstone about four miles north of Chelmsford.

A dark-green eruptive mass, which occurs associated with cherty gray rocks, containing a few quartzite pebbles at Prue's mine, WD 252, to the southwest of Trout lake, near the acid edge of the nickel-bearing eruptive, may have a bearing on the adjoining deposits of zinc and lead ore. Thin sections consist mainly of pyroxenes, hypersthene being in largest amount, though some crystals having the characteristic pleochroism, show oblique extinction. Part of the dirty, fibrous-looking pyroxene having extinction angles of 45 degrees or more, and little or no pleochroism, should be called diallage. The feldspar, which makes hardly more than a third of the section, is labradorite in rather short, stout prisms, less often laths, embedded in the pyroxene, and reversing the usual arrangement has clear centres with brown, almost opaque rims. There is a very little interstitial quartz. This norite is much more basic than the nickel-bearing norite two miles away to the north, and differs from it greatly in habit, so that there is probably no connection between them.

Another dark green-gray, fine-grained rock was collected near a nickel deposit four or five miles north of Onaping, where it seems to have penetrated between the nickel-bearing norite and the Laurentian. This, however, has an entirely different character, consisting essentially of serpentine and magnetite, enclosing areas of still fresh olivine. A little augite and some crystals of brown biotite are scattered through the section also, but in too small amounts to be of importance in naming the rock, which must be called peridotite, largely changed to serpentine.

A somewhat similar rock collected from dikes in granite at Michipicoton falls near lake Superior may be mentioned here. It originally consisted of about equal amounts of olivine and biotite, the olivine now almost altogether changed to serpentine and a carbonate. Augite may also have been present in the beginning, but can now hardly be distinguished. The rock, which may be called picrite, or perhaps better, biotite-peridotite, may be compared with dike rocks from near Magpie river in the same region, and from Goetz lake, not far away, consisting of serpentine with some fresh olivine, biotite and augite (17).

Drillings in Blezard

Having found strong magnetic attraction on lot 8 in the second concession of Blezard township, Mr. J. V. Miller, in charge of explorations for Mr. Thos. A. Edison, decided to do some development work at the spot, which is about a mile and a half north of the Little Stobie mine on the basic edge of the southern nickel range. At the time of my visit a pit sunk about ten feet in the norite showed some ore, consisting of pyrrhotite, chalcopyrite and pyrite. The country rock is dark and basic-looking in spite of the distance in from the edge. Later a diamond drill hole was sunk 1,030 feet, and Mr. Miller has been good enough to provide me with cores at every fifty feet. In general the sections of core are much alike, except at 264 feet, where brownish schist with pyrite and many scales of mica, and also vein quartz, were encountered, and at 900 to 950 feet, where fine-grained flesh-colored granite, no doubt a dike, occurs.

Thin sections were made of drill cores from 50 feet, 550 feet, 850 feet and 1,000 feet. The four sections are all of quartz-norite with a little quartz, a large amount of plagioclase (andesine to labradorite) and a large amount of dark minerals. The quartz is partly interstitial and partly intergrown with feldspar as micropegmatite. In the section from 50 feet depth the feldspars are somewhat brownish, but on the whole very fresh, while all the pyroxene has been changed to rather fibrous hornblende. The section from 550 feet is fresher still, and contains much hypersthene (also pleochroic monoclinic pyroxene), a little diallage, hornblende and biotite. The sections from 850 and 1,000 feet are badly weathered, perhaps because somewhat crushed, and the lowest one is the worst in this respect.

It is evident that the word weathering as generally applied to these rocks is not to be taken in a literal sense as due to the action of surface conditions. Probably the different stages of so-called weathering shown in the cores are to be accounted for by the greater circulation of underground water in parts which have been sheared or crushed.

Micro-Norite Groups

A curious group of very fine-grained, almost compact rocks, dark greenish-gray on fresh surfaces, but weathering paler gray, with prominent bands of green, was briefly referred to in last year's Report (18), as having a doubtful position with reference to the nickel-bearing eruptive. When opportunity offered last summer these rocks were ex- specimens were collected. Their field re- amined in the field and characteristic lationships are still obscure, though it was found that the largest area occurs close along the basic edge of the nickel-bearing eruptive from Blezard mine to Murray mine. The rock is not continuous for this distance, but is greatly mingled with other rocks, such as hornblende porphyrite, amygdaloidal masses, and green schists. So far as could be determined these fine-grained norites or gabbros are older than the nickel norite which encloses fragments of them, in places almost forming a breccia. Besides the large area just mentioned similar rocks occur near Joe's lake on the northern range, and possibly also near Sultana mine at the southwest end of the range ; but here there has been no attempt to determine their extent. The Murray mine area is extensive, covering probably some square miles, but the fine-grained norite is so intimately

(17) Bur. Mines, 1902, p. 179.

(18) Bur. Mines, 1903, pp. 294-5.

mixed with the other rocks mentioned that no attempt was made to separate it in mapping. So far as observed the micro-norites are not in themselves ore-bearing, though at the edge of the nickel eruptive they may be more or less penetrated by the sulphides.

The appearance of these rocks in thin sections is very different from that of the typical coarse-grained nickel-bearing norite, though the general composition of plagioclase running from labradorite to andesine, and hypersthene, with one or two other forms of pyroxene, is the same. The quartz, often pegmatitic, of the nickel-bearing norite seems almost wholly absent in the fine-grained variety, and biotite is much less common. The tendency to a plate-like shape of the feldspars too is not observed.

In the micro-norites the feldspars are usually in less amount than the dark minerals, and often form polygranular areas, made up of separate, often fairly well-formed, crystals of about equal diameters in different directions. The feldspar (usually labradorite) is very fresh as a rule, though the individual crystals are crowded together and sometimes suggest crushing. Some of the crystals seem unstriated, but crystals with twin halves are common, as well as sections with more complex twinning. In some weathered specimens there is a greenish rim between adjacent crystals.

The pyroxene, which is later in ago than the feldspar, usually makes up more than half the rock as granules of nearly equal diameters, either scattered or assembled in small clusters. In some sections there are also larger crystals of pyroxene of a porphyritic kind. The general word pyroxene is used because there are undoubtedly monoclinic as well as rhombic varieties present. The color is usually pale gray with a faint pleochroism, pale reddish-brown, yellowish-brown and bluish-gray, though there are sections in which the pleochroism is almost entirely wanting. As a considerable number of the crystals show parallel or approximately parallel extinction, we may call them hypersthene, or enstatite where pleochroism is lacking ; but many of the crystals in all thin sections examined have an undoubted extinction angle, ranging from a few degrees to forty-five, and hence cannot be called rhombic pyroxene, but should be named diallage when fibrous-looking, or augite in other cases. The two varieties of pyroxene are exactly alike in every respect except the extinction angle, and one cannot resist the impression of a continuous series connecting forms with no apparent angle of extinction with forms which must be rotated 45 degrees from the cleavage or prismatic edges to become extinct. In one or two sections there are a few crystals much larger than the rest enclosing feldspars poikilitically.

With the colorless minerals, quartz is sometimes sparsely found, and among the colored ones, a very little biotite, and in one case ragged, poikilitic hornblende of a brown color. Magnetite in small square crystals with no hint of leucoxene is always found, and may form as much as a sixth of the whole section, while sulphides are less common and more irregular in arrangement. Where dark-green ribs stand out on weathered surfaces thin sections show bands of green secondary hornblende along minute fissures permitting water to circulate.

The very fine-grained, uniform textured micro-norites seem to shade into porphyritic rocks in places, sometimes with black hornblende crystals alone, sometimes with white areas as well. In general composition the ground-mass is like the rock just described, while the large hornblende patches are seen to be more or less composite areas of a poikilitic kind, often associated with some quartz and plagioclase of larger dimensions than the surrounding feldspars. In some of the porphyritic specimens the pyroxene has largely changed to hornblende, and it may be that the hornblende and dioritic schists and the hornblende porphyrites mixed with the micro-norite are simply sheared and weathered forms of the rock.

It is less probable that the amygdaloid rocks found with the others have any connection with the norite, as no transitions toward them have been noticed; but the oval white areas which give the amygdaloidal effect consist mainly of short equi-dimensioned plagioclases very like those of the micro-norites though of a larger size. There are also some quartz grains with the plagioclase. The ground in which the seeming amygdules are enclosed consists to the extent of four-fifths of green, secondary looking hornblende with some magnetite, epidote and a few grains of plagioclase.

Hutton Township Iron Range

As a large number of iron locations had been taken up in Hutton township and the next (unnamed) township to the west (19),during the past two years, it seemed desirable to study these iron ranges more in detail than had been done previously by representatives of the Bureau of Mines; and some time was occupied in mapping the range and examining the associated rocks, part of the work being done by Mr. Culbert after I left the field. The Hutton iron deposits have been known for several years, but until 1902 the region had not been studied by geologists. During the past two summers, however, Professor Leith of Wisconisn university has had parties at work mapping the iron ranges for economic purposes in the interest of certain iron companies. In a brief account of the Hutton township deposits given by him in last year's Report, he compares them with those of the Vermilion iron district in Minnesota. (20), and discusses their probable origin.

At present the Hutton township range is best reached from Sudbury by a continuation of the wagon road leading to Dawson on Vermilion river. The road for some miles to the north of Dawson is excessively rough and hilly while crossing the tuffs, and the nickel-bearing eruptive; but afterwards follows gravel plains and morainic ridges with few outcrops of solid rock, what there is being coarse reddish granitoid gneiss of the Laurentian, until it ends at Osborn's camp, near the foot of Moose mountain, where there are several comfortable log buildings, one occupied by a caretaker. Further travel over the ranges must be done by trail and by canoe.

Canadian Pacific railway engineers last summer located a branch line to connect Moose mountain with Sudbury, finding, it is said, a very easy route without heavy grades or much rock cutting; but it may be supposed that the branch will not be built until there is a prospect of mining operations on a large scale. The projected road might prove of considerable value for some porperties on the northern nickel range as well as for the iron properties.

Moose Mountain

Owing to the widespread presence of iron ore field work in the Moose mountain region usually had to be done with the dial compass, and had always to be checked with the dial; so that on cloudy days, which were numerous last summer, work was possible only along survey lines or by running pickets from survey lines. Sections were traversed across Moose mountain at short intervals as far as ore was found, or the dip-needle or compass indicated magnetite beneath the drift or swamp, but the geology of the adjoining rocks was taken up only incidentally.

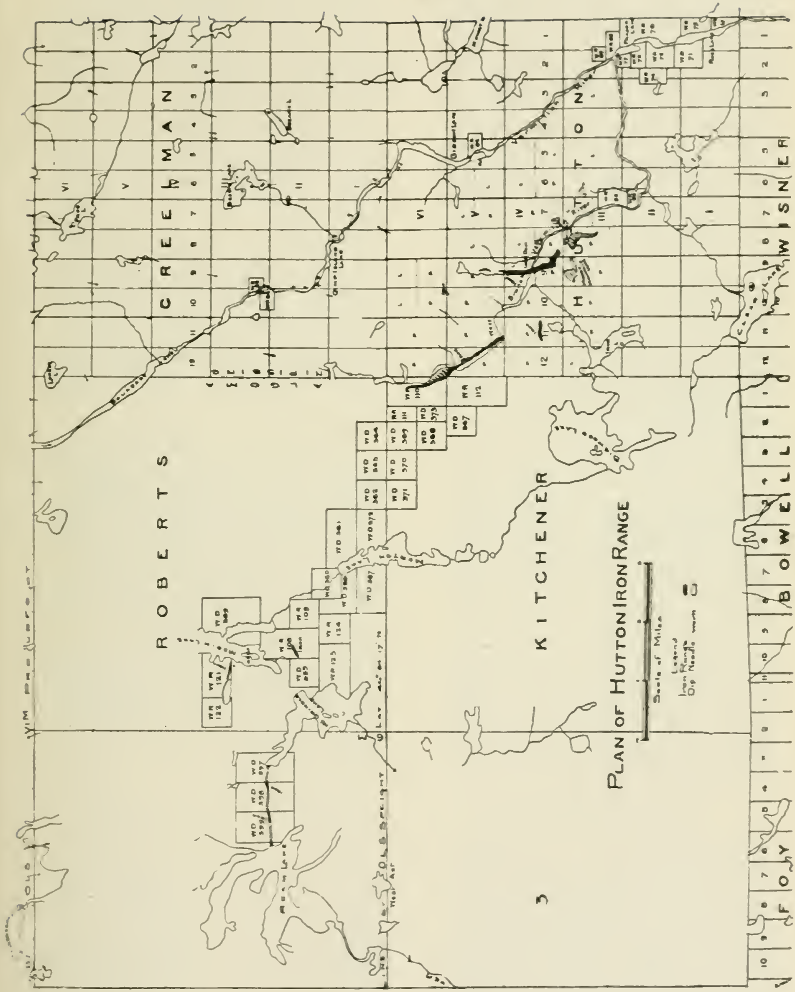
The largest outcrops of ore are on the main hill not far from the points where diamond drilling was done, so that this portion of the range is naturally taken up first. A large amount of stripping has been done exposing sections across the ore, usually of glacially polished surfaces often suggesting solid iron; but sometimes strikingly banded with gray or white layers of silica. Occasionally the banding is of magnetite and dark-green hornblende instead of silica, and the distinction is quickly made by hammering on the surface, silicious parts showing a white powder, the hornblende parts dark-gray or greenish-gray. In the purer parts the ore is highly magnetic, fragments being fairly strong natural magnets, and the soft steel of a hammer acquires a quite powerful induced magnetism, attracting broken fragments of the ore in a long string. These are of course dropped as the hammer is removed from the surface of the ore.

The banding of ore with hornblende or with silica is often greatly bent and contorted and no very constant direction of strike can be noted, though in a general way the strike of the banding tends to be parallel to the strike of the range as a whole. at the southern end running roughly northwest and southeast, but toward the north trending nearly north and south.

Intimately mixed with the ore in some places one finds irregular bands or masses of pale-green epidote, apparently filling cavities due to shearing or slight faulting.

On Moose mountain the ore is more or less mixed with other rocks such as greenstone and granite, and the former rock forms the walls of the iron formation on each side dipping under it on the brow of the hill towards camp. Besides the ore exposed on the hill there are points of strong local attraction with one or two outcrops of ore in the swampy ground to the southwest, apparently completely separated from the main body by greenstone or green schist. Still further to the south and west there is granite. generally considered Laurentian, but certainly later than the

(19) Since named Kitchener township.
(20) Bur. Mines, 1903, pp. 318-321.


PLAN OF HUTTON IRON RANGE
Scale of Miles
Legend
Iron Range
Dip Needle
ROBERTS
KITCHENER
CREELMAN
HUTTON
WISNER
BOWELL
FOY

banded ore, since small dikes of it penetrate the ore occasionally.

After a short valley where the range narrows up or is drift-covered, another hill rises toward the northwest continuing to the river (a branch of the Vermilion) at the Iron Dam. In this extension the ore is generally leaner and more silicious than on Moose mountain, though here also there are outcrops of magnetite banded with hornblende, apparently rich enough to be workable. The associated rock is largely green schist, though some parts appear massive, but the whole is greatly sheared and so far rearranged that the original character of the eruptive is hard to determine beyond the general fact that it was basic.

Near the Iron dam where the hill sinks toward the river a section shows green stone and green schist to the west, near a small lake expansion above the dam, followed by banded magnetite and silica, then green schist, once more banded silica, and then green schist and greenstone to the low ground near the river.

North of the Iron dam the band continues for half a mile in a direction nearly north and south but narrower and in general leaner, the adjoining rocks being usually green schist. The whole range is a little over a mile in length, but much the most important body of ore is exposed on Moose mountain, where it is stated that an area of 75 yards by 50 consists of good are which will run 58 to 60 per cent. in iron.

There are two patches of iron range rock to the south of the camp, largely hidden under drift deposits, but found with the dip-needle. Test pits disclose large blocks of the banded ore, and at some points ore is said to have been found in place, but it is doubtful if they will prove of importance.

Extension of the Range

About a mile and a half up the river from the Iron Dam a second iron range of some magnitude is found, beginning at about the middle of lot 11 in the fifth concession, and extending to the northwest corner of lot 12 in the same concession. A trail leads from an old camp ground generally called Black's camp on a point where the river suddenly turns northwest and runs the whole length of the range, which is parallel to the river, but a little to the northeast. The banded material can be followed with a few interruptions by drift, where the dip-needle indicates the presence of ore, for the whole distance, but in most places it is narrower than the southern range, and especially than the portion on Moose mountain.

Near Black's camp the range seems to have been faulted several times, causing slight interruptions in the continuity of the ore, and there are also minor faults of a few inches or feet. The strippings disclose ore very similar to that of Moose mountain but in narrower bands. The best is of magnetite banded with thin seams of green hornblende, and sometimes has a width of several feet; but much of the range, especially towards the northwest, is silicious and too low-grade to be of much value.

The adjoining rock toward the east is generally green schist having a strike parallel to the banded ore, but toward the west swampy ground along the river often hides the rock, though some outcrops of greenstone occur. The banded ore is not always continuous in width, but may form two bands separated by schist or greenstone. This iron range is cut off by the river, only a trace of it occurring on the south side of the bend.

A small outcrop of banded magnetite was found by us near the northeast corner of lot 10 in the fifth concession, having a width of at least 25 feet and striking a little north of west. Part of it is banded with hornblende, but most of it is silicious and very lean. A longer and apparently more important band runs for a third of a mile east and west at about the middle of lot 11 in the fourth concession.

Specimens of the ore from three points in the Hutton ranges, No. 1 from Moose mountain, No. 2 from the Iron Dam, and No. 3 from the northwest range, have been analyzed at the Provincial Assay Office, Belleville, with the following results:

Constituent.	No. 1.	No. 2.	No. 3.
Ferric oxide	58.30	52.55	43.16
Ferrous oxide	28.08	28.76	20.41
Silica	7.92	12.84	31.76
Alumina	1.22	1.49	.78
Lime	1.28	1.18	1.40
Magnesia	2.35	2.75	1.75
Sulphur	.056	.08	.06
Phosphorus	.011	.016	.094
Manganese	.20	.18	.22
Titanium	none	none	none
Total iron	62.64	59.12	46.08

The first two were of magnetite banded with hornblende, the third of magnetite banded with silica, evidently forming a very lean ore.

A number of locations have been taken up along the supposed continuation of the northwestern range of Hutton in two unsurveyed townships to the west and northwest, since named Kitchener and Roberts, but as these were located when snow was on the ground it is doubtful if any ore was found, and there is no information as to the use of a dip-needle in locating them. Several of these claims have been only incompletely surveyed, the lines not having been cut out on some of the sides. As far as possible our work covered all the boundary lines up to the long lake crossing the line between Kitchener and Roberts, but no iron range rock was observed, though banded schist much like that accompanying the ore in Hutton township was found in several places.

To the northwest of the lake just mentioned bands of the iron range rock are found in Roberts and the next (unnamed) township to the west, but these will be reported on by Mr. Culbert, who examined them after I left the field.

Geology of the Region

While mapping the iron ranges and examining the locations to the northwest a considerable amount of information was gained concerning the other rocks of the region, which were found to be much more complex in arrangement than was expected. On the old maps of the region Hutton township along the west branch of the Vermilion river and the townships west of it are colored as Laurentian; but our work shows Huronian rocks, often broken by eruptive granite, it is true, over most of it, and a very irregular contact between the Huronian and Laurentian. In general all the green schists and eruptives as well as the undoubtedly sedimentary rocks are here classed as Huronian, and all the granites and gneiss without regard to age or relationships to the previous rocks are called Laurentian. A final classification of the rocks as to age and origin must be reserved for a much more detailed study of the region than we could bestow on it.

The large areas of stratified sand and gravel in the valleys and the widespread muskegs in many places hide the bed rock completely, even for whole square miles, and add to the difficulty of mapping.

To the south of Taylor's (or Osborn's), camp near the foot of Moose mountain wide gravel plains extend along the west branch of Vermilion river, hiding the rock almost completely except for a small outcrop of greenstone about a third of a mile southeast near the road; and it is two miles before rock shows again, this time coarse porphyritic granitoid gneiss which may be assigned to the Laurentian.

Eastwards of the Moose mountain iron range as far as Vermilion river the rock where exposed is all Huronian except a dike or two of granite near the river, but the Huronian shows considerable variety, green schist extending for half a mile east of the west branch of the Vermilion, followed by a little quartzite and then graywacke (or slate) conglomerate, the latter extending for more than half a mile. The conglomerate has a fine-grained gray or green ground-mass enclosing pebbles of granite and sometimes other rocks, often sparsely scattered but sometimes crowded. East of the corner post between lots 5 and 4 the conglomerate contains large boulders of granite for a short distance, and is then succeeded by coarse white or reddish quartzite to a small lake not far from Vermilion river, where dikes of granite occur. Beyond this toward the east, greenstone and gravel flats extend to the river, the latter taken up in part as placer locations some years ago.

To the north the graywacke conglomerate is found associated with white arkose on hills near the Vermilion, and with green schist on its shore; while to the northeast of the iron range near Black's camp greenstone and slaty rocks occur.

The locations partially surveyed in Kitchener and Roberts northwest of Hutton where not covered with gravel plains consist of Huronian rocks of various kinds bordering on granite or penetrated by dikes of that rock. West of the post of Niven's line between the fourth and fifth concessions green schist occurs, banded or uniform gray-green, and with a strike of from 130 degrees to 160 degrees; while granite shows just to the southwest.

To the north are found mainly banded green schists for some distance, resembling those which accompany the banded iron range rock, though the latter was not found; and still farther north near Speight's east and west line graywacke conglomerate containing granite and other pebbles is widespread with some quartzite at points. Some bosses or dikes of coarse red granite penetrate the green schists toward the southwest, probably coming from the area of granitoid gneiss in that direction.

Except for the small group of rugged hills at Moose mountain the region has only a gentle relief as compared with the northern nickel range, and but for the drift sheet and the frequent muskegs would be easily mapped. Niven's north and south base line and Speight's east and west line are excellently cut out, and serve as good bases from which to run lines for survey purposes.

Relationships of the Ranges

In general character, the Hutton township iron ranges suggest those of various other parts of northern and western Ontario, the banding of silica and magnetite resembling the arrangement found in part of the iron-bearing rocks near Batchewana bay and of the Michipicoton region, and also part of those to the west of Fort William and near Dryden; but the entire absence of jasper is unusual, and the richness of much of the banded rock as iron ore is very unlike that of other regions, where the only workable deposits are entirely secondary and show no banding. In Hutton township all the ore is more or less banded, though in the best of it the intervening layers consist of hornblende and not of silica, and there are gradations between the bands of the two minerals. Professor Leith suggests that the banding represents some original structure, but that secondary enrichment has taken place without entirely destroying the structure. He thinks that the enclosing greenstones form a "pitching trough," as in the lake Superior iron regions, and in this way the concentration has been made possible. In this view he is probably correct, though the evidence as to a pitching trough at Moose mountain seems somewhat indefinite; and at the Iron dam just to the north and in the northern range near Black's camp, narrow bands of rich and heavy ore, banded with green hornblende, alternate with bands of lean ore banded with silica. If these also are formed in pitching troughs, it is not easy to see why the whole width should not have been enriched, instead of certain bands only.

The arrangement of the greenstone and green schist running parallel to the banded ore on each side certainly suggests that the iron range is nipped in as synclines, and the presence of intrusive patches and masses of greenstone or diorite in some places mixed with the ore may indicate a partitioning off of separate troughs, though no distinct dike has been observed to cut across the syncline, as in some of the western iron ranges.

If the large ore body on Moose mountain and the smaller but still probably important ones to the north are the result of local enrichment of the original banded material, whatever that was in the beginning, the process cannot have proceeded in the radical and complete way found at Helen mine or some of the Minnesota deposits, where all trace of the original structure has usually disappeared, and a somewhat porous and often concretionary mass of hematite or limonite presents fairly well defined borders against the lean banded rock alongside.

It is not impossible that the original deposit, however made, was richer than usual, rich enough to form an ore with little or no addition of iron from materials leached out of other portions of the range. The very compact nonporous character of the ore seems to leave little chance for percolation; though it is of course possible that an originally porous banded rock has had all its interstices plugged by the deposit of magnetite or hornblende.

A point of marked difference between the Hutton iron range and many others in Ontario is the very small quantities of pyrite or other sulphides associated with the ore. At the Helen mine there are great quantities of pyrites, and probably a considerable proportion of the ore has resulted from its oxidation; and at various other points banded magnetite and silica have parallel bands of sulphides. Siderite, which occurs in several of our iron ranges, appears to be absent also.

The age of the Hutton iron ranges is not easy to fix with certainty. The parallel green schists, the nearly vertical attitude of the range rock, and the fact that granite and granitoid rocks like the Laurentian have pushed up later, suggest a lower Huronian or Keewatin age for them; but not far off on either side of the ranges and associated with similar banded green schists are undoubted graywacke conglomerates, quartzites and arkoses that can hardly be other than upper Huronian, the equivalent of the so called "typical Huronian" north of lake Huron. So far no pebbles of iron range rock have been found in the conglomerates to determine the matter of age, and until some such decisive evidence is obtained the matter cannot be finally settled.

Similar but much leaner banded silica and magnetite occurs as small patches southeast of Clear lake in Wisner township, completely enclosed in granitoid gneisses always referred to as Laurentian; and these have been placed in the lower Huronian in a former report of the Bureau of Mines (21).

The band of Huronian containing the Hutton iron range is completely separ-

(21) Bur. Mines, 1901, p. 186.

ated from the nickel range to the south by about eight miles of Laurentian; but toward the east Dr. Bell's map connects it with the Huronian area around lake Wahnapitae, where a strip of somewhat jaspery iron range is found, with graywacke conglomerate, etc., of the Huronian. An examination of this stretch of intervening rock may some day solve the problem presented above, and help to determine the age of the nickel-bearing eruptive also.

Michipicoton Mining Division

Since the report on the Michipicoton Iron Region was published (22) much work has been done at the Helen mine, so that a clearer idea of the relationships of the ore body can be formed than at the time the field work was done.

Boyer lake, which filled a curious rock basin before mining operations began and overflowed into Sayers lake, was pumped almost dry last summer, and good opportunities were afforded for studying the basin and parts of the ore body which formerly were under water. The basin is of quite an extraordinary kind as seen from the bottom. Though only a quarter of a mile long its depth is 133 feet, and along its northern shore below the former water level, the rock walls are often vertical or even overhanging. On the south side the slope is more gentle but still reaches 30 degrees. This side has been strongly acted on by glacial ice, rounding and smoothing the rock surfaces and forming striae which run from south to 40 degrees east of south near the bottom of the basin at its southwest end.

Toward the east end the basin is walled with brown, red and yellow slopes of dried mud and yellow ochre, giving with the open cut of the mine beyond a lurid display of color.

The real basin is still deeper toward the east end beneath the ore body, which has been opened up by diamond drill to the depth of 275 feet, but whether the basin was ever actually open to this depth is uncertain. If it was, the ore has been deposited since, filling the eastern end of the basin and rising 95 feet above the old water level: but part of the ore may have been formed by slow replacement of the iron range rock originally filling this part of the basin.

Since the geology of the region about the mine was mapped, a dike of diabase about 30 feet wide, now greatly weathered, has been found by Professor Willmott to run northeast and southwest across the ore basin near the east end of Boyer lake. Most of the ore is to the southeast of the dike, which has suffered great destruction in the lake basin and no longer rises above the ore, but there is good ore to the west of the dike also, showing that on the whole its effect has not been great in determining the position of the ore body, which would probably have been formed in the basin if there had been no dike.

Mud occupied the floor of the basin to the depth of 40 to 60 feet against the ore, and a band of yellow ochre follows the dike across the pit. There is a large pocket of granular pyrite in the lake bottom to the west of the dike beyond a mass of good ore, and the two materials are said to meet sharply with no gradations. The thickness of pyrites shown by drilling is 123 feet, and it is intended to mine the pyrites for use at the sulphite pulp mill. It is said that there are about 120,000 tons of pyrites in the deposit.

There are now good opportunities to study the ore body in the large open pits and the lake bottom. A second level has been opened up at a depth of 168 feet below the old railway track, which was three feet above the original level of Boyer lake; and diamond drilling below that has disclosed 107 feet of ore of the same character. Including the hill of ore which rose nearly 100 feet above Boyer lake when mining began, there was a total thickness of 370 feet of ore in the thickest part, so far as known. The ore body proves to be 40 feet wider at the second level than in the pit, this widening taking place in 80 feet of sinking, and being due to the fact that the contact of ore and country rock on the south side dips somewhat southerly.

The ore to be seen in the open pit does not differ greatly from that produced in earlier stages of mining, consisting largely of limonite in thin, flat solid layers with porous concretionary layers between. The leaner parts toward the north of the ore body include breccia-like fragments of yellow to white granular silica having small cavities lined with minute quartz crystals,

(22) Bur. Mines, 1902, pp. 152-185.

showing that silica was dissolved and re-deposited after the shattering of the banded silica, which remains unchanged a little way to the north. In places it appears that the silica is being replaced by limonite which also fills cavities in the silica.

Large parts of the ore run above 60 per cent. of iron, but at the time of my visit mining operations were being managed so as to keep an average of 59 to 60 per cent. when dry, or about 55 per cent. wet. The amount mined per day at that time (July) was 1,400 tons, and it was stated that 800,000 or 900,000 tons had been mined in all. The mine seemed in a better condition to produce ore than when I had been familiar with it two years before, and no signs of exhaustion were visible. The ore was being shipped mainly to Hamilton and Cleveland, and it was said that its physical properties make it desirable for mixture with the Mesabi ores and hence secure it a market in the United States in spite of the duty.

A brief visit was made to the Wawa gold mining district, but as these mines will be reported on by the Inspector it will be unnecessary to speak of them in detail. At the Grace mine operations were progressing satisfactorily, and the monthly brick of $5,000 was just being sent out. As the fuel for the Grace mine requires the clearing of about 100 acres per month of the small timber of the region some other means of supplying power will ultimately be necessary. Fortunately, the splendid falls of the Michipicoton river, only a few miles away, will be available for power for the whole region if future developments make it necessary. The falls are over granite with some blebs of quartz, like certain granites near Magpie river; but narrow dikes of a dark eruptive penetrate it, and some masses of quartzite or arkose are enclosed in it.

In a general way the mines are situated in green schist or sheared greenstones not far from outcrops of granite or gneiss: and one mine, the Manxman, was simply quarrying a hillside of greenish gneissoid rock as ore.

The Iron Belt West of Hutton

By M. T. Culbert

The time at the disposal of Dr. Coleman being limited, he was unable to cover much of the ground along the iron-bearing belt west of Hutton township, and it fell to my lot to make an examination of as much territory as possible after his departure.

I left Sudbury, with one man and a few weeks' provisions, on 10th August 1903 and took to the canoe on Geneva lake, proceeding thence to Bannerman lake and along the Onaping creek to lower Onaping lake on which a long paddle brought us to the east end of the eastern arm. From this two short portages and Four-Mile lake lead to the Wahnapitae waters. This river is here expanded into a broad channel called Long lake, which lies between ridges of granite in a straight line for many miles, forming one of the most picturesque landscapes in the region. Leaving Long lake, two short portages and a pond intervene before Little Wahnapitae lake is reached, this lake being the head waters of the river Wahnapitae, which after making a big loop to the north turns south to lake Wahnapitae. Within this loop the Vermilion river and some of its tributaries take their rise, showing a peculiarity of contour on the great Laurentian plateau. Again, two portages and a pond lead from Little Wahnapitae lake to Roam lake where we pitched camp and commenced operations.

Geneva and Roam Lakes

The route from Geneva lake to Roam lake passes through country which is characterized by alternating hilly parts and gravel plains, the former predominating. No great elevations occur, the hills being mostly small and never exceeding a few hundred feet. Dr. Bell has mapped an area of the Huronian series in the vicinity of Geneva lake consisting of conglomerates, quartzites, slates and limestones. An interruption of granite occurs on the Onaping creek between this area and another area of the same series on the Lower Onaping lake. At the narrows of this lake a short distance south of the crossing of Speight's line a good outcrop of conglomerate occurs, showing pebbles of granite, greenstone, quartzite and jasper, the last named being scarce. Contacts with the granite are present near the dam at the head of the Onaping river and the granite appears to be later in age. The conglomerates are distinctly banded, showing the stratification planes, and alternating with finer grained grits which show cross-bedding plainly. Above Speight's line granite again appears and continues along the route till Roam lake is reached. Dikes of greenstone are frequent, also altered diabase and diabase porphyrites which have a mottled appearance due to aggregates of the feldspar. In many places the granite passes into gneiss with sheared bands of schist running irregularly in curves and patches, following no definite direction.

Roam lake lies in the unsurveyed blolk or timber berth between Proudfoot's base line on the north and Speight's base line on the south, and between the six-mile and the twelve-mile posts of each. These posts number from the corners, northwest and southwest, of the township of Creelman which is north of Hutton township. Roam lake is a little over six miles in length running north and south, and having many bays and arms. It is crossed by Proudfoot's base line, and extends north of it a mile or so. Granite outcrops on this north extension of the lake, but near the base line green hornblende schists appear of considerable width, followed on the south by Upper Huronian sediments, including schistoze quartzite, conglomerates and slates. Further east limestones appear in the series and more silicious rocks approaching quartzite. The schistosity of the quartzite is due to scales of muscovite arranged along definite planes, and considerable chlorite is found in thin sections. The conglomerates have a dark silicious matrix, and show pebbles of granite, greenstone and quartzite, and small jasper grains are detectable under the microscope. This conglomerate is found on Speight's line east of Morton lake, and there has a strike northwest and southeast. Interbanded with it are reddish quartzites and silicious slates with good cleavage. The pebbles are almost absent in many places, apparently grading into the quartzitic phases, the whole series being conformable. This series of rocks has a schistose or slaty structure and tne conglomerates greatly resemb'e the slate conglomerates of the north shore of lake Huron and are in all probability the same. Going east and west, on the base line from the northwest corner of Hutton. the outcrop is over two miles in length and the noted strikes vary from 290 degrees to 310 degrees, apparently dipping northeast. They seem to be more highly altered by metamorphism on Roam lake and westward where near the granite,which is of later origin. The eruption of the latter seems to have been accompanied by great dynamic activity, and faulting and folding has taken place on an immense scale, rendering detailed mapping of rocks very tedious and difficult.

The green hornblende schists which are so intimately associated with the iron deposits appear at both ends of Roam lake. A band crossing the north part of the lake runs southeastward to Morin lake and was not followed far to the west. The only iron so far discovered in this band is that on the Savage property on Morin lake. Another band crossing the southern part of the lake is narrow with few outcrops, but magnetic attractions determine the longest band of iron in the region stretching across the timber berth.

Crossing Speight's line about a quarter of a mile east of the eight-mile post, another band of schist runs southwest into the unsurveyed berth south of the base line. This was followed for a few miles, but no signs of magnetic deposits could be found with the exception of an olivine diabase dike giving slight attractions. If this band is continuous or connected with that one crossing Roam lake, the connection is covered with gravel deposits and does not outcrop. Towards the edges of these schist bands the granites are found apophysing into them in irregular stringers and dikes. Passing onward banded gneiss is found, the hornblende schist being sheared out into bands; and finally massive granite is reached, showing no basic inclusions whatever. The granite extends south to the nickel ranges with bands of schist and small scraps of iron range, samples of ore having been brought in by prospectors from various parts of the intervening country as far south as Foy township.

McCrindle Lake

Running from the northwest bay of McCrindle lake almost due west across Roam lake and two miles north of Speight's base line there is a band of iron range. It outcrops only in a few places, where it is very silicious and lean, but the parts of the band giving the strongest magnetic attractions are covered with gravel. The iron is flanked by green schist which in turn is flanked by granite, the total width of schist and iron on the outcrops being very narrow, only a few hundred yards. The drift-covered areas give strong magnetic attractions in places three hundred yards in width, and such local attractions of the needle give the only conception of what may be beneath.

Crossing Roam lake the needle dips in the canoe and after a short interruption near the west shore of the lake, where a band or dike of greenstone eruptive intervenes, the attraction is again found on the west shore. Passing towards Sandfly lake the iron range bends about ten or fifteen degrees to the south. As my provisions were limited I was unable to follow the band further in this direction, but iron properties have been taken up farther west as far as the longitude of the lower arm of the Onaping, north of Speight's nineteen-mile post.

Coming home along this route I noted the presence of green schists on the small lake, half a mile north of the base line, which drains into the Onaping river and is known on the map as the lower arm of the same.

Morin Lake

There are two small outcrops of iron near Morin lake which lies near the west boundary of the berth west of Creelman township. One of these on the shores of the lake on WR 121 runs for about a quarter of a mile, and at its widest outcrop is sixty paces in width. Much silica is present, alternating as usual with bands of magnetite, and the whole looking rather lean. The trend of the iron range is about twelve degrees north of west, the dip being almost vertical. The attractions cease to be strong within a short distance of Morin lake, being found first about one hundred yards inland and continuing till Lost End lake is reached, a small pond on the southwest of the lot. The iron ore outcrops for the greater part of its length, but presents no elevation above the surrounding green schists. Large masses of greenstone eruptives are found in the vicinity, and between this property and mining location WR 108, where another outcrop of iron is found, greenstone with some green schist occurs. The outcrop on W R 108 shows a short mass of banded iron ore and silica lying very flat and dipping to the northwest. The total thickness is from twelve to fifteen feet, but lying flat, as it does, it makes a better showing. On the line between this property and WD 359, adjoining to the west, the outcrop occurs 590 paces south from the northeast corner post of the latter property. It runs over the line only a short distance to the west, and from this point on the line it takes a direction northeast for 400 paces along a trail leading to the southeast bay of Morin lake. This showing is the least favorable of any examined as far as grade of material and area of outcrop are concerned.

A trip was made into Hutton to lot 2 in the fourth concession. Running east and west nearly across the lot extends a band of iron range with some good outcrops. This lies a short distance north of Yerkes lake and in the southern half of the lot. The iron ore, banded as usual with silica, much resembles the bands on lot 9 in the fourth and lot 11 in the fifth concession of the same township, and with the exception of the Moose mountain outcrops compares favorably with anything in the region. Green schists are associated, and granite is found a short distance south and to the west.

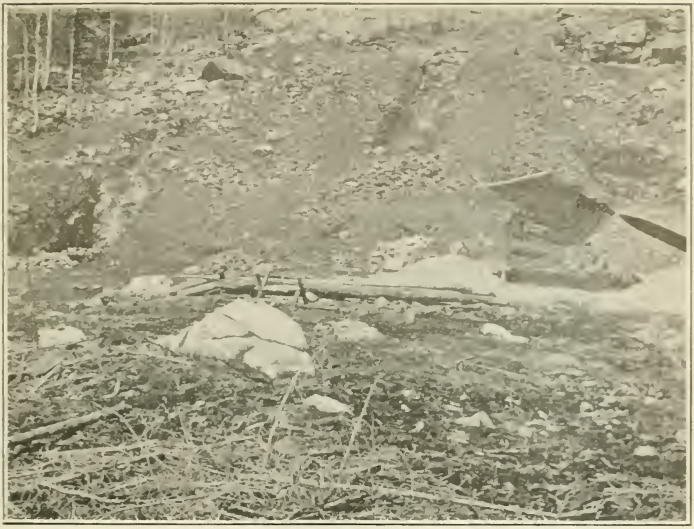
Iron Ranges in Rathbun

During the latter part of September I had occasion to visit lake Wahnapitae, and went in to see an outcrop of iron ore discovered by Henry Ranger on the boundary of the Indian reserve, and lot 24 in the sixth concession of Rathbun township. It occurs up the boundary from the lake about half a mile or more, rising in a hill from the plain to the south and about 300 yards from Post creek. This outcrop is very poor and lean, but presents some differences in association from the iron bands in Hutton and westward. The material itself is identical, being banded magnetite and silica in thin layers, but here the green hornblende schists are lacking, and in their place occur chlorite schists. On one side of the iron range occurs an eruptive much altered, but phenocrysts of plagioclase are still detectable under the microscope. The matrix is very fine-grained, showing minute lath-shaped feldspars which are probably original or may be due to later agencies causing a re-arrangement of the matrix. Mosaics of well-crystallized quartz occur in irregularly banded masses suggesting amygdules. Much secondary calcite is present, especially in small veinlets and associated with chlorite. This was probably originally an andesite, and presents an unusual occurrence among the rocks of the district. A hard, pinkish or flesh-red quartzite occurs near the iron range to the north, outcropping on lake Wahnapitae. A gravel plain lies on the reserve to the south covering the contact with the granite or Laurentian.

Other outcrops of iron range have been found between lake Wahnapitae and Hutton township, near the contact of the Huronian and the granite. Bad weather and lack of time prevented an examination of them.

Log jam, Onaping river.

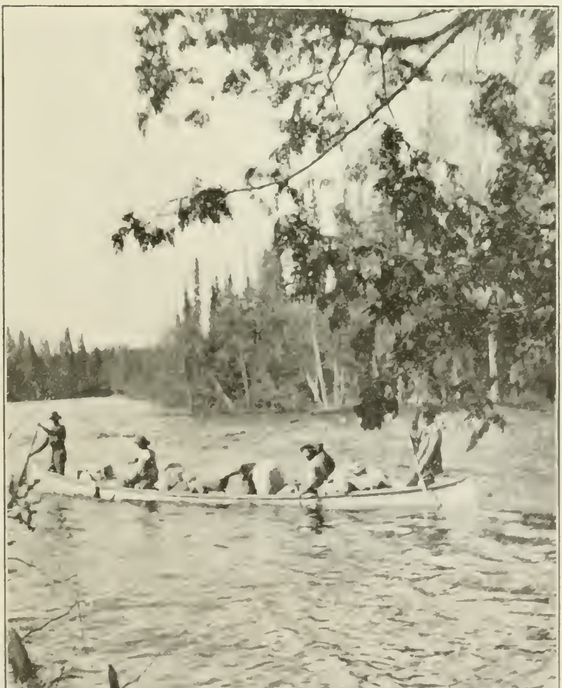
Log chute, Onaping river.



Nickel ore deposit five miles north of Onaping

Richardson feldspar mine, Bedford, Ont.

Perched boulder near Nelson river.



Missanabie river at Hell or Long rapids.

Mineral Range Iron Mining Company. No. 1 or Childs mine.

The Iroquois Beach in Ontario

By A. P. Coleman

Wave action in the cutting of cliffs, the piling up of beach sands and gravels, and the formation of gravel spits or bars across the mouth of bays is so easily recognized that old shore lines, when so well marked as those of the Iroquois Beach, are certain to attract attention. It is not surprising then to find that the wide-spread terraces and beaches of ancient lake Iroquois have been noticed by farmers and land surveyors as well as geologists for many years. In Canada Thomas Roy, an early land surveyor, was the first to call attention to this splendid beach in a paper on the "Ancient State of the North American Continent," read by Sir Charles Lyell before the Geological Society of London in 1837 (1). Roy describes in this paper a series of "terraces or level ridges" to the north of Toronto, the first at 108 feet above lake Ontario, the second at 208 feet, and higher ones at various levels up to 762 feet above the lake or 1,008 above the sea. It is not quite certain which of his beaches was the Iroquois, but the one placed at 208 feet, described as two and a half miles north of the lake, probably represents it, though his measurement is 30 feet above the real level.

Lyell was so much interested in Roy's paper that he visited Toronto in 1842 and rode north with him to examine the supposed beaches; and he reports having seen in all eleven apparent beaches, the highest 680 feet above Ontario; but he was not certain that all were due to wave action, though he says that "with the exception of the parallel roads or shelves in Glen Roy and some neighboring glens of the western highlands of Scotland, I never saw so remarkable an example of banks, terraces and accumulations of stratified gravel, sand and clay maintaining over wide areas so perfect a horizontality as in the district north of Toronto." (2) It should be mentioned here that later geologists have not been able to find the numerous terraces described by Roy and Lyell, the only well marked one being the Iroquois beach.

Theories of Origin

Both Roy and Lyell had theories to account for the supposed beaches, Roy supposing a huge lake dammed to the east and south by ranges of mountains, slowly cut away by the water till the present level was reached; while Lyell prefers to think that the beaches were formed by the sea when the land stood lower than now.

In 1843 Hall recognized the beach in New York state, described the gravel ridges used as roads, and mentioned wood and shells as occurring in the beach gravels. In 1859 A. C. Ramsay referred briefly to the Iroquois terrace north of Toronto (3); and in the following year Charles Robb, a civil engineer of Hamilton, described a series of ridges of sand and gravel, seven in number, to be seen as one goes inland from lake Ontario, referring specially to the old Burlington beach, which he says rises 110 feet above the lake (4). In 1861 Prof. E. J. Chapman of Toronto University speaks of a great fresh-water lake as having formed this and other beaches as it gradually fell (5), and in the same year Sir Sandford Fleming gives an excellent account of the beach north of Toronto, illustrating his work with the map (6).

Hitherto all the writers had looked on the beaches as either formed in a

(1) Proc. Geol. Soc., London, Vol. II., No. 51, pp. 537-8.

(2) Lyell. Travels in North America, Vol. II., pp. 103-6.

(3) Quar. Jour. Geol. Soc., 1859, p. 203; and Can. Nat. Geol., Vol. IV., p. 328.

(4) Can. Jour., New Series, Vol. V., 1860, p. 509.

(5) Ibid, Vol. VI., 1861, p. 228.

(6) Ibid, pp. 247-253.

great lake enclosed by rock or drift materials toward the east, the outlet being afterwards cut away, or else as formed by the sea when the land stood lower; but in 1862 Newberry suggests the idea of an "ice-wall of the retreating glacier as forming the northern shore of the fresh water inland sea," (7) thus introducing a new element into the discussion.

In 1863 the summary of the Superficial Geology of Canada contains a description of the Burlington heights with bones of mammoth, wapiti and beaver found in the gravel during the excavation of the Desjardines canal(8), but there is no discussion of the origin of the beach.

In 1882 Dr. J. W. Spencer described Burlington heights and the plain rising 70 or 80 feet above Ontario in its rear, (9) and suggested that floating bay ice had much to do with the construction of the great gravel bar, but apparently had not followed the beach far enough to observe its northeast tilt. In 1889 he published "The Iroquois Beach; A Chapter in the Geological History of Lake Ontario" (10), introducing the name Iroquois, describing the beach, and discussing its origin. He gives a small sketch map of its outlines, drawing on G. K. Gilbert for the part south of lake Ontario, and presents diagrams illustrating the unequal tilting of the old water plain.

In 1890 Dr. Gilbert refers to the beach, giving a rough map to indicate its extent (11). Since then Spencer has more than once published brief accounts of the beach, his volume on "The Duration of Niagara Falls and the History of the Great Lakes" summing up his views on the whole subject (12). Gilbert and Spencer were the first to give a clear idea of the extent and character of the old shore, and its differential uplift toward the northeast; but they differed as to its cause, Dr. Gilbert accounting for it by an ice-dammed body of fresh water with an outlet through the Mohawk valley into the Hudson; while Dr. Spencer believed that it was formed at sea level by an extension of the gulf of St. Lawrence.

In 1899 the present writer mapped and described the portion of the beach crossing the county of York, giving an account of fresh water and other fossils found near Toronto and Hamilton in Iroquois gravels, and supporting the glacial lake theory (13).

Professor Fairchild in his report on the Pleistocene Geology of Western New York (14) gives the first large scale map of a considerable part of the Iroquois shore, reproducing, however, Dr. Spencer's rough sketch map of the shore to the north and east. Prof. Fairchild accepts the glacial lake theory and speculates on the tilting of the beach during Iroquois times, concluding that most of the warping is of post-Iroquois age.

My own work of mapping the beach in the Province of Ontario began in 1898 with the section near Toronto and was extended from time to time in each direction. The work was practically complete two years ago, but was not published, as it seemed desirable to trace the northeastern shore as far as possible. After several visits to the region between Campbellford and Havelock on the north side of Trent river, and also to the hills north of Madoc, which rise high enough to receive the beach, the conclusion was reached that it could not be traced farther, either because it had not been formed in that region or because the Laurentian hills with little drift upon them were not suited to record the event.

(7) Prof. Fairchild's Pres. Address, Geol. Sec. of Am. Assoc., Vol. XLVII., 1898, p. 33

(8) Geol. Can., 1863, p. 914.

(9) Am. Jour, Sc., Vol. XXIV., pp. 410 and 415.

(10) Roy. Soc. Can., Trans., 1889, pp. 121-134.

(11) History of Niagara River, Com. Niag. Reservation, 6th An. Rep.; and Smithsonian Rep. for 1890 (pub. 1891).

(12) Pp. 44-57.

(13) Lake Iroquois and Its Predecessors at Toronto; Bul. Geol. Soc. Am., Vol. 10, pp. 165-176; also The Iroquois Beach, Trans. Can. Inst., 1898-9, pp. 29-44.

(14) 20th An. Rep. New York State Geologist, 1900, p. r. 105, etc.

Detailed Account of Iroquois Beach

Beginning at Niagara the beach may be traced with scarcely an interruption, except where river valleys have cut below its level and destroyed the terraces and gravel bars, westward to Hamilton, then northeast at varying distances from Lake Ontario to a point three miles northwest of Trenton: where it bends to the west once more forming a large bay with numerous islands. In this part the continuous shore line cannot be followed. The most easterly point is a small island near West Huntingdon on the Madoc railway: and the most northerly point is just north of the Trent river near Trent bridge. Though long stretches of the beach are occupied by various main roads easily followed by driving, it was found that much of the shore, especially toward the northeast end, could only be worked out on foot, owing to lack of roads and the wooded character of the country. For mapping purposes the old county maps were used, and were found on the whole quite satisfactory, though new roads and also railroads have frequently been made since the maps were published. The most inaccurate of these maps is unfortunately that of the county of Peterborough, where the final search for the northward extension of the beach was made.

The lack of a contoured map showing the elevations has been greatly felt, since at many points distant from railways or canals or from lake Ontario, the fixing of elevations can only be done by the aneroid, an unsafe method where there are not constant check readings.

The elevations of railway stations, sections of the Trent canal, etc., given in White's "Altitudes in Canada," have been used as fixed points, and from them hand level determinations have been made of numerous terraces and bars of the old shore. Where the distance is not too great and the slopes are suitable, work with the hand level is fairly accurate, certainly much more accurate than the average barometric determinations.

In the mapping, special attention was given to the main beach, but in most cases bays cut off more or less from the open lake by bars have been roughly mapped also. Usually the shores of bays are much less strongly marked than the main shore, owing to their protected position, which mitigated wave action.

The criteria for determining the beach, such as shore cliffs cut in hills of boulder clay, beaches of sand and gravel, or bars and spits of the same materials, are easily recognized; and often boulder-strewn fields a little below these levels give additional evidence of wave action. The characters of old beaches are admirably given by Dr. Gilbert (15) in U. S. Geological Survey Reports, and are well described also by Dr. Spencer (16) in his work on Niagara Falls and and the Great lakes.

The gorge of the Niagara below the escarpment has been cut largely since the Iroquois stage of water, and gives at Lewiston a fine exposure of the old gravel bar formed at its former mouth. The lower part of the river bank on both sides is formed of red Medina shale, covered on the American side by drift materials, especially thick cross-bedded gravels. From the level of the river to the terrace on which the lower part of Lewiston stands is about 57 feet, giving approximately the thickness of the solid rock; and above this, though a little inland, rise the coarse stratified gravels, often with a very steep dip to the south, to a height of 122 feet above the river, or 124 feet above Ontario, according to my hand level determination. The U. S. contoured map makes the level between 360 and 380 feet above the sea, or 114 to 134 feet above Ontario.

On the Queenston side the gravel bar is not in evidence, but the water line is clearly marked as a cut terrace at the foot of the escarpment just to the south of the main road leading to St. Davids. After a mile or two the rock cliff of the Niagara escarpment withdraws some miles to the south, round the bay-like valley of St. Davids, and the shore cliff, which is still followed by the road, rises but little above the Iroquois level, while a gently rolling plain runs southwards from its edge.

From St. Davids to Homer the same conditions are found, and all the way from Queenston the Iroquois terrace of flat rich land stretches with a very gentle slope northward toward lake Ontario.

At Homer gravel bars commence, the shore cliff having sunk to the old water level, and a shallow bay to the south is cut off in this way. The gravel ridge extends across Welland canal to St. Catharines, furnishing a good foundation for St. Paul and other main streets of the city, but is cut off abruptly by the river, whose channel was evidently

(15) Topographic Features of Lake Shores, U. S. Geol. Sur., 5th An. Rep., 1883-4, pp. 76-123.

(16) Duration of Niagara Falls, etc.

pushed to the westward by the growth of the bar.

The bar rises about 21 feet above the Grand Trunk station or 122 feet above Ontario. Beyond this the usual low shore cliff of clay extends once more to the westward and is followed by the main road for about three miles; but here the road descends and henceforth keeps to the foot of the cliff. At Fifteen-mile creek a ravine has been cut displaying beach gravels resting on unstratified clay; and a little to the east the low shore cliff is broken by Jordan river. Here the Niagara escarpment approaches the shore again for a mile or two.

From Jordan to Beamsville there is little change, except that the clay cliffs grow higher, the escarpment once more receding for a mile or two, and the soft Medina shale often forms part of the shore, usually however with almost stoneless till overlying it. West of Grimsby the bare or thickly wooded Niagara escarpment rises immediately above the Iroquois plain, and continues in this position to a point a mile or two from Stony creek, where there is a bay-like recession. West of Stony creek a valley interrupts the old shore for about a mile, and beyond it a gravel bar extends to the foot of the Niagara escarpment, at a bold promontory facing northeast; while from this to Hamilton the foot of the cliff forms the shore line.

Except for the approach or recession of the Niagara escarpment and an occasional gravel spit or bar near a stream crossing there is great uniformity in the shore line, which begins on the Niagara seven miles from lake Ontario and gradually comes nearer to the present shore, until near Grimsby the two are only a mile apart. Everywhere the gently sloping plain of fertile clay soil covered with orchards and vineyards extents almost unbroken to the northward, while somewhat hilly land of clay or red shale stretches to the south unless for a space the rock cliff of the Niagara formation forms the shore. This lakeward sloping plain is perhaps the most favored region in Canada as to climate, soil and beauty of scenery, and is mainly given up to fruit farming.

The Beach near Hamilton

One of the most interesting points on the whole Iroquois shore is found in Hamilton and its vicinity where the sharp turn to the northeast takes place, and several writers have mentioned or described the arrangement of gravel bars and bays in the modern and ancient lakes, Dr. Spencer having specially studied it (17).

A long bar cuts off the present Hamilton bay from lake Ontario, enclosing a triangular body of water five miles long and quite deep. At the west end of the bay a cliff of stratified sand and gravel rises 116 feet, called Burlington heights. After a width on top of only a few hundred feet where narrowest, it sinks as suddenly toward the west to a marsh at the same level as lake Ontario. This curious embankment was cut through many years ago to make an outlet for the Desjardins canal running westward to Dundas, but formerly the drainage of the Dundas valley escaped by a channel round the north end of the gravel bar. From this narrow ridge the bar runs southward through the cemetery and Dundurn park and the upper portion of the city of Hamilton to the foot of the "mountain" south of James street, forming a gentle curve with its hollow toward the east.

During the excavation of the canal it was found that blue clay underlies the stratified sand and gravel which are piled up to form the heights; but at present the lower part of the ridge is covered with talus, then stratified sand appears up to 57 feet, followed by fine and coarse gravels, often cross-bedded and mostly cemented to conglomerate.

South of the marsh and west of the gravel bar the land rises to a flat terrace 78 feet above the bay, and sections displayed by brickyards and sand pits, sometimes both on the same property, show gravel, sand and clay.

For instance, at Crawford's sand pit the succession is :

	Feet.	Above bay. Feet.
Clay making red brick..	6	78
Gravel	30	72
White sand	5	42
Hard pan	4	37
White sand, with mammoth tusks and bones		33
Level of bay		0

East of the bar and descending toward Hamilton bay one finds some cemented gravel, but more sand and especially brown silt.

Excavations made for the Hunter street tunnel in Hamilton cut through the gravel bar, and the section showed at that point 30 feet of coarse stratified gravel, often cross-bedded and sometimes containing boulders two feet in diameter, followed by two feet of brown

(17) Spencer, Am. Jour. Sc.,Vol. XXIV., 1882, p. 415; also Trans. Roy. Soc. Can., 1889, pp. 129, etc.; Geol. Sur. Can., 1863, p. 914.

unstratified clay and eight feet of blue till enclosing a few stones. The brown clay is an old soil and contains quantities of partly decayed wood as well as mammoth remains (18). Bones of mammoth, wapiti and beaver were found in the Desjardins canal cutting about 70 feet above the lake, and since then many tusks and fragments of bones of mammoth have been found near King street west in sand pits at levels from 33 to 42 feet above the lake. Colonel Grant reports also "a shoulder blade of a large moose or deer," and horns of a buffalo, the latter from the Desjardins cut.

It is evident from the old soil more than 30 feet below the surface that dry land existed to at least that depth before the water rose sufficiently to permit the formation of the Burlington gravel bar. That the earliest water level was lower still is very probable from the finding of mammoth tusks and bones only 33 feet above the present lake, or 83 feet below the top of the bar. They were probably not washed to the spot by wave action, for long slender tusks, quite unworn, though now fragile from loss of organic matter, occur in the sand, no doubt deposited there by the death of the animal. The flats and bars beside the old Dundas bay were favorite haunts for these elephants, perhaps to get the breeze and escape the flies in summer.

While the bay must have been small and shallow in the earlier part of the Iroquois age it must have grown deeper and deeper, the dam-like gravel bar rising to correspond, until at the end the bay was over 100 feet deep and extended west to what is now Dundas, enclosing almost as large an area as the similarly shaped Hamilton bay. The materials for the bar were probably derived from the shore to the southwest along the foot of the Niagara escarpment, where accumulations of boulder clay still exist. Dr. Spencer calls attention to the fact that the pebbles of the bar are largely of Hudson river rock instead of Niagara limestone as might have been expected, so that they must have been ice-borne from the north or east.

Burlington Heights to Toronto

From Burlington heights to Toronto the Iroquois shore presents much the same features as from Queenston to Hamilton, a broad flat clayey surface sloping gently toward lake Ontario with a shore cliff of clay to the north varying in height but almost always distinguishable. From Burlington to Oakville the shore is nearly straight and runs parallel to that of Ontario, but about two miles inland. The streams flowing to the lake cut ravines into underlying Medina shale, thus destroying for a space the beach and its shore cliff, but the interruptions are unimportant. A little east of Waterdown station, however, a long gravel bar runs southwest toward Hamilton bay, thus partly overlapping the great Burlington bar, whose coarse conglomerates are so strikingly displayed on the Grand Trunk railway to Hamilton and Dundas.

About two miles after passing from Halton county to Peel the regular trend of the beach is broken by a deep bay before it crosses the Credit river, and Hudson river shale shows in the cliff which rises ten or twenty feet above the flat shore. Here a gorge has been cut through 20 feet of boulder clay and a somewhat greater thickness of shale, and above the clay are ten feet of beach materials, coarse gravel now cemented into a conglomerate.

The low shore cliff rises not far north of the Grand Trunk railway, and may easily be followed when passing by train from Burlington to the Credit bay. Beyond the Credit there is a gravel bar, and then low shores and the usual flat terrace to Cookstown, where a gravel bar occurs. From this village to Lambton Mills the main road between Hamilton and Toronto, called Dundas street, follows the old shore, partly above the low cliff of clay, partly on the terrace at its foot and partly on gravel bars across the openings of valleys.

At Lambton the Humber river cuts off the beach with its wide and deep valley and a bay extends three miles north to Weston. East of the Humber valley a great gravel bar extends for two miles to Davenport station on the Northern railway property, the Davenport ridge, though the shore cliff to the east is often called by that name.

The Davenport bar evidently crowded the Humber out of its old valley, now filled with stratified sand and clay, and forced it to cut a new valley, which is now walled with Hudson river shale for 30 or 40 feet at the bottom, and with boulder clay and later drift deposits above.

The Davenport ridge is greatly exploited for sand and gravel for building purposes in Toronto, and in a layer of clay beneath 20 or 25 feet of gravel horns and less often bones of caribou are found, sometimes in considerable quantities. A number of years ago

(18) The Iroquois Beach, A. P. Coleman, Trans. Can. Inst., 1898, p. 36.

Mr. Thompson reported finding a stone muller and arrowhead with bones and horns of deer while digging gravel at a depth of 20 feet from the surface, so that there is a strong probability that Indians dwelt on the shore of lake Iroquois.

To the north of Toronto the Iroquois terrace on which the city is built lies at the foot of a steep shore cliff of boulder clay and sand, and was once thickly strewn with great stones washed out of the clay. At Reservoir park a small gravel beach has furnished many fresh water shells of four or five species, including campeloma, pleurocera, sphaerium and unio, almost the only undoubted evidence as to the character of the water, though unios were reported from the shore in New York in early days.

The Don valley interrupts the beach for more than two miles, and a wide bay runs to the north with a broad series of gravel bars with lagoons between, very much like Toronto island of to-day, cutting it off from open water to the southeast. The town of York is situated near the west end of this bar, which is exposed in many sand and gravel pits, in one of which a mammoth's tooth was found a number of years ago. The York gravel bar has grown westwards like the Davenport bar and the present Toronto island. The source of the materials for the eastern bar, as well as for the modern island, is no doubt to be found, as suggested long ago by Sir Sandford Fleming, in the destruction by wave action of Scarboro' heights.

The sections afforded by the tributaries of the Don and Humber show a very large amount of sand and clay with some gravel also, filling in the old bays and extending to the eastward toward Scarboro' heights, the thickness sometimes reaching 100 feet, and exceeding 50 feet over a number of square miles. In one such deposit on a tributary of the Don, a quarter of a mile west of the main river, wells sunk to investigate the drift disclosed at a level 35 feet below the Iroquois terrace, sand and gravel partly cemented by lime to a depth of 38 feet, ending on what appeared to be a weathered surface of interglacial clay. A little above this the sand contained unios, sphaeriums and plueroceras. Though the evidence is not altogether conclusive, it points strongly toward a stage of water in the earlier Iroquois times 70 feet lower than when the final gravel bars were constructed, and confirms the evidence previously referred to near Hamilton.

Scarboro' to Colborne

At the eastern end of the York gravel bar the Iroquois shore approaches closely the shore cliff of lake Ontario, and 4 miles from York it ends abruptly against the highest part of Scarboro' heights, the present lake having cut back its shore far enough to destroy the old beach for half a mile. This is the only instance where the present lake encroaches on the boundaries of its predecessor, and this happens because a lofty morainic spur here runs southward from the Oak ridges. On each side of the gap at Scarboro' heights the Iroquois shore is deeply incised in the boulder clay with cliffs from 70 to 150 feet high. East of the heights the shore turns off to the northeast forming a bar south of Highland creek and being interrupted by the Rouge river two miles beyond, where another long bar occurs.

Continuing northeast beyond Pickering and Whitby the beach recedes 7 1-2 or 8 miles from lake Ontario, and then bends southwards again near Oshawa and Bowmanville. There is a large bay north of Newcastle and one of the boldest promontories on the whole shore projects to the south at Newtonville, where for a few miles the Kingston road follows the gravel bars and terrace of the old beach. Northwest of Port Hope there is another deep bay reaching 7 miles inland from lake Ontario with a drumlin island about 4 miles north of the town. Where the Midland railway crosses the beach near Quay's there are heavy gravel bars used for ballast, the level being 311 feet above Ontario.

From this point the beach follows the south side of the bold morainic ridge of central Ontario to Baltimore north of Cobourg, where a stream valley interrupts it for about two miles; and then draws a little nearer lake Ontario behind Grafton and Colborne.

For the whole distance from Hamilton the shore has been steadily rising, near Colborne reaching a height of 356 feet above Ontario, as determined by Dr. Spencer, but the beach is everywhere a unit. Though the gravel bars may be split up by lagoons, they all rise approximately to the same height, the differences between adjoining bars seldom exceeding five feet and never ten. These bars probably rose a few feet above the lake as they do now above lake Ontario, e.g., at Toronto island, so that the foot of the shore cliff in places where bars or beaches do not occur is somewhat lower, and the old water level should be put perhaps five feet below the top of the bars.

Colborne to Trenton

Three miles to the northeast of Colborne near Silver lake the shore is found to have lost its unity, and there are bars at three levels, the highest 28 feet above the lowest. The gravel bars are massively developed on a promontory south of Silver lake, where they approach within a mile and a half of lake Ontario. Another interesting feature occurs here in the fact that Silver lake is really a small bay of lake Iroquois cut off by these heavy bars from the main body of water, so that its drainage is not towards lake Ontario two miles and a half away and 360 feet lower down, but by a stream flowing north and east to the Trent river. The valley of this stream must have been 30 feet below the highest level of lake Iroquois, implying a narrow strait running north from Colborne, making an island of the mass of high morainic hills between this and the river Trent, or perhaps a peninsula united to the mainland toward the west only by the gravel bar just referred to.

Beyond Silver lake the Iroquois terrace is strongly marked on the southeast flank of lofty morainic hills, where the wide expanse of open water allowed powerful wave action; and north of Brighton gravel bars once more occur at different levels, the difference being greater than at the last point. Three miles northeast of Trenton the large island ends in a bold promontory, rising in a very striking way above the flat Iroquois terrace with its gently sloping surface thickly covered with boulders.

Here the separation of the gravel beaches and terraces is still greater than at Brighton or Silver lake. As Dr. Spencer gives the level of the old shore as 436 feet above Ontario in one paper and 386 in another, and as this is a specially interesting point on the old shore, a line of levels was run from the Trent, practically at lake level, to the highest terrace, giving the following results :

	Above L. Ontario. feet.
Highest terrace, faint	450
Well-marked terrace	441
Rear of gravel beach	386
Slightly lower bar on road..	374
Rear of boulder pavement	339

The most prominent level is that at 386 feet, and it is that which Dr. Spencer has adopted in his later writings as the true water level. His earlier esimate. unless a misprint. may have been obtained from the terrace. which is put at 441 feet in the table above. The morainic hills behind rise at least a hundred feet higher and command a splendid view of the country in all directions except west. One of the highest hills some miles to the northeast appears to have a terrace cut upon it, and was later found to be an island.

If we start at the lowest beach, 374 feet above Ontario, we find the highest water level to be 76 feet above it; but if we take the two best marked features, at 386 and 441 feet, the difference in level is 55 feet.

Rounding the point of the hills the separated terraces may be followed southwestwards for about a mile and a half into a bay, and then north for a mile, after which the shore runs west, but is not very distinct, owing partly to the sandy, shifting nature of the soil, and no doubt also partly to the sheltered position, where wave action must have been feeble. It proved impossible to carry the line round to the old strait now occupied by the creek draining Silver Lake.

Islands to North and East

Owing to the faintness of its shore the great bay to the northwest of the Trenton promontory could not be mapped satisfactorily, and must be left until contoured maps make it possible to fit its position by the elevation. The bay probably goes as far west as Castleton and contains quite an archipelago of small and large islands, including twelve which have been wholly or partly mapped within the great bend of the River Trent. Some of these islands were low and show only the lower beaches, while others rise high enough to provide a respectable series of beaches, and some of the latter have been measured by hand level. There are also shoals, flat-topped drumlin hills with stones scattered thickly over them, which did not quite reach the surface of the bay, though sufficiently wave-washed to remove the clay from the bouldery till during the later stages of lake Iroquois.

A low-lying island with widespread gravel deposits lies about four miles north of the promontory, near Trenton. Another rises between this and Codrington, and a larger one between this and Warkworth. There are smaller islands west, northwest and north of the latter town, and a long island between it and Campbellford. The largest island of all extends for about seven miles northeast, and southwest a mile or two north of Campbellford, and displays a fine set of beaches toward the northeast, where the hills fall away rapidly toward the Trent River at its southward bend, after the northeasterly course from Rice Lake.

At this point well-developed beaches were found at 432, 442 and 475 feet above lake Ontario, the highest 43 feet above the lowest, and Dr. Gilbert, here or a little southwest, found a beach ninety feet above the lowest. Except on the north no land high enough to receive the beaches can be seen for many miles.

There is a small island about two miles north of Frankfort, with four gravel beaches, the highest 47 feet above the lowest; and across the river an island six miles long runs off to the northeast as a central hill bordered by the Iroquois terrace. About halfway along this island on the northwest side is Oak Hill lake, a pretty sheet of water with no apparent outlet, really a bay of lake Iroquois, cut off from the main lake by a massive gravel bar, through which drainage now takes place as springs. People living near the lake report that it has a depth of 43 feet, as shown by soundings, and that the only fish in it before it was artificially stocked were minnows. A fine wall of small stones pushed up three or four feet by winter ice encloses most of the shore.

By hand level from the nearest point on Trent river, the elevation of Oak Hill lake above Ontario is made 435 feet. A boulder pavement begins at 398 feet, and gravel bars occur at 414, 430 and 466 feet, the last being the very well-defined bar enclosing the lake toward the northwest.

At the northeast end of the same island a small, marshy pond is enclosed in a similar way. To the north of this extensive boulder pavements and gravel beaches are found, and leveling from Madoc Junction makes their elevations 395 (small beach), 450, 460 and 475 feet, considerably higher than those near Oak Hill lake, three miles to the southwest, and not wholly accordant with them.

From this point a hill can be seen rising above Iroquois level, five or six miles to the northeast, the last place where the beach as been found. This island, which is 140 miles from Hamilton, in a direction 57 degrees east of north, rises as a prominent morainic ridge a little southeast of the railway between Madoc Junction and Madoc at mile 19, the nearest station being West Huntingdon. Gravel beaches occur at 440, 492 and 498 feet above Lake Ontario, the last being the highest level yet observed with certainty on the Iroquois beach in Canada.

All the hills referred to as rising above Lake Iroquois in the form of islands are morainic, most of them formed of boulder clay, but some partly kame-like with extensive rudely stratified masses of coarse and fine gravel, easily distinguished as a rule from the more uniform, well stratified and horizontal deposits of the old beaches.

North of Trent River

Splendidly formed gravel beaches, evidently made by powerful waves rising in a wide stretch of open water to the east and northeast, rise south of the river Trent a short distance from Campbellford; but the corresponding beaches to the north appear to be wanting. Careful search near Havelock has not disclosed any, though kame gravels somewhat suggestive of wave work are found just north and northeast of the village at levels of 454 to 500 feet; none of these, however, are horizontal enough for beaches. Search has also been made north of Blairton station on the C.P.R., with similarly doubtful results. In the former region flat sheets of limestone simulate water levels, but north of Blairton the hills are rounded knobs of Laurentian rock, on which waves could leave little impression, and the sparse drift materials are sand instead of boulder clay, providing poor materials for beach formation.

The same conditions prevail north of Madoc, near Eldorado and Malone, where the ground rises high enough to show the beach, flat limestones capping the higher hills in places, other hills being Laurentian or of the Hastings series. Here, however, there are some slopes of boulder clay, which should have retained the terraces and beaches if they had been formed; but no shore terraces or beach deposits were found, though they are so well marked on the island near West Huntingdon twelve miles to the south. Unless better success follows later attempts to find the Iroquois beach to the north of Havelock, Blairton and Madoc, we must conclude that in all probability it never existed there at all.

Southwest of Havelock, however, about a mile west of Trent bridge, a distinct gravel bar is found at 75 feet above the river, or 436 above Ontario, while at 455 feet there is a possible beach. About three miles southwest along the north bank of the river there are beaches at 424 and 436 feet, and still nearer Hastings a beach was found at 447 feet (aneroid). Just west of Hastings a gravel deposit of imperfectly rounded stones suggesting river action is found 36 feet above the present river, and similar gravel beds occur farther down the river at about the same or a somewhat less height above it, but these probably have nothing to do with the Iroquois beach.

As the bay leading southwest from the beaches near Campbellford (at 432, 442 and 475 feet) narrows greatly, until at the outlet of the present Rice lake it is only about a mile wide with steep morainic hills on each side, one can no longer expect to find beach terraces or gravel bars of a well-defined character. If the tilt of the Iroquois shore is taken as three or four feet to the mile in this region the long narrow bay must have reached nearly to the southwestern end of the Rice lake basin, though no distinct old shores have been found along this narrow body of water. However, the elevation of the beach north of Port Hope, four miles from the southwest end of Rice lake, is only 311 feet, leaving a difference of 59 feet between them. As the lake is here very shallow and only 30 feet deep at any point, it is probable that the old bay stopped some distance short of Bewdley, the end of the present body of water.

From the map it will be seen that the southwest end of Rice lake is only a few miles from lake Ontario at Port Hope, so that there was a comparatively narrow isthmus in Iroquois days connecting the large morainic peninsula which projects towards Trenton with the mainland to the west. The range of great morainic hills here sinks almost to the level of Rice lake, and the people of Port Hope claim that the most satisfactory outlet for a canal from the chain of lakes connected with Trent river will be toward lake Ontario at this point instead of by the lower Trent to the bay of Quinte.

Lake Peterborough

It was thought at first that the old bay corresponding to Rice lake sent an arm up the valley of the Otonabee river to Peterborough, but an examination of the ground shows that the valley is so narrow and in places so steep-walled between drumlins and moraine ridges that the waters above must be looked on as a separate lake, connected with the bay just described by a short bit of river having but little fall.

Above the short stretch of river lake Peterborough expands to a width of two or three miles west of the Otonabee, and must have covered a wide flat of clay reaching beyond the Midland railway with rather indefinite shores where the moraine rises to the west. The lake narrows toward Peterborough and the deposits become sandy, and finally gravel terraces rise above the flat at the upper end where a great river, probably draining the upper lakes or lake of those days, entered it from the north. The plain of stratified sand is at the level of 388 feet, where the C. P. R. station stands, but ascends to 404 feet at the Grand Trunk station. The highest point in Peterborough, occupied by a park and court house, is a drumlin which formed an island at the upper end of the lake; and a little above this the present river banks show stratified coarse gravel representing the upper limit of delta deposits formed by the old river, one terrace rising to a height of 432 feet.

Below Peterborough the present Otonabee (which is really the Trent above Rice lake) has done very little cutting, its valley being hardly at all depressed below the clay plain mentioned above, but it has a rapid descent above the city. The new lift lock of the canal, which overcomes a rise of 65 feet, is placed in the high morainic hills to the east of the river, and the canal below is at the level of the old lake flat.

The Beach in New York

From the Niagara river at Lewiston the Iroquois beach has been traced by Dr. Gilbert and Prof. Fairchild (19) in a fairly direct course eastwards to Sodus on the south shore of lake Ontario. There a promontory somewhat like that near Trenton projects eastwards, with a great bay to the south, and islands and smaller bays diversify its shores as far as Rome, a long, narrow bay, like that of Rice lake, entering the basin of Cayuga lake. At Rome Dr. Gilbert discovered an old channel forming an outlet towards the Mohawk valley and the Hudson river; so that this great lake was drained far to the south of the present outlet of Ontario, its waters entering the sea at New York.

To the north of Rome the shore turns westward once more as far as Constantia, and then north to Adams Center, where it bends to the northeast toward Waterdown. Two miles south of this town the highest beach is about 454 feet, or a little more, above lake Ontario, the highest point recorded with certainty on the southeast side. Dr.

(19) See map by Prof. Fairchild in Pleistocene Geology of Western New York, 1900. His map has provided the materials for the portion of the old shore east of the Niagara given in the present paper.

Gilbert and Professor Fairchild do not carry the beach farther, but Dr. Spencer believes he has found fragments of it in the Adirondacks to the northeast, the last which he has measured being at Fine, 972 feet above the sea, or 726 feet above Ontario. However, as so skilled an observer as Dr. Gilbert, who examined the supposed beaches with Dr. Spencer, dissents from this view, and holds that they have been formed in local bodies of water, or in connection with glacial action, it is doubtful whether this extension of the shore should be accepted.

It is to be noted that the old shore north of the great bay from which the outlet opens is split up into several beaches, as it is on the north shore from Colborne towards West Huntingdon. Prof. Fairchild has made profiles of the different beaches in that region, and finds them irregular in regard to separation, though there seems a tendency for the separation to increase toward the north, the greatest amount recorded being 51 feet, near Waterdown (20).

The general characteristics of the shore in New York State are like those in Ontario, and do not require special mention; but it should be stated that the first recognition of the splitting up of the beaches north of the outlet, both in the United States and in Canada, is due to Dr. Gilbert, who connected this divergence with a tilting of the basin during Iroquois times.

Tilting of the Beach

The early work of Gilbert and Spencer on the two sides of the lake brought out the startling fact that the old shore is no longer horizontal, but is tilted up toward the northeast, the lowest level being at Hamilton, where the beach rises only 116 feet above lake Ontario; and the highest, as far as they know, at Trenton on the Canadian side at 386 feet, and Adams Center and Watertown, in New York, at 411 and 484, a difference of from 270 to 368 feet. The conclusion was reached that the rate of tilt is not uniform, but increases toward the northeast, or, more exactly, in a direction N. 28 degrees E., being estimated by Dr. Spencer at 1.6 feet per mile at the southwest end of the lake, and at 5 feet per mile in the region of Watertown.

In carrying out the present survey of the Iroquois beach a number of elevations have been determined, partly in new localities, partly redeterminations of points of importance which had been examined by Dr. Spencer or others; and some changes in the probable rate and direction of tilt result from these investigations. Special attention has been given to the height of gravel bars, since they may be supposed to give the most uniform results, rising of course a few feet above water level, but probably as in the case of lake Ontario at present, not reaching more than 5, or at most 10 feet above the average lake surface. Determinations of the foot of the shore cliff are less certain, owing to the slipping of loose materials when cut in drift deposits. In some cases the level as determined from the foot of a cliff is considerably below that measured on adjacent gravel bars, so that it has been decided to use only the summits of bars in working out the differential elevation. Unfortunately, there appear to be no statements in print as to whether gravel bars or shore cliffs were employed in fixing the levels in New York State.

Using the latest information and comparing the relative levels of points on each side of lake Ontario, isobases may be worked out showing the direction of the tilt of the old shore, the results giving N. 20 degrees E. as most probable. Accepting this as correct, it is convenient to divide up the shore into somewhat equal lengths along this line, using well determined levels for the purpose, and to work out the rate of elevation per mile in each.

The distance in a direction N. 20 degrees E. between Hamilton (116) and York (190), which stands on a well developed gravel bar a little northeast of Toronto, is 36 1-2 miles and the difference in elevation 74 feet, giving a rate of tilt of 2 feet per mile, differing considerably from Dr. Spencer's rate of 1.6 as determined from the height of Carlton station. It has been found however that the height given in his table for Carlton of 171 feet above Ontario, is about 7 feet below the summit of the gravel bar to the north of the station.

The next section chosen is from York to the gravel bar near Quay's, north of Port Hope, the rise being from 190 to 311 feet or 121 feet in 35 1-2 miles, averaging 3.4 feet per mile. Up to Port Hope the beach is practically a unit, the only variations being due to more powerful wave action in some places than in others, and not amounting at most to more than 5 or 10 feet.

From Port Hope to West Huntingdon, the last point to which the beach has been traced, the matter is much more complicated, since the old shore is split up into several beach levels, probably diverging, and the question arises which level should be taken for comparison, the lowest, the highest or some prominent intermediate beach.

(20) An. Rep. N. Y. State Geologist, 1900, p. r. 110.

The first carefully measured point where the divergence is distinctly marked is Trenton, where good beaches occur at 374 and 386 feet, and a well-marked terrace at 441, a faint one appearing about ten feet higher. As Trenton is 18 miles in the direction N. 20 degrees E. of Quay's, the tilt works out to 3.44 feet per mile for the lowest beach, 4.17 for the next, which is the best defined of all, and no less than 7.16 for the terrace at 441 feet.

If we compare with the beaches near Havelock, Madoc Junction and Campbellford we find more difficulty still, for the elevations at the three points, respectively 31, 32 and 33 miles in a direction N. 20 dgrees E. of Quay's, are not entirely in accord. The lowest beaches southwest of Havelock and north of Campbellford are at 436 and 432 feet, giving a tilt of 4 and 3.67 feet per mile. The highest beaches near Madoc Junction and Campbellford are at 475 feet, giving a rise of 5 feet per mile: but no corresponding beach has been found with certainty near Havelock. Dr. Gilbert however has found a difference of 90 feet between the lowest and highest beaches near Campbellford, which would greatly increase the rate per mile for the highest.

On the West Huntingdon island there are good beaches at 492 and 498 feet, but higher water levels could not be recorded here, since the island does not rise above the last gravel bar. As the distance northeast of Quay's is 37 miles, the differential elevation is 5 feet for the highest.

The Mohawk Valley Outlet

Dr. Gilbert showed long ago that lake Iroquois drained through the Mohawk valley toward the Hudson, and drew the inference that if the known tilting of the land was in progress during the existence of the lake its effects should be recorded in the beaches. The splitting up of the gravel bars just referred to as occurring northeast of Colborne he observed, and connected with this cause, and believed that Burlington heights and other points near Hamilton would be found to give evidence of lower water levels at the southwest end of the lake during its earlier than during its later stages. Between the extremes there must be of course a pivot where the water level remained constant (21). Professor Fairchild looked for evidence as to such a differential change of levels north of the outlet near Rome, and found the beaches greatly split up, as they are in eastern Ontario, but did not think that a regular spreading apart of the beaches could be proven (22), and concluded therefore that differential elevation during the lifetime of lake Iroquois was improbable.

The lack of regularity in the spreading of the beaches is apparent in Ontario also, though there is a marked increase in the divergence as one goes northeast. The first well-marked splitting up of the levels is at Silver lake, three miles northeast of Colborne, where there are three beach levels, the highest 28 feet above the lowest. Near Trenton, nine miles farther, the separation of the two main water levels is 55 feet, giving a rate of spread of 3 feet per mile. On the island north of Campbellford, 13 miles farther northeast, it is only 43 feet by my determinations, but 90 by Dr. Gilbert's. The latter difference between the highest and lowest beaches would give a divergence of 2.7 feet per mile between Trenton and the point just mentioned.

If the beaches spread 28 feet at Silver lake and 55 feet near Trenton, 9 miles away, in the direction N. 20 degrees E., they should converge and meet 9 miles southwest of Silver lake, about at Quay's gravel pit north of Port Hope. If a line is drawn at right angles to the direction N. 20 degrees E. from the outlet of lake Iroquois, near Rome, it passes a little south of Quay's, so that two modes of attacking the question agree pretty closely in their results, thus confirming each other.

If the divergence observed northeast of the hinge line from the Mohawk valley continues to the southwest, we should expect some evidence of lower water levels in that direction, though the divergence cannot be assumed to be so great as 3 feet per mile, since the rate of differential elevation per mile is less to the southeast. If we take the two as proportional we shall have a divergence between Port Hope and York of 2.45 feet per mile, which would put the lowest formed beach at York or Toronto at about 86 feet below the highest beach, which of course is the only one left exposed. If we carry out the same reasoning with reference to Hamilton, we find between Toronto and Hamilton an additional divergence of about 1.44 feet per mile, which amounts to 52 feet, or in all to about 139 feet. This would carry the original water level of lake Iroquois at its southwest end, below the present level of Hamilton bay, but the data obtained from the spreading of the

(21) 6th An. Rep. State Reservation at Niagara, 1888-9, p. 70; also History of Niagara River, Smithsonian Rep. 1890, p. 241.

(22) Pleistocene Geol. Western N.Y., 1900, p. r. 111.

beaches northeast of Port Hope are not sufficiently certain to make these results more than a rough approximation to the truth.

On the other hand, we have a considerable amount of direct evidence bearing on the question. At Toronto what are almost certainly Iroquois beach deposits, though half a mile south of the old shore, rest on an eroded surface of interglacial clay about 70 feet below the Iroquois beach level to the north. As the last ice advance intervened between the laying down of the interglacial clay and the opening up of the Iroquois basin, we must suppose that the upper sheet of boulder clay, which is quite thick at points both east and west, was removed during a time when the water stood 70 feet lower than at the last stage of the Iroquois lake.

At Hamilton an old soil with trees and bones of various animals was found in the Hunter street tunnel 30 feet below the top of the Iroquois gravel bar, so that the earlier water level must have been lower than that. To the west of this, as shown on a previous page, mammoth tusks and bones, evidently not waterworn, occur 33 feet above the level of Ontario, or 83 feet below the top of the Iroquois beach half a mile away. The bones and tusks occur together in a layer of sand, and similar remains are found a few feet higher up (42 feet above Ontario) in another sand pit a short distance away, so that we may suppose that the bones were not washed to their present resting place, but that the animals died where the bones are found. If this supposition is correct the water of lake Iroquois must at that time have been 80 feet lower then than at the latest stage.

The great thickness of the gravel bar at the Desjardins canal, and its extraordinarily narrow wall-like form suggest the same thing. When the canal was cut clay was found at about lake level: above this there are 57 feet of stratified sand, and then coarse gravel, largely cemented to conglomerate, to the top. The upper 60 feet of coarse gravel, scarcely at all interbedded with sand, could hardly have been piled up in deep water, but must have been built to the full height by successive additions as the water rose.

We have then evidence of two kinds showing that differential elevation took place during the existence of lake Iroquois; the splitting up of the beaches toward the northeast, and at the other end the presence of old soils and the remains of land animals buried from 30 to 80 feet beneath the latest gravel bars of the old lake. The evidence seems sufficient to settle the matter.

In working out the differential elevation of the beach as now found we must keep in mind that from Hamilton to Rome on the south of Ontario and to Port Hope on the north the level is that of the last stage of lake Iroquois and that its continuation toward the northeast is to be looked for in the lowest prominent beach of the series found beyond the hinge line. The higher beaches, beyond the line where they split up, represent continuations of buried beaches toward the southwest, the highest towards the northeast corresponding to the lowest toward the other end of the basin. The difference in present altitude of the extreme ends of the earliest beach of all cannot be less than 500 feet, and may be greater than that, while the difference of level between the ends of the latest formed beach (116 at Hamilton and 498 at West Huntingdon) is only 382 feet.

Conditions of Iroquois Time

The swinging of the old beaches about a fulcrum running 20 degrees north of west from the outlet near Rome, New York, gives clear proof that the body of water was completely enclosed and not an extension of the Gulf of St. Lawrence; for otherwise the divergence of the beaches would run from end to end of the old shore, growing less however toward the southwest. This confirms the evidence as to the character of the water afforded by the unios found in Iroquois gravels in New York, and the campelomas, etc., in deposits of that age in Toronto. The water was fresh (23).

There is little doubt as to the character of the dam. It must have been the ice of the retreating glacier, which had withdrawn from the basin of lake Ontario, but still blocked the St. Lawrence valley to a height sufficient to turn the water southeastward into the Hudson. The highest part of the old shore, near West Huntingdon, is now 742 feet above the sea, but doubtless it then stood much lower, since the deformation recorded in the beach has taken place since then. Still it was high enough above sea level to allow of a current through the Mohawk valley to the Hudson.

The exact position of the ice dam is not easy to determine, partly no doubt because the barrier was slowly shifting toward the northeast. One would think that morainic deposits should record the stages of retreat, but so far no definite evidence of the kind has been found. Some points however seem fairly certain. There was wide open water surrounding the old islands near West

(23) Bull. Geol. Soc. Am., Vol. 10, p. 167.

Huntingdon and north of Campbellford, for the series of beaches at these points gives evidence of heavy wave action; and the latter point must have been exposed to open water for a long time, for there is a range of 43 feet between the highest and the lowest beach. It is curious however, to find only the lowest beach well marked a few miles away, to the north of Trent river, as if the region, which is drift-covered and well adapted to receive a beach, had been protected from wave action before that time by still unmelted ice.

The ice front appears to have covered the high hills north of Madoc and probably for a long time extended over Napanee and parts of New York State north of Watertown ; and Dr. Gilbert's early map shows its position perhaps as well as any map that could be constructed now (24).

The climate was probably considerably colder than now but not quite Arctic, for even in the early days of lake Iroquois tamarac and spruce lived near its shore at Hamilton, and mammoths and caribou were very common, while wapiti, buffalo and beaver occasionally visited the shore, and man himself apparently fashioned stone tools at Toronto Junction. The crumpling of sand beds probably of Iroquois age in east Toronto may indicate the shove of icefloes or bergs, but the water was not too cold to be inhabited by a number of shell fish which still live in lake Ontario.

Duration and Age of Beach

The old shore of lake Iroquois is as mature as the present shore of Ontario, and it probably required as long a time to carve down its promontories and build its gravel bars and spits across the mouths of wide bays as the present lake has needed for operations of the same nature. Unfortunately, we have no very trustworthy chronometer for the work of either. That they required about equal amounts of time, and that both together have occupied a large part of the time since Niagara began to cut its gorge from Queenston heights to its present position seven miles to the south, is pretty certain ; but opinions as to the age of Niagara vary from 5,000 or 7,000 years to 35,000, and a final settlement of the time limit has not been reached. I incline to the longer estimate, since 2,500 years seems far too short for the work of lake Ontario in cutting down Scarboro' heights and shifting the materials ten miles to the westwards to build up Toronto island.

The question may be approached from another side. How long did it require to deform the old beach to the extent of 500 feet since the lake began, or 320 feet since its beach was finished ? If Dr. Gilbert's estimate of 42 feet per hundred miles per hundred years, as drawn from the shifting of water levels on the present lakes, is correct, the time since the Iroquois lake was drained off is not less than 67,000 years, and since its beginning not less than 100,000 years. The assumption that these processes of elevation and depressions go on uniformly is however decidedly improbable. It is more likely that such changes begin gently, attain a maximum, and then slowly decline; and the present rate of tilting probably represents the slowing down of the movement before it finally ceases, so that the change of level may have been much more rapid in earlier times.

However, the movement of elevation may not represent a simple wave. There may have been accelerations and retardations in the process, the latter corresponding to the better marked beaches to the northeast of the hinge line. Altogether this method of estimating the time gives only vague suggestions, and the other seems the more trustworthy. We may conclude then that the Iroquois lake lasted not more than 17,500 years, and probably less ; and that the time since it was drained has been of something like the same duration.

Between the time of lake Iroquois and that of lake Ontario intervened the comparatively short period of retreat of the ice from the St. Lawrence valley, indicated probably by beaches rising to 135 feet above lake Ontario in the Bay of Quinte region; and a somewhat longer period when the gulf of St. Lawrence invaded the basin of lake Ontario, though the waters of the basin appear to have remained fresh from the large inflow of the Niagara and other rivers.

Economic Geology

The Iroquois beach in Ontario is of greater importance economically than at first would be imagined, since it affects in various ways the farmer, the railway engineer and the builder. It is not an accident that the old shore is the favorite locality for main roads and for farmers' houses and buildings, for the top of the shore cliff in clayey regions gives the driest

(24) 6th An. Rep. State Reservation at Niagara, 1888-9, p. 69.

locality in the farms it traverses, and the gravel spits and bars where the ground is low and muddy are even more important as giving good drainage and solid foundation for roads and farm premises. The gently sloping terrace below the shore cliff in most cases furnishes the richest clay land of the country, as below the "mountain" in the fruit-growing region south of Lake Ontario, and the farms "at the front" to the north of the lake; but toward the east these fields are apt to be marred by the stones washed out of the boulder clay cliffs by waves of the ancient lake. Even these boulders, however, are put to use for foundations, and where derived from limestone regions, for lime burning to supply local needs. The gravel bars across the mouths of old bays supply the favorite road-building material, especially in districts where clay is the prevailing soil, and the township roads are better where such gravel pits can be opened than elsewhere. The stone roads of the country are largely metalled with broken stone from the boulder pavements of the old beach.

The railroad engineer makes good use of the level terrace of the Iroquois shore, the Grand Trunk occupying the flat land near the foot of the old shore cliff for many miles south and north of the west end of Lake Ontario, while the Canadian Pacific does the same thing near Toronto. The wonderful gravel bar at Burlington Heights has furnished a high level causeway across the marshy flats between Hamilton and Dundas, which both railways and gravel roads have been glad to put to use. Even more important to the railways has been the convenient supply of ballast which the gravel bars afford in different parts of the Province. Such pits have been opened near Waterdown, York, Brooklin and Quay's, for example.

The importance of the old shore to towns and cities is well shown by the fact that many of them are planted on the well-drained gravel bars or the flat terrace of the old beach, St. Catharines, Hamilton and Toronto all occupying this position. The clay flats of old bays or lake slopes are used in many places for brick-making, the shallow water sand deposits are used in making mortar and cement and the shore gravels serve as road metal and for concrete. How serviceable these materials are may be seen from the immense excavations in the old gravel bars at Hamilton, and at Toronto Junction and York, where similar bars provide sand and gravel for use in the city. The red brick burned at Hamilton are made from the clay beds of Iroquois age to the west of the city in what was shoal water of Dundas Bay.

The old beaches of Iroquois levels to the northeast are too high up on the flanks of the great moraine (the Oak Ridges) to be of much use for railways and towns, but almost everywhere they are employed for local roadmaking and other purposes.

Lower Water Levels

When the great ice sheet withdrew from the northern flanks of the Adirondacks so far as to give a lower outlet eastwards than that through the Mohawk valley, the water fell successively to lower and lower levels, indicated, as shown by Dr. Gilbert and Professor Woodworth, by terraces and spillways where the drift has been scoured off to the solid rock by the rush of water between the ice front and the northern slope of the mountains. It is not likely that any of these halts were of long duration, but some of them seem to have been long enough to permit the cutting of terraces or the formation of beaches in the Bay of Quinte region. Later the ice withdrew so far to the northeast that the upper St. Lawrence and Ottawa valleys were free. There may have been a low level lake dammed by ice in the lower St. Lawrence, and emptying by the Champlain valley into the Hudson, as thought by Mr. Warren Upham, but no beaches have been certainly connected with it in Ontario.

Later still the St. Lawrence valley was wholly cleared of ice, and the sea entered it as an enlarged gulf of St. Lawrence, reaching past Montreal and expanding as a wide sea from the Ottawa above Pembroke to a point west of Ogdensburg in New York State.

The land stood so low at this time that sea level rose perhaps 100 feet above the surface of the present lake Ontario, and one would expect to find salt water beaches in the Ontario basin, but no marine shells have been found west of Brockville, so that we may suppose that the Niagara and other rivers sufficed to keep this great body of water fresh. The marine deposits of Ontario have been described previously (25), but part of the ground has since been covered more carefully and the results of the examination will be given here.

No distinct beaches lower than the Iroquois have yet been found in the western part of the Ontario basin, and

(25) Bur. Mines, 1901; Sea Beaches of Eastern Ontario, pp. 215-227.

the first clear evidence of water levels above the present lake are found near Port Granby, an old lake port between Newcastle and Port Hope.

Port Granby to Trenton

South of Newtonville, where a stream enters lake Ontario, a small terrace, probably wave-cut, shows at 28 feet above the lake or 274 feet above the sea, hills of boulder clay rising on each side, and the present shore cliff shows some stratified gravel overlying boulder clay. A mile or two east another terrace occurs at Port Granby, where a stream comes in. The present storm beach rises five feet above lake Ontario; the flat terrace at the postoffice is 28 or 29 feet above it and a stream terrace a little to the north rises about five feet higher or 280 feet above sea level.

Three and a half miles east of Port Granby where a bay-like depression parts the hills of boulder clay a gravel bar 18 feet above the lake runs a little north of west and south of east, evidently representing a still lower stage of water. From this point east to Port Hope no beach formation was found. In the town itself a clay flat 30 feet above the lake is possibly a terrace, and a higher flat at the foot of the drumlin on which Trinity School stands may be another, but both are too indefinite for certainty.

Similar beaches to those near Port Granby occur again east of Cobourg, a boulder pavement ending 23 feet above the lake at the foot of a low shore cliff. A little north an old island is largely covered with gravel bars, the highest 52 feet above Ontario or 298 feet above the sea. Still farther north and a quarter of a mile beyond the Grand Trunk railway, a clay flat ends abruptly in a well-marked shore cliff cut in bouldery clay hills, at about 330 feet above the sea (aneroid) and with few interruptions this shore can be followed to Grafton, where a little south of the village the height is 330 feet as found by hand level.

East of Grafton also gravel bars occur at lower levels,274 and 295 feet; and a mile west of Lake Port, near Colborne, there is a very well-defined gravel bar more than half a mile long with a front slightly convex toward lake Ontario, but a general east and west direction. This bar is 50 or 60 feet wide, and ascending from the present lake shore one finds a boulder pavement up to 23 feet, a lower bar up to 31 feet, and the highest rising to 50 feet.

Near the village of Colborne, but somewhat to the west the clay flat with shore cliff seems to run out, and gentle hills project southward as a vague promontory. To the east there are sand hills interfering with the tracing of the beach, but just east of Brighton, it once more becomes distinct with a high shore cliff against hills of boulder clay at a level of 334 feet above the sea, or 88 feet above Ontario. From this to Trenton the shore is well-defined.

Near Trenton

Near Trenton the beach levels suddenly become more numerous and better defined, probably because the body of water whose waves did the work was greatly widened toward the east. At the central Ontario railway station near the bay of Quinte a wide gravel bar runs northward at a level of 26 feet above the bay, which is the same as that of lake Ontario; and on the flanks of the great esker which forms so conspicuous a ridge to the northwest of the town, there is a pretty well-marked gravel terrace rising 78 feet above the bay. A sharply defined cut terrace at the southeast end of the esker stands 135 feet above the bay, and runs as a narrower shelf along each flank of the ridge, which rises to 190 feet at the highest point.

To the north of the Grand Trunk station at Trenton esker-like sand and gravel ridges rise as islands from the lowest flat, almost certainly a water level, and a gravel bar near a shore cliff at the Roman Catholic cemetery is 42 feet above the Trent river at the level of the bay.

Where the wide valley of the river Trent escapes from the morainic hills a series of terraces rises above it on the west side, the lowest 31 feet above the level of the bay, the second, which is also the best formed, at 55 feet, while a less defined terrace reaches 81 feet. The top of a stony ridge just above is flat, and may also represent a water level at 127 feet, but this is doubtful. The terrace at 55 feet (301 feet above the sea) is repeated at the same level by a broad gravel plain east of the river, and a cut bank south of the railway bridge shows a few feet of stratified gravel overlying shaly Trenton limestone.

It has been noted by former students of the region that the valley of Trent river is a misfit, being far too large for the present stream, and this has been explained by supposing that the waters of the upper lakes once discharged in this direction before the upward tilt of the region toward the northeast forced them into their present circuitous course by lake Erie and Niagara Falls.

East of the Trent the old shore, which is fairly constant from Cobourg to Trenton, could not be traced farther, though hills of boulder clay rise high enough to receive it not far from the river. Nor has it been traced with certainty north of Belleville, though something like a boulder pavement at 377 feet above the bay is found about a mile north of the city. About ten miles to the north a gravel pit near the Belleville and Peterborough railway stands at 140 feet above the bay or 386 above the sea. The two elevations just given were determined by aneroid, the previous ones by hand level.

Prince Edward County

Crossing the narrow isthmus, now cut by the Murray canal, which transforms the Prince Edward peninsula into an island, low land follows, partly formed of gentle swells of till, partly of the greatly decayed surface of the shaly Trenton limestone; and it is not until Wellington is nearly reached that clear evidence of old wave action is found. Here a well formed bar more than a mile long runs parallel to the present shore, but at a height of 91 feet above it. It was apparently formed in the same way as the present long bar stretching across the mouth of a swampy bay to the east of the village, connecting it with the interesting series of sand dunes on the opposite shore. The "sand banks," which rise 50 or 60 feet above the lake, are a favorite and picturesque resort for parties from Wellington and Picton.

East of Wellington the tableland of Trenton limestone so characteristic of Prince Edward county rises, often as a steep escarpment with nearly level top, and at its southeast end, where it approaches the shore of lake Ontario at Waupoos and Top of the Rock, good beaches are found at several levels. At the former village, which lies between the cliff and the shore, a boulder pavement begins at 50 feet above the lake and slopes upward to 68 feet, beyond which is a gravel terrace with fairly well rounded stones at 78 feet, another gravel bar at 90 feet, and another good bar at 94 feet. There may be a fourth at 113 feet, but the evidence is rather faint. There is a lagoon between the second and third bars, and they are formed of pebbles as well-rounded as those of the present beach.

Near the Top of the Rock, two or three miles to the west, terraces or gravel bars occur at 39 feet, 49 feet, and 73 feet, the last with a low limestone cliff in the rear

On the bay of Quinte side of Prince Edward county much of the shore is formed of sheer limestone cliffs rising from 150 to 200 feet above the water; but near some of the bays terraces may be seen, as west of Cressy, where a well-defined sand terrace stands at 42 feet, with a doubtful water level at 57 and a good beach line and bar at 83 feet. The top of the cliff here rises 192 feet above the bay of Quinte.

At Glenora, where flour mills and foundries are run by water power from the Lake on the Mountain, terraces are seen to the west of the mills, which are at the foot of a vertical cliff, in a bay-like recession of the escarpment. The lowest, which is poorly marked, is at 16 feet, the second, also poorly defined, at 55 feet, and the highest, which is well cut at the foot of the cliff, is at 62 feet.

The Lake on the Mountain appears to be a rock basin, since its outlet is over the limestone of the cliff. Its surface is 176 feet above the bay of Quinte, and its depth is said to be 98 feet at the deepest point. It is about three miles long and three-quarters of a mile wide, with a drainage basin of about four square miles, the rocks rising 30 or 40 feet above it to the south. The stream flowing from it, as might be expected, is very small, but the great height of the fall, 175 feet, makes it of some importance, since the four small turbines of four to six inches diameter generate 200 horse power. It is said that 60 feet off shore at the mill the bay of Quinte is 100 feet deep, and not far out a depth of 150 feet is reached, so that the real height of the cliff is much greater than its apparent height. To the north an almost continuous cliff rises beyond the bay leading toward Picton and stretches most of the way to Deseronto.

Beach levels were looked for between Glenora and Picton, but only one was found, at 135 feet above the bay; a more careful search may disclose lower beaches however on the drift-covered hill-sides of the narrow valley.

Prince Edward is one of the most interesting counties in Ontario in some respects, formed as it is of two flat tablelands rising in steep precipices above the bay of Quinte on the north and lake Ontario on the south, with however a large area of quite low ground toward the west from Wellington to the Murray canal. A narrow valley separates the two blocks of high land, running between Picton and Wellington, and at the higher water levels described above the two plateaus were islands. In spite of the tableland character of much of the county it nowhere rises to a greater height apparently than 220 or 240 feet above the adjoining waters, and during the time of lake Iroquois it was deeply submerged.

Belleville to Gananoque

On the north shore of the bay of Quinte there has been no success in the search for beaches, though a number of promising localities were examined. Near Napanee hills rise to 407 feet above sea level, or 261 feet above the bay, with boulder clay in many places of fair thickness, but nowhere was a beach discovered. There are stratified clays covering stratified sand and rising 21 feet above Napanee river, which is at the level of the bay below the town, but no higher terraces are to be found. East of the river above its fall at the town there are flats that somewhat suggest water levels, but these are almost certainly caused by horizontal beds of the limestone exposed in a quarry near by. As there would be a a wide sweep for waves from the south against this hill, one would expect to find beaches there.

The next point examined for old beaches was Kingston and its environs; but near Bath, while passing by steamer, one observes what may be a terrace with shore cliff east of the village. The hill near the fort east of Kingston rises nearly 130 feet above the lake, with some boulder clay, but shows no evidence of the lower beaches. However, the amount of drift is small, the rock consisting of Laurentian granite capped with limestone and coming near the surface in most places. The hills three or four miles north of Kingston rise still higher, but were not explored.

Still to the east the region near Gananoque was carefully searched for beaches, almost every hill rising high enough to take the upper beaches having been visited, but without result, though there should have been a wide stretch of water to the south. It should be noted, however, that most of the hills consist of rock without much drift. Near Marble rock, a few miles up Gananoque river, there are slopes of stony till resting on hills of quartzite and granite, which might be expected to record wave action if there had been upper water levels of any duration, but nothing of the kind was seen.

In the lower ground there is a broad, nearly flat plain of clay, forming good farming land to the east of the Thousand Island station on the Grand Trunk, much suggesting a water level; but occasionally a gently rounded surface of Laurentian shows through it, and more often flat-lying standstone crops out, so that apparently the level surface of the plain is largely due to this and not to pleistocene water action. Lower down there is some stratified sand toward the west end of Gananoque rising as a cliff 46 feet above the St. Lawrence, which is still practically at the level of lake Ontario. Sand hills a few miles west of Gananoque have the appearance of kame deposits of glacial and not wave formation.

East of Gananoque

The region east of Gananoque as far as Brockville and north to Athens and Delta was traversed in numerous places with results no more conclusive than before. The only probable water level is a continuation of the clay plain near Gananoque past Lansdowne and Mallorytown; but here also the level surface is probably due to flat beds of sandstone or limestone, which occasionally crop out as a low escarpment. The higher hills are usually of rock, though sometimes morainic.

Exploration near Smith's Falls and Perth was equally unsuccessful, though kame-like deposits exist at the former place.

As marine shells occur at Brockville, the region surrounding the town was more carefully explored, but without finding any well-marked raised beaches. The shells, which seem to be small macomas, are found in the stratified clay worked for brickmaking just north of the Grand Trunk railway. The clay rises to 285 feet above the sea, or about 40 feet above the St. Lawrence, and seems to have been deposited in a narrow bay running up the valley of the creek, with a promontory of boulder clay hills, on which the higher part of the town stands, rising 100 feet higher and projecting eastwards.

Similar stratified clay, in which, however, no fossils have yet been found, is exposed by the creek at Lyn 3 or 4 miles west of Brockville. The drumlin hills north and west of the town were not found to be terraced, and the higher hills near Lyn and north of that place showed no signs of lake or marine action, though there are structural plains caused by flat limestone or sandstone capping the irregularly rounded summits of the Laurentian. There is stratified sand on the shore of the St. Lawrence at a cemetery west of Brockville, but no shells were found there, and the sand rises only 20 feet or so above the water, with no suggestion of a terrace.

East and northeast of Brockville marine deposits with numerous shells have been found at many points, as noted in a former paper, and it was thought well to re-examine the points nearest to Brockville. Near Maitland a gravel ridge or bar south of the Grand Trunk railway, containing fragments of marine shells (macoma), was leveled once more and found to rise 331 feet above the sea, instead of 350, as determined formerly by aneroid. The shell pockets in the Gladstone gravel pit a few miles farther east, not for from Prescott, were examined again, and their level determined as 320 feet above the sea, confirming the aneroid work done in former years.

Old Beaches in New York

As the search for raised beaches on the north shore of the St. Lawrence met with so little success, some attention was paid to the south shore also, and with better results. The Canadian islands east of Kingston scarcely rise high enough to record any but the very lowest beaches, and on Howe island, the only one studied, little of interest was found. Well stratified clay rises as a low cliff near the east end, but without any distinct beach level, and the thin boulder clay on higher parts showed no sign of water action. A few isolated hills of Archaean rocks rise through the Trenton limestone forming most of the surface, one reaching 126 feet above lake Ontario, but too bare of drift materials to preserve much record of wave action.

On Grindstone Island, south of Gananoque, and just south of the international boundary, rolling hills of till give better opportunities for wave action. and here well-formed gravel beaches occur at 125 and 140 feet above the river. Morainic hills west of Clayton scarcely rise high enough for the highest of these beaches, but stratified gracel occurrs on top at about 132 feet above the St. Lawrence. At lower levels there are stratified clays with sand beneath rising 41 feet above the river, and similar materials are found in cuttings made by a creek to the south of the town, with a clay plain at 63 feet. Near Lafargeville, six or seven miles to the southeast, morainic hills show good gravel bars and beaches facing northwest at 204 and 209 feet, and less certainly at 262 feet above the St. Lawrence.

Near Ogdensburg, opposite Prescott, flat delta deposits, mainly of sand, rising 36 feet above the river, contain numerous marine shells, chiefly large macomas. though saxicava and cylichna were found also. At Norwood, N. Y., 24 miles east of Ogdensburg, marine shells are found in stratified gravel 115 feet above the St. Lawrence, or about 360 feet above the sea. A well-formed gravel beach occurs on a morainic hill northeast of the town at a slightly higher level.

I am under great obligation to Dr. Merrill, Director of the Geological Survey of New York, and to Professor Woodworth of Harvard University, for providing the opportunity to visit these old beaches and others in the Lake Champlain region, farther to the east.

As the scourways north of the Adirondacks, where the waters rushed past the edge of the ice during its slow retreat, determined the levels of the lake behind, it is evident that they must have controlled the series of beaches lower than the Iroquois level and above sea level, but Professor Woodworth's report must be awaited for detailed connections between them. He is of opinion that the higher beaches were formed at successive stages of the freshwater lake, and the lower ones formed by the sea, and this must be accepted as highly probable. It is, however, not easy to determine just which level should be looked upon as representing the highest marine beach.

Thousand Island Straits

In confirmation of this view we have the negative evidence from the north side of the St. Lawrence, where no well-defined beaches of any description occur, so far as observed, between the Bay of Quinte and Brockville. Is not this accounted for by supposing the region to have been occupied by ice while the beaches in New York were being formed ? If this explanation is accepted it may be connected with the similar lack of beaches belonging to the higher Iroquois series to the north and east of West Huntingdon. It is even possible that the ice still held the hills north of Lyn and Gananoque after the salt water had reached the present Thousand Island region, though it is evident that there was open water surrounding Grindstone island. If the limit of marine shells represents also the highest level of the sea when the Thousand Island straits were first opened by the withdrawal of the ice, the water stood 86 feet above the present river at Maitland and 115 feet above it at Norwood, N. Y.. 33 miles away in a direction a little north of east. The difference seems rather large however, to be due to differential elevation toward the northeast. At Gananoque 35 miles to the southwest the elevation would be less than at Maitland, perhaps not more than 50 or 60 feet above the St. Lawrence, and may be represented by the stratified clay forming plains near Clayton.

If this assumption is correct the strait at Gananoque and Clayton was less than twice as wide as the St. Lawrence is now, and allowing for clay eroded from the river channel since the marine period, not more than 20 or 30 feet deeper than the present channel. At Lyn near Brockville the strait was still narrower, but its shore on the New York side is not exactly known.

It may be considered doubtful however if the upper limit of sea shells really represents the highest sea level in the straits, although the shell beds referred to are of coarse materials, gravel or sand, which could not have been formed in deep water. If the gravel beaches on Grindstone island, in which no shells have been found, are of marine formation, the water level must have been 140 feet above the St. Lawrence, and allowing for erosion of clay by the present river, the depth of water must have been at least 100 feet greater than now. How wide the straits were at the time is uncertain, since ice probably occupied the north shore as far west as Gananoque and perhaps as far as Napanee, but the straits can hardly have been less than 7 or 8 miles wide.

As the ice abandoned the region of the Ottawa and St. Lawrence valleys and the low land between, the sea followed up its edge, its first level being undoubtedly above that of lake Ontario at its northwestern end, but probably considerably below its level at the southwestern end, owing to the difference in altitude of the land to the northeast at the time. Though the water of the Ontario basin stood at sea level it was apparently kept fresh by the rivers which flowed into it, especially Niagara.

As the land to the northeast rose the sea withdrew until the Ontario basin was cut off from the gulf of Eastern Ontario, and the St. Lawrence river began to flow at the Thousand Islands. As suggested by Dr. Spencer, the valley was floored at first with boulder clay and later stratified materials, but these were gradually removed to form the present channel, which is mainly rocky but of an accidental character, the river practically having done no cutting into its present bed of Archaean and Cambro-Silurian rock.

The lowest beaches and terraces in the Bay of Quinte region may have been formed before the drift materials of the Thousand islands were swept off by the river.

As soon as lake Ontario was cut off from the sea, the continued differential elevation toward the northeast caused the backing up of its waters at the opposite end, so that now there are 60 or 70 feet of water in the Niagara river near its mouth and about the same depth in Hamilton bay within the Burlington barrier beach.

Summary

The succession of events in the retreat of the last ice sheet (Wisconsin sheet) may be summed up as follows, paying special attention to water levels in the Ontario and St. Lawrence valleys :

1. Retreat of the ice front to the Oak ridges moraine set free the basin of lake Ontario and drained off lake Warren ; but the St. Lawrence valley from Havelock to Watertown in New York was still blocked with ice, so that the overflow from lake Algonquin, occupying the basins of the three upper lakes, was impounded as lake Iroquois, which had an outlet past Rome, N.Y., into the Hudson. The northeastern part of the continent stood lower than at present, so that the water level at the southwest end of lake Iroquois was perhaps below the present level of Ontario, while the northeast end near the ice front is now more than 500 feet higher. The Rome outlet was above sea level, however.

2. Differential elevation in a direction N. 20 degrees E. took place during the existence of lake Iroquois until at its close the water level was 116 feet above the present lake Ontario at the southwest end, but had sunk to 440 feet at the northeast end; a line drawn from Rome to Quay's, north of Port Hope, being the fulcrum about which the swinging took place.

3. The ice dam in the St. Lawrence valley so far melted that water could escape past its front against the northern flank of the Adirondacks, and the level of lake Iroquois rapidly sank. The Rome outlet was abandoned, and the drainage took place northeast at successively lower levels past the Adirondacks, first through lake Champlain to the Hudson, afterwards to the gulf of St. Lawrence.

4. The partial or total disappearance of the ice dam left the St. Lawrence channel, 330 feet or more lower than at present and at the level of the sea, but the influx of fresh water from the upper lakes and the narrowness of the

strait near Brockville and Gananoque kept the water fresh, so that marine animals went no farther west than Brockville.

5. Continued rising toward the northeast at length raised the St. Lawrence channel at the Thousand islands above sea level, and the present river began to flow, lake Ontario being cut off from the gulf of St. Lawrence, but with its basin at such a tilt that the water at the southwest end was probably 70 feet lower than at present; while at its outlet it was probably at least 20 or 30 feet higher than now, because of the clay deposits not yet excavated from its bed.

6. The St. Lawrence cut down its channel through the soft drift materials to bed rock in most places, lowering lake Ontario to its present level at the outlet. Gradually the elevation toward the northeast backed up the water at the southwest end of the lake, and this process is still progressing, causing dead water at the mouths of all the rivers entering that end of the lake.

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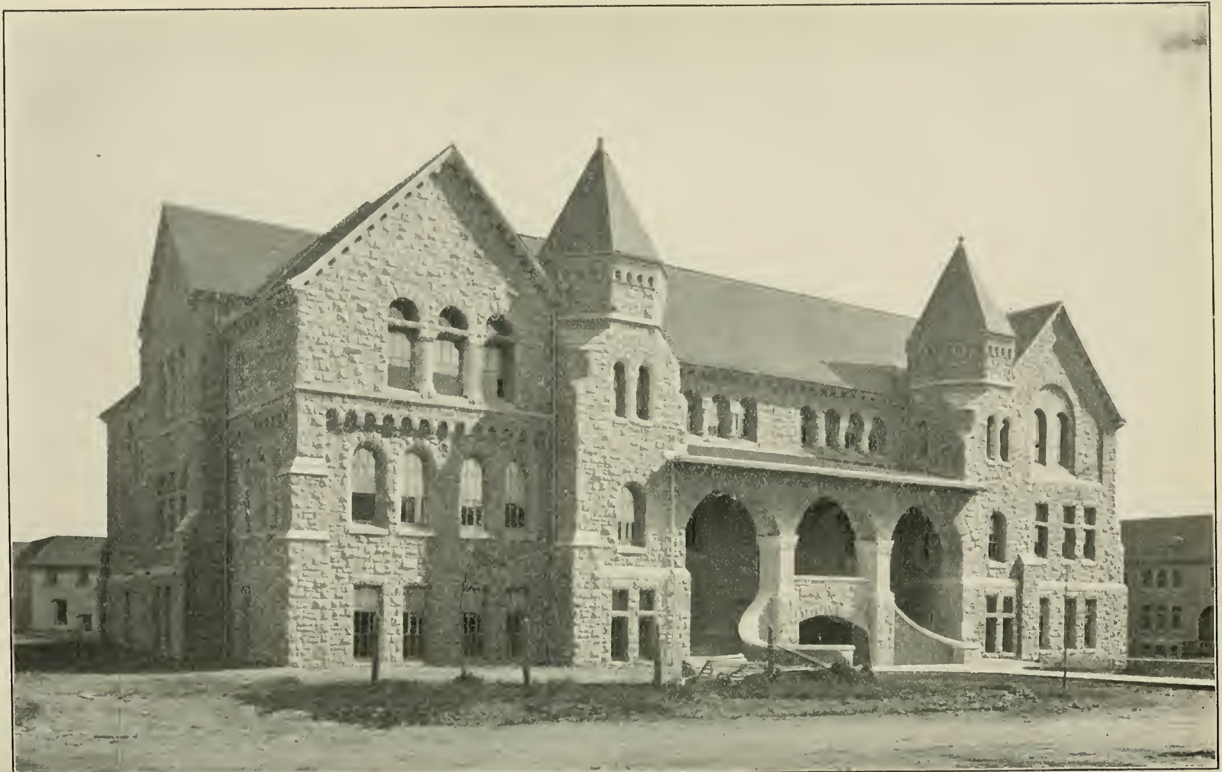

Geology and Mineralogy building, School of Mining, Kingston; built of Kingston limestone.

REPORT OF
THE BUREAU OF MINES, 1904
PART II.

THOS. W. GIBSON, Director

The Limestones of Ontario

BY

WILLET G. MILLER, Provincial Geologist

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PREFACE

In the following Report on the Limestones of Ontario an attempt has been made to give a brief account of the present uses of limestone and lime, but the object chiefly sought is to show where limestones of various chemical compositions are to be found. For convenience in reference and to assist those who are in search of raw materials of particular kinds the limestone localities in the Province have been arranged under the headings of counties and districts. If attention is paid to what is said on a following page concerning the characteristics of certain limestone formations, the searcher for stone of a special chemical composition, after referring to the map on page 23, will have little difficulty, by merely reading the report, in locating areas in which suitable outcrops are to be found. Details can be gained by field work.

Although the report contains only one hundred and twenty-six pages, its preparation has entailed much labor. Literature, published during the last sixty years on the limestones of the Province, and special treatises and reports on other countries, have had to be consulted. The report contains over two hundred and sixty extracts from papers by various writers.

Since the preparation of the report was begun, two or three industries, which use limestone or lime as a raw material, have come more prominently before the public. Among these are "sand-lime brick" and "hydrated lime." Even at the present time it is difficult to get much reliable information on these industries.

HYDRATED LIME

In the manufacture of hydrated lime sufficient water is added to quick lime to satisfy its chemical affinity for water. The equation which represents the union of the two substances is:—CaO (quick lime) + H_2O (water) = $Ca(OH)_2$ hydrated lime. In other words water is added to take the place of the carbon dioxide which has been expelled on the burning of the limestone to quick lime, as shown by the following equation:—

$CaCO_3$ (limestone) = CaO (quick lime) + CO_2 (carbon dioxide gas).

It is a well known fact that quick lime gradually slakes on exposure to the air and passes back into calcium carbonate, $CaCO_3$. It is found that hydrated lime. $Ca(OH)_2$, does not exhibit this tendency to take up carbon dioxide, and that its strength is not lost when it is kept in storage under ordinary conditions.

In order to know what percentage of water should be added to a given mass of quick lime to produce hydrated lime, it is necessary to know the percentage of lime (calcium oxide) and magnesia (magnesium oxide) in the quick lime. Theoretically, 56 parts of calcium oxide require 18 parts of water, and 40 parts of magnesia require the same amount. A ton, 2,000 lb., of quick lime which contains, for example, 60 per cent. of calcium oxide (lime) and 35 per cent. of magnesia will require:—

$$\left(\tfrac{18}{56} \times \tfrac{60}{100} \text{ of } 2{,}000\right) + \left(\tfrac{18}{40} \times \tfrac{35}{100} \text{ of } 2{,}000\right) = 385.7 + 315 = 700.7 \text{ lb.}$$

of water.

On account of the fact that heat is generated in hydrating lime, more or less water is evaporated during the process. Hence it is necessary, if water is added in the open, to add more than the theoretical amount. Lime high in calcium oxide will generate more heat during the process of hydration than lime made from dolomite.

Of course if more water is added to quick lime than is required to form hydrated lime, the product will tend to become pasty. On the other hand sufficient water should be added to avoid the chance of some of the quick lime not being hydrated.

The stages in the manufacture of hydrated lime used in one factory are: (1) Grind quick lime to state of fine division; (2) Add water; (3) Put in agitator and thoroughly mix; (4) Put in bins and allow to cool for a few days; (5) Draw off and sift. It may be added that in the last stage instead of using extremely fine silk screens for sifting or bolting as formerly, air separators are now used in some factories.

Hydrated lime is used in the same way as quick lime for any of the purposes to which the latter is applied. Being in the form of powder it can be mixed dry with other materials and thus has some advantage over quick lime. It is easier to handle than the latter, as it can be shipped in bags like cement. It would appear that the uses which are being found for it are likely to considerably enlarge the consumption of quick lime from which it is made. The two substances are sold at about the same price, the water in hydrated lime counter-balancing its greater cost of manufacture.

In addition to its employment in mixtures for dry mortar, which is ready for use on the addition of water, hydrated lime seems to have a large field as a substance suitable for mixing with Portland cement. Mixtures of the two sell at a lower price than pure Portland cement, and it is claimed that when equal amounts of the two are mixed together they produce a mortar of any strength required under ordinary conditions. Such a mortar is said to work smoothly under the trowel, and to give greater spreading qualities than the ordinary variety, thus accelerating brick-laying and similar work. The use of lime in cement is believed to render the finished work more water proof.

SAND-LIME BRICK

Since the manufacture of sand-lime brick appears likely to become a very important industry within a few years, in which case it will consume a large quantity of lime, it will not be out of place to give a brief account of the process of manufacture.

The raw materials used are sand and lime. These are well mixed together, moulded, and hardened by being subjected to the action of steam under pressure. This variety of brick should not be confused with what is known as silica-brick. The latter is used for refractory purposes and is also made from sand and lime, but comes more properly under the head of vitrified brick, since, in the process of hardening, the lime and part of the sand are fused together, producing anhydrous calcium and magnesium silicates. In the production of sand-lime brick on the other hand, the lime and part of the silica unite to form hydrated calcium silicate, and closely related compounds.

In the manufacture of silica-brick about three per cent. of lime is used. while in the sand-lime variety the percentage employed is from 5 to 10.

Any lime can be used in the manufacture of sand-lime brick, but fat limes or those high in calcium oxide are preferred to those containing much magnesia. Hydrated lime is being extensively used. Almost any variety of ordinary sand can be used, but there should be a certain percentage of very fine particles.

It is said that the first experiments in the manufacture of bricks from sand and lime were made at Potsdam, Germany, a little over thirty years ago. The city is situated in a region in which clays and building stone are scarce, but is surrounded by sand plains. Hence attention was attracted to sand as a source of building material. The bricks were first hardened by simple exposure to the air, a process which required several months but produced good bricks. About 1880 the discovery was made that the freshly pressed bricks of sand and lime could be hardened in a few hours by steam under pressure. Since then the industry has reached large dimensions in Germany. It is only within the last three years that it has received much attention in America. The majority of the seventy-five or more manufacturers in the United States began production in 1904. Plants are in operation in about thirty states. Companies have been incorporated in Canada, at Brandon, Ottawa and Montreal.

The rapid growth which the industry has made in Germany and in the United States is shown by the following: In the former country there were five factories in operation in 1896. In 1903 the number had risen to about 200, with an annual output of between 350,000,000 and 400,000,000 bricks. Within about three years from the time the first factory was erected in the United States seventy-five or more were in operation.

The natural color of sand-lime bricks is white or gray, but they can be produced in any color desired by adding pigments to the raw material before it goes to press

In sections of the country where sand is plentiful and brick clays scarce, sand-lime bricks, it would appear, will be the building material of the future. The fuel cost is comparatively low.

SLAG CEMENT

Slag cement, produced from blast-furnace slag, is becoming an important competitor in some parts of the world with Portland cement. The two materials possess similar properties, but the former is produced at a much lower price than the latter.

GENERAL NOTES

From what has been said in the above paragraphs it will be seen that constant and very rapid changes are in progress in the industries which use limestone or lime as a raw material. A report such as this one on the Limestones of Ontario soon gets out of date so far as the information concerning industries is concerned. The data on the character and distribution of raw materials have a more permanent value.

No attempt has, however, been made in the following pages to give details concerning processes. The man who desires to keep abreast of the times in regard to the particular industry with which he is connected should subscribe for and read some reliable technical journal. Such publications dealing with almost every industry are now to be had.

Since the report was written an international committee, appointed by the Geological Surveys of the United States and Canada, on pre-Cambrian nomenclature, has decided on a new classification. Among the changes proposed is the use of the word Laurentian in a more restricted sense than formerly. The name is now to be applied only to granites and gneisses of pre-Cambrian age, and does not cover the crystalline limestones of the Grenville series, which are called Laurentian in a few places in this report.

As some of the analyses of limestones in the report are given in terms of the carbonates of calcium and magnesium, and others give the percentages of lime, or calcium oxide, and magnesia together with carbon dioxide, it may be well to state, for the benefit of those who do not possess a knowledge of chemistry, the method of determining what amounts of the carbonates the percentages of the oxides represent and vice versa.

The percentage of calcium carbonate in a limestone is equal to the percentage of lime, or calcium oxide, multiplied by 100 and divided by 56. For example, a limestone which contains 54 per cent. of lime contains $54 \times \frac{100}{56} = 96.4$ per cent. of calcium carbonate. On the other hand, a limestone with 90 per cent. of calcium carbonate contains $90 \times \frac{56}{100} = 50.4$ per cent. of lime.

To change the percentage of magnesia or magnesium oxide to magnesium carbonate, multiply by 84 and divide by 40. A limestone containing 20 per cent of magnesia has $20 \times \frac{84}{40} = 42$ per cent. of magnesium carbonate. A rock with 30 per cent. of magnesium carbonate contains $30 \times \frac{40}{84} = 14.2$ per cent. of magnesia.

W. G. M.

REPORT OF
THE BUREAU OF MINES
1904

Vol XIII | Part II

Thos. W. Gibson, Director

Limestones of Ontario

By Willet G. Miller

During recent years the Bureau of Mines has received frequent inquiries as to whether limestones of suitable quality for various industries, in which these rocks are now being used, were to be found in the Province. There being no systematic description of our limestones, it has often been difficult, or even impossible, to satisfactorily answer these inquiries. Many analyses of Ontario limestones have been made during the last fifty or sixty years, but the descriptions of the quarries and outcrops are scattered through many reports, and are thus accessible with difficulty to the public. The writer accordingly undertook the preparation of the present report. As he has been able, owing to duties in connection with other mineral industries, to give only a part of his time during the past season to field work on the limestone areas, it has been found impracticable to visit certain of the important localities. In order, however, to give some account of the limestones of all parts of the Province, copious extracts have been made from the Reports of the Geological Survey of Canada and other publications, many of which are long out of print.

The chemical composition of the samples collected has been determined by Mr. A. G. Burrows, analyst to the Bureau.

It is hoped that the collection of analyses and descriptions herewith presented will serve in some measure at least to fill the need that has existed for information on this division of our mineral resources.

Value of Limestones.

Many States of the Union and other countries have published elaborate reports on limestones and the industries in which they are used as raw materials. In Ontario few of our people yet realize that limstones form an important part of our mineral resources. The writer, while in the field during the past summer, felt that many persons misunderstood the nature of his work. Limestone to them was common rock and nothing more, recalling Wordsworth's lines:—

"A primrose by the river's brim
A yellow primrose was to him
And it was nothing more."

When one is seen breaking off samples, "pounding the rocks," many persons think that he must be after gold or some other precious metal. It is not realized that during recent years a number of important industries have either come into being or have been perfected which depend on limestone as a base. A good limestone deposit, if favorably situated, may be of as much benefit to a community as a metal mine.

The State Geological Surveys of both New York and Michigan have published important reports on limestones. The report of the former State is by Dr. Heinrich Ries, and is entitled "Lime and Cement Industries of New York." An interesting account of the marls of Michigan is given in the seventh volume of the Survey Reports of that State. Since the limestone formations in these two States are so similar to most of those of Ontario, the two reports mentioned are of much value to us.

Uses

Although the quantity of rock used in some industries is not in itself of great money value, still it is impossible for certain works to be established in a locality where limestone of suitable quality cannot be obtained at a satisfactory price.

Industries that were not dreamed of twenty years or less ago are now firmly established. One of these is the manufacture of calcium carbide, which has developed into a world-wide industry. Ten years ago the manufacture of Portland cement was but a business almost unknown on this continent. It has now become one of the greatest in America. In Ontario much capital has been invested in it, and well-situated deposits of marl and limestone are eagerly sought for. Then, within the last two or three years several beet-root sugar factories have been built in the Province. These require lime of a very pure quality. Our wood-pulp industry is also a growing one, and it is believed that it will in time add much to the wealth and prosperity of our population. The sulphite pulp process requires a limestone high in magnesia, of quite different character from that used in the manufacture of beet-sugar. Our smelting industry is also becoming greater yearly, and limestone suitable for certain smelters sometimes has to be sought for at a distance, e.g., limestone occurring near the town of Renfrew has been found to be of the quality required at Sudbury, and has been quarried and shipped thither. In the varied industries in the vicinity of Sault Ste. Marie limestones of three or four kinds are required. One quarry has been operated on an island in Georgian Bay and two others were purchased in the State of Michigan. If we had had a fairly complete knowledge of the limestones situate adjacent to the Ontario shore of Lake Huron, it is probable that it would not have been necessary for the company to go out of the Province in order to find this part of their raw materials. It is believed that this Province has vast undeveloped iron deposits. Some of these are situated within easy access of the great lakes, and the ore can be shipped without difficulty. Other deposits lie at such a distance from water routes that if they are to be worked the ore will have to be smelted on the ground, and the fuel must be charcoal. In reducing wood to charcoal, valuable by-products are formed. One of the most important of these is acetate of lime. In the preparation of this material a pure lime is required. Thus it is seen that, in the manufacture of charcoal iron, limestone is required, not only for smelting the ore, but also in the preparation of one of the wood distillates. As there are very few occurrences of ordinary solid limestone in some of the more remote northern parts of the Province, it would seem that some of the marl deposits in lakes and marshes are likely to become of economic importance.

It is easy to demonstrate that limestone plays a very important part in the industrial economy of any nation. Having in abundance raw materials or unused resources in connection with which for many purposes limestone is required, or can be profitably employed, especially timber, iron ore and water power, our limestones should be considered as being among our valued assets. An accurate knowledge is required of them for use in those industries which are capable of great expansion in the Province.

At the present time the value of the products of three or four of our industries in which the rock plays an important part, represents about 20 per cent. of our total annual mineral production of over $13,000,000. Limestone has as great a bearing on the wealth of other countries.

The following is a list of manufactures and industries—arranged in alphabetical order—some, of course, consuming only a small amount of lime, in which limestone is used as a raw material: Acetate of lime, agricultural uses, ammonium sulphate, beet sugar, bone ash, building stone, calcium carbide, carbon dioxide, cement (natural and Portland) chalk, chloride of lime, as a dehydrating agent, disinfectant, in dyeing, gas manufacture, glass, furnace linings, lime for mortar and whiting, lime pencils used in the oxyhydrogen light, lime water, lithographic stone, marble, as a polishing material, potassium dichromate, pottery glaze, for preserving eggs, etc., pulp and paper making, as a chemical reagent, silicate brick, smelting of iron, lead, etc., soap, soda manufacture, tanning.

It would be impossible to treat fully of these uses in the space available in a report of this character. An attempt will, however, be made to give information of a general nature, adapted to the needs of those who may desire to learn to what use certain materials can be applied. The technical man or specialist in lime, cement and other industries has much valuable literature available among the numerous treatises which have been published during late years. This report, it is hoped, will be of value to the specialist in informing him where he can procure in the Province limestones of various qualities.

The following contractions are made in the references to previous publications, viz. : G.S.C., Report of the Geological Survey of Canada ; B.M., Report of the Bureau of Mines, Ontario ; Roy. Com.. Report of the Royal Commission on the Mineral Resources of Ontario, 1890.

Acetate of Lime

In the preparation of this material, from one of the distillates produced in the manufacture of charcoal, it is desirable to have as pure a lime as is obtainable. Magnesia and other materials serve no purpose, except to add to the weight of the acetate of lime and thus increase the cost of freight and handling when shipment is made to works where the acetic acid is extracted from the compound. It is likely that much charcoal will be produced in this Province, where coal is lacking for metallurgical and other uses, so that it becomes important to know the location of deposits of limestone adapted to this use.

There are already four charcoal plants in Ontario—at Sault Ste. Marie, Longford Mills, Fenelon Falls and Deseronto. At the first and last-mentioned places the charcoal is consumed chiefly in blast furnaces.

Suitable limestones for making acetate of lime occur in the Trenton group, and in the Corniferous ; certain crystalline limestones of the Laurentian system also possess the right chemical composition.

Agricultural Uses of Lime

Lime, added to certain soils, has a beneficial effect, especially on those of a heavy clay character. It makes the soil work more easily, promotes drainage and causes a more rapid decomposition of vegetable matter. A certain amount of lime is necessary in soil as food for plants. Its effects on soil are, therefore, both physical and chemical. Magnesian limes have been held to be less suitable for agricultural uses than those which contain little or no magnesia. Some limes contain small amounts of phosphate and potash, substances essential to plant life, which adds to their value as fertilizers.

Ammonium Sulphate

In the production of liquid ammonia from ammonium sulphate the latter material is decomposed by lime, usually in the form of milk of lime, with the separation of calcium sulphate and ammonia. Caustic lime is, however, employed at times with the object of utilizing the heat evolved in the process of slaking.

Beet Sugar

In the manufacture of this material a supply of very pure limestone is essential—unless, as in Europe, the more costly, but more effective and closely-related compound, strontia, is used in place of lime. Limestone, when burned, supplies two materials which are used in the production of beet sugar, viz., carbon dioxide gas and lime. The sugar factories of Ontario have used limestone from the quarries at Amherstburg and at St. Mary's. Analyses of the rock from these quarries are given under the headings of Essex and Perth counties respectively.

Bone Ash

In the production of phosphate of lime from bones lime is used to precipitate the impurities dissolved out of the bone by hydrochloric acid, the lime combining to form calcium chloride.

Building Stone

The use of limestone in the form of blocks for building and structural purposes has been considerably affected during the last ten years or so by the substitution of concrete—crushed stone and cement. Formerly, for instance, dimension stone was used exclusively in bridge work and for locks and other canal structures. On the Trent Valley Canal, however, concrete is being used in place of stone, and the same is the case in many of our railway bridges. There are two reasons for this. Cement and crushed stone are more easily transported to the points where the work is carried on, and the cost of labor in concrete work is much less than where cut or dressed stone is used. Some large buildings in the Province are built of concrete, for example, the beet-sugar factory at Peterborough. Concrete blocks, which resemble those of stone, are also coming into use. Thus, while the stone industry in some respects is likely to become of less importance, it will grow in other directions.

Crushed stone is being extensively used in the paving of streets. Most of this is limestone, on account of this rock being more easily quarried and crushed than granite, trap and other crystalline rocks. Limestone holding flint, silicified fossils, etc., makes as good, and in some cases better, crushed stone than the purer varieties. Thin-bedded limestones are as suitable for crushing as thick-bedded ones. This has brought about the development of quarries, which in the old days could not have turned out material of much marketable value.

That dimension stone is still preferred to concrete, for some purposes, is seen in the fact that a large number of dressed blocks from the Crookston quarries, have been used during the last couple of years in the construction of the power plants at Niagara Falls.

Limestone is likely to be used for many years in the construction of important buildings in localities, as, for instance Kingston city, where material of good quality can be obtained at a low price. In the ordinary type of dwelling, however, even in such places stone, on account of its higher cost, is being replaced by brick.

The finer classes of marbles are now replaced to a considerable extent in interior decoration by artificial imitation materials, which cost much less and appear to serve the purpose as well as genuine marble.

To sum up, it can be said that, while the older stone industry is likely to become less important as the years go on, the newer, that of crushed stone, will reach such dimensions that there will be a gain in production.

It may be added that crushed limestone for concrete purposes sells at about $1.30 per cubic yard f.o.b. Toronto. Granite and trap bring as high as $1.65 per yard. Many thousands of cubic yards of crushed stone are used annually in this city. About five miles of macadam roads have been built some years. The fragments of rock for this purpose should have an average diameter of about two and one-half inches.

Calcium Carbide

The method of manufacturing this material, which has come widely into use during the last 10 years in the production of acetylene gas for illuminating purposes, is fully described in the earlier reports of the Bureau of Mines (Vol. IV., pp. 137 to 166, Vol. V., pp. 32-41, and Vol. VI., p.p. 26-32).

The raw materials used are lime and coke dust; it is said charcoal could be used if it were lower in price, and that it would be a more suitable material in some respects, being free from sulphur and other impurities found in coke.

The two materials, lime and coke, are reduced to fine powder, intimately mixed together—theoretically in the proportion, by weight, of 87 1-2 of lime (CaO) to 56 1-4 coke (C)—and fused into a mass in an electric furnace. The chemical equation which represents the reaction is: CaO (lime) + C_3 (coke) = CaC_2 (calcium carbide) + CO (carbon monoxide).

When water is added to the fused material, calcium carbide, acetylene gas (C_2H_2) is given off. This reaction is as follows:

CaC_2 (calcium carbide) + H_2O (water) = $CaOH_2O$ (hydrate of lime) + C_2H_2 (acetylene).

"The hydrate of lime obtained from the decomposition of the carbide with water can be used again in the manufacture of the carbide, or it can be employed in the manufacture of ready-mixed mortar." (1) Concerning the value of the hydrate of lime produced by this decomposition it is further stated: "At the present time private information from America shows that calcic carbide can be produced at a little under £4 a ton, and the beautifully pure lime obtained by the decomposition would be worth to the gas manager at least 10s. a ton; and as a ton of the carbide will give rather more than 1 1-4 tons of quicklime, or 1 3-4 tons of slaked lime, £3 10s. may be taken as the cost of the acetylene produced from a ton of the material." (2) As this statement refers to conditions that existed ten years ago, allowance will have to be made for the prices given. The object in giving the quotation is merely to draw attention to a source of pure lime.

(1) B.M., Vol. IV., p. 161.
(2) Ibid, p. 147.

In the year 1903 the value of the calcium carbide produced in the Province was $144,000.

It will be seen from the chemical composition of calcium carbide that calcium (lime) is the only constituent of limestone that is used. Magnesia and impurities commonly present in limestone are objectionable; the higher the percentage of lime held by the rock, the better.

Calcium Chloride

This compound which is used as a drying agent on account of the fact that it absorbs water with avidity has the formula $CaCl_2 + 2H_2O$. Another similar substance, $CaCl_2$, possesses the same property and is used as a dehydrating agent, but it cannot be employed, like the former, in cases where carbon dioxide is present, without absorbing it.

These two materials are produced from the normal chloride, $CaCl_2 + 6H_2O$, by heat. If care is taken not to heat this chloride above 200 deg. $CaCl_2 + 2H_2O$ results. If the temperature is raised above this point $CaCl_2$ is formed

The normal salt is produced, along with carbon dioxide, when limestone is treated with hydrochloric acid, and the reaction is represented thus:

$$CaCO_3 + 2HCl\ (5H_2O) = (CaCl_2 + 6H_2O) + CO_2$$

Carbon Dioxide

This material, commonly called carbonic acid gas, has several uses in the arts. It is most commonly obtained from limestones for commercial purposes by heating them to such a temperature that decomposition results, quicklime and carbon dioxide being formed. The gas may also be extracted from these rocks by treating them with acids, when effervescence takes place and the gas is liberated. At several well-known places carbon dioxide issues from the crust of the earth; and at one locality in New York State the gas originating in this way is collected and used.

The method of producing carbon dioxide and the use made of it in the beet sugar industry have already been mentioned.

Liquid carbon dioxide, formed by subjecting the gas to presssure, has come into use during recent years. It has been employed as a fire extinguisher and for charging liquids with the gas. The use of gas in the so-called soda-waters is well known.

Dolomite and magnesite are preferred to stone high in calcium carbonate in the manufacture of carbon dioxide. Marl has been made use of at Buffalo.

Chalk

The use of this material for writing on blackboards is a very general one. It has been replaced to some extent for this purpose by crayons of talc or soapstone.

Chloride of Lime

This substance is commonly known as "bleaching-powder." Its chemical constitution is not definitely known but its formula is probably $CaOCl_2$. It is white in color, has the odor of hypochlorous acid, and is extensively used as a bleaching agent. It is also employed as a disinfectant, and as an antiseptic.

It is prepared by treating slaked lime with chlorine. The limestone used in the production of the lime should be very pure and thoroughly burned. If magnesia is present the compound tends to deliquesce and is less stable. Sand and clay should also be absent. If coloring materials, such as iron or manganese, are present in lime it is not adapted to this use.

Dehydrating Agent

Quick lime absorbs water with ease, and on this account is used to some extent for dehydrating alcohol and other materials.

Disinfectant

Owing to its strongly caustic character, quick lime is of use as a disinfectant.

Gas Manufacture

Slaked lime having an affinity for hydrogen sulphide and carbon dioxide is used for extracting these substances from illuminating gas.

Glass

The commoner varieties of glass are mixtures of the silicates of lime and soda. The raw materials are essentially lime, sand (silica) and sodium carbonate, which are melted together. Instead of lime, lead oxide may be used; and potassium carbonate may replace sodium carbonate. Ordinary window glass is a sodium-calcium glass. Instead of lime, crushed limestone is commonly used, on account of the fact that lime when stored may change in composition, before being used, by the absorption of moisture and carbon dioxide.

Limestone for glass-making should be free from coloring materials, such as iron. While magnesian limestones have been used, those practically free from magnesia are preferred, as this ingredient makes the glass less fusible.

The Corniferous limestones in the Erie and Huron area of the Province, and those of the Trenton group, farther east, are adapted to glass-making. Heretofore the lime used in the industry in the Province has been imported.

Below are given two analyses, No. 1 from Blair county (Pa.), and No. 2 from Sandusky (Ohio). The former is used for window glass, the latter for lime flint glass: (3)

	1. Per cent.	2. Per cent.
Lime carbonate	97.23	55.60
Magnesium carbonate	1.48	41.43
Silica	1.01	1.00
Alumina	0.02	0.40
Ferric oxide	.....	0.12
Ferric carbonate	0.165	.....
Organic matter	0.09	0.05
Moisture	......	0.40

Furnace Linings

Lime has been melted only at a very high temperature in electric furnaces. It therefore can be classed as a good refractory substance, and is used in lining parts of reverberatory furnaces in the manufacture of steel. In the Thomas-Gilchrist process the lime in the furnace serves an additional purpose in extracting the phosphorus from the iron. The lime phosphate thus produced has, moreover, a value as a fertilizer.

Oxyhydrogen Light

Lime has a high melting point, and emits an extremely bright light when the oxyhydrogen flame is impinged upon it, as in what is ordinarily known as the lime-light.

Lime Water and Milk of Lime

When quick-lime is treated with water it forms, as already stated, calcium hydroxide, $Ca(OH)_2$, or slaked lime. This substance is somewhat soluble in water, the solution being known as lime-water. The solution takes place with difficulty in cold water (1 part in 760 parts), and with still more difficulty in hot water.

The thick paste formed by slaked lime with water is known as milk-of-lime.

Lime-water has a strong alkaline reaction and combines with the carbon dioxide of the air to form calcium carbonate. Breathing through a tube into lime water also causes a white precipitate. A grotesque use of this has been made by quack doctors.

(3) Bull. 44, N. Y. State Museum, p. 654.

Lithographic Stone

The only limestone which has been found to be perfectly suited for use in the lithographic art, is, peculiarly enough, that first employed for the purpose, which is obtained from the Upper Jurassic strata at Solenhofen, in Bavaria. The stone is not only rare, but valuable. It has been sought for in many parts of America, but with little success. Stone from various States has been used to a limited extent. Ontario has probably produced as much as any other part of America. Although, however, attempts have been made to establish an industry here during the last fifty years, little progress has been made, and no lithographic stone has been quarried for some years.

The requirements for a good stone are that it shall be fine in grain, of a homogeneous texture, not too dark in color, and free from quartz, pyrite and other minerals which are commonly found in limestone. It should, moreover, possess sufficient porosity to absorb ink and be soft enough to be worked readily with an engraver's tool. Varieties which possess most of the other requisites are often brittle and cannot be gotten out in pieces with large surfaces.

In Ontario lithographic stone has been quarried chiefly in the Black River formation near the village of Marmora, in Hastings County. This formation, which bounds, on the south, the Laurentian area, runs in a band from Kingston city to the Georgian Bay. Certain strata in the formation throughout the whole distance possess lithographic properties, but usually are defective owing to the development of small crystals of calcite. In the township of Rama, on Lake St John and Lake Couchiching, similar strata to those of Marmora have been tested. Thin sections taken respectively from the Marmora and Bavarian stone showed considerable difference when examined microscopically by the writer. The Marmora stone exhibited a more uneven texture owing to the presence of secondary crystals of calcite, while the Bavarian was uniform in character.

Strata in the Niagara formation at the head of Lake Temiscaming have also attracted attention as being of possible value for lithographic purposes; as have also certain strata in the township of Brant near Walkerton.

Lime

Before proceeding further with the description of the uses of limestone and lime, it will be well to discuss briefly the burning and slaking (4) of lime.

Lime Burning

The burning of lime is an operation similar to that which, when other materials are dealt with, is known as calcining (from the Latin calx, calcis, lime, since limestone was apparently the first substance thus treated). In burning limestone or calcining other substances gases and vapors are driven off and the substances themselves are reduced to powder or to a friable condition.

The receptacle in which lime is burned is known as a kiln (a word which is closely connected in origin with the word coal). Lime kilns are varied in form, ranging from the cruder kinds, which consist of a few loose stones, built into an enclosure, to the more highly developed forms, lined with brick or iron, which show almost as much ingenuity in construction as do furnaces used for metallurgical work. In remote districts limestone has often been burnt by piling it on a log heap or brush pile.

At the present time a comparatively small proportion of the lime produced in Ontario is made in the old-fashioned pot kiln. The bulk of the lime trade has gone into the hands of a few companies and individuals, operating in all about 30 draw kilns located at points convenient to the chief markets.

The pot or set kiln has among its disadvantages that of being intermittent in operation, necessitating loss of time for cooling after burning and before drawing and recharging; while the draw kiln is continuous.

A rectangular exterior of rough stones enclosing in heavy walls a pot-like cavity 8 to 10 feet in diameter by 10 to 14 feet deep composes a pot kiln. The charge is fired and drawn through a single grate chamber, say, 15 inches wide, which runs from the front, underneath the kiln, to the rear wall. Frequently these kilns are built in a series in one continuous structure. A pot kiln 8 feet in diameter by 10 feet high will hold about 800 bushels of lime, and requires between three and four days for a burning, with a consumption of 20 cords of wood.

The draw kilns of to-day differ very little from the first ones erected 15 or 20 years ago; in fact, some of the latter are still in use, but with labor-saving improvements, in many cases, in methods of charging or loading and of drawing the kilns. A kiln of the latest design will have approximately the following dimensions: outside, 18 feet by 22 feet plan at bottom, tapering slightly towards the top, 53 feet high, and with an arched way beneath, into which tram cars run to receive the charge of burnt lime on drawing from the bottom of the kiln; interior of furnace (cylindrical) inside the fire-brick lining, 2 feet in diameter at the bottom at the discharge gate, 6 feet 4 inches by 9 feet 6 inches at the fire-boxes 12 feet above the discharge gate, 6 feet 2 inches by 9 feet 2 inches at 12 feet higher still, and the same cross-section as at the fire-boxes at 13 feet higher or at the top of the fire-brick lining of the kiln; at this point and to the top 8 feet higher the kiln widens out into the charging or loading hopper 2 1-2 feet greater in cross-section. There are four fire-boxes, built in pairs opposite each other in the longer sides of the kiln; above them the charge of limestone is subjected to the flames, while below in the 12-foot drop to the discharge gate it has a chance to cool before being drawn. These are the maximum figures for the kiln burning gray lime, where the limestone is porous and allows the gases of combustion, etc., to escape with the least hindrance. A kiln burning lime from compact limestone may have to be built 10 feet shorter and proportionately smaller in cross-section in order to prevent the charge choking the draught.

The kilns are built of stone, with walls of a minimum thickness of 6 feet, braced outside at intervals from top to bottom with heavy logs or I-beams and tie rods to counteract bulging. Where possible a site is chosen for the kiln directly below the quarry, so that the top of the kiln will stand about level with the floor of the quarry to facilitate loading.

Broken stone in all sizes up to 10 or 12 inches, excepting the fine material, is charged in for a heaping load twice every 24-hour day, and at the same time one-half ton or so of fine coal mixed in to help heat the upper portion of the charge preparatory to its arrival opposite the fire places. Porous, quick-burning gray limes may usually be drawn every four hours, whereas the more compact, hard limestones frequently take six hours for complete elimination of the carbonic acid gas. The maximum output per 24 hours of any such kiln amounts to about 500 bushels, and the minimum to

(4) Two verbs of similar form are used in the same sense—slake and slack. In the former the sound of the letter a is long, in the latter short.

about 300 bushels, depending on the size of furnace and quality of stone. One kiln producing 400 bushels per 24 hours uses in the same period seven cords of hardwood.

The fuel used in lime kilns is of various kinds—wood, coal and gas being used. Natural gas, where available, is one of the most suitable fuels, and several kilns in this Province, in the vicinity of Port Colborne, make use of it.

During late years in many of the more thickly populated parts of America wood has become scarce and too costly to be employed as a fuel in lime-burning. This has brought about the more common use of coal and the death of very many of the small lime-kilns, which in some sections of the country were found on almost every farm. More attention is being paid to the loss of fuel which took place in the older types of kilns, and some of those recently invented, in which coal is used, are much more economical of both fuel and labor.

At the present time about half of the operating draw kilns are burning coal. Coal fires have not so long a flame as wood, partly because the draught must be considerably checked in order not to exceed the permissible maximum temperature in the kiln, and partly because the combustion or heat thereof is of a much more concentrated form. These conditions are adverse to lime burning, but may be overcome in part by a reduction in the cross-section of the furnace at the fire-places. In addition, however, a strong draught must be generated, as subsequently explained, to overcome the dissociation-pressure of the carbonic acid gas in the furnace. To do this, without making too hot a fire, the natural draught of air is supplemented by mixing with it in about equal quantities a portion of the inert gases (largely carbonic acid gas) from the interior of the kiln. By means of piping, a blower and a gasoline engine, a portion of these inert gases is drawn off from the upper part of the kiln, mixed with the required amount of air and forced under the fires at the desired pressure. The flames are carried to all parts of the charge and a good upward draught maintained without overheating the lime.

Different limestones require different treatment, both as to temperature and as to strength of draught, on account of which coal fuel has at first frequently been considered inferior to wood. However, with a knowledge of the principle of burning the new fuel, and after a few days' careful experimenting, there appears nothing to hinder making just as good lime with coal as with wood.

During the year 1903 the lime kiln operators in Ontario numbered 190, their total output amounting to 3,400,000 bushels, valued at $520,000; of this, 85 per cent. was manufactured by 20 of them, giving to each of these an average production of 170,000 bushels. The remaining 170 operators turned out an average each of only 2,600 bushels, made doubtless in the old set or pot kilns. Fourteen years ago, in 1890, the Province contained 508 lime-burning establishments, and the production for that year was about the same as for 1903.

When limestone is burned under proper conditions it is broken up or dissociated into lime and carbon dioxide, as shown by the following equation:

$CaCO_3$ (limestone) + heat = CaO (lime) + CO_2 (carbon dioxide).

The characteristics of these substances are described on other pages of this report.

Carbon dioxide is a heavy gas, and does not pass out of the top of the kiln as a gas lighter than air would tend to do. This point is often not considered in the building of kilns, the construction frequently being such that much of the carbon dioxide freed from the first part of the limestone burned remains in contact with other parts of the heated stone and thus prevents the easy burning or calcining of those parts of the limestone which are immersed in an atmosphere of the gas.

Limestone is not decomposed at a low red heat, but is converted at a bright red heat into carbon dioxide and lime. The temperature at which the decomposition is effected, and consequently the amount of fuel consumed, depends upon the facility afforded the carbon dioxide for escape when it has been expelled from the stone. Hall found that pieces of limestone enclosed in a tube, and consequently under a high pressure, resisted decomposition, even at the temperature of the porcelain kiln, and melted with a loss of, at most, 1 per cent. It has also been shown that under great pressure, which is equivalent to a temperature at least sufficient to decompose the rock, if not under pressure, limestone can be moulded almost like putty without the loss of carbon dioxide (5).

The writer has been told by lime-burners that they find the rock to burn most readily when it is moist. Hence farmers and others who do their burn-

(5) F. D. Adams and John T. Nicholson. An Experimental Investigation Into the Flow of Marble. Can. Rec. Sci., Vol 8, pp. 426-436, 1902. Also in Phil. Trans., Roy. Soc., London, series A, Vol. 195, pp. 363-401, plates 22-25, 1901.

ing when most convenient prefer to carry on this work during the winter and spring, the periods of the year when the stone is most highly saturated with water. An experiment conducted by Gay-Lussac, many years ago, explains this phenomenon, of the apparently more easy burning of moist than of dry stone, and proves that it is due to the fact that the moisture volatilized from the stone tends to carry off the carbon dioxide evolved, thus, as already shown, promoting the calcining of the rock.

Gay-Lussac, in the experiment referred to, placed pieces of marble (limestone) in a tube, which was so arranged in a furnace that the temperature could be easily regulated. One end of the tube was connected with an apparatus for the evolution of steam (steam is also, it should be noted, given off when moist limestone is treated), and the opposite end with a contrivance for collecting the carbon dioxide. The temperature was raised so high at first that the marble began to be rapidly decomposed, when, by impeding the draught, it was reduced to a dark-red heat, so that all evolution of carbon dioxide ceased. When water vapor was permitted at this moment to pass over the red-hot lime, carbon dioxide again made its appearance in considerable quantity, and continued to pass off under these circumstances in a manner entirely dependent upon the current of vapor. It stopped when the vapor was cut off, and began again immediately upon its admission. Hence, it follows directly that the decomposition of the limestone is effected at a lower temperature by the agency of water vapor (steam) than under ordinary circumstances. The same effect, however, may be produced by a current of air as by steam, and the action of the vapor is consequently only mechanical, tending to form an atmosphere around the blocks of limestone, which is void of carbon dioxide, and is thus in a fit state for being permeated by the gas, as a vacuum would be. In the one case, the escaping carbon dioxide has to overcome the pressure of that which has already been evolved, while in the other this is entirely obviated, the kiln being free from carbon dioxide, or filled with a gas of a different nature (6). It has also been shown that when quicklime is exposed to a current of carbon dioxide at a white heat, a temperature at which limestone is readily decomposed under ordinary circumstances, the lime absorbs sufficient of the gas to cause it to effervesce vigorously with acids, and is no longer slaked with water. In other words, the lime has been caused to take up carbon dioxide and to again become limestone.

(6) Knapp's "Chem. Tech.," 1st American edition, Vol. 2, pp. 356 and 367.

The practice of burning moist limestone cannot, however, be considered an economical one, as fuel is consumed in expelling the moisture. The best type of kiln is that in which a current of air replaces that of steam or water vapor.

Carbon dioxide begins to be given off from limestone when the latter reaches a temperature of 750 degrees F., but decomposition is not complete till 1300 or 1400 degrees are reached. The more quickly limestone is burned at the highest temperature the more readily it slakes. In burning, the temperature should remain as constant as possible. When lime is overburned, it slakes slowly and incompletely. If the temperature, on the other hand, gets too low the cores of the larger lumps of rock in the kiln are left unburnt. A dense limestone is more difficult to burn than an open-textured one. Limestone containing clayey material is apt to sinter if heated to a high temperature. Part of the rock then remains unburned, being coated with a slag-like substance. Moreover, certain limestones containing clay produce hydraulic limes and cements, which harden under the action of water, as described under cements, and cannot be used as ordinary lime. Limestones containing sulphur are unsuited for the production of lime, since the sulphur oxidizes to sulphate, which in course of time reacts with alkali, and produces the white efflorescence frequently seen on brick work. When coal carrying sulphur is used as the fuel in burning, the same results are brought about.

In burning a pure limestone loses theoretically 44 per cent. of its weight by the escape of carbon dioxide. There is also a decrease in volume which is said to be usually 16 to 18 per cent., but ranges from 12 to 21 per cent. Lime has a specific gravity of 3.09. A bushel weighs 70 pounds.

In the cruder kinds of lime-kilns, the fuel comes in direct contact with the stone, the two materials often being in alternate layers. Such kilns are known as the intermittent kind. In the more modern, the kilns, which are usually cylindrical in form and lined with iron plates, instead of brick as formerly, are so arranged that the flame only comes in contact with the limestone. The fire boxes, supplied with grates, are built in the side of the kiln, some distance from the bottom, and the flame burns inward and upward through the rock. The burnt lime is drawn off from the bottom. Such kilns are known as continuous or draw-kilns. Burning the fuel in contact with the stone is objectionable, owing to the fact that ash becomes mixed with the burned lime and introduces impurities into it.

Lime Burning at Saw Mills

To give an idea of the cost of the production of lime when the quarries are situated near lumber mills, the following data taken from the report of Prof. L. W. Bailey may be used. (7). In comparing the cost of production of lime at St. John, N.B., with that at Rockland, Me., the industry at the latter place being favored by "a duty of six cents per 100 lbs., including the weight of the barrel, which was equal to 13⅝ cents a barrel, or about twenty per cent. on the value as delivered in United States markets," Prof. Bailey goes on to say, "In several respects St. John has great natural advantages, making the competition more equal, one of these being the situation of the quarries and the facilities for shipment (the quarries at Rockland being distant two miles and a half from the kilns); and another, the cheapness of fuel, the latter consisting largely of the refuse from lumber mills. In several instances, indeed, as at Randolph and Baker's, the saw-mills and the lime-kilns are run by the same owners, side by side. The cost of Rockland limestone, placed in the kilns, is twenty cents a barrel, as against ten cents a barrel at St. John. The cost of kiln-wood at Rockland is $3 for the small cord, as against $2 at St. John. Cordwood burned in a kiln at St. John costs ten cents for each barrel of lime, while at Rockland it is fifteen cents. The Rockland people estimate that their lime costs, ready for shipment, seventy-two cents per barrel, while the freight to Boston is thirteen cents and the price eighty-five cents, leaving no profit. The following figures show the corresponding cost at St. John:

	Cents.
Stone at kiln	10
Boring (labour)	5
Cordwood	10
Barrel	16¼
Trimming barrel	1½
Foreman	½
Repairs	½
Interest on investment ..	¾
Duty (to U. S.)	14
Freight (to U. S.)	18
Consular certificate......	½
Total, per barrel	77 cents."

(7) G.S.C.. 1897, pp. 81, 82 M.

These figures should be of use to any person who contemplates starting a lime industry in Ontario, the conditions in some localities in this Province being almost the same as at St. John.

In order to give an idea of the size and character of the kilns from which these results are obtained the following description of the kilns at Randolph and Baker's saw mill, referred to above, may be quoted: "There are here two kilns, each with a capacity of 120 to 140 barrels of lime per day, and therefore for the nine months during which they are kept running—March to December—yielding from 25,000 to 30,000 barrels of lime. They are built of brick, faced with stone, about thirty feet in height; hopper-shaped inside for the upper third of the height, then with a straight funnel for the next third to the level of the fire, and again widening out to the lower floor, from which the lime is drawn. The limestone is put in at the rear of the kiln above, and the burnt lime drawn out from the front of the kiln below, while the fuel is fed in at the side, at the height of a few feet above the floor, from which the burnt lime is drawn. The two kilns are enclosed in a large gravel-roofed shed, which extends to the edge of the wharf, so that the lime is protected from the weather even when being shipped." (8)

Prof. Bailey's interesting summary of the lime industry in New Brunswick throws light on another subject which has been referred to by the present writer in this report, viz., the quality of lime produced from stone which carries a high percentage of calcium carbonate, and little or no magnesia. Speaking of the St. John lime, he says: "It has at all times been preferred to other limes for use in the Maritime Provinces, but as an article of export has only acquired importance in recent years." (9)

"The character of the St. John limestones is further indicated by the subjoined analyses, made in the laboratory of the Survey. Previous to analysis the specimens were dried at 100 degrees C., the hygroscopic water thus abstracted being as follows, respectively:—No. 1, 0.09 per cent., No. 2, 0.04 per cent., No. 3, 0.05 per cent. (10):

(8) G.S.C., 1897, p. 80 M.

(9) Ibid, p. 79 M.

(10) Ibid, p. 81 M.

——	No. 1.		No. 2.		No. 3.	
Carbonate of lime	95.60		99.05		98.39	
" magnesia	0.44		0.88		0.71	
" iron	0.13		0.05		0.05	
Alumina	0.11		0.01		0.02	
Silica, soluble	0.16	4.27	0.09	0.26	0.04	1.19
Insoluble mineral matter	3.54		0.14		0.82	
Organic matter	0.46		0.02		0.31	
	100.44		100.24		100.34"	

Slaking of Lime

Little care is often taken in the slaking of lime. Much better results are obtainable, however, by following certain well-known principles. Lime when dry at ordinary temperature is unaffected by carbon dioxide, but when heated, as shown above, takes it up readily. It, however, combines with water with avidity, with the evolution of so much heat that sulphur can be set on fire and wood has even been ignited. The reaction which takes places during the union of water and lime—the change from quick-lime to slaked lime—is represented by the following equation: $CaO + H_2O = Ca(OH_2)$. The higher the percentage of oxide of calcium (CaO) contained in lime the more heat is given off and the slaking is correspondingly more rapid. Such limes are called fat limes, probably on account of the resemblance of the white, pasty mass produced to fat. Fat limes slake in the air by absorption of water vapor. Hence they should be protected from the atmosphere as much as possible. That slaked lime when so protected will keep indefinitely is shown from the statement that "in removing the ruins of the castle of Landsberg in order to lay the foundations for a new building, it is stated by Jahn, that a lime pit of considerable dimensions was found in one of the vaults. The surface of this mass of lime was carbonated to the depth of a few inches, but all below that was in the state of freshly-slaked lime, only somewhat more dry. This lime, which was certainly more than 300 years old, and valued at several hundred florins, was consequently used in constructing new buildings." (11)

Limes carrying smaller percentages of oxide of calcium are called lean limes.

The temperature of slaking should be attended to, as it influences the quality of the lime. When no more water is added to the lime than it can absorb, it does not form a soft, but a sandy powder, and is said to have been rendered poor by slaking.

(11) Knapp's "Chem. Tech."

Lime is divided by the trade into two main classes, white lime and gray lime. Besides the color, the other distinguishing points are the slaking and settling qualities, some limes acting more quickly in these respects than others, and also making a stronger set. As a general rule gray lime is employed for foundation mortars where the color is immaterial, and white lime for facing, interior plastering, white mortars, etc. For building it is customary to place the lime in slaking tubs, or in flat boxes constructed of boards, and to pour as much water into them as will nearly cover the lime. If lime is moistened with water in the dark it presents a lively, luminous appearance.

Marble

In the trade the term marble is sometimes loosely used, being applied to various rocks. Properly, it should be restricted to a variety of limestone which is capable of taking a good polish and is suitable for use as a decorative material. These varieties are usually what are properly called crystalline limestones. Certain kinds of other limestones, especially some fossiliferous examples, also make handsome decorative materials.

Marbles are variously colored. Some of the most highly prized are mottled. Marbles which contain intermixed serpentine, such, for example, as that found near Charleston lake, in Leeds county, have a handsome appearance when polished.

In Ontario very little use has been made of the crystalline limestones which are adapted to decorative and monumental purposes. At the present time, so far as the writer knows, only two quarries are worked, and in only a small way, for marble. A local manufacturer at Renfrew uses a small amount of the white crystalline limestone from the quarry in the town for monuments. A small amount of pure white marble is also quarried about four miles from Haley station, west of Renfrew. This material has been used in some of the recently-erected public buildings at Sault Ste. Marie, and in combination with brick gives the buildings a rather handsome appearance. The dark-gray mottled marble which was formerly worked at Arnprior is referred to on another page, as are also the quarries which were opened near Madoc and Bridgewater. The quarries at the latter place have recently been made more accessible by the building of the Bay of Quinte railway northward from Tweed. Reference to marbles will be found under the headings devoted to counties and districts--Frontenac, Hastings. Renfrew, Algoma, Thunder Bay. It will be seen that the Province possesses a considerable variety in marble resources which are as yet practically undeveloped.

The marble used in this country nearly all comes from the large quarries of the United States. Although we have native varieties that are as good, trade prejudices favor the imported article. Many of the cheaper kinds of tombstones are made of Vermont stone—chiefly the "Vermont blue"—but marble is also imported from Georgia, Tennessee and other States.

For interior decoration, such as wainscotting, imitation marble has replaced the natural material to a considerable extent.

Mortar

The use of lime in mortar appears to have been known in pre-historic times. Its employment is largely empirical, and little more is known, by many users, of the character of lime to-day than was known some centuries ago. The slaking of the lime and the mixing of mortar is often still carried on in a very crude way.

The effects produced by the presence of magnesia in quicklime are not well understood. Limestones carrying all percentages of calcium and magnesium carbonates, from none of the latter to the percentage which makes the rock what is theoretically a true dolomite, are burned for lime. Men who have always used the Niagara limestone, for example, say that in order to make good lime the rock must be magnesian, while other lime men and writers claim that 25 or 30 per cent. of magnesia renders the stone unfit for burning, notwithstanding the fact that such material has been used for years in some localities. This subject—the effects produced by magnesia—needs investigation. Theoretically it would appear that those limestones that carry the highest percentage of calcium carbonate are the most suitable for burning, but practically the presence of magnesia in lime used for ordinary purposes seems to be of no importance. In plaster magnesian lime sets more slowly, and thus has some advantages where time is needed to give a smooth finish to the surface before the plaster hardens. It would also seem that lime which is practically free from magnesia, although it may make a stronger material, needs more careful slaking than does magnesian lime. I am told that in some parts of Europe this fact is recognized, and that lime is sometimes slaked in underground pits for several months or a year before being used. This prevents "pitting" in plaster, which appears to be due to imperfect slaking, namely, the formation of small pits in the plaster after it has hardened. These are apparently caused by the gradual absorption of water and consequent swelling of small portions of lime, which were unslaked at the time the plaster was laid on the wall.

The water used in slaking the lime should not contain an appreciable amount of soluble salts, as these may effloresce in time and cause a white deposit on brick or stone work, thus marring its appearance. Sulphur, oxidized to sulphate, brings about the same effect.

After slaking, sand is added to the lime. The sand prevents shrinkage, and necessitates less lime being used. In course of time the slaked lime changes to carbonate by the absorption of carbon dioxide from the air, but the complete change of the hydrate to carbonate may take years.

In slaking very fat lime it is stated that about 2 1-2 volumes of water to one of lime should be taken. Magnesian limes require less. If an excess of water is used the temperature is lowered, and the slaking is incomplete. It is claimed that from 1.25 to 2 volumes of sand should be used to 1 of paste. This in the case of fat lime means 3 to 5 volumes of sand to 1 measured volume of lime, which gives a plastic mortar that does not crack.

"In the structures of the ancient Egyptians, as in the Great Pyramid, mortar was freely employed, but it consisted almost entirely of sulphate of lime. A specimen taken from an ancient Phoenician temple, the highest stone of which was a few years ago five feet below the level of the ground, was quite similar to that found in some of the castles in Europe, and was like a piece of solid rock. It was made of burnt lime, fine sand, coarse sand and gravel. It was a concrete rather than a mortar; the lime had become completely carbonated. Ancient Greek mortars from ruins in the neighborhood of Athens are in very perfect condition. They contain no gravel. Mortars from ruined buildings in Herculaneum, and from Rome and its vicinity, appear to have been made from burnt lime and puzzolana, or volcanic ash." (12).

"Common mortar is made with fat lime, and clean, sharp sands in the proportions, usually, of 1 to 5 by volume." (13).

stone belongs to the Niagara formation, and according to Mr. Sjostedt of the Lake Superior Power Company, possesses the composition given below. Analyses of other limestones used at Sault Ste. Marie, Ont., were also kindly furnished by Mr. Sjostedt. These are from quarries in Michigan, at Petoskey and Trout Lake and from Drummond Island:

	Dolomite. (Cockburn I.)	Limestone (Petoskey.)	Limestone Trout L.
	per cent.	per cent.	per cent.
Insoluble	4.5	1.0	.69
Iron and Alumina	.5	2.0	.33
Cal. Carbonate	52.0	84.0	98.01
Mag. Carbonate	41.0	10.0	.85
Undetermined	2.0	3.0	....
	100.	100.	

	Dolomite (Drummond I.)
	Per cent.
Silica	4.33
Iron Peroxide and Alumina	4.14
Calc. Carbonate	51.18
Mag. "	39.38
Phosphorus	.224
Sulphur	..025

Minor Uses

Limestone in a state of fine division may be used for polishing the surfaces of marble and other materials not possessing very great hardness.

In the manufacture of potassium dichromate from chrome ore, lime, as free as possible from silica and magnesia, is used along with alkaline salts.

In the manufacture of pottery, lime is used in the body of the ware and also as a constituent of the glaze.

On account of its disinfectant and antiseptic properties, lime is employed in preserving eggs, etc.

Lime-water and other compounds of lime are in frequent use as chemical reagents.

Lime plays an important part in the manufacture of soap. It is used to form caustic soda and potash from carbonate of soda and the pearl ash of commerce, respectively. It is also used in the saponification of tallow and in other ways.

In soda manufacture, by the Leblanc process, limestone is used to change the sulphate of soda into caustic soda.

In tanning, lime is employed to remove the hair from the skins.

Lime is also used to free the rags used in paper manufacture from dirt, and to decompose glutinous substances.

Pulp and Paper Making

In the manufacture of sulphite pulp a lime as high in magnesia as is obtainable is preferred, although other limestones have been employed. The limestone of Cockburn Island, in Georgian Bay, is used at Sault Ste. Marie. This

(12) Thurston, Materials of Engineering, Part I., pp. 20-21.
(13) Ibid., p. 22.

Silicate Brick

Sand and lime are fused or partly fused together in the manufacture of silicate bricks.

Smelting Ores

One of the most common and important uses of limestone is as a flux in the smelting of iron, lead, and other metals. The action of the lime reduces the metals, and the impurities in the ores, such as silica, are carried off in the slag.

Limestones carrying a high percentage of calcium carbonate are preferred for use as a flux, but as the analyses of limestones used at Hamilton, Midland and Deseronto show, Ontario blast furnaces do not all use such stone. Rock high in magnesia is often employed on account of the greater cost, in some localities, of the varieties higher in lime.

The percentage of phosphorus and sulphur in limestone used for blast furnace work has also to be considered.

Crystalline limestone from the town of Renfrew has been used in the smelting and refining operations at Sudbury.

The following interesting note on the stone used at the Hamilton Steel & Iron Company's plants has been furnished me by Mr. C. B. Fox, M.A., chemist and metallurgist to the company:

"The stone we have been using in our blast furnace for several years is a dolomite, which is obtained from the mountain about five miles south of the city. An average analysis of this stone, for a considerable period, is:

	Per cent.
Silica	.75
Alumina and ferric oxide	1.00
Lime	30.24
Magnesia	20.18
Phosphorus	.021
Sulphur	.050

"In our steel works we use calcium carbonate for desulphurizing and removing the phosphorus from the steel in the open hearth process. This has an average analysis as follows:

	Per cent.
Silica	2.00
Alumina and ferric oxide	1.10
Lime	51.00
Magnesia	1.10
Phosphorus	.015
Sulphur	.05

"This calcite stone comes from the vicinity of Port Colborne, on Lake Erie, the nearest point to Hamilton at which calcite stone is found, all the limestone of our mountain being dolomite, with silica running from one-quarter of one per cent. up to six or eight. If the silica runs above three per cent. it hardly pays to use it here.

"It is generally conceded by blast furnace men that dolomite stone takes more fuel than calcite when used in a blast furnace, and calcite is generally supposed to be more efficient in the removal of sulphur. When smelting lean ores requiring a large amount of flux (i.e., where the proportion of ore to stone is lower than 3 to 1), the slag is liable to be dark and spongy, and difficult to handle when dolomite is used. On the other hand, it is claimed for dolomite that it prevents sticking and hanging in a furnace, and causes the stock to descend more easily.

"We have had samples of stone from a quarry at St. Mary's, which shows the stone there to be a calcite of about the same purity as that from Port Colborne. I suppose you have often seen this Port Colborne stone, as it contains a great amount of the fossil coral Columnaria alveolata, and these parts of the stone are usually highly impregnated with oil."

Analyses of the stone used in the blast furnaces at Midland and Deseronto will be found in the sections devoted to Simcoe and Addington counties respectively. The Port Colborne and St. Mary's limestones are described under the heading of Welland and Perth counties respectively. The stone which Mr. Fox says is used in the Hamilton blast furnace is quarried in Wentworth county.

Soda Manufacture

At the works of the Canadian Electro-Chemical Company, Sault Ste. Marie, caustic soda and bleaching powder have been produced during the last two years. The raw materials used are lime and common salt.

Whiting and Whitewash

Pure chalk is the material most commonly used for whiting, but certain varieties of marl have been substituted.

Lime, mixed with water to the proper consistency, plays the part of paint in white-washing. It tends to preserve wood and acts as a disinfectant.

Cements

Cement materials, or those substances which, unlike ordinary lime, are used in forming mortars that harden under water, fall naturally into three classes:—(1) Hydraulic lime, (2) hydraulic or natural rock cement, (3) Portland cement. To these can be added pozzuolana, a name which is used for mixtures of ground blast furnace slag and slaked lime. The name pozzuolana was originally applied to a tufaceous rock in Italy.

Hydraulic properties increase in quick-lime with the increase in the percentage of the clayey constituents. When these reach 8 or 10 per cent. hydraulicity begins to be developed. If 18 or 20 per cent. of these aluminous impurities are present the product, after burning, has to be ground fine before it will set.

All these cements owe their hydraulicity to the formation, while burning, of silicates and aluminates of lime and magnesia, which, together with calcic-hydrate, gradually crystallize and harden when exposed to water.

Hydraulic limes are made by burning limestones which contain about 20 per cent. of impurities, chiefly aluminium silicate. Fat limes are rendered hydraulic by the addition, as stated above, of certain rocks as pozzuolana and strass, or slag, burned clay and other materials, which contain silica and alumina in the proper state of combination.

Natural Rock Cement

Certain argillaceous limestones when burned possess the property of hardening under water, and are known as hydraulic limestones. One of the chief localities in the United States where such limestones occur is Rosendale, N. Y. Natural rock cement has been produced in large quantities here, and cements of this class are commonly known as Rosendale.

In Ontario limestones suitable for the production of natural rock cement are known to occur in several localities. The rock has been worked for many years at Thorold and at Nepean.

"In the Chazy formation, a bed of grey argillaceous magnesian limestone occurs a few feet above a blackish-brown band, which is marked by the shells of Leperditia. This magnesian layer, which weathers of a yellowish color, has a conchoidal fracture, and holds small geodes of calc-spar, may be traced by its mineral characters, and by the underlying fossiliferous bed, from Hawkesbury as far westward as Allumette Island. At Nepean, on the shore of the Ottawa, it has a thickness of 6 feet, and has for many years been quarried for the manufacture of a hydraulic cement. . . . A specimen of the cement (produced from the rock at this place), gave to Delesse, lime 39.70, magnesia 9.58, soluble alumina and oxide of iron 19.74, insoluble argillaceous residue 30.98 ; — 100.00. It is probable that this bed may yield a similar cement in other parts of its distribution. . . In the township of Lougborough, on the 1st lot of the 18th range, are beds which resemble that of the Chazy just described, and have been found to yield a hydraulic lime. A similar bed, 3 feet in thickness, occurs in the ditch around the fort at Kingston, and has been used as a cement. . . . .

"In the Niagara formation near Thorold, a band of dark grey argillaceous limestone. 8 feet in thickness. yields an excellent cement. Its color after calcination is yellow. A specimen examined by Delesse contained 3.37 per cent. of moisture, without any carbonic acid. Its farther analysis gave lime 53.55, magnesia 2.20, silica 29.88. alumina and oxyd of iron 12.70. sulphate of lime, 1.58 ; — 99.91. This cement was found to set in 10 to 15 minutes, with disengagement of heat. A portion placed in water 10 minutes after mixing became as solid as another portion which had set in the air, and was only immersed at the end of two hours. . . . . This cement has been largely used in the construction of many public works, and was employed in building the piers of the Victoria bridge. . . . . This layer of water lime does not appear to be continuous throughout the Niagara formation. At Limehouse, in Esquesing, there is a band of 9 feet, which is wrought to a considerable extent, and yields a good hydraulic lime. At Rockwood also a band of limestone three and a half feet thick, associated with a layer of chert, is said to yield a water-lime. The last two localities are in the Niagara formation, but are not supposed to be the equivalents of the Thorold stone." (14)

The Onondaga formation contains beds of argillaceous dolomites, associated with the gypsum deposits, which yield a hydraulic cement. "Analyses of this dolomite from Oneida and Paris are given below. The calcined rock from Oneida gave to Delesse. lime 36.93, magnesia 26.74, clay 36.33 ; — 100.00. It heats very slightly when mixed with water, and yields a cement of good quality. The calcined material from Paris contained lime 53.82, magnesia 35.93, clay 10.25. A specimen from this formation, on the 14th lot of the 2nd range of Brantford, yielded a cement which hardened under water in the course of five minutes. Similar beds are found at Point Douglas on Lake Huron; and it is probable that the materials fit for the manufacture of water-cement may be found almost everywhere along the outcrop of the Onondaga formation." (15)

The manufacture of natural rock cement at Napanee Mills is referred to in later pages, under the section devoted to Addington county.

Analyses of limestones used in the manufacture of natural rock cement in Ontario and at a few important foreign localities are given in the following table :

(14) G.S.C., 1863, p. 806.
(15) Ibid, p. 807.

—	1	2	3	4	5	6	7	8	9
Calcium carbonate	45.30	39.91	51.33	56.28	47.07	45.91	35.60	45.54	67.14
Magnesium "	12.77	34.15	40.91	20.07	30.32	26.14	19.26	32.46	2.90
Alumina aud Ferric oxide	12.52	....	....	2.20	2.71	11.38	4.84	{ 1.41 { 13.03	7.49
Silica	....	....	....	....	....	15.37	33.80	17.56	18.34
Insol. argillaceous residue	19.77	22.10	5.50	20.90	19.64	....	....	....	....
Water and loss by ignition	9.64	3.84	2.26	.31	.20	1.20	6.82	....	3.94
Total	100.00	100.00	100.00	99.76	99.94	100.00	100.32	99.90	99.81

1. Nepean. 2. Oneida. 3. Paris. 4. John Brown's quarry, Thorold. 5. Alex. Manning's quarry, Thorold. 6. Rosendale, N.Y. 7. Akron, N.Y. 8. Milwaukee, Wis. 9. Coplay, Penn.

The quarries from which the rock used in the manufacture of natural rock cement is obtained at Thorold, Queenston, and Limehouse are described on pages 108-109 of the First Report of this Bureau.

It will be seen that the limestones from which natural rock cements are made are variable in composition.. Unlike Portland cement, many of these cements, practically 90 per cent. in America, carry a comparatively high proportion of magnesia. Those containing little or no magnesia, if the percentage of argillaceous material be right, set more quickly, and are said to be the stronger cements. Such calcareous cements, in Europe, are known as Roman cements.

The kilns used in burning natural rock cement are similar to those used in burning ordinary lime. Care must be taken not to heat the cement to too high a temperature and thus bring about sintering. After burning the material is ground to a fine powder and sifted.

"The natural rock cement industry has been materially interfered with during late years by Portland cement. When the demand (for Portland cement) is completely supplied by American manufacturers, we shall have works in this country producing 2,000 barrels per day more than in Germany, and the same result will be reached here as in Germany, namely, the complete replacement of the common natural cement rock cements by artificial Portland." (16)

Portland Cement

A very rapid growth has been witnessed in the Portland cement industry in North America during the last 15 years. Judging from the prices at which cement is being sold at the present time, and from the general state of the industry, the output on this continent about equals the consumption. A few years ago prejudices existed against the use of domestic cement, and much of the supply was obtained from Europe. It has now been thoroughly proved that American cements are not inferior to any of the brands produced abroad. In some respects the industry has reached a higher state of development on this continent than elsewhere.

Portland cement was invented in England, receiving its name from its supposed resemblance to Portland stone. In general, this cement acts like ordinary natural rock cement, but being of a more definite chemical composition, it possesses superior physical properties, and is used for all the more important structural purposes. In Germany, as already stated, natural cement has practically been entirely replaced by Portland.

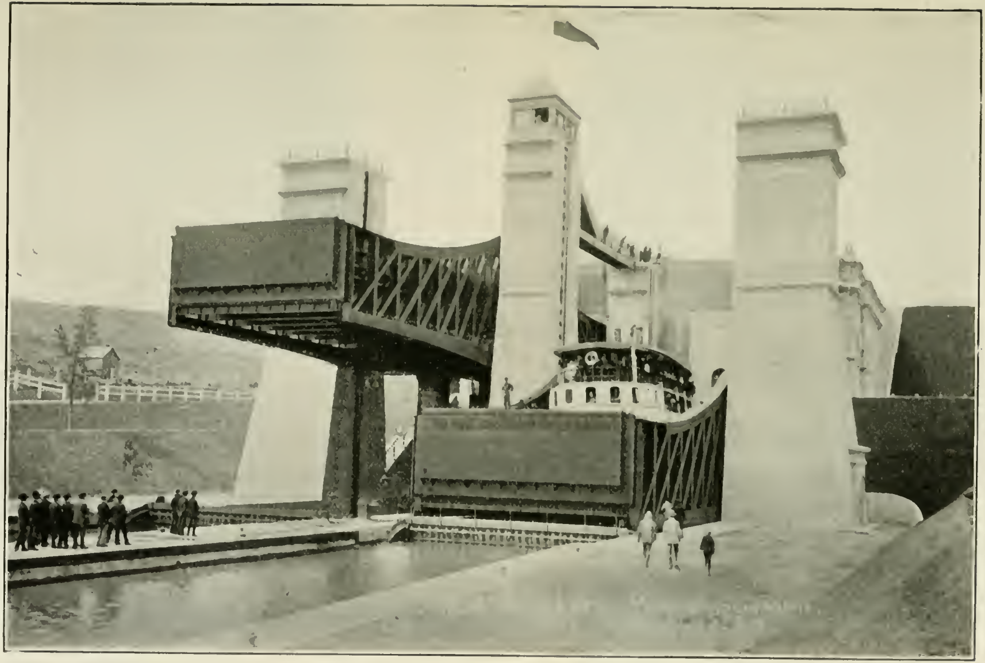
Portland cement is made from a mixture of clay and carbonate of lime. In this Province all the plants which have been in operation up to the present time use marl as their source of carbonate of lime. It is claimed that a saving in the cost of manufacture can be made by substituting solid limestone for marl, as is done in the great majority of the plants in New York State and elsewhere. It should be remembered, however, that many of these limestone are argillaceous, and thus do not require the addition of clay to the cement mixture, a small percentage of pure limestone being added to bring the mixture up to the right chemical composition. One or two plants which are to use limestone in place of marl are under construction in Ontario, as is also the plant at Hull, Que. The limestone to be used by these plants belongs to the Trenton group and is not argillaceous.

In Europe, where the cement industry has reached great proportions, chalk of suitable chemical composition is found in many places. By using it the cost of manufacture should be less than if either marl or limestone is employed.

Magnesia, in proportion above say 4 per cent. in the manufactured material, is carefully avoided in the production of cement. Although much attention has been paid to the subject, comparatively little is yet known as to the exact effects which magnesia has on cement.

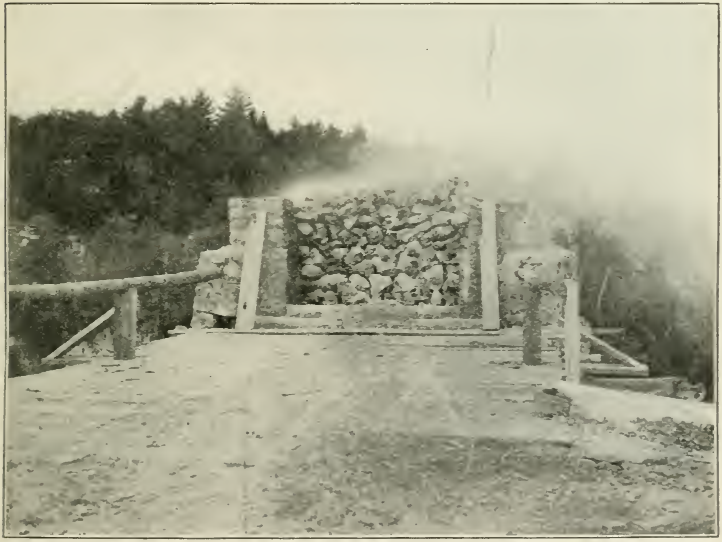
The reader who desires details concerning the methods of manufacturing and character of Portland cement, as well as the means employed to test its quality, is referred to the numerous treatises on the subject which have been published during late years. It will suffice to state here that in the older processes of manufacture the materials were usually dried, ground together, and then moistened and moulded into bricks. These bricks were then calcined or burned to clinker, after which they were ground to a fine powder, which represents the cement as it comes into the market. Of late years the rotary kiln has replaced the older form. The materials, after being suitably ground and mixed, pass into a large inclined revolving tube. The materials entering at the upper end are subjected to a temperature high enough to produce clinker before, in their gradual passage through the tube, they emerge at the lower end. This clinker is then ground to a fine powder.

(16) S. B. Newberry, Brickbuilder, 1897, p. 108.



Hydraulic lift lock on Trent Canal, Peterborough, constructed mainly of cement ; 26,000 barrels cement used in concrete work ; substructure of lock said to be largest monolithic mass of concrete in the world.

"Drawing" a lime kiln, showing freshly burned lime.



Top of loaded lime kiln being burned, Rockwood. Wellington County.

D. Robertson & Co's lime kilns, 2½ miles northwest of Milton. Limestone beds for burning only are in background on hillside. Halton County.

An ancient "set" kiln for burning field boulders; 10 feet high, inside measurement.

Lime kilns at Limehouse, showing double fire-door and forced-draught pipes. Halton County.

In the Twelfth Report of the Bureau of Mines a short account of the cement plants which were in operation in the Province in 1902 is given. The following extracts are taken from it:

Cement Making in Ontario.

"The manufacture of Portland cement in Ontario had its origin at Marlbank in the county of Hastings and at Shallow lake in the county of Grey, at nearly the same time about twelve years ago. The present centre of the industry is in the county of Grey, where six out of the nine producing plants are situated. A brief description of these and the other factories in the Province, and some account of the new establishments which appear likely to be manufacturing cement shortly, may be found of interest.

"The works of the Hanover Portland Cement Company, Limited, are situated at Hanover, Grey county. Its marl beds are a mile and a half distant, and its clay deposits close to the works. The plant consists of a brick factory, and brick and cement warehouses, and includes drying darres, wash mills, ball and tube mills, slurry grinding and pumping machinery, automatic carriers, etc. The kilns at present in use are five Bachelor set kilns and one Schneider continuous kiln. The capacity of the plant is 150 barrels per day, but the company has recently offered for sale $180,000 worth of 7 per cent. cumulative preferred stock—the total authorized capital being $500,000—with the proceeds of which it is proposed to increase the capacity to 650 barrels per day, construct a railway to the marl deposits, develop a water privilege on the Saugeen river for power purposes, and make other improvements. The company's brand of cement is the "Saugeen." A siding connects the factory with the Grand Trunk Railway. D. Knechtel is president and J. S. Knechtel managing director.

"The Lakefield Portland Cement Company, Limited, began the construction of their plant at Lakefield in the county of Peterborough in 1900, and were manufacturing cement early in 1902. The works are situated on the Trent canal and were planned with a view of utilizing an all-water route for the transportation of cement to Montreal and lower ports. The whole of the machinery is operated by electric power derived from the Trent canal, which affords a large economy in fuel for power purposes. The completion of the canal would, it is estimated, enable the company to reduce its coal bill for cement burning to the extent of $15,000 per annum. Three kilns only were installed last year, but three more are now being added, which will give the plant a capacity of about 200,000 barrels per annum. The company's brand is "Monarch," and it has taken well in the market. J. M. Kilbourn is president of the company, F. A. Kilbourn, secretary-treasurer, and A. S. Butchart, superintendent.

"Manufacturing was begun at the Sun Portland Cement Company's works at Owen Sound in October of last year, the output up to 31st December being about 8,000 barrels. The site of the plant consists of about 4½ acres of land, lying between the bay at Owen Sound and the Grand Trunk Railway, with which line the works are connected by switches, and there is ample dock room for unloading and storing coal as well as for shipping cement. The manufacture is by the dry rotary kiln system. The buildings were erected with the view of producing 600 barrels of cement per day, but machinery for one-half this output only was installed. Additional facilities are being added to bring the capacity up to 500 barrels per day. The marl bed is at McNab lake in the township of Keppel, about 2½ miles from Shallow lake, where the company's railway connects with the Grand Trunk system. The marl is loaded on ordinary cars by means of a steam derrick, which will lift from the bed and place on the cars about 700 tons per day. These cars are hauled by the company's locomotive to the Grand Trunk at Shallow lake and thence to the mills by special G.T.R. trains. The clay beds are in the village of Brookholm, about three-quarters of a mile from the factory, to which it is at present delivered by team. Mr. James A. Cline is secretary and general manager of the company.

"The Owen Sound Portland Cement Company, Limited, has its works alongside of the marl deposit at Shallow lake on the Grand Trunk railway. The wet process of manufacture is employed. The power, mixing and grinding capacity of the plant is equal to 1,000 barrels per day, but the kilns now in use cannot put through more than 525 barrels. Rotary kilns are being added to place the burning facilities on a level with the rest of the plant. Mr. R. P. Butchart is manager of the company.

"Mr. M. Kennedy is president, and Mr. J. W. Maitland, secretary-treasurer, of the Imperial Cement Company of Owen Sound, which has an authorized capital of $250,000. The works are situated at Owen Sound, and have a capacity of 300 barrels per day. The process used until last year was the dry system, but was changed to the "semi-wet," drying being done in rotary dryers, and burning in stationary Alborg kilns. Marl is procured from Williams lake, about fourteen miles from Owen Sound on the Canadian Pacific railway, and clay close to the works. The company's product is branded as "Imperial," and is marketed mainly in Ontario and Manitoba.

"Another plant at Owen Sound is that of the Grey & Bruce Cement Company, Limited, which began making cement in 1902. The capacity is about 300 barrels daily.

"The Canadian Portland Cement Company, Limited, whose head offices are at Deseronto, operates two factories, one at Marlbank and the other at Strathcona. In 1902 the capacity of the former was 600 barrels per day, but in the autumn the installation of additional kilns and machinery was begun to increase the capacity to 1,200 barrels per day, and the work will now shortly be completed. The raw materials are marl, of which there are large deposits at Dry and White lakes, and blue clay. In mixing the wet process is employed; in burning rotary kilns are used, and grinding the clinker is done in ball and tube mills. At the Strathcona plant, the capacity of which is 300 barrels per day, mixing is carried on by the wet process, burning by continuous shaft kilns, and grinding by ball and tube mills. This company's brand is the "Star," which is favorably known.

"The plant of the National Portland Cement Company, Limited, which began producing cement since the beginning of the present year, is situated at Durham, in the county of Grey. The marl beds are at Wilder's lake, some miles away, where the marl is raised by a steam dredge and placed in hopper cars on a line of railway connecting with the works. The rotary kiln system is employed, and the works have a capacity of 1,000 barrels per day.

"The factories mentioned in the foregoing paragraphs comprise all those which have been completed and are at the present time actually producing cement, but there are two or three more which are now in process of construction.

"Among these is the plant of the Raven Lake Portland Cement Company, Limited, which was incorporated in 1902, and the directors of which are: Hon. Geo. McHugh, Lindsay; J. H. Carnegie, M.P.P., Coboconk; John Lucas, Toronto; Thomas Christie, Toronto; Duncan Robertson, Toronto; W. Sargeant, Barrie; Thos. McLaughlin, Toronto. The last named is also secretary-treasurer, with offices at 16 King street west, Toronto. Raven lake is a sheet of water about 354 acres in extent, lying alongside the Coboconk branch of the Grand Trunk railway, about 1½ miles from Victoria Road station. The water is about one foot deep, and underlying it is a body of marl said to be from 10 to 20 feet in depth. The buildings which are now being erected will stand between the railway track and the lake. Four rotary kilns are to be installed at the outset, each 60 feet long, with a drying extension 40 feet in length, making a kiln practically 100 feet long. The output of these four kilns is expected to be 700 barrels every 24 hours. Provision is being made for an easy enlargement of the plant by installing additional kilns. The work is being done under the supervision of Mr. R. F. Wentz, of Nazareth, Pennsylvania, who has had long experience in erecting cement factories. The buildings are to be fire-proof and of steel-frame construction. All machinery is to be operated by electric power generated at Elliott's Falls on the Gull river, some twelve miles away. Special features claimed for this undertaking are water power with dams already built, and proximity of marl supply and factory to the railway, thus obviating the expense of constructing and operating branch lines.

"The Ontario Portland Cement Company, Limited, is building a cement plant at Blue lake in the township of South Dumfries, where, and in the marshes surrounding the lake, there is a large deposit of marl. A siding from the Grand Trunk railway will run to the stock-house door, while the works themselves are within 75 feet of the marl bed. Clay underlies the marl. Manufacturing will be by the wet process; rotary kilns 70 feet long will be used for burning. The buildings are of brick with steel and iron roofs, and are being erected of size sufficient to allow of additional machinery being put in if required. At the outset the output will be about 500 barrels per day. The company, whose head office is at Brantford, has an authorized capital of $450,000. The officers are E. L. Goold, president; W. S. Wisner, vice-president; W. C. Elliott, managing director, and E. D. Taylor, secretary-treasurer.

"Hitherto all the Portland cement produced in Ontario has been made with shell marl as the ingredient supplying the necessary carbonate of lime. It is contended by some that where solid limestone can be obtained of the required chemical composition, it can be substituted for marl with advantage in economy of manfacture. The marl as it is raised from the beds of shallow lakes, where it is usually found, contains a great deal of water, which must be got rid of in the process of manufacture, and which adds to its weight and consequently to the expense of handling. Solid limestone on the other hand carries less moisture, and the crushing to which it requires to be subjected can be performed at less cost than is required for expelling the water from the marl.

"The Belleville Portland Cement Company has been organized to manufacture Portland cement from limestone and clay, by what is known as the dry rock process. Roughly speaking, this means the crushing of the limestone in large gyratory crushers, after which the clay is mixed with the rock in the proper proportions. The material then passes through the rock dryers, and the small amount of moisture driven off. It then passes to the rock pulverizing rooms, where it is reduced in Griffin mills to the fineness of flour. From this room it goes to the kilns to be dried or burned, issuing as clinker, which is then ground or pulverized to the proper degree of fineness for finished cement. The company's rock deposit is said to be of fine quality and to contain a very large quantity of raw material. It is entirely bare of covering. The clay beds lie close by, and the railway connecting the works with the Grand Trunk runs directly through them, so that the cost of hauling will be small. The equipment of the mill will be of the most modern type. Grinding machinery will be operated by direct connected engines, and the outlying portions of the plant by electricity. The buildings will be of stone with expanded metal and concrete roofs.

"The situation of the works will be on the Bay of Quinte, on lot 18 in the broken front concession of the township of Thurlow, within four miles of the city of Belleville, where the company will have two docks, each with fourteen feet of water, thus enabling the regular river and lake boats to load. One dock will be used for unloading coal from Oswego, and the other for the shipping of finished cement. The plant is to have ten rotary kilns, each being rated at 250 barrels per day of twenty-four hours, thus giving a daily output of 2,500 barrels. Limestone for making the cement will be taken from lots 16, 17, 18 and 19 of the broken front concession, Thurlow township, and clay from lot 14 in the first concession, about two miles from the works. The following analyses furnished by the company's engineer, Mr. C. B. English, show the composition of the limestone and clay:

Constituent.	Clay.	Limestone.
Silica	61.70	0.60
Alumina	16.60	0.78
Ferric oxide	5.20	
Lime	2.30	54.67
Magnesia	2.30	0.54

"The Colonial Portland Cement Company, Limited, has been formed with a capital of $800,000, of which $300,000 is 7 per cent. preferred and $500,000 common stock, to erect a 1,000-barrel mill on Colpoy's bay, near Wiarton, in the county of Grey. Mr. Elbert L. Buell, of Detroit, Mich., is president, and Mr. David A. Wright, Wiarton, is secretary. The beds of marl and clay are situated in the township of Keppel, close to the site of the proposed works."

Since the foregoing was written, the plants of the Raven Lake and Ontario Portland Cement companies have been completed, and are now (1904) turning out cement.

Origin and Nature of Limestones

Most rocks are mixtures of two or more minerals. Thus one of the best known rocks, granite, consists normally of a mixture of grains of quartz and feldspar together with mica or hornblende. The grains of these minerals can usually be distinguished by the unaided eye. A few rocks are glass-like in character, and cannot be considered as mixtures. Two or three rocks, while made up of grains, contain only one essential mineral, although others are usually present as accidental or accessory constituents. Limestone is one of these. It contains as an essential mineral calcite only. This mineral is composed of calcium carbonate, whose chemical formula is $CaCO_3$. The calcium oxide, CaO, commonly known as lime, makes up 56 per cent. of this compound, and the carbon dioxide or carbonic acid gas, CO_2, 44 per cent. Most persons who have little chemical knowledge and are not familiar with the characteristics of other rocks, are acquainted with some of the reactions of limestone. It is known that if this rock is strongly heated a product is derived which has properties quite different from the rock itself. And few there are who have not noticed that when a fragment of the pure rock is dropped into an acid solution, or when acid is applied to the surface of the rock, a gas is given off, or the specimen is said to effervesce—in the language of the prospector, the rock is said to "burn." It is well to remember, however, that this effeverescence is not a sure sign that the sample being tested is calcite or limestone, as other carbonates act in a like manner when similarly treated. It also should be borne in mind that certain magnesian limestones effervesce only in hot acid.

In the weathering or decaying of rocks by atmospheric agencies the lime contained in them goes into solution. It finally becomes a carbonate, and may be precipitated or deposited directly, or it may be taken up by animals. It is from the shells or hard parts of such animals that most limestone deposits have been formed, the shells at the death of the animals falling to the bottom of the bodies of water, lakes or seas, in which they lived. Through pressure and solution these shells are broken up, and many limestones which at one time were built up of the calcareous shells of animals now give little evidence of containing organic remains. It would seem, however, that some of the oldest, or crystalline limestones, had been formed by the direct precipitation of lime from solution without the intervention of life, unless we are to assert, more strongly than the direct evidence warrants, that life existed on the earth at the time the oldest of the sedimentary or fragmental rocks were laid down.

There are many varieties of limestone, depending on physical constitution and chemical composition. Instead of being composed of pure calcium carbonate, a limestone may have some of the calcium oxide replaced by magnesium oxide, which is a compound that plays a part similar to that of lime in nature. Limestones carrying a comparatively high percentage of magnesia are called dolomites. The characteristics and uses of these are described on other pages of this report. By the replacement of all the lime by magnesia the rocks pass into magnesite, which theoretically is the pure carbonate of magnesia.

Limestones may contain more or less clay, in which case the term argillaceous is applied to them. The peculiar properties possessed by limestones of this class are referred to under the section devoted to cement.

In form and structure limestones present as great a variety as they do in chemical composition. Usually they occur in solid beds or layers. In chalk, an important economic variety, the grains are loosely held together, while marl or bog lime occurs in a loose, earthy form.

Solid limestones vary in grain from very fine, e.g., lithographic stone, to coarse. Those which have been subjected to heat and pressure, or what is called in a general way metamorphic agencies, become more compact and brighter in appearance. They are then known as crystalline limestones. Varieties of these, which take a good polish and can be used for ornamental purposes, are called marble. Crystalline limestone is characteristic of our older or pre-Cambrian series, which occupy parts of the more broken and agriculturally less productive areas of eastern Ontario. They are less abundant in the more northern and western parts of the Province.

The limestones of the Province are widely distributed. They exhibit great variety in character and in age, being found associated with rocks of all ages, from the oldest crystallized representatives to the marls which are now in process of formation in our lakes and ponds.

Crystalline Limestones

Among the much disturbed and highly crystallized rocks of what is known as the Archaean or pre-Cambrian formations—those rocks which occupy the greater part of the surface of our more rugged regions—limestone is frequently found. It is in these cases crystalline, and commonly occurs in beds or layers which incline at an angle of considerable size from the horizontal. These limestones appear to have at one time formed a layer or covering, sometimes of considerable thickness, over the underlying rocks, and owing to disturbances produced by the shrinkage of the earth's crust they have been folded and squeezed. The upper parts of many of these folds have been worn away by agencies of decay; so that now in walking over a rock surface one often finds what appear to be several distinct bands of limestone separated by rocks of various kinds. These bands have at times been mistaken for several distinct beds. In the Grenville series, so named from the locality in Quebec where these rocks wer first studied, limestone is abundant. This series belongs to our oldest system, or what is known as the Laurentian. These rocks occupy a large territory in this Province, particularly in the eastern portion, in the counties of Hastings, Frontenac, Lanark and others. In the region lying north and west of lakes Huron and Superior crystalline limestone occurs more sparingly than farther to the southeast, and is associated with a system of rocks, later in age than the Laurentian, which are known as the Huronian.

Crystalline limestones are adapted to uses to which the ordinary unmetamorphosed rocks are put. Some varieties make handsome building stones. Others are burned, as at the town of Renfrew, for lime. Frequently, however, these rocks are too impure to be thus used on account of the association of numerour minerals with them. Interesting and beautiful crystals of various kinds are often found in limestones as a matrix. These rocks are at times veritable storehouses, and are much sought after by mineral collectors. The crystals are usually easily separated, owing to the softness of the rock mass or to the fact that the limestone is easily dissolved by acids, while the crystals may be unaffected by it. The following is a partial list of minerals which occur in the crystalline limestones of the Province: Amphibole, apatite, calcite, chlorite, chondrodite, corundum, dolomite, feldspar, galena, garnet, graphite, mica, molybdenite, pyrite, pyroxene, quartz, scapolite, serpentine, sphalerite, spinel, talc, titanite, vesuvianite, zircon. Some of these minerals occur in large quantities either in or closely associated with limestones. Among these we have in Ontario deposits of actinolite, apatite, galena, graphite, phlogophite mica, sphalerite and talc, which have been mined with success. In India the gem varieties of corundum, sapphire and ruby, occur in crystalline limestone. Some Ontario localities are noted for large and perfect crystals of other minerals in the above list. Serpentinous limestones at times take a good polish, and make beautiful decorative material. Many of the magnetite deposits of the eastern part of the Province have one or both walls of crystalline limestone.

The rock for which crystalline limestone is most apt to be mistaken is quartzite, such as occurs in the La Cloche hills on the north shore of lake Huron. These rocks can, however, be distinguished from each other by simple tests. Limestone is easily scratched by the knife, while quartzite is not. The latter rock does not effervesce in acids.

"The bluish-gray limestones, which have been mentioned as yielding good building materials in the upper formation, are the source of the greater part of the quicklime used on the Ottawa, whether for mortar, for potash making, or for agricultural purposes, and it does not seem to be universally known among the settlers that there are any other beds capable of yielding lime. Persons residing in the immediate vicinity of the white crystalline limestones have been known to send to the fossiliferous beds the distance of nine and ten miles, for years in succession, for their supply, without being aware that they might satisfy themselves at home. In collecting information in respect to the geographical distribution of the rocks, it was often found in white limestone districts that a settler would be acquainted with every small accidental patch of the blue limestone to be met with in the woods for some distance, while it had never occurred to him that there was anything worthy of remark in the crystalline rocks on his own ground; and one respectable farmer, who had given me useful information in regard to the run of the upper calcareous rocks, and regretted he had no limestone on his own lot, saying he would willingly reward any one who would discover it for him, would scarcely believe me in earnest when a bed of the white crystalline variety, which was in sight, was pointed out to him for limestone." (17)

Palaeozoic Limestones

In addition to the crystalline limestones which are found among the older and much disturbed Archæan rocks, there is in the Province another group of limestones which are of great economic importance. They are found among what are known as the Palæozoic formations. The term Palæozoic means "ancient life," and is applied to these rocks on account of the fact that they contain the oldest fossils or remains of animals and plants of any of our rocks. Among the Archæan, which literally means "old," no remains of this kind have been found. If they ever were present in these rocks, there would have been little chance of their being preserved, owing to the great heat and pressure to which the Arcaæan formations have been subjected.

The Palæozoic rocks in Ontario are sub-divided into three great groups, a lower and older, the Cambrian, a middle, Silurian, and an upper, the Devonian. These groups can be thus distinguished in the field.

The Cambrian and Silurian groups were first studied in a part of Wales, and the names are derived

(17) G. S. C., 1845-6, pp. 92-93.

from sub-divisions of that ancient kingdom. The other group gets its name from Devonshire. It may also be stated for the benefit of the general reader that these groups are commonly known as systems. The Cambrian, Silurian and Devonian are again sub-divided into what are known as formations. While the systems contain rocks of various kinds—sandstones, shales and limestones—the formations are more in the nature of units. Thus one formation is composed essentially of beds or layers of limestone, while another may be made up chiefly of shale or of sandstones. The names given to the Palæozoic formations in the Province have been derived, with one of two exceptions, e.g., Guelph, from localities in New York State, where these rocks were first studied and described, most of the formations of that State stretching across into Ontario,

The following table gives the subdivisions, in ascending order from the oldest to the youngest, which are usually made in the rocks of the Province :

	Recent	Marls, clay, etc.
	and Glacial	Boulder clay, etc.
PALÆOZOIC	Devonian	Portage-Chemung Hamilton Corniferous Oriskany
	Silurian	Lower Helderberg Onondaga Guelph Niagara Clinton Medina
	Cambro-Silurian	Hudson River Utica Trenton Bird's Eye and Black River Chazy Calciferous Potsdam
	Cambrian	Animikie, etc.
ARCHÆAN	Huronian	Upper Huronian Lower Huronian
	Laurentian	Grenville, etc.

Several of the Palæozoic formations are important as sources of limestone and lime. The Chazy, Bird's Eye and Black River and Trenton afford limestone which is usually pretty pure calcium carbonate. The Corniferous formation yields a similarly pure lime. The Calciferous, Niagara, Guelph and Onondaga yield magnesian limestones. Some beds of the Hamilton are pure limestone.

The Palæozoic limestones of Ontario may be grouped according to their geographical distribution as follows : Lower Ottawa—Cambrian and Silurian; Lake Ontario and Georgian Bay—Silurian ; Lakes Erie and Huron—Devonian ; James Bay slope—Silurian and Devonian. Small detached areas or outliers are found at numerous points over the Archæan, e.g., in the northern parts of some of the eastern counties and on islands in lake Nipissing; important exposures of Niagara limestone are to be seen at the head of lake Temiskaming.

The accompanying sketch map shows the chief geological divisions in the older portions of Ontario, where the outcropping rocks are in large part limestones of varying age and composition.

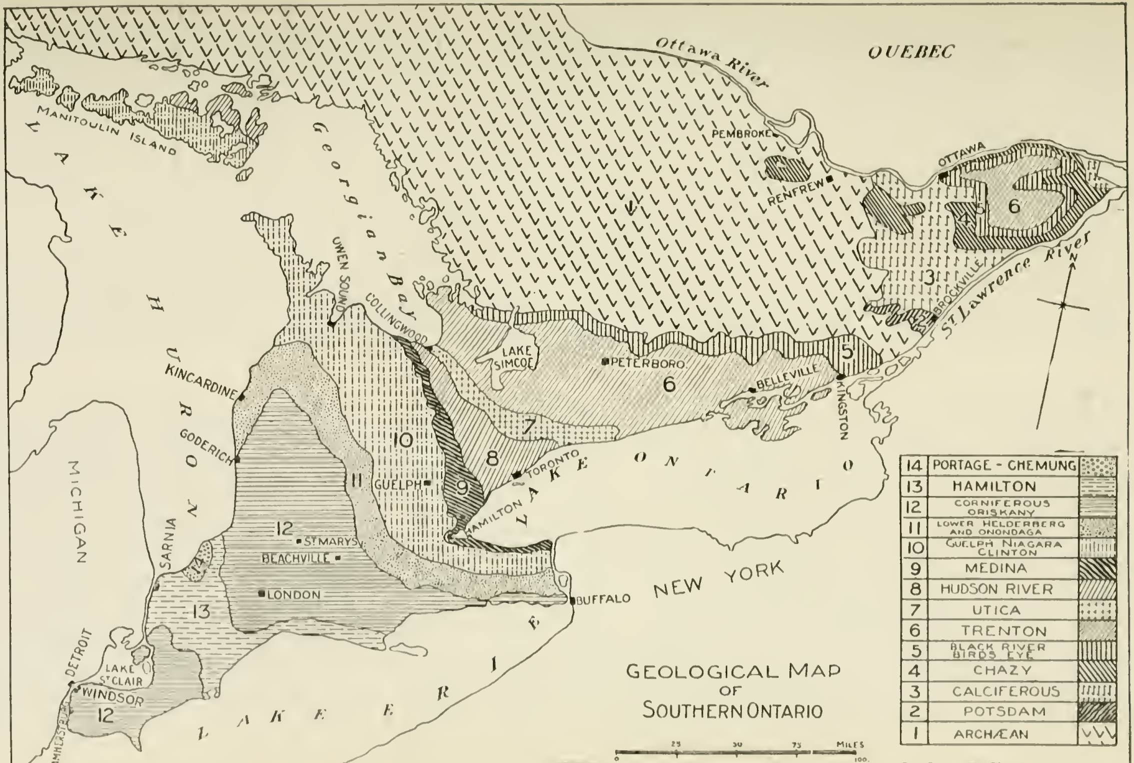
Lower Ottawa Area

This Palæozoic area is bounded on west by a line which runs roughly from Brockville to the vicinity of the town of Perth, and thence to the Ottawa river, a little north of the mouth of the Madawaska river; its other boundaries are the Ottawa and St. Lawrence rivers. Detailed descriptions of the rock outcrops in this area are to be found in recent reports of Dr. R. W. Ells of the Geological Survey Department.

The limestone formations occurring here are the Calciferous, Chazy, Bird's Eye and Black River, and Trenton. The first mentioned is found in the counties of Leeds, Grenville, Lanark, Carleton and Russell. It consists chiefly of dolomitic and sandy limestones—frequently spoken of as "bastard" limestones.

L. Ontario—Georgian Bay Area

This Palæozoic area is separated from that of the lower Ottawa by the Archæan belt, which crosses the St. Lawrence river between Brockville and Kingston, and extends southward into the Adirondack region.



GEOLOGICAL MAP OF SOUTHERN ONTARIO

The Silurian strata, or beds, in this area show a slight dip towards the southwest. Hence in travelling over the land surface from the eastern to the western end of lake Ontario, we pass from the older to the newer formations. Outcrops of the Calciferous and Chazy have not been definitely observed in this area.

Kingston is known as the "limestone city" on account of so many of its prominent buildings being constructed of limestone, of the Bird's Eye and Black River formations, which afford excellent stone in numerous near-by quarries. The exposures of these formations extend northwestward to the Georgian bay and Manitoulin island, forming the southern boundary of the broken Archæan regi- of southeastern Ontario. Numerous quarries, which afford the best of stone for many structural purposes have been opened in these formations, e.g., at Crookston, Longford Mills and elsewhere. The rock usually carries a high percentage of calcium carbonate, and is thus well adapted for use in Portland cement, for lime, for the production of calcium acetate, for beet-root sugar purposes, etc.

The Silurian formations outcrop in the form of belts which run in a northern or northwestern direction, the western boundary of the area being formed by the Lower Helderberg, which runs from near the head of Niagara river to the shore of lake Huron, in the county of Bruce.

In chemical composition the limestones of the Bird's Eye and Black River are similar to those of the closely related Trenton. The southern part of this latter belt has its western boundary in the neighborhood of Newcastle, a few miles west of Port Hope. On the Georgian bay it outcrops in the territory lying between Collingwood and the mouth of the river Severn, along the northern edge of Manitoulin island and on some of the smaller islands in the North Channel.

The Trenton, and Bird's Eye and Black River belong to the Lower Silurian, or as it is sometimes called, the Ordovician. The limestone-producing formations of the Upper Silurian are the Clinton, Niagara, Guelph and Onondaga. They are characterized, in distinction from those of the Lower Silurian, by the presence of a considerable amount of magnesia. The Clinton formation, which has a thickness of 80 to 180 feet, is made up in its lower part essentially of shales of various colors, which are at times more or less ferruginous, and in its upper parts chiefly of dolomitic limestone. The "cement" manufactured at Thorold comes from this formation. The formation is well developed on Manitoulin island and at other points farther south. It forms the base of the escarpment at Hamilton and elsewhere; is underlaid by the Medina sandstone, and passes above into the Niagara limestone.

The Niagara formation enters the Province from New York state in the county of Lincoln, and extends northwestward to Cabot's head on lake Huron and to the Manitoulin island. At Hamilton and elsewhere throughout its course it forms the upper part of the escarpment, or "mountain," which forms such a striking feature in the topography.

The strata which are placed at the uppermost part of the Niagara in the neighboring States are in this Province grouped under the name of Guelph, after the town in the vicinity of which some of the best outcrops are found. The maximum thickness of this formation is about 160 feet. The greatest development of the formation is found in the counties of Grey, Wellington and Waterloo, but outcrops are found at various points from the Niagara river to the shore of lake Huron in the county of Bruce. Exposures on the southern side of Manitoulin island, at the mouth of South bay, have been provisionally called Guelph. The limestones of this formation are for the most part white or light-colored, and have usually a peculiar semi-crystalline or granular texture. All of the stone of this formation is magnesian. It affords excellent building material in many localities, and burns to a high-class lime.

The Onondaga formation enters Ontario from New York state a short distance above the falls on the Niagara river, and follows the general outcrop of the Guelph to the vicinity of the Saugeen river on lake Huron. Much of its surface is covered with recent deposits, but portions of the counties of Welland, Haldimand, Brant, Oxford, Waterloo, Perth and Bruce are underlaid by it, and in it the gypsum deposits in the vicinity of the town of Paris and elsewhere occur. The formation is made up of thin beds of magnesian limestone of light gray or yellowish color, together with greenish calcareo-argillaceous shales. Some of these shales furnish material suitable for the manufacture of hydraulic cement. The salt deposits of the Province are situated near the base of the formation.

The Lower Helderberg appears to extend as a thin band along the western border of the Onondaga from lake Erie to lake Huron. Exposures have been found only in the townships of Bertie and Cayuga. It here represents only a small portion of the New York state formation of the same name, and consists of thin bedded dolomites, or magnesian limestones, with interstratified shales and a brecciated bed, chiefly of dolomite fragments, at its base; the total thickness does not exceed fifty feet.

Devonian of L. Erie and Huron

It will be remembered that the limestones of the Lower Silurian and Cambrian, with the exception of those of the Calciferous formation, usually contain a high percentage of calcium carbonate, with little magnesia, while those of the Upper Silurian — the Clinton, Niagara, Guelph and Onondaga — are characterized by the presence of magnesia in considerable amount. This difference in chemical composition is doubtless due to the character of the sea water in which the limestones of the various formations were laid down. It is reasonable to infer that during Lower Silurian times the waters of the Palæozoic sea carried a comparatively small amount of matter in solution. As time went on evaporation took place, and there was a tendency for the salts of magnesia to be precipitated. Hence we find the calcium of the Upper Silurian limestones replaced to a greater extent by the closely related metal magnesium. At the time the Onondaga rocks were being formed the waters of the sea had become so concentrated that deposits of gypsum and even rock salt were precipitated.

During Devonian times the waters appear to have again become somewhat like what they were in the Lower Silurian period, owing to the depression of the land surface or to some other cause, and the Ontario Devonian limestones, those of the Corniferous and Hamilton formations, contain as little magnesia as those of the Cambro-Silurian period.

The Corniferous formation—from the Latin, cornu, a horn, so called from the nodules of hornstone which it frequently encloses—occupies two large areas, separated by a band of the succeeding Hamilton formation, in that part of the Erie and Huron peninsula which lies southwest of a line running from the mouth of the Grand river on lake Erie to the outlet of the Saugeen on lake Huron. The more eastern of these areas extends over portions of the counties of Welland, Haldimand, Norfolk, Brant, Oxford, Perth, Huron and Bruce. The shore of lake Erie from the head of the Niagara river to Port Rowan lies upon the formation, but in some localities exposures are few on account of deposits of glacial and recent age. The western area occupies parts of Essex, Kent and Lambton counties.

The limestones of this formation show a considerable variety. In some localities, e. g.. at the town of Hagersville, they contain nodules of flint or hornstone, which unfits them for the manufacture of lime, but makes them adapted for use as road material. At St. Mary's, Beachville and Amherstburg they produce when burned a very pure lime which is used in the beet sugar industry and for other purposes. Good building and dimension stone has been quarried from the outcrops of this formation at numerous points; stone from the Amherstburg quarry, for instance, has been used in the construction of some of the canal locks at Sault Ste. Marie.

The Corniferous is also of interest on account of its being the storehouse of the petroleum of the region.

The Hamilton formation, so named from the town of Hamilton in New York state, and not as has sometimes been erroneously supposed, from the city of that name in Ontario, succeeds the Corniferous in ascending order. It consists mainly of soft calcareous shales, associated with which are a few beds of limestone. It extends across the counties of Norfolk, Elgin, Kent. Middlesex and Lambton and the south part of Huron. The limestone beds seldom outcrop at the surface. Those in the vicinity of Thedford and Stoney Point, on lake Huron, have been found to carry a high percentage of calcium carbonate.

The sketch map shows the relative position of the limestone-bearing formations which have been described, as well as those of other character—Potsdam sandstone, Utica and Hudson river shales, Medina sandstone, and Oriskany sandstone—which come in at various points in the series from the base of the Cambrian to the top of the Ontario Devonian.

Northern Pala ozoic Area

In the imperfectly explored region north of the height of land and tributray to James bay, limestone strata of Upper Silurian and Devonian age are known to occur. Much of the surface is low and drift-covered, and outcrops of solid rock over a large part of the district are not numerous. Dr. Robert Bell, who has explored the region. says "The most northerly section of Ontario, or that bordering on the lower part of the Albany river and James bay resembles the most southerly portion. or the peninsula between lake Huron and the lower lakes, in being underlaid by almost flat-lying Silurian and Devonian rocks, while the great intermediate tract is occupied by a part of the great Archæan area which stretches to the Arctic regions." Outcrops which appear to belong to the

Niagara, Guelph and Corniferous formations have been observed in the area to the south and west of James bay. These will be referred to again in the section dealing with counties and districts.

In the Archæan region, lying between the older settled parts of the Province and the level territory to the north of the height of land small areas or outliers of the Palæozoic strata have been discovered, such as that at the head of lake Temiskaming which has been already mentioned. These, though of small size, may, like the one just mentioned, be of economic importance in the future.

From what has been said, it will be seen that the youngest of the rocks lying in the region north of the height of land, with the exception of glacial and recent deposits, are of Devonian age. Hence no true coal or coal-bearing rocks, namely, the Carboniferous, are to be found there. There is no known reason, however, why oil-bearing strata, such as those of southwestern Ontario, should not be looked for in this northern Devonian.

Limestones of Recent Age

In a geological sense a rock is a substance which makes up an important part of the earth's crust. In form it may be solid or loose. Hence marl, or bog lime, as it has recently been named, can be classified with limestone. Marls in many cases contain a high percentage of calcium carbonate, and thus resemble in chemical composition some of the older limestones of the Province, such as those of the Trenton and Corniferous formations.

During recent years marls have been much sought after for use in the manufacture of Portland cement, on account of their purity and comparative freedom from magnesia. Now that the chemical composition of the older solid limestones is better known, cement works have begun to use them, in preference to marl. It is claimed that it costs less to grind a solid limestone to powder and get it into form resembling dried marl, than it does to extract the water which forms a high percentage of the latter. Marls are adapted for use in many other processes to which solid limestones are put.

Beds of it are widely distributed throughout the Province, and occurrences will be mentioned under the next heading.

Marl is formed usually in small bodies of water by the deposition at the death of small organisms of their calcareous shells, which organisms have their habitat in lakes and ponds, and by the precipitation of calcium carbonate from solution. While this precipitation may be due to some extent to inorganic agencies, it is believed that minute organisms play an important part in the process.—(Geol. Sur. Mich. Vol. VIII., part 3, p 41.)

Limestone Occurrences by Localities

In preceding pages a brief description has been given of the general distribution of limestones throughout the Province. We shall now take up the occurrences by counties and districts. Mention will be made of important outcrops and quarries, and analyses of samples will be given. Although the writer has visited many outcrops and collected numerous samples for analysis, the time at his disposal has been too limited for him to gain, at first hand, all the information he could have wished. Free use has been made of the reports of the Geological Survey and papers by other workers. The counties and districts are arranged in alphabetical order.

It will be found in the following pages that the description of the limestones of one county will frequently apply to those of adjoining counties. Hence in searching for information on Frontenac county, for example, it will be well to look up the descriptions of Leeds, Lennox and the other counties which adjoin it.

Addington and Lennox

Limestones of two ages, Laurentian and Cambro-Silurian, are of economic importance in these united counties. The Marlbank marl deposits, of recent age, which have been used extensively in the production of Portland cement, are a short distance beyond the boundary of the counties, in Hungerford township, Hastings county. The cement plant at Strathcona, formerly Napanee Mills, which is the oldest of the kind (Portland) in Canada, uses this Hungerford marl.

The southern part of the counties for a considerable distance north of lake Ontario, is underlaid by Trenton limestone, under which we group not only the Trenton proper, but also the closely allied Black River and Bird's Eye formation. The contact between these formations and the Laurentian area to the northeastward follows a line which runs roughly from Frontenac county past Mud lake to Centreville in Camden, and thence northward by Tamworth and Beaver lake to Clare river. "Where the line between the third and fourth ranges of Sheffield comes upon Clare river, there occurs the greatest thickness of the beds observed in one mass in this part [of the counties.] It presents a cliff of about 40 feet. . . while on the same bank of the river, within seventy yards. the rock is gneiss" (18). Further notes on the distribution of the Silurian rocks in these counties are given in the descriptions of the adjoining counties of Frontenac and Hastings. The analyses quoted in these descriptions show the characteristic chemical composition of the Trenton rocks.

"Further west, Amherst island and the whole of the peninsula of Prince Edward county, are apparently entirely occupied by the Trenton formation, which abounds with fossils everywhere.

"The Black River formation, seen at Kingston, continues westward along the shore of lake Ontario as far the village of Bath, where it is overlaid by the Trenton limestone. The latter thence extends across the peninsula of Adolphustown to Deseronto, where the basal beds holding Receptaculites are seen in the bed of Sucker creek about half a mile south of the Grand Trunk railway near Deseronto junction. The outline of the formation north of this is somewhat irregular, and the Trenton limestone occupies basin-shaped areas upon the Black River to the north of Napanee, whence it extends northwest into Tyendenaga township. The Black River limestone shows in a bold escarpment on the west line of the township of Richmond, about six and a-half miles north of the Bay of Quinte, and a short distance south of the crossing of the Salmon river, whence the southern boundary of the formation continues southeasterly to the shore of the bay. The rocks are well exposed near Shannonville station on the Grand Trunk railway, where there is a boss of granite and quartzite upon which the newer limestone is deposited. The Black River limestone forms the north side of the Bay of Quinte at Ox Point, about three miles east of Belleville, and large and valuable quarries are here located in the massive beds near the summit of the formation. The opposite shore in Prince Edward county, at Massasauga Point, is of Trenton limestone. At Ox Point the strata are, in places, inclined at an angle of ten to fifteen degrees, probably indicating an underlying boss of the crystalline rocks.

"The Trenton comes in to view west of this place in a cove, and is again seen at Belleville on the Moira river, and northward along this stream for several miles, the exact contact with the Black River formation not yet being traced in this direction. From the Moira river the Trenton continues along the north side of the Bay of Quinte, and is well seen in low-lying ledges in rear of the town of Trenton, which is just beyond the western limit of map-sheet No. 112." (19)

The following table of analyses of Trenton limestone was kindly furnished by Mr. H. C. Mabee, chemist to the Deseronto Iron Company. Mr. Mabee states that the limestone used as a flux in the furnace comes from cuttings along the Bay of Quinte railway, between Strathcona and Yarker. The samples, the analyses of which are given in the table, from along the railway thus represent a pretty complete, approximately east and west, line across the township

(18) G.S.C., 1863, p. 179.

(19) G.S.C., Sum. Report, 1901, pp. 177, 178.

Locality	$CaCO_3$	$MgCO_3$	Insoluble Silicious	Al_2O_3 Fe_2O_3	Phos.	Sulph,
Samples from yard, Deseronto Iron Co'y	91.014	.98	4.78	1.58	......	.147
" south of Yarker	92.4	.88	5.10	1.22	.084	.21
" " on B.Q. Ry	87.77	3.74	3.73	2.76	.02	.074
" " "	89.50	2.09	4.50	2 07	......	.063
" " "	89.26	3.03	6.07	1.55	.009	.107
" " "	91.44	3.50	3.97	1.91	.002	.078
" " "	90.07	1.73	4.81	2.78	.013	.104
" " "	88.21	4.26	4.89	1.18	......	.063
" " surface shale	78.93	3.75	9.31	7.08	......	......
Sample from Point Ann, near Belleville	88.746	4.13	3.88	1.80	......	.159
" quarry at Newburg	93.3		5.00	.701	.15	.11
" Bath cut, B.Q. Ry	95.7		1.98	1.00	.06	.14

of Camden. Some of the analyses are of samples only, and not shipments, as the phosphorus and sulphur are present in too high percentages to make the stone suitable for blast furnace work. The silica also occasionally runs too high. The analysis of the Point Ann rock seems to represent a poor variety, judging from other analyses, with which the writer has been furnished, and which will be found under the heading devoted to Hastings county.

These samples represent for the most part picked material—material suitable for use in the blast furnace.

The following is the result of an analysis made of a sample of stone from Rollins' Hill, Napanee:

Silica..............	1.44
Ferric oxide and alumina	1.68
Lime	53.82
Magnesia......	.98
Carbon dioxide	42.40
	100.32

"At Napanee Mills we own a quarry in connection with our cement mills (natural rock cement). As far as we have worked yet we find that there are five or six layers of good cement stone, the aggregate thickness of which would be about four feet, the layers being separated from one another by layers of limestone. The cement stone commences, perhaps about two feet from the surface. We commenced work there about ten years ago. In connection with the cement works we employ about 30 men as regulated by the demand. Some parts of the work are going on constantly, such as the taking out of the rock, burning or grinding. The rock is broken to a uniform size, and then put into the kiln and burned; it next passes through the crushers and grinders, and finally through screens of a certain mesh, when it is fit for the market. Our output last year was about 9,000 barrels, valued at as many dollars. The market is in Ontario, to the Grand Trunk Railway Company, for public works, etc. Our capacity is equal to 400 or 500 barrels a day. There is no doubt that the cement is first class, for by actual test it stands ahead of the Akron cement. It sets as hard, but not as quickly, as the Portland. The demand for it is increasing; it works well with our terra cotta, making a firm and solid wall by the cement rooting into the porous character of the terra cotta material. We expect it will come more and more into use. Our contracts for 1889 aggregate already three times the output of 1888." (20)

(20) E. W. Rathbun in Roy. Com., 1890, p. 84.

White dolomite (crystalline limestone) from lot 1 in the sixth concession of the township of Sheffield is thus described: (21)

"Its cleavage faces present diagonal striæ. The specific gravity of this rock is 2.684, and it contains a very little quartz and mica.

	Per Cent.
Carbonate of lime....	52.57
Carbonate of magnesia......	45.97
Ferric oxide....	0.24
Insoluble, quartz, etc.........	0.60
	99.38"

Marl

Marl occurs on lots 15 and 16 of the second concession of the township of Sheffield. "The deposit extends over an area of two hundred acres, and perhaps more, with a thickness over the greater portion of at least ten feet.

"The air-dried material is earthy, friable; color, light gray. It contains numerous shells; also some wood-fibres.

"Its analysis afforded Mr. F. G. Wait the following results: (After drying at 100 degrees C.—Hygroscopic water, equal to 0.82 per cent.)

Lime....	51.97
Magnesia....	0.36
Alumina....	0.03
Ferric oxide...	0.09
Potassa...	traces
Soda...	0.08
Carbonic acid...	41.34
Sulphuric acid.....	0.03
Phosphoric acid....	0.02
Silica, soluble...	0.03
Insoluble mineral matter... ...	0.71
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water...	5.96
	100.62

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 92.80 per cent. carbonate of lime.

"The insoluble mineral matter was found to consist of (22)

Silica	0.48
Alumina and ferric oxide..	0.13
Lime.....	0.03
Magnesia.....	0.02
Alkalies.(?)........	0.05
	0.71"

(21) G.S.C., 1863, pp. 592-3.
(22) G.S.C., 1894, pp. 25-26 R.

Algoma District

Crystalline limestones have been found at a number of points in this district. Doubtless some of these are adapted to use in certain metallurgical operations and for other purposes. Certain varieties are said to take a good polish, and can be classed as marble.

The Silurian limestones, which occur on the islands along the north shore of the Georgian bay are described under the heading devoted to Manitoulin island. (23)

Marls are found at numerous points in the district, but have as yet received little attention.

Geneva Lake

"In Geneva lake, about a mile and a half northeast of the outlet, there is an islet entirely composed of thinly-bedded light gray, dove-colored and nearly white dolomite, striking north 35 degrees east, and dipping to the westward side at an angle of 80 degrees. It is compact, and has a conchoidal fracture, but is traversed by fine threads of quartz, which prevent it from taking a good polish, otherwise it might be suitable for marble. The same rock is exposed on the east side of the lake on the point just southward of the above islet, but the band could not be found on the northern side of the lake, towards which it strikes in the opposite direction. On the railway track three-quarters of a mile south of the outlet of Geneva lake there is a fifteen-feet bed of gray to dove-colored fine-grained dolomite, weathering dark brown. It strikes north 45 degrees east, and the bedding is about vertical. This dolomite band is separated from hornblende granite to the southeast by about three hundred feet of ash-gray greywacke. The granite towards its contact with the latter becomes mixed with coarse breccia and conglomerate. On the other side, or to the northwestward, the dolomite is followed by coarse felspathic sandstone and silicious greywacke-conglomerate or breccia. At the outlet of Geneva lake the rock is a greywacke passing into granite, and it includes some black slate and a patch thirty feet thick of impure dolomite." (24)

A specimen of fine-grained crystalline limestone collected by the writer on the line of the Canadian Pacific railway near Geneva lake station, was found to possess the following composition: (24).

	Per cent.
Silica...	6.04
Alumina........	0.28
Ferrous oxide...	2.31
Lime...	27.01
Magnesia...	19.03
Carbonic acid.....	41.87
Moisture...	0.16

Lake Panache

"Impure magnesian limestones are found at several places along the northern side of Lake Panache. They are generally fine-grained and semi-crystalline, of light greyish colors, and always contain a large proportion of silica, in the form of grains and threads or strings. The purer of two specimens from the north shore of this lake, analyzed by Dr. T. S. Hunt, gave 55.10 per cent. of carbonate of lime, and 6.5 per cent. of carbonate of magnesia, the balance being insoluble matter. The exposures of limestone on this lake do not all appear to belong to one band; indeed, they may constitute a number of great masses, wholly or partly formed by a process of segregation or concretion and may be unconnected with each other. At one part of the shore, where the limestone is well exposed, Mr. Murray estimated its thickness to be 150 feet. A band of impure light greenish-gray dolomite, weathering brown, crosses the Wahnapitae river at Island Portage, about three miles below the outlet of the lake. The rocks are here nearly vertical, but undulate a good deal, and I estimated this band to have a thickness of at least 300 feet. The rocks around lake Panache and thence by the canoe route to lake Wahnapitae are described by Mr. Murray in the Geological Survey Report for 1853-56, pages 178-190" (25).

Referring to the magnesian limestones of lake Panache, Mr. Alexander Murray says:

"On the north shore of Lake Panache, about midway between the inlet from lake Lavase and its western extremity, a band of limestone occurs which where first observed appears to be both underlaid and overlaid by syenitic slate-conglomerate. The mass of this limestone, which measures about sixty yards across and may be about 150 feet thick, is of a pale gray color on fracture, weathering to a bluish gray, with thin layers, which have the appearance of chert, but are in reality only harder

(23) The following may be added: "South from Collins' inlent there are two groups, called the Fox islands and the Papoose islands; the former about 3, and the latter about 7 miles from the general run of the coast. On Bayfield's chart they are described as being composed of limestone." G.S.C., 1863, p. 193.

(24) B.M., Vol. I., p. 82.

(24) B. M. Vol. 12, p. 307.

(25) G.S.C., Vol. V., part 1, 1890-91, pp. 13-14 F.

portions of the limestone, weathering quite black. About the base of the calcareous strata some of the beds are blue, holding more silicious matter than the gray beds, while others are of a brecciated character. The beds are all more or less intersected by small veins of fine greenish jaspery-looking trap, which weathers brown or yellowish.

"To the eastward of this exposure the only indications observed of the presence of limestone were on the east side of the large island at the entrance of the south bay, and in the peninsula on the north side at the entrance of the eastern arm; in both of these localities small exposures of a black-weathering brecciated rock, which proved to be calcareous, came up in one or two parts just over the surface of the water. On the island the calcareous rock is overlaid by a black-weathering slate, which, though without pebbles, resembles the matrix of portions of the slate-conglomerate. On the peninsula at the eastern arm the brecciated rock comes directly in contact with greenstone. . .

"At the head of the lower south expansion of Lake Panache the limestones are again seen on both sides, and also on the two islands near the middle, striking about east by north and west by south, and showing a southerly dip on the north side of the exposures; but the slate conglomerate with which it seemed to be associated at other parts only appears on the south side of the large island lying at the entrance to the northern arm, and between this island and the exposure of limestone on the west side of the bay there is a point to the northeast of the limestone displaying finegrained green slate, which, though very much disturbed and intersected by quartz veins, appears to show a general dip to the northwest." (26).

Mr. Murray thinks that some of the above strata might yield good stone for burning into lime. A specimen from the section on the north side of lake Panache was analyzed by Dr. T. Sterry Hunt, and gave in 100 parts 55.10 carbonate of lime, 6.50 carbonate of magnesia, 38.40 insoluble sand and a trace of iron. A specimen of the limestone at the lower end of lake Panache, analyzed by the same chemist, gave 41.97 per cent. carbonate of lime, 2.40 carbonate of magnesia and 55.63 insoluble residue; and a specimen from the lower lake near the outlet, lying between the two ridges of the mountain range, gave 36.50 per cent. carbonate of lime with a little magnesia.

La Cloche Lake

"Along the northern arm of the larger La Cloche lake calcareous rocks or impure limestones occur at several places, passing below a considerable thickness of slate conglomerate, and they are again met with on the smaller lake to the northwest. High ridges of quartzite, standing nearly on edge and forming part of the La Cloche mountains, rise on either side of the southern arm of the larger lake, while greenstone and quartzite are found on the northern side of the smaller one. It would therefore appear that in this part of the great Huronian belt the magnesian limestones occur among the quartzites, and are sometimes more immediately associated with slate-conglomerate.

(26) G.S.C., 1853-54-55-56, pp. 181-183.

Township of Rutherford

"A band of finely crystalline limestone occurs among the Huronian rocks in the northern part of the township of Rutherford. The locality is near the boundary line between the red granite to the southward and a great thickness of quartzites to the northward. The junction of the granite to the southeast with the Huronian quartzite and hornblende schists to the northwest occurs at the south side of a rather elevated rocky island in a cove about one mile north of the western entrance to 'the passage' or channel, on the north side of which Killarney village is built. The geology of this locality and the relations of the limestone referred to can best be given by quoting the description in the Geological Survey Report by the writer [Dr. Robert Bell] for 1876, page 209:

" 'On the west side of the township of Rutherford, from the northern limit of the granite (at the elevated rocky island above-mentioned) quartzites and hornblende schists hold the shore as far as Lamorandiere bay, in the northwest corner of the township. A blackish-green, massive and rather coarsely crystalline hornblende-rock, having an exceedingly rough or irregularly pitted surface, is exposed on either side of the narrow entrance to this bay. Upon the slope of the hill, about 100 yards in from the north shore of the bay, at a point about half a mile from the above-named narrows, a band of finely-crystalline limestone occurs among the Huronian rocks. It has a vertical attitude and runs about north 70 degrees west at the part examined. Its total thickness is about 75 feet, of which the 25 feet along the northern side consists of a single solid band of nearly white finely crystalline limestone, clouded with light greenish and grayish patches. The remaining 50 feet are mixed with shaly patches of hornblende, together with a little shining granular magnetic iron ore. Adjoining the limestone on the north side is a band, only a few feet in thickness, of dark smoke-colored chert-rock, ribboned with streaks of a dull red color. It breaks easily with a fine conchoidal fracture, and appears to be identical with a rock which was used by the mound-builders for making some of their arrow-heads. This is followed to the northward by a dark-colored dioritic conglomerate, in which the pebbles are mostly small and generally widely scattered, and farther on by a very dark gray, soft, massive-looking micaceous schist, most of which is full of small pebbles. Measured from the limestone band, a thickness of between 100 and 200 feet of these rocks is exposed.

" 'On the north shore of Lamorandiere bay, a few hundred yards eastward from the outcrop of limestone above described, are two exposures of very tough massive hornblende rock, and between the two arms of the bay is a more fissile variety, interstratified with a reddish gray quartzite, which also overlies the mixed rocks. The dip is here northwestward, at an angle of 60 to 70 degrees, and the series is underlain by granitoid gneiss.' " (27)

A sample of this crystalline limestone collected by the writer was found to have the following composition:

	Per cent.
Lime	29.30
Magnesia	19.00
Ferric oxide	1.77
Alumina	.37
Carbon dioxide	43.00
Insol. residue	6.94
	100.41

Marbles

"At Garden River, near Sault Ste. Marie, the Commission visited the quarries of the Warmington Stone & Marble Co. Here we found a mountain of marble, stated by the owners to be 5,000 feet wide, 8,000 feet long, 600 feet high and of unknown depth, while the band upon which these quarries are situated is supposed to extend inland for about thirty miles." (28)

"At Garden river they are opening a quarry of beautiful dark marble, a Huronian limestone or dolomite. The Garden river band extends for many miles; it crosses Echo lake, and has been traced and mapped through that country by Sir William Logan. I do not think it is uniform in character; in one place I think the beds would be better than in others. It seems to be a very beautiful and good marble, and the openings of Garden river I consider look exceedingly promising. Wherever the Laurentian limestones occur we can quarry them for marble, but they are generally coarse in the grain. I have not seen the marble at Bridgewater, but suppose it is the ordinary Laurentian crystalline limestone. I have seen some specimens that were brought from the township of Barrie. The marble there is coarse-grained, and has specks of quartz and other minerals in it. I have seen the Arnprior marble, and think there should be no difficulty in quarrying it. Some of that marble is very beautiful. It has already been extensively used, and its value proved. All limestones capable of taking a polish are marbles." (29)

"Half-way down Echo lake, on the north side, a point of banded marble runs out. It is composed in places of alternate thin bands of pure white and colored stone, much twisted. The colored portions being harder are weathered out more prominently, and show the structure very plainly. Sir William Logan describes its appearance very fully in his report on this district. As a rule the marble is tinted. This is especially the case behind Garden River, where the same series of marbles are again tapped; but at Echo lake there is an immense quantity of the banded marble with pure white streaks. Where again accessible in the bluff about two miles north of Garden River village, on St. Mary river, the band is about a mile wide. The strike is about east and west. and the dip about 50 degrees north. The marble is quarried at this location by a Chicago company, and a railroad is being constructed into it from the river. It is a very close-grained and hard stone, and is said to take an excellent polish. The colors are shades of green and pink in different parts of the bed, blending by very soft gradations into white. It is quarried against the north and south joints, and may be got out in very large layers." (30)

Palaeozoic Limestones

"In the northern part of the Province, west of James bay, we meet with almost horizontal gray and yellowish-gray limestones, containing fossils, which, according to the late Mr. E. Billings, the celebrated palaeontologist. belong to the Niagara formation. These strata occur along the Albany river above its junction with the Kenogami, and also along the latter stream as far up as the first portage. The limestones are overlaid by a considerable thickness of chocolate-colored marls with greenish layers and

(27) B.M., Vol. I., p. 83.

(28) Roy. Com., 1890, pp. 228-229.

(29) Ibid. pp. 68-69; extract from evidence of Dr. Selwyn.

(30) Ibid, p. 76.

patches, but without observed fossils." (31)

"On Moose river, banks of gypsum occur from ten to twenty feet high, especially on the northwest side below the junction of the Missinaibi, for a space of about seven miles, or from thirty-one up to thirty-eight miles above Moose Factory. About ten feet of the lower part of the deposit consist of solid gypsum of a light bluish-grey color, but the upper portions are mixed with marl. In some sections of these banks a comparatively small proportion of the gypsum, but still large commercially speaking, is nearly white, and from this circumstance they have received the name of 'the white banks.' The geological age of these deposits cannot be far from the Onondaga formation, and it would not be surprising if salt should also be found in the rocks with which they are associated." (32)

"In the region south-west of James Bay the Corniferous formation occupies an area greater than all the western peninsula of Ontario. A large part of this, lying between the Albany river and the basin of the Moose river, comes within the northern part of the Province. It consists mostly of porous and cavernous drab grey and yellowish grey fossiliferous limestones, resting directly upon the Archaean rocks to the southward, the line of junction cutting the Missinaibi river just below Hell-gate, the Mattagami just below the long Portage, and the Abittibi just below The Otters' portage. Many of the Corniferous fossils of this district belong to species which differ from those of the formation in regions to the south of the height of land, tending to show that there was here a separate basin in these early times, as well as now. At the foot of Grand rapid, on the Mattagami river the writer, in 1875, discovered a large deposit of rich clay-ironstone in these rocks. The materials of the drift, for a considerable distance to the southward of the Corniferous formation in this region, contain fragments of this ore, indicating that it exists, and probably in the same horizon, among these rocks, in many other places besides the above mentioned locality on the Mattagami." (33)

"The last exposure of gneiss is seen about three-quarters of a mile below the lowest portage [on the Kenogami or English river] or nearly 70 miles from Long lake, following the river, and the first exposure belonging to the great continuous area of unaltered flat-lying strata is about one and three-quarter miles farther down. This consists of a thinly bedded, greenish-drab, soft, fine-grained calcareo-argillaceous sandstone, without observed fossils. Between this point and Pembina island the strata exposed in the bed of the river consist of thinly-bedded, yellowish and drab-colored argillaceous limestones and shales. In the bank just above Pembina island a section of about 20 feet consists of soft-greenish-drab, earthy and porous, argillaceous beds, from 6 to 8 inches thick; underlaid by a few feet of yellowish-drab and bright brownish-yellow calcareous beds, having a conchoidal fracture, and measuring from 2 to 5 inches in thickness. These strata are as nearly as possible horizontal. They appear to hold no fossils." Fossils found in the gravel and shingle near by indicate that the strata are Upper Silurian, and probably belong to the Niagara formation. (34)

"Leaving the foot of the Long Portage, the first exposure of solid rock,—which is also the principal one on the river [Mattagami]—begins at 17 miles, or at the head of the Grand Rapid, which is about a mile and a quarter long, and has a fall of about 20 feet. On the northern side of the river, at the head of the rapid, there is a cliff 30 feet high, consisting of dark grey bituminous limestone, inter-stratified towards the bottom with earthy drab limestone, all weathering to a drab color. Half way down the rapid, this cliff is about 20 feet and at the bottom about 40 feet in height. The thickest beds measure about 2 feet, and occur towards the top. A similar cliff runs along the opposite side of the rapid. The dip is southeastward, at the rate of one in fifty to one in one hundred. Fossils are not common in these rocks [Corniferous]." (35)

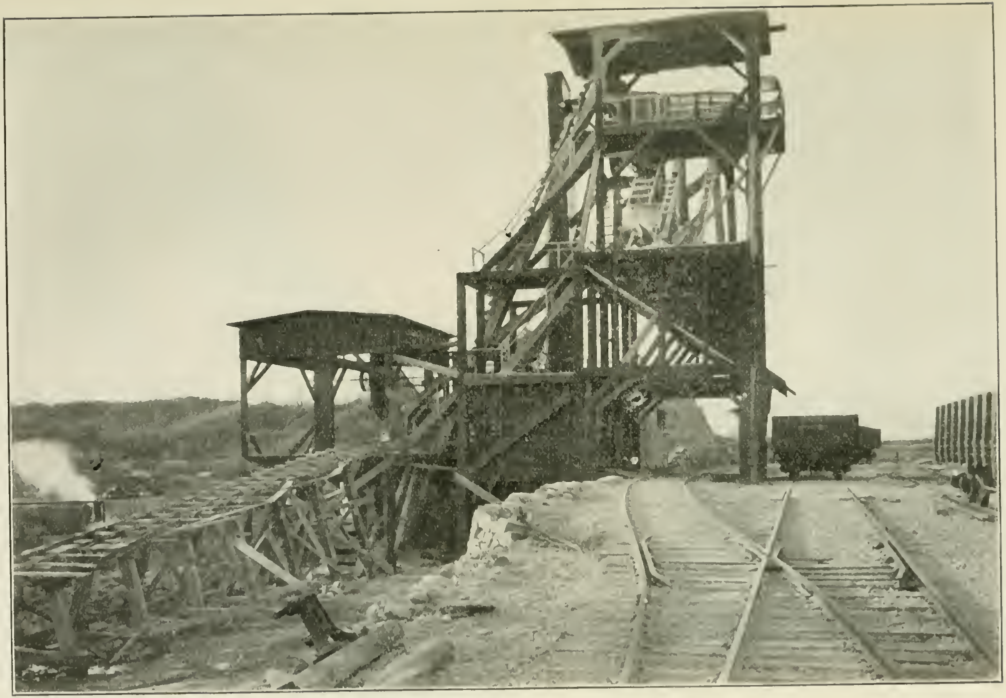
"In ascending the Kenogami river, we have a repetition of the geological conditions which were observed on the Albany. From The Forks to Mamattawa, drab and chocolate-colored marls and interstratified bands of earthy yellowish limestone are exposed in a few places. Following up the stream, at about 7 miles above Mamattawa, the bottom of the river is composed of beds of limestone, which are in places somewhat disturbed.

"The river between this spot and the Albany appears to run upon the axis of a slight anticlinal. At the end of the seven miles indicated, we enter between banks composed of chocolate-colored marl interstratified with bluish-green bands, and varying from 50 to 80 feet

(31) Roy. Com., 1890, p. 44.
(32) Ibid, p. 45.
(33) Ibid, p. 47.
(34) G.S.C., 1870-71, p. 339.
(35) Ibid, 1875-76, p. 316.

High grade limestone quarry, Anderdon, in springtime, showing dip of strata. Essex County.

Quarry of gray dolomite, Anderdon, showing floor of high grade limestone. Essex County.



Plant for crushing limestone at Anderdon quarries. Essex County.

Gray dolomite bluff, Anderdon quarries, showing debris from quarrying block stone. Essex County.

Lime kiln at Limehouse. Halton County.

in height. These banks continue on both sides, almost uninterruptedly for about 10 miles up the stream. Above this the banks, which maintain almost the same height, especially on the southern side, are mostly composed of stiff gravelly clay, with boulders, but the chocolate-colored marl is seen here and there almost to Pembina island." (36)

Brant

"The most southern exposure of the summit of the formation [Guelph], on the Grand River, occurs just above Middleton bridge, on the twenty-first or twenty-second lot of the sixth range of Dumfries. The rock is a light grey dolomite, weathering to a pale drab. . . Similar beds, with others of a pale buff color, continue up to the north end of the fourteenth lot of the sixth range of Dumfries, with a very gentle dip to the southwest; the distance across the measures being probably two miles. . . The rocks of the Guelph formation are again met with, farther up the Grand River, in the vicinity of Galt." (37)

"At Paris, on the east bank of the river, between the Great Western Railway viaduct and Mr. Wright's plaster bed, the strata of this part of the formation [Onondaga] are very well exposed. Here we have eight or ten feet of tender, brittle, greenish argillaceous dolomitic rock, often red weathering, and passing into a shale. This is overlaid by three feet of dove-colored dolomite, vesicular below, with thin eroded cellular beds; followed by a bed of one foot, compact above, but cellular below, and succeeded by a foot or more of vesicular beds. These are overlaid by about a foot of conglomerate, apparently of vesicular dolomite, with fragments of green shale; the upper part very ferruginous and decomposing. The whole is overlaid by green shales, more tender and crumbling than those below. These strata are slightly undulating, and as they are concealed near the gypsum quarry, it is not easy to give the exact horizon of this. The upper part of the gypsum bed is intercalated with much dolomite, and for two feet seems made up of alternating lenticular masses of gypsum and dolomite, the latter prevailing at the top, and succeeded by thin bedded cellular dolomite, one portion of which seems to have been broken and recemented. Examples of this are seen on the other side of the river just below the viaduct, where the green shales are overlaid by masses of similar dolomite, often stained red, and having apparently been broken and recemented into a kind of breccia." (38)

"Proceeding westward from Ancaster no exposures of rock are encountered until Woodstock is reached, at which point the erosion of the Thames has removed the glacial debris from the underlying Corniferous limestone. Both north and south of the highway rock is to be seen, not, however for some distance west of Ancaster. The road from this place to Brantford reaches the summit about two miles out and then traverses a level clay country. At Brantford although no rock is normally exposed, it has been encountered above the dam at about 15 feet below water level, and below the dam about five feet down. An opportunity was had of seeing a small piece removed in making excavations for new piers for the Brantford Power and Light Company. The sample was a hard compact gray limestone with a distinctly glaciated surface; the direction of glaciation was of course indeterminable, the rock not being in place. Conversation with workmen led to the opinion that both the striae and dip of the rock had a southwesterly direction.

"At Brantford post-glacial gravel lies directly on the rock; it is almost continuous as far as Galt and also extends west to Burford. Southward, however, it gives place to clay; for at the Cockshutt bridge, two miles south of Brantford, forty feet of continuous clay, devoid even of sandy partings, was pierced in making foundations for a new bridge.

"These post-glacial beds consist mainly of coarse sand with pebbles mostly of limestone, but many of the Archaean rocks are also represented, sometimes by fragments of considerable size. Continuing south from Brantford, clay deposits alternate with gravel, the country gradually growing less hilly to the vicinity of Waterford. South of this place several interesting exposures of Corniferous rock are to be seen. Stratified gravels prevail in the immediate vicinity of Waterford, but on passing south towards Rockford they again give place to clay, which is practically continuous to the shore of lake Erie." (39)

"Returning to Brantford, the north and south section was continued farther north, the first exposures being seen in the banks of the river at Paris, where the Onondaga or

(36) G.S.C., 1871-72, p. 113.

(37) Ibid, 1863, pp. 338-9.

(38) G.S.C., 1863, p. 350.

(39) B.M., Vol. 12, p. 142.

gypsum-bearing formation is encountered. Near the bridge over the Grand river at this place fifteen feet of soft, thin-bedded shales with interlaminations two to four inches thick of soft limestones are exposed. An analysis of this limestone was made to ascertain its general nature and its content of gypsum, of which substance it proved practically free, as a glance at the analysis will show :

	Per Cent.
Water	0.33
Insoluble residue	3.32
Calcium oxide	27.77
Magnesium oxide	15.15
Carbonic acid	33.42
Sulphur	0.60

"In spite of its association with the gypsiferous shales, this rock is therefore very free of both alumina and sulphur. The uppermost layers however are more cavernous than the typical rock analysed, and contain small particles of gypsum. The shaly portions are soft and friable, and resemble the Don Valley shales of the Hudson River formation as exposed near Toronto. These shales are practically the same as the slate at gypsum quarries, of which an analysis will be given later.

"At Paris the rock is covered by a thick deposit of post-glacial gravel similar to and probably continuous with that at Brantford. About a mile and a half below the town are situated the gypsum quarries or 'plaster mines,' as they are called locally. The Grand has hollowed out its bed through the gravel which rises to an elevation of 100 feet or more above the high water level, at which point the rock is exposed for a half mile along the river. The method of quarrying is to run tunnels about five feet square into the hillside and to enlarge these passages into chambers where good material is encountered. The product, as brought to the mouth of the tunnel, consists of mixed slate and gypsum, both gray and pure white in color. The gypsum occurs in irregular cracks in the shale with its fibres arranged at right angles to the walls, or as selenite in ramifying veinlets traversing the slate in all directions. Some portions of the rock are filled with crystals of gypsum, while in certain places the valuable material seems interbedded. Speaking roughly, the white product would average about 15 per cent. of the rock quarried. The residue, however, contains more or less gypsum and is ground and sold for land plaster. The slate assays as follows :

	Per Cent.
Water	0.75
Silica	52.02
Alumina	8.03
Ferric oxide	3.80
Calcium carbonate	9.90
Magnesium carbonate	2.34
Sulphur	1.00

"At present three men are working in a tunnel which has been driven about 600 feet into the hillside, and which has been worked for nine years. Previous to this tunnel fourteen others, some of them extending to greater distances into the hillside, had been excavated. At various other points along the river valley similar deposits occur, and there is no doubt that a practically inexhaustible supply of the material exists in the vicinity.

"The Paris waterworks are situated two miles above the town, at which point a copious spring bursts out of the gravel. The water is somewhat calcareous, as is seen in considerable deposits of travertine containing impressions of leaves and various small organisms. These are the only fossils to be seen in the vicinity." (40)

Marl

"On lots 18, 19, 20 and 21 of the first concession, South Dumfries, an excellent deposit of marl is seen in Blue lake which itself covers 10 acres, while the marl beds probably extend over 40 acres. The deposit would average thirty feet in depth of pure white marl, said to contain 98.83 per cent. carbonate of lime. The hills surrounding the lake are of moraine origin and show no stratification. Clay occurs in the hillside to the north of the pond. This location is very well disposed for the stablishment of a cement plant, as a spur of 1,000 feet would suffice to put the product on the rails. Some work had been done, at the time of my visit, with the object of establishing a cement works on the property, which has been acquired by the Ontario Portland Cement Company, of Brantford, with Mr. E. L. Gould, Brantford, as president, and Mr. W. G. Elliott, manager." (41)

Bruce

In the following quotations a summary description is given of the important limestone outcrops in the county of Bruce.

(40) B. M., Vol. 12, pp. 147-8.
(41) Ibid, p. 149.

"The same two formations [Medina and Clinton] occupy the lake front of the townships of Albemarle and Eastnor, with the exception of the peninsula terminating in Cape Crocker. This consists of Hudson River strata; and is overlooked from the westward by a bold escarpment, in the lower part of which the two formations occur. The summit of the Medina series disappears beneath the waters at Cape Dundas, while the Clinton continues along the water line, as far north as Cape Chin, rising at Cape Gun, and Point Hungcliff to about the height of a hundred feet.

"At Cabot's Head, the very summit of the Medina formation is seen at the water's edge, and there rest upon it about twenty-six feet of dolomite similar in its coloring and its weathering to that of Owen Sound, which it also resembles in holding silicified fossil. . . . On the dolomite, repose 103 feet of red marly sandstone, partially striped and spotted with green, and interstratified with beds of red and green argillaceous shale; none of which exceed six or eight inches in thickness. The green argillaceous beds appear to be quite free from calcareous matter, and the stone is carved by the Indians into tobacco pipes. These red and green strata are succeeded by about fifty-five feet of green calcareo-argillaceous shales and thin-bedded limestones and terminated by the massive limestones of the Niagain series." (42)

"Farther on, escarpments of twenty- or thirty feet of the limestone [Corniferous], run through the west half of Carrick, and are said to extend southward into Howick; while, to the north, the outcrop of the formation crosses the south-west corner of Brant [township], and is seen upon the Teeswater, near the east line of Greenock. The general trend of the strata would bring them upon Lake Huron, near the mouth of the Saugeen River. No exposures have, however, been observed at this point, nor for seven miles to the south-west, along the coast. Beyond this, however, nearly horizontal buff-colored beds appear, at about two feet above the edge of the lake; holding numerous organic remains, which are frequently replaced by chert. These beds come out at intervals along the shore, the surface of the same stratum being sometimes exposed for a considerable distance; they occupy altogether a distance of four or five miles. . . . Beyond this another interval of concealment occurs, to within three miles of Point Douglas. Here, a yellowish calcareous sandstone skirts the coast line; and proceeding along the beach towards the point, the sandstone is found to be associated with calcareous beds, holding numerous nodules of chert, with black bituminous shales, and blue and drab dolomites; one bed among which is fit for hydraulic cement. The whole of these strata appear to be devoid of fossils; but they contain crystallized celestine, quartz and calcite, in geodes and fissures. A black band, of a coarsely crystalline granular texture, overlies the sandstone, and appears to be composed of an aggregate of imperfect crystals of calcite; while the color results from the presence of bituminous matter, which exists, in a greater or less proportion, in all of the beds. Ascending in the section, which at Point Douglas displays a thickness of twelve feet, thin calcareous beds of a dark color occur, separated by very thin layers of black bituminous shale. Above them the upper part of the cliff is occupied by thin blue layers with pale yellowish beds, sometimes more than a foot in thickness, marked by small lenticular crystals of brownish calcite, and by epsomites. Portions of these non-fossiliferous strata continue to occupy the coast to the southward, with gentle undulations, to a point about half a mile beyond Little Pine Brook. Here, fossiliferous cherty beds, similar to those on the other side of Point Douglas, are seen, overlying the highest of the strata already mentioned, in detached isolated portions, for upwards of a mile; beyond which, no rock is exposed for upwards of twenty-five miles.

"Near the village of Kincardine, in the sixth and seventh lots of the township of that name, is a quarry, on the land of Mr. C. R. Barker, where from fifteen to twenty feet of the formation are exposed, consisting for the most part of thick bedded light and dark grey granular limestone, which are quarried both for building stone and for burning, and yield a very white lime. The lighter colored beds contain a few corals. No chert was observed here, but the rocks are bituminous; and towards the top are thinner beds, interstratified with layers of a dark brown inflammable shaly limestone, some specimens of which contain a large proportion of asphaltum." (43)

"The Onondaga or gypsiferous formation, which overlies the preceding rocks, consists chiefly of a dolomite, which is generally too thin bedded for building purposes. On the fourth lot of the second range of Brant, however, at the Oxbow on the Saugeen River, it presents several thick beds of a very fine-grained yellowish grey dolomite, which appears

(42) G.S.C., 1863, pp. 319-20.

(43) G.S.C., 1863, pp. 371-5.

to be well fitted for architectural purposes. It is free from stains, may be split with regularity, and works with facility; when fresh from the quarry it may be cut with a saw, but soon hardens on exposure. Two bands of this stone, each about ten feet in thickness, occur in this formation. The higher one, which is at its summit, is here exposed at the surface; and offers facilities for quarrying. It is made up of massive beds, some of them two feet in thickness; and a bed of three feet occurs in the lower band. Beneath the upper band is a bed of light grey oolitic rock seventeen inches in thickness which has been used with advantage in the neighborhood for supporting the axles of mill-wheels." (44)

"Beds of a fine-grained yellowish-grey stone, well fitted for lithographic purposes have lately been found among the dolomites of the Onondaga formation in the township of Brant. They occur in the bed of a small stream, about half a mile south of Walkerton, where several strata of the stone from two to eleven inches in thickness occur in a section of fifteen feet. The beds at this place are traversed by natural joints, which cause the rock to divide into somewhat narrow portions; but the stone is found to be well adapted for lithography, and larger slabs may probably be found elsewhere in the same formation. Equally good specimens of it were obtained from the Oxbow on the Saugeen River, on the third lot of the seventh range of Brant. The stone from this formation, being magnesian, is attacked by acids more gently and with less effervescence than ordinary limestone. This peculiarity in the action of the acids, which are employed in the lithographic process, is said to be an advantage." (45)

"Exposures of thin bedded dolomites [of the Onondaga formation] are met with, at several points, nearly to the mouth of the Saugeen. About a mile below the village of Paisley, in the township of Elderslie, strata of this kind are seen, containing small lenticular crystals of calcite. The lithological characters of many beds at the summit of this formation are, however, so much like those of the overlying water-lime group, that it is not easy to draw a line of division between them." (46)

"The base of the limestone [of the Niagara escarpment] comes upon Colpoy's Bay, and crosses it probably about two miles and a quarter from its bight. Thence it keeps rather close upon the north side of the bay; while the escapment gradually rises, according to Bayfield's chart, to a height of 350 feet above the level of Lake Huron in the bluff which faces Hay Island, to 300 feet in the next bluff north; and to 200 feet in Cape Paulet. The Clinton formation occupies perhaps a hundred feet at the base of the most southern bluff, and is seen in the second; but the summit of the formation comes to the level of the water at the extremity of Cape Paulet. The cliffs along the coast, from this to Cape Chin, are altogether occupied by the Niagara escarpment, and vary in height from 130 to 150 feet, being often nearly vertical. The limestone of which they are composed approaches to white in color; the beds are massive, and a majority of them appear to be magnesian. These cliffs would supply an unlimited amount of a superior material for the purposes of construction. The limestone abounds in corals. . . .

"The summit of the cliff at Cabot's Head is, by measurement, 324 feet above the lake, 184 feet of this, at the base, are occupied by the Clinton formation; leaving only 140 feet of the Niagara formation in the escarpment. In the transverse section presented by the coast between Cabot's Head and Cape Hurd, higher portions of the series are, however, met with. The coast intersects the strata obliquely; but from the position where the base of the limestone comes to the lake, the distance to the strata of Cape Hurd would be, at right angles to the strike, about 12 or 13 miles. The slope of the strata, as ascertained by a measurement of two miles and a half, being about 37 feet in a mile, the whole thickness of the limestone, provided the dip is constant, would thus be about 450 feet. It is probable, however, that the slope diminishes towards the main body of the lake; this may considerably reduce the thickness, and some part of the strata may belong to the succeeding formation. The rock is a pale buff or yellowish white, and weathers to a drab. It is divided into massive beds, many of them being 9 and 10 feet thick; they are cut into rhomboidal forms by two sets of parallel joints, one running N. 85 deg. E, and the other S. 29 deg. E. Some of the thickest beds appear to be a mass of corals, and most of them present a very rough and irregular exterior. Great blocks of the rock, some of them fifty tons in weight, have fallen from the cliffs, and are scattered along the shore. . . .

"It seems probable that the coast from Chief's Point to Cape Hurd, a dis-

(44) G.S.C., 1863, p. 821.
(45) Ibid, p. 835.
(46) Ibid, p. 351.

tance of 50 miles, runs very nearly on the strike; but it has still to be ascertained whether the coast may not include some part of the succeeding formation. The rock, all the way, is a whitish sub-crystalline magnesian limestone, presenting at Tobermory Harbor, Lyell Island, the mouth of the Riviere aux Sables, near Chief's Point, and other places, a number of characteristic fossils. 'The Rankin River, falling into the Riviere aux Sables (north), discharges the waters of a chain of lakes, which, with the river first named, occupy a valley running parallel with Lake Huron, for ten miles; at a distance of two miles from it. A low escarpment occupies the west side of the valley; but we have not yet been able to ascertain whether this may give clearer evidence of the true summit of the Niagara rocks than is afforded by the coast." (47)

Marl

" Deposits of this material are abundant in the counties of Bruce and Grey. One of these, on the twenty-fifth lot of the fifteenth range of Carrick, covers about six acres, and was found to have a depth of twenty-seven inches. It is very pure and white, and is covered with a thin layer of black mould, forming the soil of a meadow. Other deposits, estimated at forty acres in all,occur in the immediate neighborhood. On the sixth lot of the first range of Brant, north of the Durham road, marl occurs in a peaty meadow, beneath a foot of soil. It is two feet in thickness and extends over seven acres. Another locality in the same township is on the seventieth lot of the first range, south of the same road; where it is seen in the banks of a little stream, near its junction with the Saugeen, and has in some places a thickness of three feet." (48)

Carleton

The geology of this and adjoining counties has been described during the last decade by Dr. R. W. Ells, Dr. H. M. Ami, the late Mr. N. J. Giroux, and other officers of the Geological Survey. The reader is referred to the reports and maps published by these gentlemen for details concerning the distribution of the limestone-bearing formations—the Calciferous, Chazy, Black River and Trenton. (49).

(47) G.S.C., 1863, pp. 331-3.
(48) Ibid, p. 764.
(49) G.S.C., 1899, G., etc.

The limestones, especially the Trenton, of the county have been quarried extensively for lime-burning and for building stone. The largest quarries now operated are Robillard's, on the Montreal road, about three miles from Cumming's Bridge. Many old quarries have been abandoned for some years. Large quarries are situated near Hog's Back on the east side of the Rideau river. These are in the Trenton. That the limestone of this formation is here very pure is shown by the fact that the Portland cement plant now being constructed at Hull is to use this rock as the source of calcium carbonate.

Among the largest quarries in the Chazy is that known as Wright's cement quarry on the south side of the Ottawa above Mechanicsville. The stone from this quarry is referred to under the heading devoted to cement.

"In the eastern areas the Palæozoic formations are well developed, the principal being the Postdam sandstone and the Calciferous limestone, which are particularly well exposed in the south-eastern part of Lanark county and the southern portion of the county of Carleton. The beds of these formations are in a nearly horizontal position, though in places they are inclined at angles of ten to fifteen degrees. They constitute the lowest members of the Ottawa Palæozoic basin and rest directly upon gneiss and limestone of the Archæan. In the townships of Huntley and Nepean, as also in Ramsay, the Calciferous passes regularly up into the Chazy and on into the Black River and Trenton. There is usually a gradual passage upward from the Potsdam sandstone into the Calciferous limestone, and in places these transition beds are from thirty to fifty feet thick. This portion frequently contains an abundance of fossils, as in the township of Goulbourn, though they are not often easily obtained in a good state of preservation." (50)

"Between Britannia and the Chats Falls, which forms the first break in the navigation, the rocks along the south shore are divisible into Calciferous and Chazy. The former of these constitutes a belt nearly six miles in breadth, between Brittania and Berry's Wharf, the rock being chiefly a buff-weathering dolomitic limestone. The limestones cross the river and show along the beach on the north shore for several miles above the town of Aylmer, where they are overlaid by green-gray Chazy sandstones and shales. On the south

(50) G.S.C., 1897, p. 58 A.

side, these latter extend from below Berry's Wharf to Fitzroy Harbor at the foot of the Chats Falls, capped on the tops of the hills inland by Chazy limestone, which also appears along the shore in the township of Torbolton, about Buckhams Bay, where the rock has been extensively quarried for building stone. Further inland, the Calciferous rests upon and passes into the Potsdam sandstone. This flanks, on the north and east, a long tongue of Laurentian gneiss and limestone, which extends south and east from Fitzroy Harbour to within ten miles of the city of Ottawa. These crystalline rocks have associated with them large areas of intrusive syenite and diorite which have broken through the crystalline limestone and associated gneiss. . . .

"The rocks between Fitzroy Harbour and Arnprior, on the southern side of the river, are mostly crystalline limestones of Laurentian age, cut by numerous dykes and masses of reddish syenite and diorite." (51)

"This, and the two following stones, represent the material of three of the more important beds (here referred to in descending order) at Messrs. H. Robillard & Son's quarry on the twenty-second lot of the first concession of Ottawa Front, township of Gloucester. . . Geological position—Trenton formation, Cambro-Silurian.

(1) "Stone from the first bed. Thickness of the same, eighteen to twenty-four inches. Structure, moderately fine-crystalline; color, dark gray. Its composition was found by Mr. Wait to be as follows : (after drying at 100 degrees C. —Hygroscopic water, = 0.03 per cent.)

Carbonate of lime.....		97.87
Carbonate of magnesia...		1.13
Phosphate of lime (tribasic)	0.39*	
Alumina...	0.04	
Silica, soluble....	0.05	
Bisulphide of iron....	0.13†	
Insoluble mineral matter ..	0.59	
Organic matter	0.08	1.28
		100.28

* Corresponding to 0.079 phosphorus.
† Corresponding to 0.07 sulphur.

"This stone is extensively quarried for structural purposes.

(2) "Stone from the third bed of Messrs. H. Robillard & Son's quarry. This bed has a thickness of from fifteen to twenty inches. Structure, fine crystalline; color, light gray. An analysis by Mr. Wait afforded the following results : (after drying at 100 degrees C. —Hygroscopic water = 0.04 per cent.)

Carbonate of lime.......		98.25
Carbonate of magnesia...		0.78
Phosphate of lime (tribasic)	0.37*	
Alumina	0.04	
Silica, soluble.....	0.02	
Bisulphide of iron........	0.06†	
Insoluble mineral matter...	0.60	
Organic matter	0.04	1.13
		100.16

*Corresponding to 0.074 phosphorus.
† Corresponding to 0.03 sulphur.

"This stone is largely used for building purposes.

(3) "Stone from the fifth bed of Messrs. H. Robillard & Son's quarry. Thickness of bed, twelve to twenty inches. Structure, somewhat coarse-crystalline; color, faintly brownish light gray. An analysis by Mr. Wait, gave as follows : (after drying at 100 degrees C.—Hygroscopic water = 0.06 per cent.)

Carbonate of lime		98.68
Carbonate of magnesia...		0.90
Phosphate of lime (tribasic)	0.17*	
Alumina...	0.17	
Silica, soluble...	0.02	
Bisulphide of iron...	0.04†	
Insoluble mineral matter ...	0.32	
Organic matter...	0.01	0.73
		100.31

* Corresponding to 0.035 phosphorus.
† Corresponding to 0.02 sulphur.

"This stone is employed for building purposes." (52)

(4) "From an outcrop on the southwestern side of Hemlock Lake, township of Gloucester. Geological position, Chazy formation, Cambro-Silurian.

"A very fine-grained and compact, greenish-gray, yellowish-brown and reddish-brown weathering, massive limestone. An analysis by Mr. Johnston showed it to have the following composition : (after drying at 100 degrees C.—Hygroscopic water = 0.98 per cent.) cent.)

Lime...	19.78
Magnesia...	10.55
Alumina...	0.75
Ferric oxide	0.27
Ferrous oxide...	1.71
Manganous oxide...	0.38
Carbonic anhydride	26.03
Sulphuric anhydride....	0.07
Phosphoric anhydride...	0.14
Silica, soluble...	0.60
Water...	0.20
Insoluble mineral matter	38.81
	99.29

(51) G.S.C., 1894, pp. 58-59 A.

(52) G.S.C., 1899, pp. 32-33 R.

"The insoluble mineral matter consisting of :

Silica	24.20
Alumina	6.77
Ferric Oxide	3.23
Magnesia	1.47
Potassa	1.46
Soda	0.15
Water (ignition)	1.53
	38.81

"The band from which this argillaceous magnesian limestone was taken has been supposed to be an extension of the beds affording a cement-stone, which are worked by Mr. C. B. Wright on the thirty-fourth lot of the first concession, Ottawa Front, of Nepean township, in the above-mentioned county of Carleton. (53)

Marl

"From a deposit on the east side of MacKay's or Hemlock Lake, lots one and two of the Junction Gore of the township of Gloucester, Carleton county. The deposit has a thickness of about five feet, but its extent is not known.

"The air-dried material is earthy, slightly coherent; color, yellowish-white. It contains numerous shells, also root-fibres.

"Agreeable with the results of an analysis, conducted by Mr. F. G. Wait, it has the following composition : (after drying at 100 degrees C.—Hygroscopic water 0.46 per cent.)

Lime	52.24
Magnesia	0.13
Alumina	0.13
Ferric oxide	0.09
Potassa	traces.
Soda	do.
Carbonic acid	41.16
Sulphuric acid	traces.
Phosphoric acid	0.02
Silica, soluble	0.11
Insoluble mineral matter	1.08
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water	4.90
	99.86

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 93.29 per cent. carbonate of lime.

(53) G.S.C., 1898, Vol. II., p. 19 R.

"The insoluble mineral matter was found to consist of : (54)

Silica	0.72
Alumina and ferric oxide	0.24
Lime	0.04
Magnesia	0.02
Alkalies	0.06
	1.08"

Dufferin

In this county the Clinton strata "are limited by a bold escarpment, composed of the rocks of the Niagara formation, which succeeds" or overlies them. "The inclination of the measures being very small, probably not exceeding thirty feet in a mile, the outcrop of the series, particularly at the summit, presents a very indented outline, running into deep bays in the valleys of the principal streams where bold ravines are worn in the rock above, (e.g., on the Nottawasaga in Mono). Several minor undulations occur north of this, in Mono and Mulmur."

"Though the Clinton strata are thus easily traced by the conspicuous escarpment which rises precipitously above them, they themselves are but seldom seen, being for the most part concealed by a talus of debris." (55)

"The river Credit, in Caledon, is flanked on both sides by the cliffs of the Niagara limestone, in some places a hundred feet high; these, in ascending the valley, meet on the ninth lot of the fourth range of the township, near Bellefontaine, and form a crescent-shaped precipice, over which the river falls in a cascade. In the valley of the Nottawa, similar cliffs prevail; and at Orangeville some of the rock, of a yellowish-white, would take a sufficient polish to constitute a very useful marble. The cliffs continue through Mulmur and Nottawasaga." (56)

Quarries are worked in the limestone near Orangeville, and in other parts of the county.

Dundas

The following notes describe the general distribution of the limestone formations in this county. Additional information will be found in recent Summary Reports of the Geological Survey.

" . . . "Black limestone occurs in the northwest corner of Williamsburg, about a mile from the right bank of the South Petite Nation River. Being the most west-

(54) G.S.C., 1894, pp. 23-24 R.

(55) Ibid, 1863, pp. 315-6.

(56) Ibid, pp. 327-8.

erly exposure of black limestone met with, connected with the southern division of the Ottawa and St. Lawrence trough, it is probable that it may belong to the Birdseye and Black River formation. There is nothing to contradict this view in the aspect of the rock, but no fossils have been obtained to confirm it. Farther down the river, at the eleventh lot of the second range of Winchester, similar beds hold Leperditia; but here also the formation is uncertain. Still farther down, at Armstrong's Mills, on the twelfth lot of the fourth range, and in several places in the neighborhood, quarries are opened in black limestone beds, but there they are characterized by Trenton fossils. From this vicinity similar limestones occur at intervals all the way to Crysler's mills, in Finch, and nearly the whole of the township appears to be underlaid by such strata in a generally horizontal attitude." (57)

"The town of Iroquois is apparently nearly on the eastern limit of the Calciferous, on this shore of the river, since at Sheik Island the next recognized outcrop is of the dolomitic limestones at the base of the Chazy formation." (58)

"Few mineral substances are found in the area to the south of the Ottawa in economic quantity. Quarries are, however, numerous and are situated generally in the limestones of the Black River formation, which has been found to yield the best quality of stone for building purposes. Others have, however, been worked in the limestones of the Calciferous, Chazy and Trenton, as also in the heavier sandy beds at the base of the Chazy, which are especially well suited for foundation work. There is a large quarry of this rock about two miles east of the village of South Mountain, on lot 2, range I., Mountain township. The most important quarries in the Chazy limestones are near the village of Winchester, on the road thence to North Williamsburg. The rock here is used both for lime-burning and for building stone. On lot 7, range I., Winchester, there is an excellent quarry of flaggy limestone in layers of about six inches thick, from which flags of any required size can be obtained. This is owned by Mr. William Bolton. A similar flaggy limestone is seen in a quarry on lot 39, range VIII., Williamsburg. These are near the base of the Chazy limestones, while most of the Winchester quarries are in the grayish somewhat nodular limestones belonging to the upper portion of that formation." (59)

(57) G.S.C., 1863, p. 173.

(58) G.S.C., Sum. Rep., 1899, p. 134.

(59) Ibid. p. 136.

"About two miles, in a northeasterly direction from Van Camp's Mill, Calciferous limestone occurs in thin beds and much disturbed, with characteristic vugs of pink and white calcite. This place has been opened as a quarry.

"The formation is also well exposed in the neighborhood of South Mountain, and all along westward of this place. . . .

"On the road from Mountain to Smirleville, similar outcrops (Calciferous) also appear, and at about one mile and a half north of Mountain station, this limestone is full of rounded and angular pieces of quartz, varying in size from a pea to a melon, and angular pieces from a fourth of an inch to a foot across. This conglomeritic rock has a very homogeneous matrix, which exhibits plainly all the characters of the Calciferous. The dip of these beds on the south of the exposure, is S. 20 degrees E. $\angle$ 18 degrees, and on the north side is about 100 yards wide, the dip is N. 10 degrees W. $\angle$ 12 degrees.

"The Calciferous also appears near Ormond Corner in the township of Winchester, Dundas county, in beds of limestone, as well as on the east point of Racket River, on the south side of the St. Lawrence, where ledges of dark-gray, sandy limestone outcrop. The south shore of the river northward for some distance from this place, is low and without rock exposure, but Calciferous blocks are numerous." (60)

"Limestones of this age (Chazy) are also seen about two and a half miles west of Grantley, and at about three miles south of Chesterville. They also appear, associated with shales, about two miles northeast of West Winchester, as well as on lot 22, range XII., Winchester township." (61)

Durham

"In Darlington and Clarke, according to Dr. Bigsby, the Silurian boulders (limestone) generally occur in groups, and not scattered like those of Laurentian origin." (62)

"At the latter place [Cobourg], and between it and Port Hope, there are some small exposures of blackish-gray, thin-bedded nodular limestone and shale, which, among other Trenton fossils hold Lingula Canadensis and Asaphus megistos.

"The farthest up exposures of Trenton limestone, near the lake shore, occur

(60) G.S.C., 1896, p. 62 A.

(61) Ibid, p. 62 A.

(62) Ibid, 1863, p. 895.

about a mile south of the village of Oshawa in Whitby, where the dip is N. < 25 degrees; and at Bowmanville, where a quarry has been opened for the purposes of the Grand Trunk Railway, at the summit of the formation. The strata here dip to the northwestward at a small angle, and, as they must finally crop out with a southward dip, it is plain that the beds of the quarry are on a southward side of a synclinal form, and that, after running to the northeast on the strike for some uncertain distance under the drift, they must ultimately turn northward to conform to the deeper strata seen farther northward." (63)

"The most eastern exposures of the Utica [shale] formation, on the north shore, are just above those of the Trenton already mentioned as occurring to the south of Oshawa, and near to Bowmanville." (64)

Elgin

This county is drift-covered and few descriptions have been published of its geology. It is believed to be underlaid chiefly by the Hamilton formation, although the Corniferous appears to lie directly under the clay in some localities. In a well drilled at Vienna 35 or 40 years ago it is said that Corniferous limestone was met with beneath 240 feet of clay. The point at which the drilling was done lies about 40 feet above Lake Erie. (65)

The following log gives information on the underground geology of another part of the county:

"At about the same time that the boring at Vienna was made, one was also made at Port Stanley, to a depth of 298 feet. The record is as follows: [probably all Hamilton] (66)

	Feet.
Surface..... :...	172
Black and brown shale........	30
Light coloured shale.........	16
Limestone.....	80"

Essex

Rev. Thomas Nattress, B.A., has kindly furnished the writer with the following interesting account of the limestones of Essex county, together with photographs of the quarries which are reproduced in this report.

Anderdon Quarries

"The exposures are in Anderdon township in the southwestern part of the county, and on Pelee island, in lake Erie.

"In Anderdon, within a few hundred yards from south to north, there is an outcrop of three several qualities of limestone (67). The overlying deposit is a magnesian rock, gray in color, of which some 32 feet in depth has been exposed in quarrying. There are some indications that the thin bedding that forms the surface deposit on Pelee island begins not far south of this point of measurement, going to show that the approximate maximum depth has been reached. There are five beds of this dolomite, measuring, from above downward, two, eight, four, eight and ten feet in thickness respectively. The lower eight-foot bed is unsurpassed as dimension stone. The four and ten-foot beds are also of very fine quality, the latter, however, showing some chert. An analysis of the former, the four-foot stratum, shows $CaCO_3$ 60.903, $MgCO_3$ 36.463, $CaSO_4$ 0.071, $(FeAl)_2O_3$ 0.230, SiO_2 2.350.

"The surface beds, so far as exposed, are somewhat weathered, and are used for foundation stone, and road material. The quality will doubtless improve as quarrying advances in the direction of the dip. The top layer is crinoidal by contrast, and may be found to yield a fair quality of lime.

"The block stone for the locks on the first canal on the American side, at Sault Ste. Marie, was taken from these dolomite beds. So also the stone for the locks in our own canals at the same place.

"Immediately under the gray dolomite is as pure a limestone as could be desired. A large surface area is exposed and quarrying has been carried on to a depth of 25 to 30 feet. Analyses made by the Solway process people at Detroit, who own and operate these quarries, show an average of $CaCO_3$ 97.50, $MgCO_3$ 1.50, $CaSO_4$ 0.03, SiO_2 0.80, $(FeAl)_2O_3$ 0.09. Hitherto it has been put upon the market only as crushed stone and foundation stone. A test kiln has lately been put in, of 135 barrels capacity, and excellent lime is burned. One or two beds are of remarkably smooth texture, but the rock is too brittle for lithographic use. Other beds show brecciation to some extent. There is, however, no perceptible deterioration in quality.

"Under the high grade limestone is another dolomite, a fine-crystalline massive rock, a brown stone very desirable

(63) Ibid, pp. 189-90.

(64) Ibid, p. 210.

(65) G. S. C., 1866, p. 250.

(66) Ibid, 1890, p. 49 Q.

(67) See Bureau of Mines Report, 11th Vol., "The Corniferous Exposure in Anderdon," pp. 123-127, in which the geology, crystallography and palaeontology of the district are reported upon.

for building purposes. A new quarry was opened up in this about two years ago on the property immediately east of the other quarries named. There is but a light stripping of earth and limestone to contend with, yet the stone has not been put on the market. It is a stone that is easily worked: no better could be found for carving. An analysis shows $CaCO_3$ 57.28, $MgCO_3$ 41.15, a trace of $CaSO_4$, $(FeAl)_2O_3$ 0.32, SiO_2 1.25. Some of the lower strata, as revealed by dredges working in the bed of Detroit river, are very full of a branching coral. The upper beds are entirely free from foreign matter.

"The facilities for shipping from these quarries are good. The Michigan Central railway crosses the Solway Process company's property, running almost parallel with and close to the line along which the high-grade limestone runs out. A spur runs down into the gray dolomite quarry to the east side of the property, where the lime kiln is located. On the one side of it is the clean surface of the limestone, on the other the dolomite and the stone-crusher. A mile distant, either by the roadway owned by the company, or by the M.C.R., is the river. There is a dock at the river which belongs to the quarry property.

"The Solway people could use four hundred tons of their own rock from these quarries daily in the manufacture of soda ash at their works across the river. A prohibitive tariff has necessitated their buying another quarry of rock of the same quality in Michigan. As it is they employ eighty men here.

"Two records of well borings may be cited in relation to the Anderdon quarries. The Caldwell Grove well is about two miles south. Here, under eight feet of clay is: limestone, 252 feet; sandstone, 60 feet; limestone, 180 feet; shale and gypsum, 16 feet; limestone (hard), 320 feet and (soft) 297 feet, and another 265 feet, gray shale, 20 feet.

"The Parks well, some three miles southwest, showed 30 feet of sand and gravel; limestone, 228 feet; sandstone, 84 feet; limestone, 182 feet; gypsum, 12 feet ; limestone, 468 feet."

A sample of brown dolomite from the White quarry, Amherstburg, was found by Mr. Burrows to be of the following composition :

	Per cent.
Insoluble matter	1.52
Ferric oxide and alumina	.33
Lime..	30.34
Magnesia..	20.89
Carbon dioxide	46.78
Sulphur trioxide	.18
Total	100.04

Pelee Island

"Pelee Island contains some 13,000 acres of land, and has exposures of rock on the north, west, south and east sides. At the present time active quarrying is carried on at the north end only, in Capt. John McCormack's quarry. Here there is a stone-dock with ample accommodations and depth of water in the immediate vicinity, a part of the quarry property. The first 12 or 14 feet of rock is thin-bedded—as is the case on all parts of the island wherever glaciers have not planed the rock to unusual depth. The first few feet of this is much weathered. Exception should be made, however, in the statement as to both thin-bedding and excessive weathering in the case of two beds within the depths of weathered rock, averaging 10 to 14 inches each. These two strata are remarkably easy of access in each quarry and exposure, except on the east side, where the exposed depth is not sufficient to show them.

"Stone has been taken from the north end quarry during the past year for the filling of the cribs protecting the new Pelee passage lighthouse. There is probably no point in Canada where stone for such a purpose (and stone of the same thin-bedding, but better in quality than is needed for such filling), is quite so accessible as at this quarry. Were a dock to be built at the south side of the island, east of the point that runs out toward Middle Island, the most southerly part of Canada, Pelee itself would furnish an exception, for here thousands of cords are piled up along the rock beach, and are still being brought up from the lake bottom.

"The quarry on the west side of the island is the property of Captain Eugene McCormick, master of the Pere Marquette railroad transfer steamer at Sarnia. It is pre-eminently a block stone quarry, for, though the usual thin-bedding is present, and at its maximum depth, where the greatest amount of quarrying has been done, immediately behind this point almost the entire depth of the overlying formation has been denuded by glacial action.

"Block stone was taken out here for the Welland canal locks. Subsequently a Toronto firm quarried the same stone to be sawn into flags for street paving. The facilities for shipping are good. The new west dock is as fine an island dock as may be found in the country, and is close at hand. A short tramway was used to transfer the blocks from the quarry to boats.

"Considerable testing for oil and gas has been done since 1895. The well known as the Comber well near the centre of the island was the first to be put down of which official record was kept. Drillings examined by Dr. H. M. Ami in 1896 show : Post-tertiary drift, 58 feet; Corniferous, impure fossiliferous limestone, with corals, shells, carbonaceous matter, etc., 222 feet; Oriskany sandstone (more likely the pure glass sand known to the Michigan and Ohio geologists as Sylvania sandstone), 40 feet; Lower Helderberg and Onondaga, gypsiferous dolomite, 458 feet. A number of wells have since been put down in this same neighborhood. Oil has been found, but the flow is indifferent. The same statement holds good of gas.

"Two companies, one a New York company and the other the South Bay Oil Company of Cincinnati, Ohio, are boring at the south end of the island. The latter company have abandoned their first well at a depth of 750 feet, pronouncing it a 'dry hole.' No other test had been completed at the time of reporting. So far as known no well has yet been put down beyond 800 feet.

"Splendid evidence of glacial action is observable everywhere on the high-lying parts of Pelee. The amount and character of the denudation, and the distinctness of the striae, are little short of marvellous. So far as palaeontological evidence goes the formation is the same as on the main shore some 35 miles northwestward in the Anderdon quarries. The variety and relative size of fossil specimens, in the thin-bedded rock, as well as the superincumbent position of the strata, indicate a later development. The high grade limestone extending across Monroe county, Michigan, from the northwest corner of Ohio, in a northeasterly direction, and across the southeast corner of Wayne county, outcropping in Anderdon, is not exposed on the island." (68).

(68) Geological Survey of Michigan, Vol. VII., Pt. 1.

Samples 1, 2, 3 and 4 are from a quarry on the west side of Pelee island, and represent the character of the stone from near the surface, and from a depth of 6, 8 and 10 feet respectively; 5, west end quarry. Samples 6, 7, 8 and 9 are from the north end of the island. 6, the thicker layer. 8, 12 feet down in quarry. 9, towards bottom of thin bedding. 10, 11, 12 and 13 are from the south end of the island. 14 is from the west side.

Frontenac

This county possesses very valuable resources in its limestones for building purposes. The cheapness with which the Cambro-Silurian limestones are quarries in the vicinity of the city of Kingston and their good quality have caused them to be largely used in the public and other buildings. From this large use of limestone in the buildings has originated the term "limestone city."

The crystalline limestone or marble of the northern part of the county is considered to be of good quality and occurs in great abundance.

Large marl deposits are found in some of the lakes of the county.

Cambro-Silurian Limestones

"On the islands lying in the St. Lawrence, between Kingston and Gananoque, notably on Wolfe and Howe Islands, which are the largest, several good contacts are seen. On the northeast end of the latter, which is several miles above Gananoque, ledges of sandstone occur, in places resting upon the granite and filled occasionally with pebbles of white quartz. These are overlain by the green, grey and black shales, which are found at the base of the cherty limestones, near a small cove known as Bush Bay, about two miles from the lower end of the island. The beds are all horizontal. Some of the shaly layers

ANALYSES OF PELEE ISLAND LIMESTONES

—	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Insoluble residue	......	1.24	......	1.50	1.38	2.20	.90	1.44	2.26	2.54	1.32	1.62	.89	1.34
Silica	1.38	......	1.40	......	......	......	......	......	......	......	......	......	......	......
Ferric oxide	.49	.32	.45	.31	.33	.52	.30	} .42	.31	} .32	.34	.40	.19	39
Alumina	.45	trace	.47	.20	.43	trace	trace		.12					
Lime	51.60	47.20	43.06	45.14	50.08	43.34	49.70	45.72	43.70	44.36	50.32	45.52	50.04	47.18
Magnesia	2.01	6.06	10.05	7.63	4.40	9.08	4.30	7.22	9.48	8.05	3.49	7.51	4.00	6.10
Sulphur trioxide	.30	.39	.32	.30	.26	.42	.20	.67	.53	.19	.26	......	......	.17
Carbon dioxide	42.80	43.69	42.28	43.51	43.80	43.94	43.65	43.76	44.54	43.59	43.21	43.95	43.59	43.66
Loss	......	1.05	......	1.40	......	.82	.48	.72	......	......	......	1.03	.37	.74
Alkalies	......	......	.40	.40	......	......	.10	......	......	......	......	......	......	......
Total	99.03	99.95	99.17	....	100.68	100.52	99.66	99.95	99.94	99.05	98.91	100.03	99.08	99.58

are very like certain green Chazy shales of the Ottawa basin, but are not quite so hard or slaty. They pass directly up into the limestone which contains Black River fossils, and which thence occupy the whole of the island along the south side. On a road across the island from Bush Bay, the Black River limestone rests upon white quartzite about midway to the north shore. The quartzite is penetrated by red granite, and the latter is seen along the north side of the island below the mouth of Big Bay. The southwest part of the island is all Black River limestone.

"On Wolfe Island the Black River limestone is the prevailing formation. It is seen in low ledges along the shore where this is not occupied by clay or sand.

"The northern part of the island is occupied by the cherty variety with shaley layers, but near the village of Marysville the upper portion of the formation is well seen and contains great numbers of fossils, in which Tetradium fibratum is abundant. These rocks extend south of this to a point opposite the north end of Simcoe Island, when they are overlaid by limestone of Trenton age. The rocks of the Trenton formation apparently occupy all the western end of the island, and are well seen at Bear Point at the southeast extremity, from which a large collection of fossils has been obtained. The rocks of the island are all so nearly horizontal that dips cannot be measured.

"Simcoe and Horseshoe Islands off the west end of Wolfe Island are both occupied by fossiliferous sediments, partly of Trenton age. Garden Island, which lies off the city of Kingston, is composed of Black River limestone. Further west, Amherst Island and the whole of the peninsula of Prince Edward county are apparently entirely occupied by the Trenton formation." (69)

"That part of the Birdseye and Black River formation which is well marked by its fossils, after crossing the upper part of Wolfe Island, reaches Cataraqui Point, a little above Kingston, and strikes for the west end of Loughborough lake. From this westward it constitutes a third escarpment, which rises at a varying, but usually not very great distance, back from the two escarpments in which the less fossiliferous strata occur, presenting a bolder and usually more rocky front than either of them. The attitude of the whole series, including the Trenton, which does not usually show any marked escarpment, is for the most part nearly horizontal, the inclination in many instances being so small as to be almost inappreciable. In consequence, it happens that, except in the escarpments and in sections worn out in the courses of streams, the rock is seldom seen, being concealed by a great deposit of drift." (70)

"The more conspicuous and more fossiliferous escarpment presents itself about two and a half miles west of south from the upper one of the other two, on the third and fourth lots of the third range of Lougborough, where beds of brownish-grey bituminous limestone, approaching to brownish black, crop out. . . These beds strike over to the first and second lots of the eighth range of Portland; and beds resembling them are met with on the road between Portland and Lougborough, in the ninth range, about a quarter of a mile from the second escarpment. . . In the eleventh lot of the eighteenth range of Portland, on Pond Lily Lake, the third or uppermost escarpment is from a quarter to half a mile south from the middle one." (71)

'A similar bed [of magnesian limestone] 3 feet in thickness, occurs in the ditch around the fort at Kingston, and has been used as a cement." (72)

Analyses

(1) "From the Bath Road quarry, Bath road, Kingston. Geological position—Birdseye and Black River formation, Cambro-Silurian.

"Structure, compact—containing, in parts, some small inclusions of crystalline calcite; color, somewhat dark bluish-grey.

"Mr. R. A. A. Johnston has made an analysis of this stone, and with the following results:

(After drying at 100 degrees C.—Hygroscopic water, 0.16 per cent.)

Carbonate of lime		90.07
Carbonate of magnesia		2.52
Carbonate of iron		0.26
Alumina	0.14	7.72
Silica, soluble	0.12	
Insoluble matter	7.46	
Organic matter		0.27
		100.84

"This stone is largely used in the city of Kingston for building purposes.

(2) "From the Wolfe Island quarry, Wolfe Island, opposite Kingston Harbour. From the three-foot bed. Geological position—Birdseye and Black River formation, Cambro-Silurian.

(69) G.S.C., Sum. Report, 1901, pp. 176-7.

(70) G.S.C., 1863, pp. 183-4.

(71) Ibid, p. 185.

(72) Ibid, p. 806.

"Structure, compact—traversed by an occasional very thin seam of crystalline calcite; color, dark brownish-grey.

"An analysis—conducted by Mr. R. A. A. Johnston—gave as follows:

(After drying at 100 degrees C.—Hygroscopic water, 0. 12 per cent.)

Carbonate of lime	94.81	
Carbonate of magnesia	2.33	
Carbonate of iron	0.29	
Alumina	...	
Insoluble matter	2.90	3.02
Silica, soluble	0.12	
Organic matter	0.28	
	100.73	

"This stone has been used in several public works, viz., Fern's Point lock, piers and abutments of Kingston Mills, Grand Trunk Railway bridges, and for heavy base courses in several public buildings—and these, after a lapse of some forty years, are said to be in as good a state of preservation as when first built." (73)

Crystalline Limestones

Limestones of this class are widely distributed in the central and northern parts of the county. The distribution of the various bands and belts will be found described in the reports by the late Mr. H. G. Vennor of the Geological Survey. The marbles of the township of Barrie have attracted particular attention.

"North of the Long Lake, an expansion of the Mississippi, the limestone is mostly blue in color and often slaty. This character is well seen along the road from Ardock to the head of Long Lake; but in the vicinity of the intrusive masses the bluish color disappears and the rock changes to a highly crystalline cream-coloured mass, in places affording a white marble, often of great beauty." (74)

Analyses

"From lot twenty-seven, range nine, of the township of Barrie. Geological position, Laurentian.

"Structure, very finely crystalline; color, pure white.

"An analysis by Mr. R. A. A. Johnston gave the following results : (After drying at 100 degrees C.—Hygrosopic water, — 0.07 per cent.) (75)

(73) G.S.C., Vol. 4, 1888-89, pp. 25-6 R.

(74) Ibid, 1896, p. 56 A.

(75) Ibid, 1888-89, p. 27 R.

Carbonate of lime	54.02	
" of magnesia	42.63	
" iron	0.64	
Alumina		
Insoluble matter	2.52	
Silica, soluble		
	99.81"	

1. "Is a white and coarsely-crystalline dolomite, from the fourth lot of the tenth range of Loughborough. It leaves when dissolved in acids a residue of quartz and serpentine, and contains traces of oxide of iron and of phosphates. . . .

2. "Is a fine-grained white marble from Mazinaw Lake, and is a pure dolomite. . . . .

	1.	2.
Carbonate of lime	55.79	53.90
" of magnesia	37.11	45.90
Peroxyd of iron	traces.	.....
Insoluble quartz., etc.	7.10	.....
	100.00	99.80

(3) "A magnesian limestone from the sixth lot of the tenth range of Loughborough is coarsely crystalline, but strongly coherent, snow-white in color, vitreous, and almost translucent. This rock contains small crystals of tremolite, grains of quartz, often rose-colored, bluish and greenish apatite, and scales of yellowish-brown mica. Its analysis gave 4.00 per cent. of insoluble matter and 7.50 per cent. of carbonate of magnesia, with but a trace of oxide of iron. Cold dilute acetic acid dissolved the carbonate of lime, with 3.65 per cent. of carbonate of magnesia; and the residue, which consisted of a mixture of dolomite with the foreign minerals, gave to hydrochloric acid, 36.70 per cent. of magnesian carbonate." (76)

Analyses of crystalline limestones from various parts of Frontenac county are given in the following table :

Constituent.	1	2	3	4	5
Insoluble residue	2.92	......	.....	......	......
Silica	.....	3.24	1.56	5.40	1.18
Ferric oxide	.56	1.14	.41	.72	.41
Alumina	trace	.82	.53	.68	.62
Lime	50.12	44.52	49.68	25.02	48.54
Magnesia	3.66	8.00	4.27	23.49	5.27
Sulphur trioxide.	......	.29	.06	......	.14
Carbon dioxide..	42.92	40.62	43.38	45.44	43.44
Loss	.08	......	......	......	......
Alkalies	......	......	.....	......	.40
Total	100.26	98.63	99.83	100.75	100.00

Sampe 1 represents the white crystalline limestone near Bedford station; 2 is from the kiln near Parham station;

(76) G.S.C., 1863, pp. 592-3.

3 represents the rock at Reynolds', south of Verona; 4 is from Goodbery's quarry near kiln, Verona; 5 is from a point two miles north of where Goodbery gets stone for his kiln.

Marl

"A great portion of the bottom of Loughborough Lake is a thick deposit of marl; and the bottoms of all the lakes from this to White Lake, in Olden, are in greater or less degree composed of the same material." (77)

Glengarry

Calciferous, Chazy, Black River and Trenton limestones are found in this county. Their distribution is given in the Geology of Canada, 1863, pp. 116, 126, 171-172.

" The Chazy limestone at Hawkesbury and Lochiel also encloses phosphatic nodules, from one-fourth of an inch to an inch in diameter, blackish-brown without, but yellowish-brown within, and giving off abundance of ammonia when heated." (78)

"The railway at Glen Robertson is presumably near the line between the Trenton and Black River, the beds of the former showing to the south and also to the west at Alexandria." (79) The characteristic fossils of the Black River are abundant at the Glen Robertson quarries.

Calciferous Formation

"A valuable quarry in rocks of this formation [Trenton] is located near Alexandria, on lot 27, range V., of Lochiel, about 200 yards to the south of the road. The rocks are heavily bedded and dip S. 10 degrees E. < 7 degrees. They are vertically jointed and blocks of any dimension can be obtained, as the limestone is easily split horizontally. It is highly fossiliferous, and contains small seams of a black bituminous substance. It is rather hard to work, but of very good quality. In places the rock contains small veins of white calcite, and in certain portions has a mottled, pinkish aspect from the presence of pink calcite. In others it assumes a greenish hue, due to a thin coating of a shaly bituminous mineral. This stone is used in the construction of the new Reformatory at Alexandria" (80).

The log of a well drileld for water "on the northern bank of the Garry river, a branch of River Delisle, where ledges of grayish fossiliferous Trenton limestone occur, holding crystals of clear white calcite and small partings of black, shiny, very friable shale," gives the thickness of the limestone strata, as follows:

Depth	Character of rock.	Formation represented and thickness.
Feet.		
0	Dark grey impure limestone, holding fossils..............	Trenton : 470 feet or more.
470	Dark grey impure limestone, softer than preceding; no	
570	fossils detected	Black River : 100 feet (assumed thickness)
	Dark gray impure limestone, underlain by greenish-grey calcareo-arenaceous shales—at times fine-grained, at others coarse and more highly arenaceous. Obscure	
755	fossil remains detected in the upper calcareous beds...	Chazy : 185 feet.
	Hard, compact, dark, chocolate-colored limestone, prob-	
786	ably magnesian ; no fossil remains observed	Calciferous : 31 feet, or more.

"The undertaking was abandoned at 790 feet." (81)

"The Calciferous limestones have a very considerable development on this sheet, and the soil overlying them is generally poor and thin or sandy, unless covered with heavy beds of clay, as in Soulanges county, the eastern part of Glengarry and some parts of Huntingdon.

"The principal places at which the Calciferous formation has been observed are as follows: At Manotick, on the Rideau River, the beds resembling those seen at Glen Nevis. They are also well exposed at Manotick station and to the south of this place. Similar rocks also occur on lot 20, range 6, Osgoode township, Carleton county, the dip of which is S. 88 degrees E. < 6 degrees. They are also well exposed along the road between ranges 6 and 7. Osgoode, from Vernon Corner north for about three miles as also on lot 23, range 12, Mountain, Dundas county, and near Van Camp's mill, and they again appear about three and a half miles west of Winchester, with a dip of S. 45 degrees E. < 4 degrees to 6 degrees.

"About two miles, in a northeasterly direction from Van Camp's mill, Calciferous limestone occurs in thin beds

(77) G.S.C., 1863, p. 764.

(78) Ibid, p. 462.

(79) Ibid, Sum. Report, 1899, p. 135.

(80) G.S.C., 1896, pp. 62, 63 A.

(81) Ibid, 1895, p. 69 A.

and much disturbed, with characteristic vugs of pink and white calcite. This place has been opened as a quarry.

"The formation is also well exposed in the neighborhood of South Mountain, and all along westward of this place towards Kemptville and Merrickville, and southward towards Easton's Corners and Irish Creek. It thence continues on to North Augusta and to the shore of the St. Lawrence as far as Prescott and down the river to Cardinal.

"This formation is also seen on the Castor River, at about three and a half miles southeast of Russell. Sandy calcareous basal beds of the same formation can be seen about two miles south of Smirleville, where they have been greatly altered, and hold pebbles and lenticular pieces of quartz.

"Rocks of this formation extend westward from the eastern half of the township of Grenville, and beds of the same can be seen near Hickston Corners, Hell Gate swamp and Spencerville station on the Prescott and Ottawa railway. On the Nation River, near Spencerville station, the rocks have been disturbed and altered, so that, along with the ledges of characteristic brownish-weathering, dolomitic, fine-grained, gray limestone of Calciferous age, patches of banded sandy limestone occur, which probably are of Chazy age, or else represent much altered portions of the Calciferous.

"On the road from Mountain to Smirleville similar outcrops (Calciferous) also appear, and at about one mile and a half north of Mountain station this limestone is full of rounded and angular pieces of quartz, varying in size from a pea to a melon, and angular pieces from a fourth of an inch to a foot across. This conglomeritic rock has a very homogeneous matrix, which exhibits plainly all the characters of the Calciferous. The dip of these beds on the south of the exposure is S. 20 degrees E. ∠ 18 degrees, and on the north side is about 100 yards wide, the dip is N. 10 degrees W. - 12 degrees.

"The Calciferous also appears near Ormond Corner in the township of Winchester, Dundas county, in beds of limestone, as well as on the east point of Racket River, on the south side of the St. Lawrence, where ledges of dark-gray, sandy limestone outcrop. The south shore of the river, northward for some distance from this place, is low and without rock exposures, but Calciferous blocks are numerous.

"At the bottom of Hungry Bay these limestones appear in a small knoll, holding large pockety vugs of pink and white calcite associated with iron pyrites. Some of the upper beds are slaty, and where the calcite occurs the rock is of a grayish-buff colour, compact and with a very fine grain, almost fine enough to be used for a lithographic stone, were it not that it contains certain inclusions which unfit it for that purpose. The dip is here S. 30 degrees 5. This place has been opened for a quarry and some of the material used in the construction of the Canada Atlantic Railway bridge was obtained from it.

"The Calciferous also appears on a small brook which empties into the River a la Graisse, lot 17, range VII, Lochiel, but the dip could not here be ascertained.

Chazy Formation

"The Chazy, in this area, has not so wide a distribution, but is generally well defined, both by the character of its shales and sandstones and by the fossils contained in the upper or limestone portion. In the western part of the sheet about one mile north of Manotick station, ledges of bluish-gray and grayish limestones appear, which probably belong to this formation. Not far from Berwick, also, are ledges of dark bluish-gray limestone dip S. 40 degrees E. 4 degrees. These beds extend northwest from this place as far as Cannamore post-office, and continue on in this direction. A similar rock also occurs in the northern part of Dundas and the southern part of Russell.

"Limestones of this age are also seen about two and a half miles west of Grantley and at about three miles south of Chesterville. They also appear, associated with shales, about two miles northeast of West Winchester, as well as on lot 22, range XII, Winchester township.

"On the north shore of the St. Lawrence, at a small point opposite the northeast corner of Barnhart Island, there is a fine exposure of greenish and black Chazy shales. They are very concretionary and nodular in places, but no fossils were observed. The dip is N. 10 degrees W. 2 degrees. These shales are exceedingly thin and splintery and are easily crushed in the hand.

"At the northeast end of Sheick's Island, opposite Mille Roches, are fossiliferous flat-lying Chazy limestones. A quarry has been opened here and a quantity of material taken out for the construction of the canal. Specimens were collected from these quarries. The limestone at this place is bluish-black in colour, very hard, with a flinty fracture, highly fossiliferous, and holds small dots or specks of clear calcite. It is of fairly good quality, though somewhat, seamy in places. On weathered surfaces, which are of a brownish gray colour, it is seen to be concretionary, and the partings of the beds, which vary from six to twenty-four inches, are very rough, blackish and pitted. I am told that 15,000 cubic yards a year have been taken out. The rock, in some places, is in beds of nine to ten feet thick, with generally a parting at about five feet from the surface.

Trenton Formation

"The Trenton formation, with which is associated the Black River, has a very extensive development in this area. In the western part of the sheet, beds are well exposed from Billings Bridge along the main road to Britannia, where also the Chazy is well seen. The Trenton is also well exposed near Mr. Henry Onderdonk's, a short distance to the northwest of Aultsville, as well as in the township of Russell, on one of the branches of the Nation River. It also appears about Crysler in the township of Finch, Stormont county, and thence extends eastward towards Moose Creek.

"Near South Finch, the bed of the Payne River consists of Trenton limestone, and there are also fine exposures about South Finch, Lodi, and other points in the vicinity" (82).

Grenville

The Calciferous is the only one of the limestone-bearing formations reported as occurring in this county. A little above Maitland in the township of Augusta layers of limestone are interbanded with sandstone. Similar exposures are seen down the river to a point a little below the town of Prescott.

"The quarries in the Calciferous formation yield stone principally for local use. The stone is largely dolomitic, but the quarries are not extensive. Along the St. Lawrence east of Prescott, where this formation is extensive, several large quarries are, however, found, and are worked somewhat extensively. The principal quarries in the Black River limestone at Mille Roches, Glen Robertson, etc., have already been referred to" (83). See also under Dundas, Glengarry and other eastern counties.

Grey

"In Collingwood the deposit [the Utica formation in the 3rd and 4th ranges of the township], consists of dark brownish-black shales, interstratified with occasional beds of compact brownish limestone." (84)

Clinton Formation.—"From Collingwood, the general outcrop [of the escarpment] turns to the northwest; but it presents a very deep sinus, southward, up the valley of the Beaver River, reaching nearly to the centre of the township of Artemisia; and another up the valley of the Bighead, in St. Vincent, Sydenham and Holland. A third indentation carries the outcrop a few miles up the Sydenham River, which flows through the town of Owen Sound into the bight of the bay.

"Though the Clinton strata are thus easily traced by the conspicuous escarpment which rises precipitously above them [capped by Niagara strata], they themselves are but seldom seen, being for the most part concealed by a talus of debris. The base of the series, however, is nearly as well marked as the summit, by the sandstone of the Grey band, which crops out from below them, and forms a low, but distinct terrace. . .

"In several places in the township of Sydenham the thin-bedded limestones of the Clinton formation are seen to rest upon the red and green shales of the Medina. . . .

"In these townships [Collingwood, Euphrasia, St. Vincent and Sydenham], the Clinton formation also spreads out somewhat wider than usual; and the red ferruginous band, which marks the upper part of it, is met with in several exposures, though nowhere sufficiently charged with iron to constitute a workable ore. In the second lot of the fourth and fifth ranges of St. Vincent, in a bed of bluish shale, near the summit of the formation, crystals of gypsum are disseminated in some abundance.

"At Owen Sound the Medina rocks [sandstone] are limited above by about twenty feet of dolomite, which here constitutes the base of the Clinton formation. This dolomite, which is of a yellowish color and weathers yellowish-brown, contains, in great numbers, a few species of silicified fossils. . . Between it and the base of the massive limestones, which are classed with the Niagara series, the surface is covered with red clay. The strata from which this is derived, no doubt, represent the iron ore bed, and are seen in several places within a circuit of three miles. From the bight of Owen Sound, the Medina and Clinton formations are traceable along nearly the whole lake front of the township of Keppel; and in the vicinity of Cape Commodore their entire thickness can be determined by actual measure-

(82) G.S.C., 1896, pp. 62, 63 A.

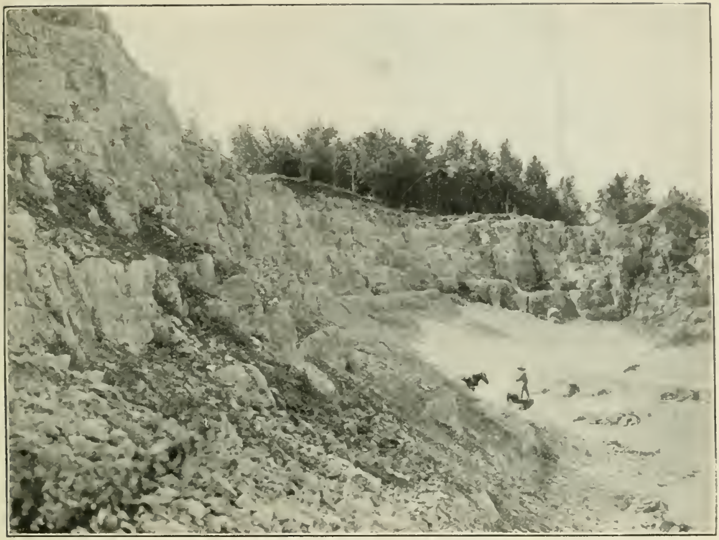
(83) Ibid, Sum. Rep.. 1899, p. 136-7.

(84) G.S.C., 1863, p. 211.

Engineering building, School of Mining, Kingston; built of Kingston limestone. Frontenac County.

Limestone quarry at Dolly Varden siding lime kilns. Halton County.

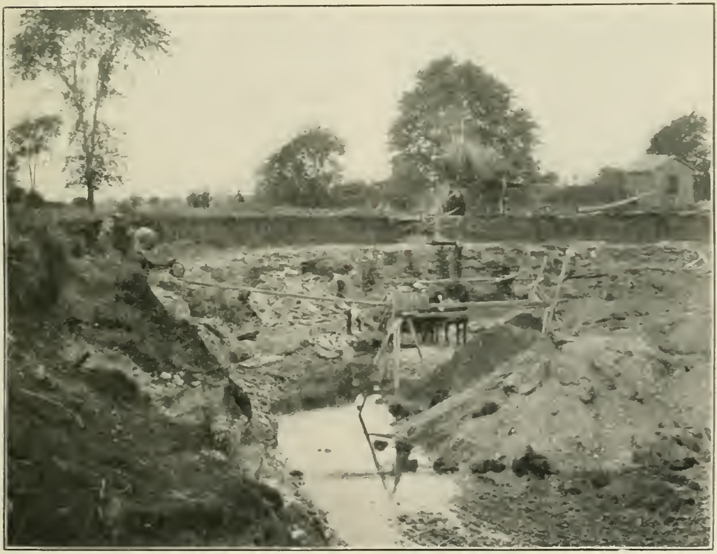
Lime kilns at Dolly Varden siding. Halton County.



Kelso limestone quarry. Product used in making gray lime. Halton County.

Limehouse; a series of old "set" kilns, with new "draw" kiln on right. Halton County.

Lime kiln at Delta. Leeds County.



Limestone quarry at Beachville. Product used in making lime for building and refining beet sugar. Oxford County.

ment. Strata of the Hudson River formation here constitute the base of the cliff, above which the red and green Medina shales present a volume of 109 feet. Resting upon these, the Clinton formation shows about 36 feet of thin-bedded magnesian limestone, between which and the abruptly overlying escarpment of the Niagara series, there is a thickness of about 150 feet. In this the strata are partially concealed; but a considerable portion of them appear to be red shales. The base of the Clinton appears to cross Colpoy's Bay, at about three and a half miles, and the summit, at about two and a quarter miles, from its western extremity; having a mile and a quarter for the breadth occupied by the formation. From this it would appear that the slope of the strata in this part is about 120 feet in a mile." (85)

Niagara Formation

"The cliffs [of Niagara limestone] continue through Mulmur and Nottawasaga; and on the twenty-fourth lot of the twelfth range of the latter township the whole mass of this limestone to the highest part of the escarpment, has been ascertained by measurement to be about 160 feet thick. As far as seen its color appears to be greyish at the base, gradually passing upwards into buff or yellowish-white; most of the beds being banded with the two colors. The rock, which is magnesian, is harder in the lower than the upper part, and appears to be encrinal for most of the thickness; the encrinites abounding towards the top. It maintains the same colors and characters along what is called the Blue Mountain ridge through Collingwood [township], to the point where the ridge approaches nearest to Lake Huron; and it is probable that the formation thus far does not diminish in volume.

"In the valley of the Beaver River, in Euphrasia and Artemisia, the same limestone has a thickness of at least 120 feet. At the head of the valley, on the 26th lot of the 10th range of Artemesia, the stream falls over a precipice of 70 feet of this magnesian limestone. Flowing thence rather to the east of north, it is flanked on both sides by bold escarpments of the rock, which gradually separate from one another; leaving between them a beautiful and fertile valley, which in a distance of about eight miles attains a breadth of three miles. In several places the escarpment becomes perpendicular, and in a precipice on the right side of the valley, about the 10th lot of the 3rd range of Euphrasia, 47 feet of the rock appear to constitute a single massive bed, without divisional planes. The color of the rock is, as before, a pale buff or yellowish-white, and the weathered parts display obscure encrinites and corals.

"The escarpment on the left side of the valley continues northward into St. Vincent; and then makes a sharp turn to the westward, running for ten miles in that direction on the right or southern side of the valley of Big Head river, which is supplied from it with several tributaries. On the left side of this stream, and between it and Owen Sound, the limestone spreads out into a high flat-topped hill, situated chiefly in Sydenham, and presenting to the northeast a vertical escarpment. The encrinal portion of the limestone is well displayed at the summit, while the characteristic Pentamerus oblongus occurs on both sides, at the base in the first range of South Sydenham.

"The two streams which flow into the bight of Owen Sound, the Potawatamie from the southwest and the Sydenham from the south, fall over precipices of 20 and 50 feet respectively, of the lower part of the same limestone; the bottom of which is from 20 to 30 feet beneath the cascades. On the 13th lot of the 2nd range of Derby the escarpment which runs between these two falls presents a height of 60 feet; at the base of which there occurs a bed abounding in corals. . . .

"The rock of the escarpment in this neighborhood abounds in excellent material for the purposes of construction. About two miles south by east from the town of Owen Sound there are unworked strata of a white or pale grey color, of which the upper beds are from two to four feet thick, and the lower ones occasionally over twelve feet. The upper bed might be quarried to an almost boundless extent, and would give a very fine and lasting stone. The lower beds are likewise fit for building purposes, but being at the base of an abrupt precipice, they cannot be so conveniently quarried. Large loose blocks, however, skirt the escarpment, and these would furnish a supply for a great length of time. About a mile and a half up the Sydenham River there has lately been quarried from the lower beds of the escarpment some fine stone for the lighthouse constructed on Griffith's Island. The road south from Owen Sound, on the line between Sydenham and Derby, crosses the base of the limestones, about a mile and a half from the town. After a rather sharp ascent over the lower part of the escarpment, it gradually rises for some distance, and reaches what is considered the summit

(85) G. S. C., 1863, pp. 315-319.

of the formation, on the 6th lot: the total thickness being about 150 feet." (86)

"The bold escarpment formed by the Niagara limestone in Derby appears about two miles west of the town of Owen Sound, and between this position and Colpoy's Bay it sweeps round towards the heights above Cape Commodore, in a line conforming in some degree to the shape of the coast, but presenting a less salient curve. The base of the limestone comes upon Colpoy's Bay, and crosses it, probably, about two miles and a quarter from its bight."(87)

Guelph Formation

"Exposures of these dolomites [of the Guelph formation] are again met with on the Rocky Saugeen River, upwards of forty miles N.W. from Fergus. One of them occurs about three miles beyond Durham, where the Garafraxa and Owen Sound road crosses the river. Here the rock has been quarried for building stone, and for burning into lime The lower part is a light greenish-grey sub-crystalline magnesian limestone, divided into beds of from eight to ten inches thick with very obscure fossils; while the upper part is a greyish-white coralline mass, seven feet thick, in several beds, of which the thickest is 3 feet. . . Another of these exposures is at the junction of the Rocky Saugeen with the main stream, in the rear of the 62nd lot of the 3rd range of Bentinck; where about 25 feet of the rock are seen on the right bank. The upper 12 feet consist of a rough, irregular bed of greyish-white dolomite; underlaid by a buff colored compact stratum, divided into layers of from 3 to 4 inches. . .

"The exposures which have been mentioned between Puslinch and Bentinck belong to the upper part of the formation, and indicate the strike of its summit northward, as far as the Rocky Saugeen. In this region, with the exception of the space occupied by the westward spur of the Niagara series on the Rockwood anticlinal, the Guelph formation presents a breadth of about 25 miles, opposite to Puslinch, which gradually increases to 35 miles opposite to Bentinck. This great breadth is probably due in part to the fact that the country rises with the general slope of the strata, to the edge of the eastern escarpment, though at a somewhat smaller angle; and in part also to a series of north and south undulations, which appear to exist in this region. . .

"From Bentinck northward the strike of the summit of the formation appears to continue in the same bearing as between Puslinch and Bentinck, for about 25 miles, to the Riviere aux Sables (north). The base, however, folding successively over the supposed anticlinals of the Beaver River and Owen Sound, the breadth of the formation becomes reduced, between the latter place and the Riviere aux Sables (north), to ten miles; which is about the same as that which it appears to have between Guelph and Breslau.

"It has already been stated that the strata seen near the mouth of Riviere aux Sables, at Chief's Point, probably strike along the coast by Lyell Island to Cape Hurd, and belong in part to the Niagara formation, whose characteristic fossils are met with in several localities along the shore. These strata, however, have for the most part the lithological characters of the Guelph formation, and some of their undescribed species of Murchesonia have a strong resemblance to others found in this series. . . so that it is not impossible that some of the strata along this coast may constitute a passage between the Niagara and Guelph formation." (88)

The composition of the limestones belonging to the Silurian formations in this county is similar to that of the same strata in Wentworth and other counties. Analyses of Guelph, Niagara and Clinton limestones are given in the descriptions of limestones of other counties. They all carry a fairly high percentage of magnesia.

Marl

Marl deposits are numerous in the counties of Grey and Bruce. "On the 26th lot of the 1st range of Bentinck, a deposit of marl has been traced over 8 or 10 acres of low ground, which is covered with heavy timber. The marl is very solid and pure, and where examined was found to be four feet in thickness." (89)

Following is an average analysis of marl used in the manufacture of cement at the Imperial works, Owen Sound: (90)

(86) G. S. C., 1863, pp 328-9.

(87) Ibid., p. 331.

(88) G.S.C., 1863, pp. 342-344.

(89) Ibid, p. 764.

(90) Cat. Ont. Min. Exhibit, Buffalo, p. 82.

(1.)	Per cent.
Silica	1.43
Iron oxide	0.18
Alumina	0.20
Lime	50.62
Magnesia	2.09
Ignition loss (carbonic acid and organic matter)	45.58
Alkalies	nil
Sulphates	nil

(2) "From a deposit occurring on lot twenty-four of the ninth concession of the township of Artemesia. . . . The deposit covers about twelve acres, and has a depth of at least seven feet.

"The air-dried material is earthy; slightly coherent; color, yellowish-white. It contains a few shells and some root fibres.

"It was found by Mr. F. G. Wait to have the following composition:

(After drying at 100 deg. C.—Hygroscopic water 0.34 per cent.)

Lime	48.73
Magnesia	0.73
Alumina	0.28
Ferric oxide	0.25
Manganous oxide	traces
Potassa	"
Soda	"
Carbonic acid	38.99
Sulphuric acid	0.06
Phosphoric acid	0.02
Silica, soluble	0.21
Insoluble mineral matter	8.30
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water	3.30
	100.87

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 87.02 per cent. carbonate of lime.

"The insoluble mineral matter was found to consist of :

	Per cent.
Silica	5.56
Alumina and ferric oxide	2.17
Lime	0.06
Magnesia	0.04
Alkalies	0.47
	8.30

(3) "From a deposit at Shallow Lake, township of Keppel. . . The deposit extends over an area of upwards of five hundred acres, and has an average depth of about six or seven feet.

"The air-dried material is earthy, somewhat coherent; colour almost white. It contains no visible shell remains or root-fibres.

"An analysis by Mr. F. G. Wait showed it to contain :

(After drying at 100 deg. C. Hygroscopic water equals 0.30 per cent.)

Lime	52.52
Magnesia	1.04
Alumina	0.08
Ferric oxide	0.16
Manganous oxide	traces
Carbonic acid	42.47
Sulphuric acid	0.02
Phosphoric acid	0.01
Silica, soluble	0.08
Insoluble mineral matter	1.74
Organic matter, viz., vegetable fibre, in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water	2.70
	100.82

" Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 93.79 per cent. carbonate of lime.

"The insoluble mineral matter was found to consist of : (91)

	Per cent.
Silica	1.22
Alumina and ferric oxide	0.32
Lime	0.03
Magnesia	traces
Alkalies	0.17
	1.74 "

"Deposits of calcareous tufa occur in many places along the base of the Niagara formation in the counties of Grey and Simcoe. The most considerable known is on the banks of the Beaver River in Euphrasia and Artemisia, which probably covers 1,000 acres. An area of about 300 acres of tufa, with an average thickness of five feet, occurs in a similar geological position at the falls of the Noisy River in Nottawasaga." (92)

Haldimand

The limestone formations—Onondaga, Lower Helderberg or Water Lime, and Corniferous—of this county are briefly described in the following notes :

Onondaga Formation

"The exposures of the Onondaga formation in Canada, so far as yet examined, appear to belong chiefly to the

(91) G.S.C., 1894, pp. 29-31 R.

(92) Ibid, 1863, p. 804.

upper portions, from the summit to a little below the gypsum-bearing beds. These portions consist of dolomites and soft crumbling shales, which are greenish, and sometimes dark brown or bluish in color, and are often dolomitic. The dolomites are mostly of a yellowish brown or drab color, and are in beds which seldom exceed a foot in thickness. They often exhibit the vesicular or the lenticular cavities just described. Some beds of a bluish dolomite are also met with; and many of the strata, both above and below the gypsum, contain such a proportion of clay as makes them fit for hydraulic cement.

"The beds of gypsum are never continuous for long distances, but appear as detached lenticular or dome-like masses; the strata above them being arched over and often broken, while those below constitute an even undisturbed floor. The gypsum is interstratified with the dolomite, and often separated by beds of it. The layers of gypsum may sometimes extend for a quarter of a mile, but they have always been found, on working, to be lenticular in form, and to gradually thin out, until the strata above and below the masses come in contact. This peculiar structure gives rise to mounds on the surface, which are regarded by the inhabitants as indicative of the presence of gypsum beneath.

"Between the Niagara and the Grand River the workable masses of gypsum, if any are present, are concealed by the drift, but on the Grand River they are seen twelve or fourteen miles above its mouth, in the third range of North Cayuga, and thence are traced to Paris. Their strike appears to coincide with the general course of the river. A large deposit of gypsum, which has been extensively wrought, occurs on the land of Mr. Brown, about three miles below the village of Cayuga, on the left bank of the Grand River. It is supposed to extend over at least sixty acres, and is generally covered only by drift. In some parts, however, portions of thin dolomitic beds are found, resting upon the gypsum, which is five feet in thickness and very pure. The lower portion includes some thin interrupted layers of dolomite, which are vesicular when weathered. In a well sunk upon this bed, near the proprietor's house, there were found beneath the gypsum about twenty feet of dolomite, containing small portions of gypsum, beneath which, at the bottom of the well, were three or four feet of unmixed dolomite, fit for water cement. The dip of the bed, which is about S. 20 degrees W. 2 degrees would carry it under the level of the river; and the position of the summit of the formation, which is seen at a little distance on the other side of the river, would apparently give a thickness of about ninety or one hundred feet above the gypsum. This upper portion of the formation, as seen in Jones's tract, consists of a dark ferruginous shale, with nodules of yellowish-grey chert; interstratified with greenish marl, containing harder layers. The thickness of these beds is about thirteen feet, and they are surmounted by about five feet of yellowish shale and tufaceous dolomite, with vesicular bands.

"About five miles above Brown's plaster bed, gypsum occurs in Indiana, on the left bank of the river, and about four miles farther, near to York, on both sides. The following is a descending section of the strata observed in the latter vicinity, near Mount Healy, at the plaster bed of Mr. Taylor :

	Ft.	In.
Drab-colored dolomite, with some blue layers, in beds of about five inches..	2	3
Greenish shales...	3	0
Drab-colored vesicular dolomite, yielding good lime..	1	6
Blue thin-bedded hard limestone, said to be fit for hydraulic purposes.	1	7
Pure white gypsum, with bluish bands.....	3	6
Blue schistose argillaceous dolomite, some of it fit for water cement...........	5	0
Grey dolomite, with joints at right angles to the beds, which are thicker at the bottom than at the top, and separated by partings of shale....	6	0
	22	10

"In the bed of the river at York is a stratum of solid limestone, which would underlie the above section: it holds small quantities of galena. The dip of the measures in this part, judging by the strike of the summit of the formation, is, like that of Cayuga, about S. 20 degrees W.; but it is not easy to determine the slope. If we assume the thickness of the overlying portion to be the same as before, the distance of the summit, which is nearly five miles, would give a slope of about 20 feet in a mile.

"Three adits have been opened in this plaster bed at Mount Healy, and afford good opportunities of studying the gypsiferous rocks. One of the most remarkable characteristics is the irregular nature of the bedding. Some of the layers of dolomite immediately below the gypsum, to the east of it, are seen to augment and to then diminish considerably in thickness in the distance of a few feet; giving thus, at first sight, the appearance of undulations, while the beds beneath are completely horizontal. In the central opening, a layer of dolomite, not seen in the others, is interstratified with the gypsum; and in one of the adits, the gypsum bed is observed to thin out, the strata from above bending downwards, and conforming to it. It results from these irregularities in the beds that sections in different portions are by no means concordant. In one part three or four feet of dolomite overlie the gypsum bed, the upper part being vesicular, and a portion of it filled with crystalline carbonate of lime. Here, immediately resting upon the gypsum, is a reddish ferruginous layer, followed by two inches of green shale. In another opening, this thin layer of shale is succeeded by a few inches of plastic calcareous clay; to which succeed very thin bedded vesicular dolomites, whose surfaces are marked with the branching lines already described. Farther on, this layer of shale becomes a foot or two in thickness; and it includes portions of travertine, which is sometimes compact like alabaster, and forms considerable masses in the fissures of the overlying beds. At about three feet above the principal mass of gypsum, a second interrupted layer is met with, which is very pure. It is generally only a few inches thick; but it swells to a foot or two in some places, and in others is wanting.

"At Aikman's plaster bed, a mile and a half above York, on the left bank of the Grand River, the mass of gypsum is seven feet in thickness, but is divided into six layers by interstratified bands of dolomite, of from two to six inches; the same band varying in short distances. The upper portion of gypsum is two feet thick, and is pure and white: the lower portions are mixed with dolomite and are less pure. Immediately above the gypsum is a sandy ferruginous layer of from two to six inches: then after some layers of dolomite, occur eighteen inches of greenish shale, followed by four feet of yellowish vesicular dolomite. For the next two miles, as far as Seneca, the gypsum appears occasionally, in thick rounded masses, enveloped and underlaid by green shales, the lower portions of which sometimes include small interrupted layers of the mineral.

"About two and a quarter miles across the measures, in a direction nearly S.W. from Seneca, there is an exposure at McKenzie's mills, of about twelve feet of beds belonging to this formation, which may be fifty or sixty feet higher in the series than the gypsum. The section consists of drab-colored dolomite, sometimes vesicular, interstratified with hard blue slaty layers, and with green shales; which sometimes include thin dark-colored laminae. The same strata are met with again at Barton Creek, about a mile south from McKenzie's mills. Some of the beds at both places yield good lime, but others are unfit for burning." (93)

Lower Helderberg

"The third locality in which characteristic fossils of the Lower Helderberg, or Water Lime, formation have been found, is at Rattlesnake falls, on a small tributary of the Grand River, on the thirty-fifth and thirty-sixth lots of the first range, south of the Talbot road, in Cayuga, where a series of beds occurs, very much resembling those of Jones's tract [see under Welland county], but showing not more than half the thickness." (94)

Corniferous Formation

"Many of the beds [of the Corniferous formation], contain silicified organic remains. These, in some localities, as in North Cayuga, and at Port Colborne, are found weathered out and loose in great abundance, at the surface of the ground. Some of the beds are little more than an aggregate of silicified organic remains, with so little calcareous matter that the whole mass coheres, after the carbonate of lime has been dissolved out. The Corniferous limestones, unlike the great mass of the Middle and Upper Silurian strata in Western Canada [Ontario], effervesce freely with acids, and are not dolomitic. . . .

"To the west of the Grand River, in the counties of Haldimand and Norfolk, the Corniferous limestones are often seen resting on the Oriskany formation, and forming small eminences, which present escarpments, with the sandstone at their base. These limestones are here of a drab color, and abound in chert. The organic remains with which the strata abound are entirely silicified in many of the beds, while in others they have undergone no such change. . . .

"Higher in the series, along the same line of country, blue limestones, sometimes to the amount of 20 feet, with grey beds in less volume, are associated with chert layers, and interstratified with bands of a drab-colored limestone. These strata are sometimes quarried, and yield stone fit for building purposes." (95)

(93) G.S.C., 1863, pp. 347-9.
(94) Ibid. pp. 354-355.
(95) Ibid. pp. 366-371

Quarries

"On the bank of the Grand river, four miles south of Cayuga, my brothers own a quarry. It is a limestone, but is magnesian, and is not good for lime. Under that bed there is a layer of stone that could be manufactured into cement. Some years ago a quantity was burned in an ordinary lime-kiln. Only a few barrels were made, but it worked as well as the Thorold, and very much like it. The stone is grey and brown in color; a considerable quantity was quarried as building stone, and they get blocks from twelve to fifteen inches thick; it has been used at Dunnville. The quarry extends along the bank of the river about half a mile. The stone does not stand the weather as well as the sandstone; it is more liable to crumble. About three miles from Ridgeway there is Corniferous limestone. It is extensively used in making lime, and makes a first-class article, very white and about the same quality as the Beachville lime." (96)

"A third excellent exposure in this vicinity is at Teitz' quarry, lot 1 in the fourteenth concession of Walpole, which probably lies at a higher horizon than either of the preceding. About ten feet are exposed of roughly-bedded limestones with numerous fossils, which are in some respects different from the assemblage at the two other quarries. Some species are found here which are rare or quite absent from the previously described deposits.

"At Springvale, lot 6 in the fourteenth concession of Walpole, outcrops an even bedded non-fossiliferous limestone showing glacial striae west-southwest on the surface. The heaviest beds are eight to ten inches thick and of a whitish gray color. Below the level of the quarry the rock is said to be a blue limestone, but this requires confirmation. The non-fossiliferous limestone shows increasing silica on descending. The average lime made from the rock has hydraulic properties and requires about 16 to 1 of gravel to make a durable cement. (97)

Analysis :

	Per cent.
Moisture	0.15
Silica	3.69
Alumina	3.29
Ferric oxide	1.89
Calcium oxide	31.58
Magnesium oxide	17.79
Ignition loss	44.73

"Overlying this and a few rods west of the exposures are beds of Oriskany sandstone six to eight feet in thickness. . . .

"The fossils, with the exception of the ganoid fragment, are mostly casts, the calcareous matter of the shell having been dissolved. Two sorts of stone are quarried from this exposure, an extremely hard variety with silicious cement which may prove useful for grindstones and for refractory purposes, and a soft friable example possessing insufficient coherence to make a satisfactory building stone. Above the sandstone, towards the northwest corner of lot 6 in the fourteenth concession of Walpole, is a ridge of Corniferous rock, presenting the characteristic fossils of the coralline beds and many fragments of trilobites. . . .

"Southwest of these deposits, on the farm of Elias Shoap, lot 9 in the thirteenth concession of Walpole, is an excellent exposure, showing 20 feet of vertical section. The upper strata consist of about ten feet of thin-bedded fossiliferous cherty limestone with corals predominating, as at Rockford. This is underlaid by five feet of soft sandstone as at Springvale, while the bottom five feet consist of hard indurated sandstone with silicious cement.

"But occasional small outcrops are seen from this point to Hagersville, where are situated some of the most extensive quarries in the district. Glacial striae west-southwest are observed on the surface rock. The upper ten feet of this section show the cherty coralline limestone with a predominance of favositoid corals, below which lie six or eight feet of more heavily bedded and less fossiliferous stone of excellent quality for building purposes. Underlying this layer are two feet of stone, which is practically all flint, and is succeeded by five feet of good blue limestone, giving the following analysis (98) :

(96) Hon. J. Baxter in Roy. Com., 1890, p. 55.

(97) A sample of the lower flinty layer in the lime kiln at Springvale was collected by the writer. Mr. Burrows found it to have the percentage composition given in column 1. Another general sample from this quarry had the composition shown in 2 :

	1.	2.
Moisture	.30	.....
Insoluble residue	1.60	23.24
Alumina	trace	1.28
Ferric oxide	.62	1.10
Calcium oxide	30.26	39.04
Magnesium oxide	20.80	1.17
Carbon dioxide	46.62	31.78
Sulphur trioxide	.33	.15
	100.53	97.76

(98) Samples collected by the writer at the Hagersville quarry were found to have the following composition :

	1.	2.	3.
Insoluble residue	16.50	12.68	4.78
Ferric oxide	.94 (with alumina)	.72	.92
Alumina		.26	.22
Lime	41.92	44.00	46.52
Magnesia	.67	3.77	4.85
Sulphur trioxide	.32	.18	.41
Carbon dioxide	34.37	38.66	41.42
Moisture	5.28	.....	.60
	100.00	100.27	99.72

1, lower 3 ft. of quarry; 2. lower layer at the northeast corner of the quarry; 8, above lower 3 ft. of quarry face.

	Per cent.
"Moisture	0.24
Insoluble residue	5.32
Ferric oxide	1.21
Alumina	3.99
Lime	45.14
Magnesia	1.64
Carbonic acid	35.46
Loss on ignition	40.89

"The writer is informed that a drill hole 87 feet exposed nothing but continuous limestone. Most of the product of these quarries is made into rubble, in which an extensive trade is carried on. The percentage of silica has the effect of rendering the rock rather hard, and somewhat impairs its value as a building stone on account of the added difficulty of chiselling.

"Two miles south of Hagersville, at the 'Gore,' the soft sandstones of the Oriskany crop out, underlaid as usual by the smooth non-fossiliferous limestone.

"Following the road from Hagersville to Cayuga, the first exposures are of the hard cherty limestone seen at the cutting of the M.C.R. This rock underlies the sandstone and separates it from the "waterlime"; it was not observed at Springvale and does not appear to be continuous. The Oriskany sandstone reaches a thickness of 15 feet in this vicinity, and shows distinct traces of glaciation in a west-southwest direction. The rock itself is more compact and of better grain that that at Springvale, and is quarried at several points along the road. The above mentioned chert is absent at many points, the sandstone being directly succeeded by the smooth limestone, an average analysis of which gives:

	Per cent.
"Water	0.35
Silica	3.44
Alumina	2.34
Ferric oxide	1.86
Calcium oxide	26.61
Magnesium oxide	17.47
Ignition loss	44.96

"On lot 40 in the fourth concession of North Cayuga, this lime rock is again exposed where a quarry has been opened by Mr. J. Best. The upper ten feet consist of the even-bedded gray non-fossiliferous limestone, while the lower part shows the same lack of fossils but is of a bluish hue, and capable of being quarried in larger blocks. The analysis of this rock is as follows:

	Per cent.
"Water	0.55
Silica	4.14
Alumina	26.60
Ferric oxide	1.56
Calcium oxide	20.09
Magnesium oxide	14.51

"The unusually high percentage of alumina is remarkable; this rock might well be used to enrich others in the vicinity whose content of alumina is too low for the best results in the manufacture of hydraulic cements. The surface of the rock at this quarry shows distinct glacial striae running west-southwest. The overlying soil is heavy boulder clay. On lot 36 I.S. of North Cayuga, the valley of denudation of Rattlesnake creek shows an excellent section of these lower beds, about 30 feet being exposed. The upper portions consist of the non-fossiliferous waterlime beds, separated by shaly layers, while at the bottom of the section bluish, friable limestones crop out. Much of this stone is fine-grained and very uniform; it should afford examples suitable for lithographic work.

"We have therefore in this vicinity thirty or forty feet of the so-called waterlime belonging to the Lower Helderberg series resting on a shaly blue limestone, and covered in places by a narrow bed of chert, or where this is absent, succeeded directly by the Oriskany sandstone showing a maximum thickness of twenty feet. Close above the sandstone are the coralline layers of the Corniferous, which is attested by the fact that in many of the fields surrounding the sandstone exposures, fossils of this type may be collected. . .

"From this vicinity southward to Cayuga no more exposures are encountered, the rock being hidden beneath a uniform bed of clay. South of this town outcrops are well known, but the expedition was not carried so far." (99)

The Hagersville quarry, operated by the Hagersville Contracting Company, is situated near the town. The stone makes good road material and is used chiefly for this purpose and for concrete. The quarry has a depth of about 12 feet and covers a considerable area. The upper layers contain silicified fossils and chert nodules which add to its value as a road material, but the lower three and one-half feet is pretty free from fossils, and has been used by the St. Thomas car wheel works as a flux. The crushing capacity of the plant is about 400 tons a day. In summer 80 or 90 men are employed. In winter the force is less. Shipments are made by the Michigan Central and Grand Trunk railways. The crushed stone is shipped as far west as Windsor. The color of the beds in

(99) B. M., Vol. XII., pp. 143-7.

the quarry is dark gray to blue.

A small lime kiln is operated at Winger's quarry, Springvale. Hitching posts for horses are also made from the lime and crushed stone. About 9 feet of rock are exposed in the quarry. The upper 3 feet of rock is soft and breaks irregularly. The lower layers are brittle and break with a flint-like fracture. The stone is fine-grained.

The dip of the beds, which is slight, appears to be westward or southwestward. Limestone comes to the surface at the corner of the road at Gill P.O., and between this point and Hagersville.

What is known as Decew's sandstone quarry lies near the road about 2 miles northeast of Gill P.O., and about 5 miles from Hagersville. The face of the quarry is 12 to 15 feet in height. The rock is thick bedded, massive, medium grained, rather friable, gray-weathering sandstone. On fresh surfaces it has a light reddish color. The lower bed, as it lies in place, appears to have a thickness of about 6 feet; and the upper ones are nearly as thick. To the south rather thin-bedded limestone underlies the sandstone. This limestone is fine grained, soft and appears to be argillaceous. The overlying sandstone, which outcrops on the road, but rises little above the level of the surrounding country, thins out rapidly to the southward. The sandstone represents the Oriskany formation, and the underlying limestone belongs, apparently, to the Water-lime series. A sample of this limestone was taken for analysis, and was found to have the following composition :

	Per cent.
Silica	1.58
Ferric oxide	1.25
Alumina	.10
Lime	30.18
Magnesia	19.78
Carbon dioxide	45.35
Sulphur trioxide	.13
	98.37

The following analyses show the composition of some argillaceous dolomites from this county :

	1.	2.	3.
"Carbonate of lime	39.91	51.33	25.20
" of magnesia	34.15	40.91	19.70
Argillaceous residue	22.10	5.50	52.20
Water	3.84	2.26	2.90
	100.00	100.00	100.00

"The first two analyses are by Delesse; 1 is a dark earthy rock, from Martindale's gypsum quarry at Oneida; 2 is a specimen of the vesicular dolomite, brownish-yellow in color, from the gypsum quarries at Paris, on the Grand River; and 3 is a greenish crumbling shaly rock from the same locality." (100)

Haliburton District

The character and distribution of the crystalline limestones of this district are described in the following notes :

"The study of the Grenville series in Monmouth, showed beyond a doubt that this series is a sedimentary one. It includes a great development of bedded white quartzites, evidently altered sandstones. The associated limestones also, that occur in heavy bands, and, as everywhere else in the Grenville series, are in the form of white crystalline marbles, were in a few places along the line of the Irondale, Bancroft and Ottawa railway, seen to hold little dark strings suggestive of remnants of the original limestone in a less altered condition. On this account, a careful search was made, which resulted in the discovery of two localities in which the limestone was almost unaltered, being very fine in grain and blue in color, and bearing a strong resemblance to the limestones of more recent formations. In such cases the blue limestone is interstratified with the ordinary white coarse-grained marble of the Grenville series and passes into it, there being evidently portions of the limestones which have escaped metamorphism. These occurrences serve to dispose of any lingering doubts concerning the sedimentary origin of the limestone in question. The localities where these unaltered limestones are best seen are lot 27 of range 14 of Monmouth and lot 28 of range 11 of the same township." (101)

"In the southern and eastern portions of the sheet the Laurentian contains an abundance of crystalline limestone and has all the characters of the Grenville series of Sir William Logan, in which series, as is well known, nearly all the mineral deposits of economic value occurring in the Laurentian in Quebec and Eastern Ontario are found. In the north-western portion of the area on the other hand our explorations have so far failed to discover any crystalline limestone, the country being apparently occupied by gneiss alone. As townships in which this crystalline limestone is especially abundant, Lutterworth, Minden, Snowdon, Dysart, Glamorgan, Monmouth, Cardiff and Brudenell may be mentioned, as well as the township of Galway lying to the south of the area embraced in sheet 118.

"The discovery of so large an area of the Grenville series in this district is

(100) G.S.C., 1863, p. 625.

(101) Ibid. Vol. XI., 1898, p. 109 A.

most encouraging, as indicating the probable occurrence in it of large and valuable mineral deposits.

"The relation of the Grenville series, in this district, to the rest of the Laurention which is free from limestone, has not as yet been definitely determined, although the limestones and their associated gneiss seem in certain cases to partially inclose areas which contain no limestone. Another noteworthy fact is that throughout the area occupied by these Laurentian rocks, the dip is uniformly in an easterly direction, usually at moderate angles. Only at one or two points have westerly dips been observed, and these are quite local." (102)

Lutterworth Township

"In this township there is an abundance of excellent crystalline limestone, especially in that part of it which lies to the east of Gull Lake. Much of this is very pure and constitutes a veritable marble, as on lots 19 of ranges 4 and 5, and on lot 20 of 5, while elsewhere it contains grains of hornblende, mica, serpentine and other minerals scattered through it. This limestone would yield excellent lime, and could also be employed for building purposes if sufficiently accessible. It is, however, rather coarse grained for very fine work or for statuary.

"There is a local tradition that silver was formerly mined at Miner's Bay on the east shore of Gull Lake. No workings are known to exist, however, and no ore is ever known to have been discovered in the vicinity. A little molybdenite in flakes and crystals was found in the gneiss at this locality. This may, on account of its silvery appearance, have been mistaken for an ore of silver.

"Molybdenite disseminated through crystalline limestone also occurs on lot 23 of range 5.

"Graphite was observed in small quantities in the gneiss and limestone at several localities. I am informed that it occurs more abundantly on lot 15 of range 4.

"A deposit of iron ore on lot 5 in the northern part of range 5 and the southern part of range 6 of this township, was at one time worked quite extensively, several hundred tons of ore were extracted and shipped, but work was discontinued seven or eight years ago. Two large openings and several small holes have been excavated in the deposit, but are now for the most part filled with water. The country rock is a reddish gneiss, interstratified with many small amphibolite bands, as well as with a small band of crystalline limestone" (103).

"There is a great deal of very good marble through the Haliburton country, of the ordinary white crystalline variety. It is both in Snowdon and Glamorgan, and some variegated has been obtained from 17 in the 1st concession of the latter township. Some has been polished that came from Galway, and some taken from lot 32 in the 5th of Snowdon has been used for monumental purposes" (104).

Halton

"The strata of this section [Medina and Clinton] are limited by a bold escarpment, composed of the rocks of the Niagara formation, which succeeds. By this escarpment they are easily traceable from Flamborough West, in a northeasterly direction, through Flamborough East into South Nelson. On entering the latter township they take a sweeping turn northward, and maintain a general course somewhat westward of north, for 75 miles, from South Nelson to Collingwood." (105)

"Northward from Flamborough East, the massive beds of encrinal limestone, [see section given under county of Wentworth], which pass below the cherty band, form the crest of the lower escarpment, and appear to gradually increase in thickness in that direction. . . . On the seventh lot of the seventh range of Nassagaweya there is a vertical precipice, in some places a hundred feet in height. It is capped by the encrinal band, while the Pentamerus bed is probably at the base; but though the stratigraphical place of the black shale would thus be in the cliff, it has not yet been detected. Nearly the whole mass of rock appears to be a light grey, drab-weathering limestone, usually presenting a black surface in the cliff, from the presence of minute lichens. Much of it appears to be magnesian, and it for the most part abounds in encrinites. It is well adapted for building purposes, but it seems too porous to be made available as a marble. Some of the beds are well adapted for burning to quick-lime, and these probably contain a smaller proportion of magnesia. Though the very base of the limestone is concealed by a talus of debris, its near proximity is indicated by the copious streams of water which flow along

(102) G.S.C., Vol. VI., 1892-93, p. 4 J.

(103) Ibid, p. S J.

(104) J. B. Campbell in Roy. Com., 1890, p. 83.

(105) G.S.C., 1863, p. 315.

its whole outcrop, from the more argillaceous beds beneath, and issue from among the debris; depositing in their course, large quantities of calcareous tufa.

"In a cutting of the Grand Trunk Railway at Limehouse, on a tributary of the Credit, on the twenty-first lot of the sixth range of Esquesing, the base of the Niagara limestone is seen resting on the beds of the Clinton formation. This has there a thickness of only 34 feet; not much more than one-third of what it presents in Flamborough West. It consists of 10 feet of a bluish shale, resting on the Grey band as a base, and overlaid by 7 feet of red shale, which represents the iron ore bed [i. e., the summit of the Clinton]. To this succeeds eight feet of bluish shales. followed by nine feet of water-lime This bed of water-lime rests on a thin bed of arenaceous shale, with a thin seam of reddish sandy clay holding crystals of iron pyrites, and supports a light grey partially magnesian limestone, belonging to the Niagara series, of which only 27 feet are exposed in the cutting. The characteristic Pentamerus oblongus has not been seen here" (106)

"Proceeding northward, the upper escarpment of the Flamborough West section is found to merge into the plain above, and disappears. Black shales and limestones, such as occur in it, are however met with in the sixth range of Nassagaweya. on the Grand Trunk railway, between three and four miles back from the edge of the lower or main escarpment. It is probable that the whole formation is carried westward. in a narrow spur, on the axis of a small anticlinal." (107)

"At Limehouse, in Esquesing, there is a band of nine feet [of water lime], which is wrought to a considerable extent, and yields a good hydraulic lime." (108) This band is in the Niagara formation, but is not supposed to be the equivalent of the Thorold band.

Analyses

(1) "Dolomite, from Limehouse, township of Esquesing....This stone occurs in a band nine feet thick, in beds varying from three to seven inches. Geological position—Clinton formation, Silurian. Collected by Dr. R. Bell.

"A bluish-gray, yellowish-brown weathering, very fine crystalline, compact dolomite. Its analysis afforded the following results :

(After drying at 100 degrees C.—Hygroscopic water, equals 0.27 per cent.)

Carbonate of lime			48.07
" magnesia			39.63
" iron			0.69
Sulphate of lime			0.10
Alumina		0.21	
Silica, soluble		0.37	
Insoluble matter, consisting of :			11.60
Silica	7.60		
Alumina	2.07		
Ferric oxide	0.40		
Lime	0.05	11.02	
Magnesia	0.19		
Potassa	0.53		
Soda	0.18		
			100.09

"This stone has been wrought to a considerable extent, and yields a good hydraulic lime. The cement sets slowly and hardens during several weeks, after which it is said to possess great strength." (109)

(2) "Dolomite, from a quarry at Christie's Siding, west half of the third lot of the sixth concession of the township of Nassagaweya. . . Geological position —Niagara formation. Silurian.

"A light bluish-gray, fine-crystalline, massive, dolomite. Its analysis afforded the following results : (110)

(After drying at 100 degrees C.—Hygroscopic water, 0.10 per cent.)

Carbonate of lime		54.12
Carbonate of magnesia		45.45
Carbonate of iron		0.58
Sulphate of lime		0.17
Alumina	trace	0.30
Insoluble matter	0.30	
		100.62 "

Among the lime kilns in this county are those of Messrs. D. Robertson & Co., which, together with the quarries, are situated on lot 4 in the seventh concession of the township of Nassagaweya. The two kilns have a capacity of 33,000 lbs. each per day. The lime is used over

(106) G.S.C., 1863, p. 327.
(107) Ibid. p. 330.
(108) Ibid, p. 806.
(109) G.S.C., 1895, p. 16 R.
(110) Ibid, p. 17 R.

a large part of the Province, going as far east as Peterborough. The company furnish the following analysis of their lime:

Lime (calcium oxide)	60.08
Magnesia	35.67
Silica	.20
Iron oxide	1.34
Carbon dioxide	2.71
	100.00

The limestone burned to produce this lime would contain about 33 per cent. of lime and about 20 of magnesia, which represents a slightly higher percentage of calcium carbonate and a slightly lower percentage of magnesium carbonate than is given in the preceding analysis from Christie's siding.

Hastings

The limestones of this county are varied in character and are found in large outcrops in numerous localities. Many crystalline varieties are found in the Grenville or Hastings series of the Laurentian system. Attempts have been made to work these as marbles at several places. These are described in following pages.

Dimension stone of large size is furnished by the quarries in the Trenton group at Crookston, and formerly at Point Ann, near Belleville. A cement plant is now under construction at the latter place, the limestone being of suitable character for use in the manufacture of Portland cement.

The Trenton or Black River formation furnishes excellent building stone in many places, and the lithographic layers which are found in it near the village of Marmora and elsewhere have attracted considerable attention.

Marl deposits are known to occur in many localities. The deposit at Marlbank on the line of the Bay of Quinte Railway has been worked for a number of years to furnish material for the cement plants at Marlbank and Strathcona.

Many descriptions of the limestones of the county are to be found in the reports of the Geological Survey, from which several of the following extracts have been taken. The reader is referred to these reports for further details.

Trenton Group

"Turning westward the two escarpments [of the Trenton group] take a course somewhat parallel with Clare River, to Sugar Island on the south side of Stucco Lake, but the lower occasionally crosses to the north side on the way. On the east side of the Moira River the escarpments are more widely separated than hitherto, the lower occurring about a quarter of a mile, and the higher 5 miles down the stream from the lake. On the west side, the second escarpment rises abruptly from the river in the third range; the beds of the lower deposit are cut nearly in two, upwards of a mile from the river, by a projecting ridge of gneiss, which extends for 3 miles to the southwest from Stucco Lake. At the termination of this Laurentian spur on the third lot of the fifth range of Hungerford, an escarpment rises about fifty feet high in nearly horizontal strata. The lower beds, exposed at a distance of about a hundred yards from the gneiss, consist of pale bluish drab calcareous rock, without fossils, and may belong to the lower deposit; while the strata at the summit are dark brownish-grey or blackish limestone, in pretty regular courses of from two to three feet thick, holding Leperditia and some small univalves.

"Below Hungerford Mills, on the twelfth lot of the tenth range of Hungerford, which is on the northwest side of the Laurentian spur, strata are exposed at the edge of the river, which must be near the base of the lower deposit. They are in ascending order, as follows:

"Dark blue limestone, 7 inches.

"Drab-colored limestone of very fine texture, in courses of 3 inches thick, supposed to be fit for lithographic purposes, 9 inches.

"Red arenaceous limestone, passing into calcareo-arenaceous shale at the top, 8 inches.

"Grey limestone, 4 feet. Total, 6 feet.

"Professor Chapman of Toronto states that in the red calcareo-arenaceous rock of this place there is between forty and fifty per cent. of magnesian carbonate of lime. The lowest and nearest Silurian dolomite to the eastward, of which the horizon is certain, belongs to the Calciferous, and this fact would rather strengthen the evidence afforded by the Piloceras at Kingston Mills as to the age of the Hungerford strata. . .

"At the lower end of Hog [Moira] Lake on the south side, on the nineteenth lot of the thirteenth range of Huntingdon, beds very nearly corresponding in character with those of the Hungerford section form a low cliff close to the beach. The same rock appears to form the base of several outlying Silurian patches in Madoc, and to be traceable to Marmora.

"The section at the Marmora iron works, on the bank of the Crow River, is in ascending order as follows:

"Shaly limestone, filling depressions in the surface of contorted Laurentian gneiss, which contains beds or veins of fine-grained syenite; 1 foot.

"Red sandstone, soft and calcareous; the color is deep red in the divisions of the beds, and lighter towards the middle of them; one or two thin interstratified layers are greenish; 8 feet 3 inches.

"Yellowish-white compact limestone of a character fit for lithography. This increases to four inches about twenty yards to the N.N.W. in the strike, where however it appears to have too many crystals for lithographic purposes. It has rough slightly dentated interfitting surfaces, with a greyish-brown film between in some parts; it has also small light green and some dark olive green patches ; 1 inch.

"Greenish calcareo-arenaceous shale, spotted with red, with a few quartz pebbles, and a few cavities, as if calcareous pebbles had been worn out of them. At the top there is a thin layer of snuff-brown earth, probably manganesian, passing into green shale; 3 feet 5 inches.

"Mottled grey and greenish-white argillaceous limestone, slightly bituminous; 1 foot 5 inches.

"Dark grey bituminous limestone, somewhat shaly in part; 2 feet.

"Light grey compact slaty limestone; this would probably form good building stone; it is strong and very even, but rather thin bedded; some of it appears fine enough for lithography; 2 feet.

"Light brownish-grey compact limestone in a single bed; this is apparently fine enough in texture for lithographic purposes, but not of the right color; it has a small quantity of bitumen in it. Though seemingly one bed, it splits apart in some places, and shows surfaces with short tooth-like interfitting columnar projections, having a thin film of bituminous matter between; 1 foot 7 inches.

"Light brownish-grey calcareous shale, the last inch and a half becoming a hard limestone in an even bed; 10 inches.

"Light brownish-buff compact very fine limestone, the grain wholly impalpable; the lower half is more homogeneous than the upper, which holds thin lenticular crystals of calcspar; the upper inch, which is just above the part holding most crystals, fits upon it in tooth-like projections of a marked character, the projections having columnar sides at right angles to the bed, an inch long in some places; a thin film of bituminous shale darkens the surface; in the lower part there are obscure tooth-like divisions. This is the Marmora lithographic bed, the best stone being in the lower portion. When exposed to the weather, this part is generally affected by gash-like cracks, which appear to terminate both ways, and run in two general directions, dividing the mass into rhombodial forms; but there are other gashes which run at a small angle to these; the stone weathers nearly white; 2 feet.

"Light grey limestone; the fracture is conchoidal and slightly scaly; the stone is strong and tough, and it would make a good building stone. It weathers slightly yellowish at the joints and bed divisions; the beds are from three to four inches thick, but aggregated beds of a foot and more occur; some of them separate in tooth-like projections, with a film of bituminous shale between. Large slabs may be obtained, some of them six feet square; some of the surfaces are waved; 5 feet.

"Light greyish-brown compact smooth limestone, weathering into gashes like the lithographic stone, and more divided into joints than the bed below; 2 feet 2 inches.

"Brownish-grey compact limestone, rather lighter in color than the previous bed, with lenticular crystals of calcspar; this would make lithographic stone were it not for the crystals; 7 inches.

"Brownish-buff compact limestone, with a conchoidal fracture; there are lenticular crystals of calcspar in the bed, but much smaller than those of the previous layer. This might yield lithographic material; it is doubtful, however, whether the crystals are not too numerous; 7 inches.

"Darkish grey very compact limestone, with a conchoidal fracture; 5 feet 8 inches.

"Measures concealed, 5 feet. Total, 41 feet 7 inches.

"These beds, in which no organic remains have been detected, are succeeded by about forty feet of limestone, having much the same lithological characters, in which fossils are sufficiently abundant, though many of them are obscure. Those which have been recognized belong to the Birdseye and Black River formation. In this section there appears to be such a passage from the arenaceous beds at the bottom to the compact limestones, which become fossiliferous at the top, as to induce the supposition that the whole belong to the formation named, notwithstanding the two Chazy species found at Vanluvin's mills. The rock of Kingston, which appears to be nearly destitute of fossils, presents many intances of the columnar structure so prevalent at Marmora. It frequently contains small masses of yellow blende. Geodes holding sulphate of strontium occur in the limestone at Kingston and near Sydenham, but these minerals have not been met with in what is considered its equivalent to the westward." (111)

Following are analyses of samples of lithographic stone from the quarries

(111) G.S.C., 1863, pp. 179-183.

on the south side of Crow lake, near Marmora village :

	No. 1.	No. 2.
Insoluble silicate	3.71	3.60
Organic matter	0.40	1.29
Calcium carbonate	89.98	88.03
Magnesium carbonate	2.78	2.50
Soluble silica .. .. }	0.73	0.49
Alumina .. .. }		0.57
Ferric oxide....	0.15	0.35
Ferrous oxide	0.10	0.04
Water	1.25	1.36
Total	99.10	99.23

No. 1, Light blue gray stone. Sp. gravity at 15.5 degrees, is 2.85.

No. 2, Dark blue stone. Sp. gravity at 15.5 degrees, is 2.89.

"The dark blue variety. . . is from a layer about 70 feet below the general surface of the country near Marmora, showing at the borders of Crow lake. Here some 50 feet of the overlying strata have been broken and washed away. . . Of some 27 layers examined by me only one gave encouraging results, and this is the dark blue variety, analyzed by me as above." (112)

Quarries

"I am interested in four quarries, two in North Hastings, one in Hungerford, and one in the township of Madoc. We obtain from all the quarries valuable stone for building and other purposes. The quarry in the township of Madoc is commonly known as the Victoria or McKinnon. It extends over 40 acres, and contains excellent building stone from three to fourteen inches in thickness, and in some parts of the quarry in layers of two feet in thickness. The stone is easy to take out, is hard and firm, and partakes somewhat of the nature of a lithographic stone; part of it might be used for that purpose. The property is quite convenient to the North Hastings railway, and some 300 or 400 carloads were shipped this year, part being used for the foundation of the new Parliament Buildings at Toronto. It has also been used in many of the principal buildings of that city and has given satisfaction. The Hungerford quarry is on lot 10, in the 9th concession, and quite near to the Crookston station of the North Hastings railway. The quarry was opened last summer. The stone is a firm and fine-grained [Silurian] limestone, and occurs in layers from 16 inches to four feet in thickness. It is well adapted for heavy buildings, railway bridges, etc. Messrs. Manning & McDonald, the contractors, are getting the stone from this quarry for the bridges across the Don." (113)

There are now two quarries at Crookston, the one adjoining the other. That of Messrs. Quinlan & Robertson has an opening of about 600 x 200 feet, and that of Senator Gibson 800x300. In the former quarry five layers of stone are worked. The bottom layers are said to be harder, but the stone from all the layers takes on a uniform color when aged. A sample of dressed stone at the quarry measured 32 inches. About 70 men were employed in each quarry at the time of my visit, of whom 32 in the first-mentioned quarry were stonecutters. Stone was being gotten out for use in construction of power plants at Niagara Falls. The quarries are alongside of the North Hastings branch of the Grand Trunk railway, and about one-quarter mile from the Canadian Pacific. Switches from both roads run to the quarries.

Following are analyses of Palæozoic limestones from working quarries :

PALÆOZOIC LIMESTONES

	1	2	3
Silica	3.42	1.76	5.60
Ferric oxide	.82	1.05	1.25
Alumina	.52	.34	.71
Lime...........	52.22	51.58	48.48
Magnesia...........	.72	2.11	3.65
Carbon dioxide.	41.53	42.77	41.81
Loss	.21	.23	....
Sulphur trioxide . . .	.36	.14	.08
Alkalies	.12	....	....
Total	100.12	99.98	99.58

1. General sample from the Crookston quarries. Individual beds probably contain less silica and more lime than is shown in the analysis. 2. Sample from McIntosh's quarry, near Madoc. 3. McKinnon's quarry. These three quarries are referred to in the text.

Samples from Point Ann show the following composition :

POINT ANN, BELLEVILLE.

	1	2	3	4	5	6
Silica	1.64	1.80	....	.47	.60	.80
Ferric oxide	.53	.71	.71	.55 }	.78	1.02
Alumina........	.21	.43	.95	}		
Lime........	54.06	53.46	51.80	55.01	54.67	54.31
Magnesia	.55	.64	.53	.40	.54	.65
Carbon dioxide	42.90	42.60	41.10	....	....	....
Loss	.10	1.00	....	....	....	....
Sulphur trioxide........	.41	....	....	....	....	....
Insol. residue	....	....	5.56	....	....	....
Total........	100.40	100.64	100.65	....	....	....

(112) B.M., Vol. II., p. 183.

(113) A. A. McDonald, in Roy. Com., 1890, p. 80.

Samples 1 and 2 are from the chip piles, refuse from trimming stone, at the Point Ann quarry. Sample 3 was was taken from the face of the railway cut on the quarry grounds. The residues insoluble in hydrochloric acid in 1 and 2 were equal to 2.42 and 2.70 per cent. respectively. The silica contained in these residues is shown in the analyses. The silica in the residue in 3 was not determined. Analyses 4, 5 and 6 are taken from the prospectus of the Belleville Portland Cement Company, dated January 3rd, 1903 These analyses are labelled top, intermediate and bottom respectively. An analysis of another sample of the rock from this quarry, by Mr. H. C. Mabee. is given in the table under Addington county.

Crystalline limestones from this county are described in the following terms :

(1) "is a dolomite [crystalline limestone] from lot 13 in the eighth concession of the Township of Madoc. "It is greyish-white in color, almost compact, with a conchoidal fracture, and a specific gravity of 2.849. This rock contains veins and disseminated grains of quartz.

(2) is a reddish granular dolomite from the village of Madoc, having a specific gravity of 2.834. Like the previous one, it contains quartz, and a little oxyd of iron. to which it owes its color. A portion of this, however, as in the last, is probably in the state of carbonate of protoxyd." (114)

(3) A fine-grained greyish-white magnesian limestone, lot 4 in the fifth concession of Madoc. (115). Specific gravity, 2.757.

	1.	2.	3.
Carbonate of lime.. ..	46.47	57.37	51.90
" of magnesia	40.17	34.66	11.39
Peroxyd of iron ...	1.24	1.32	.....
Carbonate of iron...		.....	4.71
Insoluble, quartz, etc	12.16	7.10	32.00
	100.04	100.45	100.00

"In the township of Madoc. on the thirteenth lot, and near the road between the seventh and eighth ranges, is a band of a fine-grained yellowish-white magnesian limestone, which would apparently yield a marble. Large blocks of a very good white marble have also been obtained from the adjoining townships of Elzivir and Marmora; that from the latter place is extremely pure, white, and compact." (116)

"Greyish limestones of this character are found in Tudor, where they sometimes form the wall rock of the veins of galena there met with. The limestones of that locality are, however, most commonly fine-grained and dark grey in color. Rocks of this character are met with all along the Hastings road in the south part of Tudor, also in lots 23, 24, and 25, range B, and on many other lots in that township. Quite as frequently however a part of the micaceous substance contained in them forms continuous sheets, imparting to the rock the character of a calc-schist. This grey, fine-grained limestone is perhaps more prevalent in Tudor than the more crystalline, granular variety to be noticed below, and is often met with in the township of Marmora, where a characteristic variety of it occurs on lot eight, range seven. It is also of frequent occurrence to the north of the village of Madoc, while to the south of it the limestone is more crystalline, and the micaceous layers are sometimes associated with iron pyrites. Similar varieties of this rock occur in the village of Bridgewater, one of them containing reddish calcspar and greenish mica.

"Granular limestone, sometimes purely white and saccharoidal, and at other times greyish, with a slightly banded structure, is plentifully met with in this region, and occupies a wide area in the eastern part of Hungerford. The town of Bridgewater stands upon another area of it, which has there furnished marble for building purposes.

"A little to the southeast of Madoc village it occurs white and crystalline, as well as grey and banded, and both varieties have been used as building stones. Other localities of this rock are Madoc, lots ten and twenty-four, range six; and Marmora, lot six, range eight, and lot sixteen, range eleven. A beautiful variety of dolomite occurs on lot twenty-seven, range one of Sheffield, and many of the micaceous limestones of this region are probably dolomitic." (117)

Marbles

The following notes on the marbles of Hastings county are taken from the Report of the Royal Commission on the Mineral Resources of Ontario, 1890. The first extract is from a statement by Mr. E. J. Whitney, pp. 80-82.

"My residence and home is at Gouverneur, in the state of New York. I am acting here as superintendent of the Hungerford Marble company's quarries. The capital of the company is $100,000. The marble at Gouverneur is very similar to the marble here, as is also the country rock, which is principally granite, gneiss and crystalline limestone. That marble sells well; in fact the de-

(114) G.S.C., 1863, 592-3.

(115) Ibid, p. 593.

(116) Ibid, pp. 822-3.

(117) G.S.C., 1866, p. 94.

mand is greater than the supply. The St. Lawrence Marble company have to run night and day to fill orders, and then cannot keep up. These crystalline marbles will stand the weather better than the metamorphic marbles of Vermont, and generally they work as easily. The quarries at Rutland, Vt., have dark stocks, and they always have orders in excess of their output, the dark being in great demand for outside work. The St. Lawrence company's marbles stand the weather better, polish as well and look as well. The Gouverneur quarries produce a blue stock that cannot be produced in the Rutland. There are a great many bands of that kind of marble here, and speaking generally all through the country there is any quantity of marble; all that is required is to go down far enough to where it is sound. Under similar circumstances on the other side of the line marble of satisfactory character is produced, and I am satisfied that as good can be found here, and that there is an enormous quantity of it; in fact I think there is no limit to the quantity. Very little of the Rutland marbles is used for outside work on buildings; it is not good for that purpose. The marbles here are good for either inside or outside work. Almost all colors are found, white, salmon, grey, black, mottled, drab, with black veins, with white veins, verde-antique and dove blue. All through St. Lawrence county, in New York, there are gravestones of crystalline marble that have been up 70 years, and they are perfect yet, though they were cut out of the surface rock. It will stand next best to granite, but will not moss like granite, and will stand fire better than any other stone. The old Fowler mansion, at Gouverneur, was built over fifty years ago out of just such stone; in 1874 it was burned down, and in 1875 some of the stone was taken to build an hotel. The only effect the fire had upon the stone was where it had gone out through the windows; there it crumbled the corners a little. In the academy at Gouverneur there is a slab that has been up since 1839, and it is as clean as when new. I had a marble shop burned down; the Italian marble all broke into little pieces, the granite also cracked to pieces, while the corners of the crystalline limestone just crumbled. There is no doubt that it makes the best building stone. Wherever marble takes a turn or bend it is never sound, but where it straightens out again it is good. I think the black marble here will turn out to be good, it is only a question of depth; in the Rutland quarries they did not get any that was good until they got to a depth of 100 feet. Good black marble is scarce, and if it is first-class it is worth as much as statuary; but as a general thing we cannot rely upon getting any quantity of it without being clouded. The demand is limited; the present price of a good fair article is $6 or $7 a foot sawed. The company has opend up two properties or quarries, one of them in the village of Madoc and the other about a mile and a half south of Bridgewater, on the Scootamatta river. The Madoc quarry was opened in the latter part of Auggust, 1887. The band is about 900 feet wide from east to west; it curves, and I have traced it as far as Hog lake, a distance of about two miles from north to south. The lower wall on the east is granite; it dips about 10 degrees to the west. The upper wall is a mixture of granite and lime rock, but not what can be called a conglomerate. The dip is 10 degrees to the west. Beyond to the west is a slate which in some places is tipped up 30 or 40 degrees; in other places it is nearly horizontal. It would be good for roofing, but that it splits a little too thick. At present we have sunk on the Madoc property to the depth of 38 feet, but it is our intention to drill down 300 feet in order to get marble that will do for polishing. The marble is very good, the color a grey black. Its hardness is greater than that of the Vermont white marble, and about equal to the Italian marble. We find that the quality gets a good deal better as we go down. We have not as yet taken out any merchantable marble from that quarry, though we have taken out blocks part of which would be merchantable. At the quarry we have a 30-ton derrick, a diamond drill, a channelling machine, an Ingersoll gadder, a 35-horse power boiler, two steam pumps, and all the tools required; we have a full set of quarrying machinery. To run our machinery would take from eight to ten men, including one machine runner and two foremen; the rest would be quarrymen. The average wages here is $2.75 for machine runner, and $1.25 for quarrymen per day of ten hours; the wages are about the same as in New York State. Besides the Madoc quarry this company is working a white marble quarry near Bridgewater. The location there is about 40 acres in extent. The band is about 500 feet wide, and the course is about northwest and southeast. I have seen where it crops out a couple of miles above Bridgewater, but not below. It crops out at the surface, where work has been carried on. There are several small ridges, each of which shows white marble. The lower wall is granite; the upper wall is gneiss, and is very clearly defined. The marble is white, but has some cloudings of blue and green. The pitch is about ten degrees from the perpendicular to the west. There are two thin layers of salmon-colored stone, one about ten inches and the other eighteen inches. At the village of Bridgewater there is similar marble, and it was quarried twenty-five years ago to build a church and some private buildings. We worked our quarry there this summer, removed most of the surface material, and got down about 12 or 14 feet; the work was all done by hand. The quality of the marble is very good, and improves as we go down. A large amount of the surface stone taken out would only answer for building, but good merchantable marble is now exposed. We employed ten men there till about the 1st of August. We intend to test the property with a diamond drill. There is no property that I know of that could be so cheaply quarried as this one. It could be worked a good deal cheaper than the Madoc quarry. The marble would be suitable for monumental work ; the low grade would make good trimmings for buildings, and the higher for interior and monumental purposes. The price at the mill would be $2 a cubic foot for the better, and down to fifty cents a foot for the poorer qualities. The shipping facilities are not good; we can only ship by hauling a distance of three and a half miles to Tweed (118). In a direct line, we are a mile and a-half from the railway. We were talking of putting up a marble mill, and running it by water power, and we could get a head of water of eight feet, but that has not been decided on as yet. The company has bought fifty acres from the Canada Company and ten acres from Mr. Clapp, a mile and a-half east of Bridgewater, on which there is a blue marble similar to that of Rutland. There is a good band of it from 50 to 100 feet wide; it is distinct from the other. On the Canada Company lot there is a large band of serpentine marble. I have examined it once, but have not done anything to it. In serpentine, as a rule, there is a great deal of unsoundness, but this is fair; there is some white in it, and that makes it sounder. There are very few serpentine bands that I have seen as sound as this one. I do not know the width of the band, but judging from the outcroppings, I think it is from 300 to 600 feet wide."

Mr. J. E. Harrison gave evidence before the Commission on the Bridgewater marbles as follows :

"The white marble at Bridgewater is exceeding close-grained, rendering it very suitable for fine work, bearing sharp edges and undercutting. For building purposes it has few equals amongst the various kinds of stone now used, being capable of sustaining any pressure required for masonry, and being non-absorbent it is free from discoloration when exposed to the weather. This point of excellence is proved in the walls of buildings, erected from thirty to thirty-five years ago, which show no sign of becoming weathered. It has been used for over thirty years for making lime, and the lime business alone could be made very large and profitable, as has been proved by the experience of those engaged in it heretofore, notably that of the Dudswell Marble & Lime Co., of Sherbrooke, in the Province of Quebec. This firm ship, besides marble stone, an immense quantity of lime throughout the Province of Quebec and New England, reported by them to have been about 120 carloads per month for 1887. This lime, used for plastering, with clean sharp sand, is glossier, harder and whiter than a finish made of the best plaster of paris." (119)

Mr Alexander McLean's opinion as to the availability of Hastings county marbles was given as follows to the Commission :

". . . . Then, in one respect marble is very like dry goods, certain kinds are fashionable. Just at present the popular marble is the Tennessee; it is red, with white and variegated spots. There is no marble we produce that is at all like it. Those we have are principally crystalline limestone. I have seen some very fine marble in color and texture that came from back of Tweed, from a quarry that belongs, I think, to Mr. Sanford, of Hamilton. The color is white, and it is much less crystalline than the Bridgewater marble, but we cannot tell anything about that property till it is developed. I do not wish to be understood to say that crystalline marble would not compare favorably with other marbles for useful purposes. I think it will last better than any other marble, and I do not think it will stain as easily as the Italian marble. It would not take quite as good a finish as the best grades of Tennessee marble, but, of course, I have only seen what may be called surface specimens. . . . We have bought Tennessee marble ourselves in the open market. Fashion rules the demand, and there is not so much marble bought by one person that the duty would make any difference. The furniture dealers will not take marble that is not in the fashion; people will not buy an article that is unfashionable. It is impossible to force Canadian marble on the market. We have no opposition in granite from the

(118) An extension of the Bay of Quinte railway was built past this quarry in 1903.

(119) Roy. Com., 1890, p. 82.

United States. There is any quantity of fine granite in the Muskoka and lake Superior districts. It is said that it has been used for bridges, and that it is free from checks and cracks. There is no object to go into granite the way prices are now unless we get special orders. We are not making any great effort to develop that trade; but the marble business is developing rapidly." (120)

The Commissioners state the results of their own observations in the following words:

"In the village of Madoc a band of crystalline limestone of the Laurentian series has been opened to a limited extent for the production of a dark-colored marble. The band is about 900 feet across, with a north and south course where opened, lying between granite on the east side and limestone on the west, beyond which latter again there occurs a band of slate or argillaceous shale. It is nearly vertical in position, pitching about 10 degrees to the west. The marble is a fair quality, crystalline and dark-colored, polishing almost black. Checks or joints occur here and there near the surface, but are said to become less frequent as the band is sunk upon. The quarry was nearly filled with water at the time of the commissioners' visit, so that a proper examination of it could not be made, but we were informed that a depth of 38 feet had been attained, and that at that depth the open floors were six to eight feet apart. There are various colored bands, chiefly grey (which, as above mentioned, polish almost black), grey and white mixed, and in other places some white in broader bands with the grey, which could be sawn out. This marble should be well adapted for all mourning purposes, as well as for designs where a dark-colored material is required. Its specific gravity is 2.782. The machinery on the ground consists of a 35-horse-power portable boiler, two steam pumps, an Ingersoll gadder, a diamond drill, a channel machine, a 30-ton derrick and necessary tools. Cutting is made with the drill, successive borings on the same line making a clean cut of any sized block that may be required.

"The Bridgewater marble quarry is in the township of Hungerford, in Hastings county, and is worked by the company owning the Madoc quarry. The strike of the band is north and south, dipping slightly eastward from the vertical. On the east is a quartzose rock, with large masses of quartz and feldspar, immediately followed by a close-grained pink-colored syenite. On the west side is a highly altered shale, dipping at a high angle. The latter varies in places from a gneissic to a chloritic, talcose and micaceous schist, succeeded by gneiss. This band of marble is some 500 feet wide, and curves around from north and south to south 30 degrees east. Where an opening has been made it is observed that the joints are at right angles to the strike and running with the dip, and are four to forty or fifty feet apart. The open floors are two feet to ten and twelve feet part. The seams vary from six inches to ten or twelve feet apart, the average being about two feet. The marble has a pure white color, clouded bluish and greenish in places, and with bands of pinkish or salmon color in other parts. These latter bands may be sawn out, being twelve to eighteen inches wide. The marble is closely crystalline, but compact, and is shown at Bridgewater to stand the weather well. A church has been built of it at that village, as well as portions of houses and stores, and they have stood over twenty years without showing any signs of weathering. It is said to be practically identical with the marble at Gouverneur, in the State of New York. The company expect to be able to ship large blocks, which pay best. The finest quality sells at $2 and the poorest at 50 cents per cubic foot. The specific gravity is 2.751." (121)

"The parti-colored limestone beds found in Seymour (at Allan's mills), and at the base of the Trenton outliers in Marmora, and in Madoc, yield a fine-grained grey marble thickly mottled with red and yellow colors" (122)

The following table shows the chemical composition of some of the Hastings marbles, or crystalline limestones; other analyses of representatives of this group of rocks are given on a preceding page:

CRYSTALLINE LIMESTONES

—	1	2	3	4
Insoluble residue	......	2.54	1.14	....
Silica	1.37	....	....	2.70
Ferric oxide	.82	.34	.56	1.71
Alumina			trace	1.64
Lime	50.10	53.64	47.49	48.28
Magnesia	3.88	.99	6.82	4.35
Sulphur trioxide	.10	.34	.18	.34
Carbon dioxide	43.32	42.92	43.91	42.60
Loss	....	......		
Alkalies	....	.25	....	.....
Total	99.59	101.02	100.10	101.62

Sample 1 is from the marble quarry on the outskirts of the town of Madoc; 2 is from Ellis quarry on the Bay of Quinte railway, a short distance south of Actinolite (formerly Bridgewater); 3 represents a sample from Harrison's

(120) Roy. Com., 1890, p. 236.

(121) Roy. Com., 1890, pp. 75-6.

(122) G.S.C., 1863, p. 827.

quarry, Actinolite, and is probably higher in magnesia than the average; 4, Limekiln quarry, York river, near Foster's rapids, township of Carlow.

Marls

(1) "White lake deposit, lot 10. concession X, near Crookstown, Huntington township, Hastings county, 50 feet from G. T. R. and three-quarters of a mile from C. P. R. tracks. The deposit is 30 feet deep and there are clay deposits adjacent. The sample, which was taken from the bed of White lake, gave the following analysis: (123)

	Per cent.
$CaCO_3$	96.92
$MgCO_3$	0.31
Al_2O_3	0.18
Fe_2O_3	0.11
FeO	trace
SiO_2	0.98
Organic matter	not esti.
Sulphuric acid	trace
$CaSO_4$, $MgSO_4$	trace
Alkalis (K_2O) and Na_2O	not esti.
Total, estimated	98.50"

(2) "From a deposit at White Lake, lots eighteen and nineteen of the ninth conecssion of the township of Huntingdon. . . The marl extends out from the shore beneath the waters of the lake for variable distances—at some points, for one hundred feet or less; at others, for over two hundred feet or more. Little is known in regard to the thickness of the deposit, but this, in some places at least, has been found to exceed thirty feet.

"The air-dried material is earthy, slightly coherent; colour, yellowish white. It contains but few shells and no visible root-fibres.

"It was found, by Mr. F. G. Wait, to have the following composition:

(After drying at 100 degrees C.—Hygroscopic water, 0.75 per cent.)

Lime	54.47
Magnesia	0.11
Alumina	0.06
Ferric oxide	0.08
Maganous oxide	traces
Potassa	traces
Soda	traces
Carbonic acid	42.87
Sulphuric acid	0.03
Phosphoric acid	0.01
Silica, soluble	0.08
Insoluble mineral matter	1.08
Organic matter, viz., vegetable fibre in a state of decay and products of its decay such as humus, humic acid, etc., and possibly a little combined water	1.84
	100.63

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 97.27 per cent. carbonate of lime.

"The insoluble mineral matter was found to consist of: (124)

Silica	0.82
Alumina and ferric oxide	0.21
Lime	0.03
Magnesia	traces
Alkalies	0.02
	1.08"

Huron

Extracts are given from Reports of the Geological Survey, descriptive of some of the limestones in the county of Huron, where the outcroppings are of comparatively small extent.

"Farther on, escarpments of twenty or thirty feet of the limestone [of the Corniferous formation] run through the west half of Carrick, and are said to extend southward into Howick." (125)

"Where the line between the townships of Ashfield and Colborne meets the lake, a little south of Port Albert, on the Ashfield or Nine-mile River, rocks come from beneath the high clay cliffs which face the water, and are seen at intervals along the shore for about a mile. The greatest section here exposed does not afford a vertical thickness of more than six feet. The rocks resemble a part of those at Point Douglas; they are destitute of fossils, and consist, in ascending order, of gray calcareous and bituminous sandstones, cherty limestones, brown calcareous beds striped with thin bituminous shales, and pale yellowish dolomitic layers, sometimes three feet thick; marked by lenticular crystals of calcite, or by cavities from which such crystals have disappeared. At the falls of the Ashfield River, about a quarter of a mile above Port Albert, there is exposed a series of thick-bedded grey calcareous sandstones, with buff colored silicious limestones, both holding organic remains, which are more numerous in the latter. . . These fos-

(123) Cat. Ont. Min. Exhibit, Buffalo, p. 82

(124) G.S.C., 1894, p. 27 R.

(125) Ibid, 1863, p. 371.

siliferous beds, like those of Point Douglas, probably overlie the unfossiliferous strata.

"On the Maitland River, about four miles in a direct line from the shore of Lake Huron, there occurs on the first lot of the first range of Colborne, an exposure of yellowish-drab limestone. . . Beds similar to those seen on the coast and the river near Port Albert, and probably a continuation of them, occur in a cliff lower down on the Maitland, near Goderich. The following is a descending section of them :

"1. Dark grey thin bedded bituminous limestones, holding organic remains. . . 24 feet.

"2. Measures concealed by clay and debris, 12 feet.

"3. Pale grey or drab fine-grained sandstone, marked with ferruginous spots and stripes, and mottled with blue and yellowish colors; no fossils appear, 2 feet.

"4. Brownish calcspar, an aggregation of irregular crystals arranged in a bed, 1 inch.

"5. Dark brown, fine-grained sandstone, striped with bituminous layers; the rock is very soft and easily disintegrated, until after exposure to the air, when it becomes hard, 2 feet 6 inches. Total, 40 feet 7 inches.

"At the bridge across the Maitland River, about half a mile from the town of Goderich, and at a short distance below the place where the above section was measured, the following unfossiliferous beds are found exposed in a continuation of the same cliff. Four feet of dark grey bituminous and silicious limestone, followed by two feet of brecciated beds, are seen, which probably correspond to a portion of the measures, 2, concealed above. To these succeed :

"3. Pale yellowish calcareous sandstone, with ferruginous stripes and spots, 1 foot 10 inches.

"4. Brownish calcspar, an aggregation of irregular crystals arranged in a bed, 6 inches.

"5. Yellowish sandstone, with bituminous and ferruginous spots, 3 feet.

"6. Dark grey or brownish bituminous dolomite, with small lenticular crystals of calcspar ; some beds contain a large quantity of chert, and thin partings of bituminous shale, 4 feet. Total, 9 feet 4 inches.

"There is little doubt that the fossiliferous beds in all these various exposures, from Fort Douglas, belong to the Corniferous formation; while the lower non-fossiliferous strata bear a strong resemblance, in their mineral character and general aspect, to the Water-lime series. Their arrangement shows that we have here one of the minor undulations, to which allusion has been made." (126)

Analyses

"Limestone. This and the two following stones represent the material of three of the beds worked at a quarry on the eighth lot of the first concession of the township of Colborne, Huron county. . . .

"Stone from the fourth bed or layer, occurring at the quarry in question. Thickness of the band, about 6 inches —more or less.

"An ashy-brown, very fine-crystalline, almost compact limestone.

"Its analysis afforded Mr. Wait the following results :

(After drying at 100 deg. C.—Hygroscopic water 0.06 per cent.)

Carbonate of lime		95.57
Carbonate of magnesia		2.77
Carbonate of iron		0.31
Carbonate of manganese		trace
Alumina	0.01	
Silica, soluble	0.04	1.62
Insoluble mineral matter	1.30	
Organic matter	0.27	
		100.27

"Stone from the thirteenth bed or layer of the quarry from which the preceding specimen was taken. Thickness of the band, about three inches—more or less.

"A yellowish-brown, fine crystalline, dolomitic limestone. An analysis by Mr. Wait showed it to have the following composition :

(After drying at 100 deg. C.—Hygroscopic water, 0.04 per cent.)

Carbonate of lime		81.75
Carbonate of magnesia		15.06
Carbonate of iron		0.72
Carbonate of manganese		trace
Alumina	0.11	
Silica, soluble	0.02	2.78
Insoluble mineral matter	2.57	
Organic matter	0.08	
		100.31

"Stone from the twenty-fourth bed or layer of the quarry from which the two preceding specimens were taken. The thickness of the band, about six inches —more or less.

"A light yellowish-brown, fine to moderately coarse-crystalline, somewhat magnesian limestone. Its composition was found, by Mr. Wait, to be as follows :

(126) G.S.C., 1863 pp. 375-7.

(After drying at 100 deg. C.—Hygroscopic water 0.03 per cent.) (127)

Carbonate of lime		91.46
Carbonate of magnesia		6.22
Carbonate of iron		0.48
Carbonate of manganese		trace
Alumina	0.06	
Silica, soluble	0.02	1.87
Insoluble mineral matter	1.74	
Organic matter	0.05	
		100.03"

Kent

The surface of Kent is similar to that of other counties which lie along the western half of the north shore of lake Erie, and is characterized by the presence of a thick deposit of drift. Wells have been drilled at a number of points, however, in search for oil and gas, which have given us a fairly accurate knowledge of the underground geology. Shale is usually struck immediately beneath the boulder clay. This is claimed to be in some cases part of the Portage formation; in others it is said to belong to the Hamilton. The following is held to represent a typical section near the centre of the township of Raleigh: (128)

	Feet.
Boulder clay, with occasional layers of sand and gravel	184
Shale, to	205
Limestone (argillaceous) to	211
Shale, to	240
Limestone, to	246
Shale, to	247
Limestone (middle lime, slightly argillaceous), to	249
Shale, to	278½
Limestone, very slightly argillaceous, becoming almost pure lime thereafter, to	511

"Another well was drilled, during recent years, about one mile northwest of the Grand Trunk Railway station at Chatham, which reached a depth of 1,000 feet, as follows: (129)

	Feet.
Surface clay	60
Shale, black [Portage]	118
Soapstone	200
Limestone	18
Soapstone	37
Limestone	567"

Lambton

Exposures of limestone in the county of Lambton have been described in Reports of the Geological Survey and Bureau of Mines in the following terms:

"On the twenty-third, twenty-sixth and intermediate lots of the third range of Bosanquet, exposures of the rock [of the Hamilton formation] are met with, on the banks of a small tributary of the Riviere aux Sables (south). The following section in ascending order was measured on the twenty-fifth lot:

	Ft.	In.
Grey calcareous shale, imperfectly seen in a slope or talus on the stream	25	0
Grey calcareous shale, with. . . fossils	4	0
Grey solid limestone, composed of broken remains of encrinites	2	0
Grey soft shale, thinly laminated next the limestone, and filled with fossils. . . The upper part has the softness of clay	20	0
Grey decomposing shale, not well exposed	80	0
Grey encrinal limestone, weathering into small lenticular fragments, and holding bivalve shells, corals and encrinites	2	0
	133	0

"This section probably includes the strata of the neighboring exposures. . .

"At Jones's mill, on the third lot, upon the south boundary of Bosanquet, on the bank of another small tributary of the Riviere aux Sables (south), the following ascending section is exposed:

	Ft.	In.
Brownish grey-weathering shales	25	0
Grey encrinal limestone	2	0
Grey decomposing shale	3	0
	30	0

". . . . At Austin's mill, on the fourth lot of the first range of the same township, on another small stream, there is a corresponding section, where the grey encrinal limestone which forms the uppermost layer of the exposed strata, is five feet thick. Below this band, the strata are characterized, as before, by a great abundance of Spirifera mucronata; and in the bed of the stream, at a level probably fifty or sixty feet below the encrinal limestone, there is a band of solid arenaceous limestone, about 7 inches thick." (130)

The other formation, exposures of which occur in this county, is known as the Portage-Chemung. It is composed essentially of shales, which are often highly bituminous.

Logs of the numerous wells which have been sunk in search of petroleum

(127) G.S.C., 1899, pp. 33-34 R.
(128) B.M., Vol. XII., p. 41.
(129) G.S.C., 1890-91, p. 73 Q.
(130) G.S.C., 1863, pp. 382-5.

show the character and arrangement of the strata which underlie various parts of the county.

"The heavy deposits of drift continue westward from St. Mary's, being represented by rolling boulder clay, interrupted in places by deposits of gravel. After passing Lucan, some morainic hills are encountered, which however soon give place to remarkably level clay land. No rock exposures are seen over the entire region until the famous Hamilton outcrops at Thedford are reached. The excellent series of rocks rendered accessible at this point have become classic in the annals of geology, as they form an exceedingly rich hunting ground for the fossils characteristic of the Hamilton formation. So much has been published on the fauna of these rocks that it would be superfluous for the writer to deal with that side of the matter here. An idea of the richness of the remains may be gathered from the fact that, in spite of time spent in travelling, he succeeded in three days in collecting over a thousand specimens, representing 110 species. Some attempt was made by the writer to work out the fossil contents or at least to establish the characteristic fossils of the various layers, but he is glad to find that this had been done by others in greater detail than his time would permit. Professor A. A. Wright during the summer of 1900 made a complete series of measurements, and during the season of 1901, Professors Shimer and Grabau made exhaustive collections. The results of their work are published in a valuable bulletin of the Geological Society of America.

"It may be well however to describe briefly the places at which exposures are to be seen. The first is at Thedford, where the Grand Trunk railway cuts through the series to a depth of forty feet. At this point Spirifer pennata (Spirifer mucronata var. Thedfordensis of the above authors) is very abundant, as well as bryozoa of different genera. This section is also much the best for the collection of Athyris spiriferoides, Goniatites uniangularis and Cyrtina Hamiltonensis. Shimer and Grabau mention 39 species from here, mostly bryozoa and brachiopods. A second exposure is found three-quarters of a mile north of the railway cut in what are known as Hanniford's fields. A heavy limestone with crinoid stems is here overlaid by a soft shale from which weather out numerous specimens of corals which may be picked up in perfect condition on the surface of the ground.

"Besides the corals fourteen or fifteen species of brachiopoda occur.

"Fragments of bryozoa and joints of crinoids are also abundant.

"The third section is found on a small stream west of the above and presents practically the same series of rocks, reaching however a greater vertical extent. The top is decomposed coral shale underlaid by limestone in several layers, beneath which is fifteen feet of blue clay. This material makes excellent drain pipes and brick of a red color, while the overlying boulder clay burns white. The blue Hamilton shale is filled with nodules of a harder nature which prove objectionable on account of their resistance to the action of both fire and water. An analysis of one of these nodules follows:

	Per cent.
Water	0.57
Silica	17.67
Alumina	10.59
Ferric oxide	4.25
Calcium oxide	32.84
Magnesium oxide	traces.

"The nodules would seem to owe their origin therefore to concretions of lime which has entered into chemical union with the elements of the shale. The assemblage of fossils is, as would be expected, about the same as in Hanniford's fields and the railway cut.

"Probably the best section of these Hamilton rocks is to be seen in Rock Glen, where a small tributary of Aux Sables river has exposed 70 feet of the series. Another excellent section of the lower portion is seen at Marshall's Mills on the Aux Sables, about a mile above the mouth of Rock Glen. Finally small exposures are met with in the valleys of creeks cutting down to the rock on the road from Thedford to Arkona. Particularly may be mentioned a good section at 'No. 4 hill.' At Stony Point, lake Huron, the heavy limestone is exposed for a short distance along the shore. . . .

"An analysis of this limestone is given below, as well as one of what is probably the same bed from Thedford:

	Stoney Pt., per cent.	Thedford, per cent.
Water	0.14	.....
Silica	0.78	1.51
Alumina	0.13	2.19
Ferric oxide	1.56	2.49
Calcium oxide	51.74	51.26
Magnesium oxide	0.46	traces.
Sulphur trioxide	1.27	.....
Carbonic acid and loss	43.02	41.10

"It will be observed that this stone is practically free from magnesia, although the sulphur may prove objectionable for certain chemical purposes.

"Below are shown side by side sections of the Hamilton formation at Thedford as prepared by Professor Wright and by Professors Shimer and Grabau. My observations, made a year later, can add nothing to the systematic measurements

Bed No.	Shimer and Grabau.	Feet.	A. A. Wright.	Railway cut and Hanniford's fields.	Rock Glen.	No. 4 Hill.	Marshall's Mills.
				Feet.	Feet.	Feet.	Feet.
9	Calcareous Ceratopora Bryozoa beds	10	Encrinal limestone	2	4	6	......
8	Shales with Spirifer beds at base	8	Nodular shale	1	6.6	4.1	......
7	Argillaceous limestone	1.5	Upper argillaceous limestone.	14	2	1.6	......
6	Blue calcareous shale	18	Upper blue shale.	37.6	37.9	29	......
5	Calcareous shale and slaty blue limestone	6	Lower argillaceous limestone	1.3	1.3	1.3	1.3
4	Argillaceous shales with Styliolila.	1.5	Coral beds	......	3.9	3.9	3.9
3	Coral layers	3.25	Rugose limestone	......	2.6	2.6	2.6
2	Encrinal limestone	3	Lower blue shales	......	20	20	20
1	Blue shales, lower, with calcareous fossil beds	30	Calcareous blue shales	......	15	15	15
	Total	81.25	Total		84 feet.		

of these geologists. For detailed information as to the fossil content of the various layers the reader is referred to the publication already cited.

"The various shales, particularly those free from fossils, make excellent tile and coarse pottery. Mr. Jas. Cornell has for years carried on this industry at the exposure on the creek north of Thedford. Rock Glen and Marshall's Mills both furnish equally good sites for this purpose. The limestones are practically free from magnesia and alumina, making splendid lime and the even-bedded portions are easily quarried for building stone. Two miles north of Thedford a gravel ridge is crossed, beyond which a distinct beach is seen (Algonquin beach), representing the shore line of lake Huron in post-glacial times." (131)

Lanark

Crystalline limestone suitable for several purposes is found at many points in this county. At Carleton Place one of the chief lime producers in the eastern part of the Province uses this rock. In other localities the stone is quarried for use as a building material, some of it being adapted to decorative purposes.

Cambrian and Silurian limestones—Calciferous, Chazy and the Trenton group—are also found, especially in the more northeastern and southeastern parts of the county, where they form somewhat irregularly-shaped areas overlying the crystalline series of the Laurentian. The strata of these formations here are similar in chemical composition and other characteristics to the corresponding ones in the adjoining counties, Carleton and Grenville.

Exposures of the Calciferous formation are found in the townships of Pakenham, Ramsay and Beckwith.

Limestones of the Chazy formation are exposed in Ramsay and adjoining townships; those of the Trenton group outcrop in Pakenham and Ramsay.

"On the Rideau canal it [the Calciferous formation] is seen at Smith's Falls, in a cliff of thirty feet." (132)

Following are analyses of certain crystalline limestones found in this county:

—	1	2	3	4
Insoluble residue.	1.32	1.12	3.06	1.20
Silica	....	....	....	.....
Ferric oxide	.49	.38	.46	.49
Alumina				.97
Lime	50.80	51.20	49.86	43.82
Magnesia	3.33	2.28	3.36	9.19
Carbon dioxide	43.51	44.50	42.69	44.00
Water	....	.08	....	......
Loss	....	....	.31	......
Sulphur trioxide	.06	.32	.28	.46
Alkalies	....	....	....	......
Total	99.51	99.88	100.02	100.13

1, Stone used at Cameron's lime kiln, Carleton Place; 2, dark crystalline limestone, Lanark village; 3, lighter colored stone at the same place; 4, lot 2 in the fourth concession of North Burgess.

"Mr. Hoffman has examined both the bluish-grey and white layers of a specimen of this limestone, from the twenty-first lot of the tenth range of Lanark. The former contained finely disseminated graphite (the cause of their color), and likewise a considerable quantity of tremolite in crystals, some of which were

(131) B.M., Vol. XII., pp. 153-156.

(132) G.S.C., 1863, p. 118.

more than half an inch in length. The white layers, however, were free from graphite, but contained a little tremolite in microscopic crystals. Minute grains of glassy quartz were also found in both the grey and white layers. The material for the following analyses was freed as carefully as possible from impurities, and dried at 100 degrees C.:

	Grey layer.	White layer.
Carbonate of lime	77.39	90.38
Carbonate of magnesia	20.57	8.32
Carbonate of iron	.78	.51
Graphite	.16	.....
Insoluble	1.26	.90
	100.16	100.11

"A specimen of this dolomite [brown-weathering, crystalline, magnesian lime stone, abounding in tremolite], from the twenty-second lot of the eighth range of Lanark, has been analysed by Mr. Hoffman. It was separated as far as possible from tremolite, and after drying at 100 degrees C. gave : (133)

	Per cent.
Carbonate of lime	52.12
Carbonate of magnesia	42.10
Carbonate of iron	.80
Insoluble	5.78
	100.80"

Quarries

"Limestone.—From lot twenty-four, range nine, of the township of Ramsay. . . . The quarry from which this stone was taken is situated close to the Indian River, where a great thickness of this limestone occurs. Geological position—Laurentian.

"Structure, somewhat coarsely crystalline ; color, faintly bluish-greyish-white. It contains, here and there, a minute grain of pale yellow chondrodite, and numerous small scales of graphite.

"It was found—by Mr. R. A. A. Johnston—to have the following composition :

(After drying at 100 degrees C.—Hygroscopic water 0.07 per cent.)

Carbonate of lime		91.63
Carbonate of magnesia		6.61
Carbonate of iron		0.41
Alumina	0.14	
Silica, soluble	0.05	
Insoluble matter	1.13	
		1.32
		99.97

"This stone has been extensively quarried for the manufacture of lime, and small quantities have been employed in Pakenham and Almonte for foundations and facings of buildings.

"Limestone.—Occurs on lots nine and ten of the sixth range of the township of Ramsay. . . . The same stone also occurs on lots nine and ten of the fourth and fifth ranges, and on lot sixteen of the second range, and many other places in this township. Geological position—Laurentian.

"Structure, coarsely crystalline; color, white, but not pure white. It contains an occasional grain of pale yellow chondrodite, and here and there a scale of graphite.

"Agreeably with the results of an analysis—conducted by Mr. R. A. A. Johnston—it contained :

(After drying at 100 degrees C.—Hygroscopic water 0.09 per cent.)

Carbonate of lime		90.05
Carbonate of magnesia		6.51
Carbonate of iron		0.42
Alumina	....	
Silica, soluble	0.06	
Insoluble matter	3.26	
		3.32
		100.30

"This stone has been extensively used for the manufacture of lime." (134)

Marl

"From a deposit on the thirteenth lot of the fourth concession of the township of Lavant. . . . The deposit covers an area of rather more than six acres, and is over seven feet deep.

"The air-dried material is earthy, slightly coherent; color, yellowish-white. It contains but few shells or root-fibres.

"Its composition was found, by Mr. F. G. Wait, to be as follows :

Lime	53.17
Magnesia	0.06
Alumina	0.10
Ferric oxide	0.08
Manganous oxide	0.02
Soda	0.10
Carbonic acid	42.02
Sulphuric acid	traces
Phosphoric acid	0.01
Silica, soluble	0.02
Insoluble mineral matter	0.24
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water	3.66
	99.48

(133) G. S.C., 1874-75, p. 141.

(134) G.S.C., 1888-89, pp. 24-25 R.

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 94.95 per cent. carbonate of lime.

"The insoluble mineral matter was found to consist of : (135)

Silica	0.15
Alumina and ferric oxide ..	0.07
Lime......	0.01
Magnesia....	traces
Alkalies (?)	0.01
	0.24"

Lime Kilns

Mr. W. M. Cameron operates lime kilns in the town of Carleton Place. The rock burned, which is crystalline limestone, is quarried in the fifth concession of the township of Ramsay, and teamed to the kilns in winter. An analysis of a sample of this rock is given in the preceding table. The kilns are of the continuous draw-kiln type, and have a capacity of 150 bushels in 24 hours. The fuel used is wood. The lime is white and slakes readily. There is no "combine" among lime manufacturers in eastern Ontario. Lime sells for 20 cents a bushel f.o.b. Carleton Place. Competition was met in former years at Brockville with lime from as far west as Beachville. Carleton Place lime is shipped as far east as Cornwall. It meets with competition from Renfrew lime at Ottawa and Arnprior. Mr. Cameron has furnished the paper mill at Cornwall with lime, which is said to give excellent satisfaction. A sample barrel has been sent to the Eddy mills at Hull, the lime for which has been heretofore imported from Swanton, Vermont state. Mr. Cameron is a member of the firm of Cameron Bros., who manufacture lime from crystalline limestone in the village of Delta in the county of Leeds. The plant at this place is similar to that at Carleton.

A mason told the writer that "the white crystalline limestone near Lanark village and through the township of Ramsay, makes good lime. It is 'cooler' than that of Renfrew. The lime from the vicinity of Ottawa city is quick setting. By using it one can 'spread' 4 or 5 bricks, while with Renfrew lime the number is 10 or 12."

Leeds

Outcrops of crystalline limestones are found at numerous places in this county. These rocks ". . . are extensively exposed in Bastard and South Crosby; their color is usually white, but sometimes greenish-white, or white with grey bars or stripes. Small scales of graphite are invariably disseminated through the rock, with serpentine, mica, and iron pyrites, and in the twenty-seventh lot of the third range of South Crosby chondrodite is of frequent occurrence, the disseminated mineral alternating with bands containing mica. On the twenty-fourth lot of the tenth range of Bastard a bed of conglomerate is interstratified between two of the beds of limestone." (136)

The use of crystalline limestone at Delta in the production of lime is mentioned under Lanark county.

The Calciferous formation is seen at many points. "In Young [Yonge] it is exposed on the eleventh lot of the eighth and ninth ranges, at Loyada Lake, in the rear of the township, and also in Kitley, near the village of Kitley Corner. . . The stone has been used for building purposes at Brockville and Prescott, and in the neighborhood of Brockville and Mirickville ; some of which yields good lime of a dark color, producing a mortar of considerable strength." (137)

Quarries

The writer visited a number of limestone quarries in the vicinity of Brockville. Sherwood's quarry is situated a short distance northeast of the Insane Asylum. It has a face six feet in height, with thin covering of soil. The beds average about six inches in thickness. The color of the rock is dark grey or brownish. Dyer's quarry adjoins that just mentioned. It contains one bed 14 inches in thickness. Some of the stone is used in the manufacture of window sills, five or six inches in thickness. There is a quarry on the Asylum property, on lower ground than Sherwood's or Dyer's, but similar in character. This quarry lies not far from the roadside, between the Asylum buildings and the Grand Trunk railway. Rock outcrops at Murphy's Corners, where there is a good site for a quarry. Easton's quarry is about two miles northwest of Brockville on the Perth road. It contains thick-bedded, dark grey limestone. One bed has a thickness of eighteen inches. The rock contains geodes of calcite.

Following are the results of analyses of samples of the rock taken by the writer from the Brockville quarries :

(135) G.S.C., 1894, pp. 24-25 R.

(136) G.S.C., 1863, p. 31.

(137) Ibid, p. 118.

—	1.	2	3.	4	5.	6.
Insoluble residue	....	....	....	....	19.52	....
Silica	4.80	8.76	7.00	3.68	....	6.28
Ferric oxide	1.00	.99	.57	1.22	1.01	.81
Alumina	3.32	3.84	.79	.80	.81	1.05
Lime	30.10	28.31	29.20	30.94	25.92	35.00
Magnesia	15.49	15.39	17.96	17.46	15.36	12.26
Carbon dioxide	40.63	39.00	43.75	43.30	37.20	40.93
Water	....	....	.88	....	....	....
Loss on ignition	3.97	1.35	....	....	.22	....
Sulphur trioxide	.75	.47	.41	.46	.86	.62
Alkalies	.85	.90	....	....	...	....
	100.91	99.01	100.86	97.86	100.90	96.95

1. Dyer's back quarry; 2. Asylum quarry; 3. Dyer and Sherwood's quarry; 4. A more carefully selected sample than 3, from the same quarry; 5. Murphy's quarry ; 6. Easton's quarry.

Marl

"In the township of Yonge, on the thirteenth lot of the eighteenth range a bed of marl occurs beneath a marsh, and is said to extend over twenty or twenty-five acres. Its thickness was found to be seven feet, but it is reported to be fifteen feet in some parts of the deposit. Marl has also been found in the bays on the south shore of a lake in Elmsley, where it has a thickness of three or four feet, and extends beneath the water of the lake." (138)

Lennox and Addington

(See under Addington).

Lincoln

The escarpment of the Niagara formation crosses the river from New York State, and enters the Province in the township of Niagara. The 'heights' in this township are well known from their historical connections.

The sandstones, Potsdam, which underlie the Clinton formation are exposed at the mouth of the Niagara river, and in many other places in the county.

"In Canada, for reasons which will be stated in describing the Niagara formation, it is found convenient to limit the Clinton to the strata beneath the Pentamerus band, and to include this band in the Niagara formation. On the Niagara River the Clinton is thus limited to a few feet, but it gradually augments in thickness to the northward." (139)

"Crystals of the latter mineral [galena] exist in greater or less quantity in nearly all the limestones from the Pentamerus band to the summit of the upper beds [of the Niagara formation]; but they are in the greatest abundance in the latter, especially in the township of Clinton, near the village of Beamsville, where an unsuccessful attempt was made by Mr. Lee to establish a lead mine upon what was supposed to be a lode, on a lot of the eighth range of the township. . . . The supposed lode, however, appears to be rather one of the open joints or fissures, running east and west, by which these rocks are intersected in many places. In the locality in question. the fissure, which is filled up with drift. is crossed by small cracks, the walls of which are invested with crystals of pearl-spar and galena. The ore is also seen on each side of the main fissure. and is moreover disseminated throughout the limestone, near the fissure." (140)

Queenston Quarries

"The Queenston quarries are located on lot 48 on the Queenston and Grimsby stone road, in the township of Niagara, two miles west of the village of Queenston. The lot is the property of William M. Hendershot, of Thorold, and the quarries are worked by P. A. Johnston & Co., who have held them under lease since 1881. Previous to that time they had been worked for three years by Hunter, Murray & Cleveland. who had the contract for building the Welland canal aqueduct at the town of Welland; while for the preceding four years, beginning with the spring of 1874. they had been worked by Belden, Denison & Co., who had contracts for the construction of locks on the new canal. It is said that the quarries were first opened during the construction of the Grand Trunk railway.

"Seven quarries have been opened on the property. all of which are in the limestone beds of the Niagara formation.

(138) G.S.C., 1863. p. 765.

(139) Ibid, p. 312.

(140) G.S.C., 1863. pp. 324-5.

"The several beds differ essentially in color and texture—from light grey to blue, and from soft and porous to dense and crystalline.

"After stripping from two to ten feet of clay a grey limestone bed is reached, whose surface has been deeply grooved by glacial action. It is a fossiliferous rock, consisting of lime and sand, and is used in the production of lime, and for culvert and bridge works on railways.

"Below the gray is a bed of blue limestone of ten to twelve feet in thickness, composed in some of the quarries of two bands, the upper of which is a light and the lower a dark grayish blue; in others it is composed of the dark blue only. Both are crystalline, but while the upper is coarse grained the lower is fine-grained, approaching marble, and is much superior in quality to the other. This bed contains a large variety of fossil shells, is hard and durable, tools well, and takes a fair polish. The stone taken from it is used almost wholly for the bases and shafts of monuments, for which a large business has been built up. But it is used also for building purposes, the post offices at Cornwall, Niagara Falls and St. Catharines having been constructed with it besides many private dwellings and business houses.

"Below the blue limestone is a bed of dark limestone, which has a proportion of clay in its composition, is from four to six feet in thickness, and suitable for the manufacture of cement.

"Johnston & Co. employ an average of 75 men at their quarries." (141)

Gibson's Quarries

"These are the property of Mr. William Gibson, M.P., and are situated on the top of the mountain a mile and a half south of the village of Beamsville, in the township of Clinton, and two and a half mile from Beamsville station on the Grand Trunk railway. The property embraces an area of 45 acres, and the limestone rock where not exposed is covered with only a few inches of soil.

"The quarries were opened by Mr. Gibson in May, 1884, and have been worked continuously since with a large force of laborers, quarrymen and stonecutters. The amount paid for wages in 1890 was $87,440, but last year the staff of workmen was increased, and in the month of June 160 were employed; the wages paid to quarrymen alone in that month being $7,500.

"There are two workable beds of gray limestone, the upper being seven and the lower eight feet in thickness. The upper is usually the best quality, being firm, hard and crystalline; but both contain many fossils, and have openings or vughs which are lined with crystals of iron pyrites. In some parts of the quarries the beds are three in number, but the lowest is not more than two or three feet in thickness. Below these workable beds is a bed of porous gray limestone, but it is rarely of a quality fit for use.

"Three large derricks are worked by as many engines, one of which is 24 and the other two of 18 h.p. each, the more powerful one driving a steam drill in addition. Three other derricks are driven by horse-power. A fourth boiler of 35 h.p. drives three steam drills. Three small drills are used for plug and feather work.

"The stone is all cut by hand, and is used largely for the construction of bridges, culverts, tunnels and buildings on the lines of the Grand Trunk railway. The tunnel under the St. Clair river was built by Mr. Gibson with stone taken from these quarries.

"The quarries are about 200 feet above the level of the station, down to which the stone is carried in cars over a tram road built along the side of the public highway. It could be conveyed the whole distance by gravitation, but to prevent accidents the cars are stopped before they reach the main street of the village. From that point they are taken by horses to the station and empty ones are drawn back to the quarries.

Grimsby Quarries

"The Grimsby quarries are in the gorge of Forty-Mile creek, above the village of Grimsby, which cut through the limestone into the Medina sandstone and extends back through the mountain to the falls on the creek, a distance of half a mile. The quarries are the property of the Grimsby Quarry Co., of which Stephen Webster, of Toronto, is president and Frank Webster manager. The location is about half a mile in length, extending from the edge of the escarpment on either side of the gorge to near the Falls, and occupying an area of 18 acres.

"The bottom and sides of the gorge are covered with a talus of limestone and sandstone, and these stones are being removed preparatory to opening the sandstone in place. A tram-road has been built to the docks at the lake shore, a distance of one mile and a half, down which the cars are run by gravitation, and up which they are drawn empty by horses, as at the Gibson quarries at Beamsville.

(141) B.M. Vol. I, pp. 95-96.

"The mountain here is about 350 feet above the lake, and about 100 feet of the top consists of limestone and shale. Underneath the shale are bands of gray, brown and mottled sandstone, alternated with bands of shale. At one place, where it is well exposed the brown band, slightly mottled, is about 15 feet in thickness, of good texture, solid and capable of being cut into any suitable size for building purposes.

"The company was organized in 1890 with a capital of $20,000, 75 per cent. of which was paid up, but although work was commenced in November of that year, no stone was taken out until the spring of 1891.

"Stone is being supplied for the cribwork at the eastern and western gaps of Toronto harbor, but no dimension stone has yet been taken out. The company employs from thirty to forty men." (142)

"Grimsby, Ontario—In the Niagara formation at Grimsby there are beds of dolomite, one to three feet thick, from which stone has been obtained for building purposes. The rock is crystalline, brownish-gray in color, and holds a few fossils. Some of it when dressed with a plain surface has a pitted appearance. Analysis of a specimen gave : (143)

Carbonate of lime	68.92
Carbonate of magnesia	29.48
Corbonate of iron	1.10
Insoluble matter	0.50
	100.00"

Manitoulin Island

The Manitoulin, or as it is sometimes called the Grand Manitoulin, island and a number of the islands to the north and west of it in Georgian bay are underlaid by unaltered rocks of the Silurian (Cambro-Silurian and Upper Silurian) system. These rocks outcrop as bands, running across the Grand Manitoulin, from east to west, in the direction of its greatest diameter. These formations range in age from the Chazy, which has not been proved to be present with certainty, or Black River, to the top of the Niagara. It is considered doubtful whether certain beds on the south should be classed as Guelph or should be grouped with the Niagara. From the lower part of the Trenton group to the upper part of the Niagara all the formations recognized in the more southern part of the Province are present with the exception of the Medina, and they possess the characteristics of the outcrops to the north of lake Ontario and to the westward. The Niagara, e.g., here forms an escarpment similar to that occupied by this formation from the Niagara river to the Georgian bay.

These formations on the island—Trenton, Utica, Hudson River, Clinton, Niagara and Guelph (?)—present a section from north to south across the island which is unsurpassed anywhere for the purpose of study and comparison. Rocks of all these formations can be visited in a few hours. At Little Current, for example, at the water's edge and for some feet above, we have exposures of the Trenton limestone. This is capped at the top of the hill a short distance from the shore by Utica shales. The higher hills to the southward, which can be seen from the village, are underlaid by the Hudson River formation. Farther south again we meet with the Clinton and Niagara limestones.

The late Alex. Murray, Dr. Robert Bell and other officers of the Geological Survey have described the geology of the Grand Manitoulin and adjacent islands. The reader is referred to the reports by these gentlemen for details concerning the distribution of the different limestone-bearing formations. (144)

The following table gives the results of analyses made by Mr. A. G. Burrows of samples of limestone collected on Manitoulin island by the writer last summer:

	1	2	3	4	5	6	7	8	9	10	11	12	13
Insoluble matter	......	......	......	......	......	3.86	......	6.68	10.70	......	......	......	......
Silica	.40	1.43	.56	4.64	5.68	......	7.64	......	......	3.20	2.74	2.16	1.42
Ferric oxide	.50	.71	.41	1.12	.81	.72	.94	.96	1.41	1.72	.62	.88	.99
Alumina	trace	.59	.20	1.80	2.85	.32	2.44	.70	1.85	1.76	.60	.74	......
Lime	30.81	30.05	30.50	28.61	28.08	29.00	26.59	31.68	25.74	29.52	29.50	41.50	30.06
Magnesia	21.11	11.39	21.55	19.60	19.10	20.48	18.82	16.22	18.35	18.70	20.49	9.88	20.46
Carbon dioxide	47.40	46.00	47.40	43.70	43.00	45.27	41.57	42.62	40.28	43.49	45.67	42.45	47.00
Water	......	......	......	......	......	......	......	.24	......	......	......	......	......
Loss	.18	......	......	......	.16	.22	.25	......	......	1.35	......	1.74	......
Sulphur trioxide	.09	......	.23	......	.30	.12	.31	.35	.14	.21	.06	.26	......
Alkalies	.15	......	.05	......	......	.66	......	......	......	......	......	.20	......
Total	100.67	99.97	100.90	99.47	99.98	100.65	98.56	99.45	98.57	99.95	99.68	99.81	99.93

(142) B.M., Vol. I., p. 97.

(143) G.S.C., 1876-77. pp. 486-87.

(144) Reports for 1863, pp. 63, 194-6 216, 19, 320, 333-34 ;1863-6, pp. 165-179 ; 1866-9, pp. 169-177, 449-469; 1896, pp. 1 to 29 I.

Following are the localities from which the samples represented by the above analyses were taken: 1 and 3, Ryan & Haney's quarry, a few miles from Meldrum Bay P. O.; 2. Top of hill at Meldrum Bay village; 4, Gore Bay, sample of 12 feet of the uppermost part of the face of the cliff, northwest of the Fair grounds ; 5. Top of the cliff across the bay, east of the village of Gore Bay; 6. Gore Bay, one-quarter mile west of the northwest corner of the Fair grounds, cliff 6 feet; 7. Porter's quarry, just east of the Fair grounds, Gore Bay; 8. Talus along face of cliff on the east side of Gore bay; 9. Kagawong, uppermost three feet near top of cliff, along road; 10. Little Current, four feet top of cliff, west of the village; 11. Landing at lake Manitou; 12. Upper four feet of cliff at Manitowaning; 13. Fossil hill, near Manitowaning, sample from layer under fossiliferous zone.

Concerning the thickness of the several formations, which are quite undisturbed and dip slightly to the southward, the rate being estimated at about 40 feet to the mile, Dr. Robert Bell says:

"A vertical section from the mainland along the western border of the sheet, somewhat produced to the south, would show the following thickness for each of the successive formations from the base upward : (145)

	Feet.
Chocolate marls and fine sandstones (Chazy?)	100
Trenton group [Black River, etc.].	320
Utica formation...	60
Hudson River formation....	250
Clinton formation.....	177
Niagara formation....	405
Guelph formation (?)...	100
Total thickness...	1,412."

These limestones of the Trenton group and the Clinton and Niagara formations in many localities when burned produce lime of good quality. The strata in many places are also suitable for the production of stone for building and other structural purposes. The Clinton and Niagara, which afford the layers of the most uniform composition and the most easily worked, are, like those of the same formation in the more southern part of the Province, magnesian, and thus are not suitable for use in chemical and metallurgical industries requiring a lime comparatively free from magnesia. Rock high in magnesia is required in some industries, e.g., in the manufacture of sulphite pulp, and rock from a quarry on Cockburn island has been used for this purpose in the mills at Sault Ste. Marie. Limestone carrying magnesia, if the percentage of this material is not too high, can be used as flux in blast furnaces and in other industries.

"The Silurian rocks of Manitoulin and Fitzwilliam islands afford a variety of good stones for ordinary building purposes, and some kinds suitable for heavy structures. The latter may be looked for among the thickly-bedded buff-colored dolomites of the Clinton formation and the gray dolomites of the upper part of the Niagara. The Guelph formation, which appears to be represented by the highest rocks in the southern parts of these islands, is heavy-bedded and would yield stone of large dimensions, but of a porous character. . . .

"Shell Marl.—This substance is found under a few of the limited peaty swamps and marshes, and also under some of the smaller lakes or their dried-up sites on Manitoulin island. Where the soil already contains so much carbonate of lime as does that on this island, these marls will not be required as fertilizers, but they may prove useful in the manufacture of hydraulic cement. . . . .

"Lime.—The limestones of Manitoulin island appear to be all dolomitic, except those of the Trenton group and some of the beds in the Hudson River formation. Both the dolomites and the pure limestones have been calcined for use by the farmers in the various parts of the island, where they occur, and have been found to yield excellent lime." (146)

"The greater part of La Cloche Island and of the other principal islands between the north shore of Lake Huron and the Manitoulin Island, consist of dolomites and thin-bedded light grey and somewhat argillaceous limestones of the Trenton group. The upper portion of this group, of a somewhat more massive character, occurs on Manitoulin, forming the northern part of the peninsula between Wequemakong and Manitowaning Bays, and skirting the northern extremity of the island for six miles from Little Current to West Bay. In the former area there may be about 80, and in the latter 40 feet of strata belonging to this group, counting from the lowest bed, which comes to the level of lake Huron." (147)

Hudson River Formation

The Hudson River formation on the island consists of soft marly bluish-drab colored shales, interstratified with

(145) G.S.C., 1896, p. 25 I.

(146) G.S.C., 1896, p. 27 I.

(147) Ibid, 1863-66, pp. 170-1.

limestone. At Cape Smyth, on the eastern end of the island, this formation has a thickness of about 300 feet.

"To the south of Sheguiandah Bay, and of Little Current the thickness appears to be about 250 feet, and at Maple Point 220 fet. About 145 feet are exposed on Barrie Island, and 137 at Cape Robert. . . . .

"The following is a descending section of the cliff on the west side of Cape Robert:

Brown-weathering, drab and bluish-grey argillo-arenaceous limestone—mostly thin-bedded, or when thicker, breaking away in irregular lumps. This band forms the perpendicular and overhanging portion of the cliff, and is here and elsewhere on the island, characterized by a large concentric coral....	17
Crumbling calcareo-arenaceous shales of a bluish-drab color..	10
Hard grey calcareous beds, interstratified with bluish-grey shale....	3
Bluish-grey clayey shale.....	25
Hard grey calcareous beds..	2
Bluish-grey arenaceous crumbling marl....	30
	87 feet" (148)

"The edge of the plateau formed by the Hudson River formation presents itself in a high bluff all along the north side of Grand Manitoulin from Maple Point to Julia Bay. Gore Bay, in this interval, lies in a deep notch cut out of the plateau. The strata are finely exposed in the bold escarpments on either side of this bay. The southward dip, at the rate of about one in fifty, is here quite perceptible. Local slides and debris obscure the outcropping edges of the beds in some places, and the following section, from the water's edge upwards, was not obtained in one straight line, but by connecting two exposures lying close to one another, and is presumed to be almost as correct as if measured continuously. It was obtained on the east side at the entrance to the bay, commencing at the level of Lake Huron.

"1. Bluish and drab-grey argillaceous and finely arenaceous shale—bands of darker and lighter shades alternating—crumbling and wasting away easily under the influence of the weather, interstratified with beds a few inches thick and from two to fifteen feet apart, of fine-grained grey shaly sandstone and bluish-grey limestone. The limestone bands are composed of comminuted organic remains, principally small corals, but in addition there were observed a small trilobite, a Leptena, an Orthis, and Ambonychia radiata. The sandstone bands hold Modiolopsis modiolaris—81 feet.

"2. Soft fine-grained bluish-grey calcareous sandstone, and finely arenaceous limestone, in beds from one to six inches thick. The surfaces are uneven—6 feet 4 inches.

"3. Measures concealed—80 feet.

"4. Mottled drab and gray soft argillaceous and finely arenaceous limestone, (the more calcareous portions being finely crystalline and grey). The beds are from one to six inches thick, in bands of from two to four feet, alternating with others of about the same thickness, of crumbling bluish-drab finely arenaceous shale, with nodular calcareous seams. Both the soft and hard bands are unevenly surfaced and of a nodular character. The fossils are Petraia, Stenopora fibrosa, Orthis lynx and a smaller species of Orthis, a large Atrypa, an Avicula, a Strophomena and an Orthoceras—26 feet 8 inches.

"5. Dark drab-grey soft brittle fine-grained arenaceous, somewhat crystalline limestone, in beds from one foot three inches to three feet six inches thick. It holds a small silicified Orthis—10 feet 6 inches.

"6. Greenish and bluish-grey soft finely arenaceous limestone in beds from one to three feet thick, separated by layers of bluish-gray shale from two to ten inches thick. The limestone holds nodules of white gypsum from two to three inches in diameter—27 feet 7 inches.

"7. Brownish soft unevenly-surfaced earthy-looking limestone, in beds of about two inches—8 feet 8 inches.

"8. Brownish-drab and grey limestone, in uneven beds from four to ten inches thick. Fresh fractures present a mottled drab and grey color, the grey patches having a crystalline and the drab an earthy appearance. The beds contain rusty cavities, lined with rhombohedral crystals of calcareous spar. The fossils are Stromatopora concentrica and Favosites Gothlandica. Near the top is a nodular shaly layer, holding iron pyrites, which, on decomposing, stains the face of the cliff with red oxide of iron—5 feet 3 inches.

"9. Brownish and drab-grey thin irregularly-bedded or shaly limestone holding Stenopora fibrosa, silicified and abundant, together with cavities lined with calc-spar crystals. This band forms the crest of the main escarpment—8 feet.

(148) G.S.C., 1863, p. 171.

"10. Brownish and purplish-grey uneven surfaced limestone mostly in thin beds (the thickest being nine inches), Some of them are very dark and bituminous. The mass weathers yellow, and holds abundance of Stenopora fibrosa in a silicified state—37 feet 6 inches. Total, 291 feet 6 inches.

"This last mass (10) rises at a short distance back from the main escarpment in a second cliff above it, and, gradually approaching at a point half a mile nearer the head of the bay than the locality at which the previous portion of this section was measured, it joins the main escarpment, and is added to its height.

"About a hundred yards still farther back, and after an interval of concealment of about seventeen feet, a third terrace rises to the height of twenty-eight feet, but appears to gain in elevation as it recedes eastward. It consists of soft brownish and buff-grey thinly-bedded bituminous limestone, having a conchoidal fracture, and holding small irregular chalky nodules." (149)

Clinton Formation

The Medina formation is not present on the island, the Clinton resting directly on the Hudson River formation. The Clinton consists of from 125 to 150 feet of buff-weathering purplish-grey magnesian limestone, surmounted by a band of red marl, which may average 20 feet in thickness. This limestone is generally thin-bedded, and holds silicified fossils. In some places soft white nodules, similar to those found in the Clinton formation in the county of Grey, are met with in considerable numbers. This formation is well exposed near the northeastern extremity of South bay. From this point it sweeps round with a northward curve to the eastern shore of the island.

"The formation occupies a considerable area on the north side of South bay, and round the southern part of Manitowaning bay, forming the cliffs to the west and south of the village of the same name. At the southern extremity of the bay the usually thin-bedded character of the formation is interrupted by a massive section, forming the prominent part of the escarpment, known as Gibraltar Rock. Continuing to the westward, these limestones form the northern and northwestern shores of lake Manitou. Along the latter they rise in a cliff which in some places is upwards of 70 feet high. They cap the cliffs on both sides of West and Mudge bays, form the northern shore of lake Kagawong, and probably underlie the drift deposits at the north end of lake Mindemoya. They are again seen along the northern side of Bayfield sound, and upon Howe island, from which they cross Cape Robert, and are once more exposed at the entrance of Cemetery bay." (150)

The red marl band which separates the Clinton from the overlying Niagara formation probably does not average more than 20 feet in thickness, but is very persistent throughout the island.

Niagara Formation

This formation runs throughout the whole length of Manitoulin island, occupying the southern half. Its average breadth is nine miles, which with a dip of 40 feet in a mile would give 360 feet as the thickness of the formation; but its thickness may be 40 or 50 feet greater.

"The nothern boundary of the formation, rendered conspicuous by a limestone cliff varying from 20 to 200 feet in height, has the following course: After crossing the peninsula between the east end of the island and South Bay, it runs northward from Rocky Point on the northwest side of the same bay to the eastern extremity of lake Manitou, and thence follows its southern and western shores. It then runs out in a long point between the west end of Lake Manitou on one side and West Bay and Lake Mindemoya on the other. Starting from the northwest corner of this lake, it sweeps round in another promontory to the northeast corner of Lake Kagawong, and follows round its southern shore. From the west side of Lake Kagawong it crosses to Lake Mudgeemanitou, and after forming another promontory towards the north, runs southward to Lake Wolsey, reaching its east shore about the middle, from which point it continues round the southern part of the lake to the outlet. From Lake Wolsey it follows the south shore of Bayfield Sound, Sheshequaning, where it strikes across Cape Robert, and continues thence all along the shore to the western extremity of the island.

"The upper beds of this formation dip into the lake at so small an angle that they produce a low shore, and shallow water all along the south side of the island. The coast line is very much broken by shallow bays and straggling points, rendering navigation somewhat dangerous.

"The whole formation consists of thick-bedded and thin-bedded limestones of various shades of light and dark grey. Wherever the surface has been exposed

(149) G.S.C., 18866-69, pp. 111-113.

(150) G.S.C., 1863-66, p. 173-4.

to fire, by the burning of the timber, it weathers white, but when not thus scorched it is generally dark-colored or almost black, from the growth of small lichens upon it. The high promontory of Niagara limestone between Lake Manitou and West Bay suggested to the Indians the name, Metchkewedenong, or the high hill, for their village at the head of the bay. The following is an approximate descending section of the escarpment overlooking the west side of lake Manitou:

"Very massive light grey magnesian limestone; in some places smooth walls, which had once formed the sides of joints, extend, without a break, nearly from top to bottom. No fossils are recognizable —60 feet.

"Thin-bedded grey limestone, some portions holding silicified corals—40 feet.

"Limestone similar to the last, but often projecting in a separate terrace below the other. A three-feet bed, near the centre, is full of silicified coral—50 feet.

"Talus—30 feet. Total, 180 feet. . .

"On the south side of Bayfield Sound the rocks of this formation rise in a bold escarpment overlooking the lake. It is particularly conspicuous between Helen and Elizabeth Bays, and is separated by a step into two portions, the top of the lower being about 100 feet, and that of the upper between 200 and 250 feet above the level of Lake Huron. In crossing the island from north to south, after passing the brink of the main escarpment, smaller ones, making up the higher portion of the formation, are met with at intervals all the way to the south shore. They consist mostly of light grey, sometimes almost white, compact limestone, rather fine-grained and crystalline in texture. Some of the upper beds, being those on the south side of the island, are dark grey in color." (151)

St. Joseph Island

St. Joseph Island shows Trenton rocks on its north side. The Hudson River formation on this island is deeply covered with drift, and no exposures of it are seen. The base of the Clinton formation appears to skirt the south side of the island as far as Hay Point.

The following analyses, by Mr. Burrows, are of samples from Pollock's quarry, No. 1 being from the thick layer,and No. 2 from the lower argillaceous layer:

(151) G.S.C., 1863-66, pp. 174-176.

	1	2
Insol. residue	10.04	13.86
Ferric oxide	2.11	.90
Alumina	1.31	1.30
Lime	29.88	43.08
Magnesia	15.05	2.15
Carbon dioxide	40.56	35.99
Water	.90	.53
Sulphur trioxide	1.09	.89
	100.94	98.70

Cockburn Island

"Cockburn Island has a breadth of nine miles from north to south, and the dip of the strata being the same as the Grand Manitoulin, the thickness of the Niagara formation, of which this island is wholly composed, will here be about 400 feet also. Along the north shore of the island the rocks (which must be near the base of the formation) consist principally of soft buff-colored bituminous dolomites, suitable for building purposes. . . . . They are characterized by a conchoidal fracture, which, in natural exposures, parallel to the bedding, gives rise to a succession of small depressions resembling plates and saucers in size and form. These rocks were referred to in my last report as occurring at Meldrum Point (the northwestern extremity of Grand Manitoulin) . . . . Interstratified with these, on the north side of Cockburn Island, in some places there are found slaty and more bituminous bands of a dark color, and in others even-surfaced beds of a bluish-grey color, which, if not too soft, may be found suitable for flagstones. . . On the south side of the island the upper beds, consisting of grey somewhat bituminous limestone, are seldom seen, the shore being formed of sand and shingle; while on the east and west sides the limestones are exposed almost continuously along the beach. The beds are generally thick, some of them attaining upwards of six feet. Most of them are light grey in color and of a saccharoidal texture. In the interior of the island, especially towards the northern side, similar beds are occasionally exposed. They are, however, seldom seen in the form of cliffs, and, although the northern slope of the island is the most precipitous, much of it is buried under the drift." (152)

An analysis of the Cockburn Island limestone used at Sault Ste. Marie in the sulphite pulp process is given on a preceding page, under Pulp.

Quarries

The Ryan and Haney quarry, which is a few miles from Meldrum Bay vil-

(152) G.S.C., 1866-69, pp. 114-115.

lage, was visited. It is the largest quarry on the island. A large amount of stone was taken from it for use in the construction of the canal at the Canadian Sault. Considerable care seems to have been used in selecting only the best stone for the work. The result is that over the three or four acres occupied by the quarry there is much stone blasted out ready for shipment, should a demand arise for this class of rock. The accompanying photograph shows the character of this broken stone. The edge of the quarry is about 100 yards from the water's edge, and the rock has been worked down to a depth of 5 or 6 feet. The rock is brittle and breaks rather irregularly, the bedding being uneven. The dock from which the rock was loaded on to boats lies opposite Green island, 8 miles from Mississagua light. The rock, which contains few fossils and has a crystalline aspect, is flat lying, and the road is paved with the strata in place for a mile or more north of the quarry. Vertical jointing is shown, and the glacial striae have a direction S. 25 degrees W., magnetic. The stone weathers to a light grey color. Analyses of samples taken from this quarry, representing the face, and the average of the loose pieces of rock, are given on a foregoing page.

Some good building stone, to be seen in Mr. Wickett's farm house, occurs near Meldrum Bay, and it is also burned into lime, the layers free from chert appearing well adapted to this purpose. Analyses of this rock are given in the table.

The court house and registry building at Gore Bay are built of limestone quarried in the vicinity. These buildings were erected about 12 years ago. The stone weathers to a rather peculiar drab color. There are shallow quarries near the fair grounds. Just east of the grounds rock outcrops at the surface. Its thickest beds are 12 or 14 inches. A cliff on the street at the northwest corner of the grounds was sampled to a depth of 12 feet. Another sample was taken one-quarter mile west of this, on the road. The composition of these samples is shown in the table.

Samples of rock from the vicinity of Manitowaning village were obtained and subjected to analysis. The results are given in the table on page 75. The rock is used for building purposes, but no quarries of any importance have been opened up, surface rock being employed.

Analyses of samples from the following localities are also given in the table: Limestone at Manitou lake landing, 3 miles from Manitowaning, where the outcrop rises 6 or 8 feet above the level of the water; and from the upper 4 feet of the cliff at Manitowaning where the rock is rather thin-bedded and is followed by beds of similar thickness downwards of argillaceous and fossiliferous limestone.

The Manitoulin Portland Cement Company was incorporated during the past year. It is proposed to obtain the marl frome Ice lake, mix it with shale, and use the water fall at Kagawong to generate power for working the material up into cement. The fall is said to have a height of between 118 and 132 feet. At the roadside near the top of the hill at Kagawong a face of 12 or 15 feet of shale, with more or less limestone intermixed, is exposed. Samples of this and another exposure were taken, with the object of determining whether or not the material is suitable for cement purposes, should a works be established at the village.

Middlesex

The following logs of wells give an idea of the character of the drift covering and the underlying strata in this county.

"Some years ago a boring was made on the grounds of the Asylum [at London], which reached a depth of 2,250 feet, probably terminating in the upper portion of the Hudson River formation. The first rock met with is a limestone, at or near the summit of the Corniferous, as the shales, indicative of the Hamilton, found in the well at the sulphur spring in the western part of the city, are missing.

"The record of the boring, kindly furnished by Mr. W. Harris, of Petrolea, is approximately as follows (153) :—

Surface............	130 feet	
Limestone, hard...	200 "	Corniferous
" soft....	270 "	Onondaga
" hard...	100 "	with Guelph
"	600 "	and Niagara
Salt and Shale.....	100 "	if present.
Black shale........	200 "	Clinton
Red "	500 "	Medina
Limestone & shale..	150 "	HudsonRiver"

"One well in the township of Metcalfe, lot 24, concession 13, gave the following records (154) :—

Surface (clay)	48 feet	
Black shale.........	75 "	Portage
Soapstone, etc.......	273 "	Hamilton
Limestone..........	104 "	Corniferous

"A well drilled on lot 5, concession 7, of the township of Mosa showed:

Surface (clay).......	50 feet	
Black shale.........	10 "	Portage
Soapstone, etc......	230 "	Hamilton
Limestone..........	262 "	Corniferous?"

(153) G.S.C., 1890-91, p. 49 Q.

(154) Ibid, p. 52 Q.

Muskoka District

Although this district has a rough, rocky surface, limetsones are very rare in it.

Robert's Bay Band

"Robert's Bay lies to the northeast of Prince William Henry or Beausoleil island, opposite to Penetanguishene. A narrow curving inlet runs northward from the bay, which the Indians call Anim-washing or Dog's Cave. The convexity in the course of the inlet is to the south-eastward. In thi inlet I discovered a band of light grey crystalline limestone, which is exposed on the points and islands along its course for a distance of about three miles, beginning at a quarter of a mile from the head of the inlet. The band has a thickness of at least fifty feet, and is overlain by thirty or forty feet of light grey granular gneiss, mostly thinly bedded, followed by an unknown thickness of very massive, close-grained, hard, brittle, silicious, gneiss. Its dip is to the east and southeastward, at an angle of about 70 degrees, the strike following the curves of the inlet, which, no doubt, owes its origin to the existence of the limestone. In this part of its course the band is evidently passing round the south-eastern end of an anticlinal. Near the head of the inlet, and again on one of the small islands at its entrance, the limestone is rich in several of the species of minerals which often charactrize the Laurentian limestones of the Ottawa Valley. Among them are brown idocrase in very fine crystals, salmon-colored garnets (well crystallized, but very brittle), dark wine-red garnets, hornblende, graphite, quartz, pyroxene in very numerous, small, transparent, bright green crystals, iron pyrites and mica." (155)

Nipissing District

Crystalline limestones of the Grenville series, together with Silurian limestones and marls, are found in a number of localities in this district.

Dr. A. E. Barlow gives the following account of the crystalline, or Laurentian limestones of the southern part of Nipissing :

"The most important band of crystalline limestone noticed in the whole district occurs at the foot of Lake Talon, an important expansion of the Mattawa River. The presence of this band was first noted by Bigsby (156) in 1820, and later in 1844, by Logan; Dr. Bell, in 1876, also gave a short description of its mode of occurrence (157). The rock consists of whitish crystalline limestone with small thickly desseminated specks and patches of green serpentine. It is first noticed on the south side of the lake a short distance above the outlet, occupying the points along the shore, while the massive red granitite-gneiss rises into rounded hills behind. The limestone as far as can be ascertained on account of the massive texture of the gneiss, occurs as an interfoliation, dipping S. 8 degrees E. 25. Farther down, towards the chute, the rock contains a good deal of serpentine in addition to some other impurities, and occurs seemingly as a large irregular rounded patch in the gneiss. At the narrows, a short distance above the Talon Chute, the contact between the crystalline limestone and massive rather indistinctly foliated red granite-gneiss is well shown, the former dipping N. 74 degrees E. 20 degrees, while the latter, with a nearly east and west strike overtops or flows over the mass of the crystalline limestone, the indistinct foliation of the gneiss conforming in general with the line of junction between the two rocks. . .

"At the Talon Chute, there are two channels by which the lake discharges into the gorge below. The largest of the channels is situated near the north side, while the southern one has been excavated along a band of ophicalcite seventy feet in thickness, intercalated with the gneiss and dipping in a southerly direction 25 degrees.

"Smaller bands and patches of crystalline limestone, likewise occur on three of the Manitou group of islands in the eastern portion of Lake Nipissing. On the west side of the most southerly of these islands, beds of a beautiful light salmon- pink crystalline limestone occur, containing radiating crystallizations of dark-green hornblende, black biotite, and yellowish-green epidote. The strike is about N. 80 degrees E., and the angle of dip is about 65 degrees. This is associated with the prevailing rather fine-grained dark-reddish and green granitite-gneiss.

"On the east side of the Great Manitou Island (Newman Island), a few chains south of the northeast point, there is a layer or bed of pinkish limestone, weathering yellow, reddish and greyish. The strike of the dark-red and green granitite-gneiss is about S. 60 degrees E., and the dip southeast, 45 degrees. On the west side of the most easterly of the Manitou Islands, about the centre of the island, beds and patches of pinkish and whitish limestone are embedded in the dark-red and green

(155) G.S.C., 1876-77, p. 207.

(156) Shoe and Canoe, Vol. I., London. 1850.

(157) G.S.C., 1876-77, p. 207.

granitite which has a strike S. 5 degrees E., and dip to the east of 45 degrees" (158).

Serpentine and Limestone

"Pigeon Lake.—The occurrence of serpentine at Pigeon Lake, on Montreal River (Ottawa Valley), is described by Prof. Bell in his report for 1875-76. He says: 'Pigeon Lake is upwards of five miles long. On its northeast shore, at one mile up, a fine-grained, greyish-red syenite occurs. About a mile further up the same side of the lake, there is a bluff of light greenish-grey, finely crystalline diorite, with disseminated grains of iron pyrites. A small island, in the middle of this lake, opposite this point, is composed of very dark green serpentine, with strings of calcspar and chrysotile. Fresh fractures have a somewhat mottled appearance, and occasionally present surfaces of a striated or finely columnar shining aspect. The natural surface has a rough or lumpy character and weathers to a rusty color. . . . . . in the next half-mile are two more islets in the middle of the lake. The rocks of these and of the southwest shore opposite, consist of similar and lighter green serpentine, largely mixed with calcspar, constituting, in fact, a sort of limestone in the third islet. In some parts the serpentine is divided into separate pieces by thickly reticulating strings and veins of crystalline and granular light-grey calcspar, leaving the latter scattered as angular fragments through the mass.'

"The characters given by Professor Bell, it may be observed, might be applied almost word for word to some of the serpentines of the eastern townships, which are known to contain varying admixtures of carbonates, passing here and there into limestones or dolomites, and in some instances to have a brecciated structure like the last variety described in the above extract. The Pigeon Lake serpentine also resembles those of the Townships in containing chromium, and nickel. A specimen of the rock from the island first mentioned, gave, on analysis the following results:

Silica	34.591
Alumina	2.391
Chromic oxide	0.382
Ferrous oxide	8.660
Manganous oxide (with a little nickel and cobalt)	0.244
Lime	3.625
Magnesia	32.253
Grains of chromic iron	0.280
Water and carbonic acid, by loss	17.574
	100.000

"The color was blackish-green, mottled with olive-green, the fresh fracture splintery and mostly dull, but here and there presenting shining surfaces. In places the rock is traversed by minute veins, consisting of carbonates of lime, magnesia and iron. In the above analysis the carbonates were not separated, but another fragment of the rock yielded to acetic acid in the cold 21.378 per cent., the proportions of which, calculated for a hundred parts, were as follows:

Carbonate of lime	37.90
Carbonate of magnesia	51.95
Carbonate of iron	10.15
	100.00

"The carbonate of magnesia is considerably in excess of what would be required to form dolomite with the carbonate of lime, so that there must be some magnesite present, and the rock is either a dolomitic or a magnesitic ophiolite." (159)

The same locality is again mentioned in the following quotation:

"These three kinds of rocks (serpentine, steatite and dolomite) may be mentioned among those which occur in minor volume in the Huronian system. Serpentine has not yet been found at all within our present region, but some exposures of it were met with at Pigeon lake on the west branch of Montreal river, a short distance to the northward. The serpentine occurs by itself, or associated with calcspar, or passing into limestone, on some small islands in this lake.

"On the shores in the vicinity are fine-grained and massive reddish-grey quartzite, greenish-grey clay-slate, fine-grained reddish grey syenite, light greenish-grey finely crystalline diorite, with disseminated grains of iron pyrites and grey porphyry very thickly speckled with opaque-white crystals of felspar and a few of shining black hornblende. The serpentine on fresh fracture shows different shades of green, and is somewhat mottled. Under the weather the natural surface becomes rough and of a rusty color. It contains oxide of chromium, both in the form of small grains and in chemical combination with the rest of the rock, and thus resembles the serpentines of the Eastern Townships in the Province of Quebec. The writer has been shown specimens of serpentine said to have been collected among the Huronian rocks some miles north of Pigeon lake. On the point about the middle of the west shore of Abitibi lake the late Mr. Walter McOuat of the Geological Survey met with dark green serpentine, weathering dull white, strongly magnetic and containing grains of chromic iron. Mr. E. B. Borron informed the writer that he had

(158) G.S.C., 1897, pp. 89, 90, I.

(159) G.S.C., 1876-77, pp. 483-484.

heard of serpentine having been found in the country lying north of the west end of Abitibi lake. . . . . .

"Dolomites or magnesian limestones, having certain characters in common, occur sparingly in the Huronian system in the most widely separated areas of these rocks. They are usually fine grained to compact, silicious and marked by strings and fine threads of quartz and sometimes of calcspar, which have commonly a reticulating arrangement. Most of them are ferruginous, and the weathered surface is generally yellow, brown or red, but sometimes grey or black. The iron is often present in large enough proportion to form a spongy crust of the oxide. Occasionally these dolomites become rather finely crystalline, like saccharoidal marble, and nearly white. In our present region they have never been traced far on the strike, although they attain from 100 to 300 feet in thickness.

"Midway up the northeast side of Pigeon lake, already mentioned, on the west branch of Montreal river, there is a bluff thirty feet high of semi-crystalline, yellowish-gray limestone, mottled with green and reddish-brown patches and full of reticulating strings of white calcspar. The weathered surface has a ferruginous crust, from one-half to one inch thick, showing the rock to contain a large proportion of iron. A thickness of upwards of one hundred feet of the limestone is exposed at this place, and it continues northward along the shore for a quarter of a mile or more. The other rocks in the vicinity of this dolomite consist of syenite, diorite, serpentine, porphyry and different varieties of quartzite.

"On the eastern side of South bay, lake Wahnapitae, and thence around the promontory towards Outlet bay, Mr. Alexander Murray described a calcareous breccia associated with quartzites and greenstones. . . . . .

"A band of magnesian limestone occurs at Island Portage on Wahnapitae river, about four miles below the outlet of the lake of the same name. It has a width of at least 300 feet across its general strike, but owing to the undulation of the strata, the true thickness of the band could not be determined. On fresh fracture it is mostly light greenish-gray in color, fine grained, soft, somewhat impure, and weathers to a brown color. The weathered surface in some parts is marked by small corrugated ridges, like that of the Huronian limestone of Echo lake, which result from the weathering out of minute silicious streaks following the bedding. An exposure of the limestone at the head of Island Portage shows a more massive variety with a brownish gray color on fresh fracture." (160)

Palaeozoic Limestones

Small isolated areas or outliers of Palæozoic rocks are found at two or three localities in the district of Nipissing. These have been described by Logan, Murray, Barlow and other writers. No economic use has been made of the Lower Silurian limestones which occur on a number of the islands in lake Nipissing. The Upper Silurian strata, Clinton and Niagara, at the head of lake Temiskaming, have been quarried for lime, and the rock has been used for foundation stone and for the walls of one or two buildings in the villages on the shores of the lake. Recently the stone quarried in the vicinity of Haileybury village has been used in construction of culverts along the line of the Temiskaming and Northern Ontario railway. Stone of good size and quality is obtainable at a number of points.

These limestone strata are likely to be of great importance as the large areas of agricultural lands to the north and west are now being rapidly settled. Limestone is found at few places in the district, and the freight on material from the quarries to the east, down the Ottawa valley, or to the south will prohibit competition with the Temiskaming quarries. The stone here, which is of a suitable quality, will be required for burning into lime, for buildings, for railway structures, and possibly for metallurgical and other uses. It will be seen however, from the analysis given below, that on account of the presence of magnesia there are some uses to which these limestones and the lime produced therefrom are not adapted. If lime carrying a high percentage of calcium carbonate is required it will either have to be brought from a distance, or, it is possible that marl from some of the lakes in the district can be utilized.

Dr. Barlow gives the following description of the Palæozoic limestones and the associated strata of the district:

Chazy, Birdseye and Black River

"On the west side of Iron island in lake Nipissing, beds of chocolate-brown and yellowish-gray, coarse sandstone or grit, occasionally becoming a fine conglomerate, rest unconformably on the upturned edges of the gneissic rocks classified as Laurentian. The rock is composed of loosely compacted and rounded grains of quartz, more or less abundantly coated with hydrous

(160) B.M., Vol. I., pp. 81-82.

oxide of iron with little or no interstitial material. The lowest beds are of a brown color, with occasional lighter spots from which the iron oxide has been removed, while higher beds are yellowish-gray, also showing lighter colored areas. When subjected to the action of the weather, curious subspherical rings suggestive of concretionary action appear on the exposed surface, but a close inspection shows no apparent difference either in composition or texture of the part where these are developed. The beds are of good thickness, but would be useless for building purposes on account of the loose and friable nature of the sandstone. Little or no calcareous matter is present, which is a rather unusual feature, as even the coarse arkose or conglomerative lying at the base of the Manitou islands outliers contains a considerable admixture of carbonate of lime. Murray mentions the finding of loose fragments of limestone with characteristic Chazy fossils that possibly overlies these sandstones, which may thus represent the basal portion of the Chazy formation.

"The Manitou islands, five in number, are situated about the middle of the wide open space in the eastern part of the lake. The largest and most northerly of these islands is about a mile in length from east to west, and is known as the Great Manitou or Newman's island. The next in size and importance is the little Manitou or McDonald's island, while the other three are so small and insignificant that they have not been separately named.

"The most southerly of these islands is somewhat less than a quarter of a mile long, but only a few chains in width. On the southeast side of the island is a dark brown arenaceous limestone, containing angular or subangular fragments and pebbles of the subjacent gneiss. This rock is of no great thickness, and passes rapidly upward into a yellowish-grey arenaceous limestone. The whole section exposed is of small extent and thickness, the beds lying in nearly, if not quite, horizontal succession. The shore is strewn with large angular blocks of the coarse-grained, yellowish-gray, arenaceous limestone, containing many weathered and water-worn fragments of obscure cephalopod-like remains. These fragments, according to Dr. H. M. Ami, who has examined them, resemble Endoceras multitubulatum (Hall) from the Trenton and Black River.

"McDonald's island, or the Little Manitou, is about half a mile in length from north to south, and of no great breadth. At the southwest corner is a small patch of yellowish-gray limestone, occurring in beds which have little or no inclination. The only fossil remains visible at this locality were fragments representing chiefly the siphuncles of orthoceratites together with crinoid stems and casts of supposed worm-burrows. Small outlying patches were also noticed beneath the surface of the water.

"About the middle of the island, on the west shore, the thickest exposure of the whole of these outliers is exposed. The total thickness is about thirty feet, the beds showing a gentle inclination to the west. At the base is a greenish or yellowish arenaceous limestone holding decomposed fragments and pebbles of the gneissic rocks beneath. This is overlain by a yellowish, arenaceous limestone, comparatively free from coarse fragmental material, which in turn gradually passes upward into grey limestones and shales holding numerous fossil remains. The orthoceratites are characteristic and numerous, and one specimen obtained must have belonged to an individual over six feet in length.

"Small exposures of the basal conglomerate and overlying arenaceous limestone occur on the west side of the Great Manitou Island, these rocks dipping south 5 degrees, while on the south shore, near the old wharf, is a small outcrop of arenaceous limestone dipping east at a low angle.

Trenton

"Between Deux Rivieres and Mattawa are several small comparatively flat-lying exposures of sandstones and limestones resting upon the Laurentian gneiss close to the edge of the river, that are completely covered during times of freshet. The sections exposed are of no very great thickness or extent, the beds dipping in a southerly direction at a low angle. The most important of these outliers is the one situated on the north side of the river, about four miles above Deux Rivieres. The basal or sandstone beds formerly furnished material for the manufacture of grindstones of an excellent quality, while local limekilns utilized certain portions of the higher beds exposed in this escarpment.

"About six miles below Mattawa two small outliers of a light-yellowish and purplish, gray-weathering arenaceous limestone are seen in the north bank of the Ottawa river, containing abundant fossils characteristic of Lower Trenton period. Besides the rock in situ, the beach in the vicinity of these outliers contains a large number of somewhat water-worn blocks of these fossiliferous strata.

Clinton and Niagara

"The rocks of this age, exposed on the shores and islands of the northern portion of lake Temiskaming, have been of exceptional interest to geologists ever since their discovery and description by Logan in 1845. Geographically, this outlying patch is so widely separated from any locality where rocks of similar age are now known to exist, that it has been a question whether it is indicative of an area of marine submergence connected with that in which the fossiliferous strata of Hudson Bay were deposited, or whether it was in some way connected with the Niagara basin to the southwest. It has been previously asserted that these rocks belong rather to the great northern trough connected with Hudson Bay, of which they are probably an outlier, and the absence of all strata of Niagara age in the region bordering the lower Ottawa has served to strengthen this belief. Although in lithological character and color the rocks of similar age exposed on Temiscaming exhibit a marked similarity to the Niagara exposed further to the north, the rich and varied fauna characteristic of this outlier presents no corresponding resemblance, but rather a close analogy with the Niagara formation of southwestern Ontario.

"It has been shown that a pronounced similarity exists both in lithological character and fossil remains between the Niagara of the Winnipeg basin and that exposed in the vicinity of the Churchill on Hudson Bay, although these areas are now widely separated, while both present organic forms that are entirely lacking in the Temiscaming outlier. These facts, therefore, seem to prove that the seas in which the Niagara sediments of the Winnipeg basin and of Hudson Bay were deposited were practically continuous, while both were separated from the Temiscaming basin and the region to the southwest.

"The strata forming the Temiscaming outlier occur in the form of a shallow synclinal trough, occupying somewhat more than the breadth of the lake,which is here about six miles, and extending from the northern end of Moose or Bryson Island, north-westward beyond the confines of the present map. On both sides of the lake the rocks incline towards the water at varying angles, depending on the character of the shoreline; although in general the dip does not exceed 10 degrees, and angles of lesser amount are far more common. On Mann or Burnt Island, as well as on the peninsula to the north, the limestones show a very gentle westerly inclination of between one and two degrees, while on Percy Island, near the west shore, the rocks are very nearly if not quite horizontal. It is thus evident that any section made must of necessity be more or less ideal, and any thickness based on the observed angles of the dip is sure to be misleading. The whole thickness exposed in any one section is somewhat less than 150 feet, and it seems certain that the total amount of the Niagara exposed on this lake cannot be greater than 300 feet, and may be considerably less. The occurrence of loose angular fragments and slabs of grayish dolomite, resembling that exposed in the vicinity of Lake Huron and Nipissing and containing characteristic Trenton fossils, has been noticed. These are distributed at several points on the shores of the lake, and specimens were collected from the northeast shore of Chiefs Island. Although their source has not yet been ascertained, the angular character of the fragments and their abundance shows clearly that this cannot be far distant. The lake is here over 200 feet in depth, and it is just possible that below the Niagara limestone and concealed beneath the waters of the lake there exists an area of Cambro-Silurian rocks. This, however, can only be ascertained by boring, as no exposures of these rocks were encountered, although a diligent search was made with this object in view.

"The relatively smaller quantity of conglomerates and sandstones, characteristic shallow water deposits, and the rapid alternation from these coarser clastics to the fine-grained limestones indicative of deep water deposition, point to a rather sudden marine invasion; while the comparatively great volume of strata remaining shows a prolonged submergence. The fine-grained character of most of the limestones show that their deposition took place in a quiet arm or extension of the sea, not affected by the open ocean, while the abundance and character of the fossil remains are ample testimony of the genial character of its waters.

"As exposed on the west side of Wabis Bay, in the northwest corner of the lake, the lower portion of this formation is composed of a loosely coherent sandstone or grit alternating with thinner beds of a fine conglomerate, with pebbles chiefly of Huronian quartzite, most of which have a thin coating of yellowish or brownish iron oxide, while the matrix consisting of similar material in a finer state of division, contains a slight admixture of calcareous matter. The actual contact between this and the underlying slate of the Huronian is not seen, although only a few yards intervene between the exposures of the two rocks. The existing relations can, however, be made out pretty clearly, for while the compact and rather massive slaty rock which here represents the Huronian occurs in exposures with more or less rounded or hummocky outlines, the arenaceous strata of the Niagara dip off or away from these hillocks at an angle of 5 degrees.

"At Haileybury, on the western shore of the lake, close to the water's edge and cropping out from the shingle is a small exposure of light-yellow fine-grained limestone, without visible fossil remains, dipping northeast 25 degrees. The discovery of limestone with the general contour of the country in its vicinity, seem to suggest that a small patch of Niagara extends northerly along this shore towards Wabis Bay, being perhaps three miles in length by about a quarter of a mile in breadth, underlying the clay which here effectually conceals any rocks which may be beneath.

"Further south, on Percy Island, which is only a few chains in length and is separated from the western mainland by a very shallow and narrow channel, the rock exposed is a light-yellowish limestone, presenting a very uneven or cavernous surface as a result of unequal weathering. The strata are nearly if not quite horizontal and weather from yellow to brown or almost black, as a result of the iron present. Shells of various species of brachiopods are somewhat numerous.

"This fauna represents the Clinton or base of the Niagara or lower part of the Silurian.

"The northern and western points of Chief's Island rise into comparatively high ridges of massive quartzose sandstone or quartzite-grit, which present the usual rounded and glaciated outlines. Sheltered in the bay intervening between these two points is a small patch of boulder conglomerate, composed of subangular masses derived from the underlying quartzite. These are embedded in a calcareo-arenaceous matrix composed chiefly of pebbles and finer material, the whole representing evidently a boulder-strewn beach covered by later sediments of the Niagara formation. The surface of the quartzite on which this conglomerate rests, presents the hummocky character so common in the case of the hard Archæan strata, the irregular cracks and depressions being filled by the conglomerate. Subsequent glaciation has removed much of the material, so that the exposure now presents a plane surface with a more or less net-like structure, the framework being represented by the finer arenaceous cement, while the meshes or interstices are occupied by truncated sections of quartzite boulders as well as of the rounded hillocks of the solid rock beneath. Some of the boulders present in this conglomerate were evidently large concretions, as they exhibit concentric structure and weather very rusty, owing to the disintegration of the large proportion of iron present. The finer cementing material, while relatively much smaller in amount than the pebbles and boulders, is always of a greenish or yellowish color and frequentlly contains corals and orthoceratites. The action of the weather has partially obliterated the glacial striae on this finer matrix, but the sections of the quartzite boulders and hummocks exhibit these markings in great perfection.

"On the south-western shore of Chief's Island, is another small patch of a finer grained conglomerate, the pebbles of quartzite being less numerous and of much smaller size, while the matrix contains much more calcareous matter. The rock dips south-east < 5 degrees.

"A number of rather badly-preserved fossils were secured at this locality. . . . which represents the Clinton formation or lower portion of the Niagara.

"On the east side of the lake, from a point south of Chief's Island to within less than a quarter of a mile from Piche Point, the shore is occupied by a narrow fringe of the basal conglomerates and sandstones of the Niagara. The coarser beds are of the boulder conglomerates already described, representing simply a talus of angular and sub-angular fragments detached from the elevations in the immediate vicinity of the exposures, consolidated together by a finer-grained arenaceous cement of a yellowish color, in which are also embedded fragments of corals and orthoceratites.

"This boulder conglomerate passes upward into a fine conglomerate, in turn replaced by a coarse grit, and becoming finally a yellowish, rather friable sandstone. These beds run in long undulating curves, closely following the general outline of the underlying quartzite with a general westerly dip at angles varying from 10 degrees to 15 degrees. The action of the waves has in places caused this to disintegrate very unevenly, leaving a rough pitted surface. At Piche Point and for some distance north the Huronian quartzite is left entirely denuded of these deposits.

"In the bay to the south of Piche Point and between this and Wright's silver mine, there are two small patches of thinly-bedded light yellow arenaceous limestone, dipping in a southerly or south-westerly direction, < 5 degrees, immediately south of Wright's mine is another small patch of similar arenaceous limestone, dipping south-west 9 degrees.

"On the east shore of the lake, nearly opposite Bryson Island, there are two more small patches of the arenaceous limestone exposed at the shore, wrapping round the hummocks of Huronian quartzite and dipping in a southerly or south-westerly direction < 5 degrees. None of these small patches of limestone contained any visible fossil remains.

"On Burnt or Mann Island, as also on the two smaller islands between this and Bryson Island (Oster and Brisseau islands), as well as on the high promontory separating Wabis and Sutton bays in the northern part of the lake, are exposed the limestones and shales that represent the deep-water deposits of this period. The limestone is of a pale-yellow or cream color, weathering whitish, and varies in thickness from a few inches up to two feet or over. Some of the beds are very fine-grained and of rather even texture, and it is possible that some parts may prove to be sufficiently uniform for use as lithographic stone. As a building stone, it is of excellent quality. These limestones, on the north shore of the lake at Dawson Point, dip a little south of west, at an angle of between one and two degrees, rising into cliffs of over a hundred feet in height on the west side of Sutton Bay, and forming a somewhat elevated rocky plateau with gentle westerly slope, corresponding mainly with the angle of dip towards Wabis Bay. The east shore of Mann Island presents a somewhat similar, though much lower escarpment, while the western shore is a gently shelving beach, which at low water reveals considerable areas of the almost horizontal limestones. Some of the beds contain a considerable proportion of silica of a cherty character, and all the fossils are more or less silicified. The action of the weather causes them to stand out in relief, and often displays their minute structures perfectly. A large collection of these fossils was made along the western shore of Mann Island." (161)

The following is an analysis of a sample of the rock from Farr's quarry, Haileybury, Silurian limestone:

Insoluble residue	1.60
Ferric oxide, and alumina	.66
Lime	29.50
Magnesia	21.59
Carbon dioxide	46.84
Sulphur trioxide	.70
	100.89

Shell Marl

"Deposits of this kind are frequently found below accumulations of peat, the marl in these instances being, therefore, of not very recent formation, but in other cases it is found to be still in process of deposition, covering the bottoms of shallow ponds or lakes.

"Emerald Lake, about five miles west of the Opimika Narrows, is at the head waters of one of the branches of Opimika Creek, which reaches lake Temiskaming from the west immediately above the Opimika Narrows. This creek, as well as the lakes which it empties, are remarkable for their clear water. Emerald Lake itself is comparatively insignificant in size, being only about half a mile in length by a quarter of a mile in greatest width at the southern end, gradually tapering towards its outlet at the northern extremity. The lake is in a small valley, from eighty to one hundred feet in depth. At the south-east corner is a very shallow bay, affording entrance to a stream, which is fed by a number of large cold springs, that rise at the base of an amphitheatre-like gully, at the base of steep banks, composed mainly of sand and gravel. The water of the bay, although so shallow, is very cold, even during the hottest days of summer, while the whole bottom is covered with a deposit of shell marl of unknown depth. That this depth is considerable there is no reason to doubt, as the soundings made with long poles failed to reach the bottom of the deposit. Besides this bay the whole lake contains marl deposited on the bottom, while the pebbles and boulders near the outlet show a considerable coating of this loosely-coherent, earthy carbonate of lime. The water of these springs is evidently calcareous, and is found to be slightly aperient.

"According to Mr. J. F. Whiteaves, who has examined the specimens of fresh water shells obtained from this locality, the species represented are Sphoerium sulcatum (Lam.), and Planorbis Trivolvis (Say) var. Macrostomus (Whiteaves).

"A sample of the marl examined in the laboratory of the Survey was found to have the following composition.

	Per cent.
Hygroscopic water (after drying at 100 degrees C.)	1.06
Lime	48.32
Magnesia	0.04
Alumina	0.07
Ferric oxide	0.08
Manganous oxide	traces.
Potassa	"
Soda	"
Carbonic acid	38.01
Sulphuric acid	0.07
Phosphoric acid	0.02
Silica, soluble	0.10
Insoluble mineral matter	8.62
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water	4.79
Total	100.12

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 86.28 per cent. of carbonate of lime. The insoluble mineral matter was found to consist of:

(161) G.S.C., 1897, pp. 120-128 I.

	Per cent.
Silica	6.24
Alumina and ferric oxide	1.51
Lime	0.29
Magnesia	0.08
Alkalies (?)	0.50
Total	8.62

"Marl is often used as a fertilizer, and deposits such as that exposed at Emerald Lake should be of value locally for this purpose." (162)

Norfolk

There are frequent exposures of the limestones of the Corniferous formation in the townships of Woodhouse and Townsend.

"To the west of the Grand River, in the counties of Haldimand and Norfolk, the Corniferous limestones are often seen resting on the Oriskany formation, and forming small eminences; which present escarpments, with the sandstone at their base. These limestones are here of a drab color, and abound in chert. The organic remains with which the strata abound, are entirely silicified in many of the beds; while in others they have undergone no such change. . . .

"Higher in the series, along the same line of country, blue limestones, sometimes to the amount of 20 feet, with grey beds in less volume, are associated with cherty layers and interstratified with bands of a drab-colored limestone. These strata are sometimes quarried, and yield stone fit for building purposes." (163)

"It is remarked by Mr. DeCew that in the southwest corner of Windham, and along the east side of Middleton, very large boulders of Devonian limestone, probably belonging to the Corniferous formation, are of frequent occurrence, associated with others of Laurentian origin. In the latter township, the limestone masses are not found on the west side of Big Creek, while those of Laurentian rocks continue to be as abundant as before." (164)

A sample of limestone from lot 17 in the third concession of Woodhouse township, analysed by Mr. Burrows, had the following composition:

	Per cent.
Insoluble matter	5.77
Ferric oxide	.50
Alumina	trace
Lime	47.66
Magnesia	3.99
Carbon dioxide	41.73
Sulphur trioxide (SO_3)	.50
Loss, water, etc.	.21
Total	100.36

(162) G.S.C., 1897, pp. 155-157 I.

(163) Ibid, 1863, pp. 368-371.

(164) Ibid, pp. 894-5.

"At Villa Nova, lot 18 in the eighth concession of the township of Townsend, is an excellent exposure on which a quarry has been opened. About eight feet are here exposed, the upper three being a silicious hornstone with corals, and the lower five, banded limestone with numerous fossils. The best stratum for building purposes is eight or ten inches in thickness, the last layer exposed being bluer, harder and less fossiliferous than the overlying seams. One band in particular is so filled with corals and is so clean and compact that it should cut and polish to a handsome ornamental stone. A number of fossils were collected here.

"For some distance south of Villa Nova the rock is quite close to the surface and crops out at several places. At Rockford, lot 22 in the ninth concession of Townsend, are considerable exposures of coralline limestone bearing many other fossils, conspicuous among which are masses of Stromatopora. The exposures are some acres in extent, with the fossils well weathered out and lying on the surface of the fields, particularly where a small stream has aided in the disintegration of the rock. About 20 feet are exposed in all. Some flint of a reddish color is attached to many of the corals and much resembles that at Villa Nova." (165)

Northumberland

"The summit of this mass of strata [of the Trenton group], crosses Crow River at the fall, north of the town line of Marmora and Rawdon, with a slope of 42 feet in a mile. The river here flows on the axis of an undulation, on which 22 feet of the same beds again come to the surface, resting on a protrusion of Laurentian syenite in Rawdon, on Laurentian iron ore at Allan's Mills in Seymour, two miles farther down, and on fine-grained augitic trap, still two miles beyond. Large fragments of the trap, cemented together by limestone, form a brecciated bed at the base of the fossiliferous rock. Near its junction with the trap, the Silurian limestone assumes a variety of colors, red, orange, blue, green and yellow; and it sometimes happens that all these colors are displayed on one surface, giving an appearance a good deal resembling rude mosaic. In the strata south from the trap, the black chert, and the silicified fossils blackened with vegetable matter, lie on a ground of white-weathering limestone in great abundance. . . .

"The banks of the Trent below Healey's falls, which are a little above Crow Bay, at the junction of Crow River, rise in vertical limestone cliffs sometimes upwards of 40 feet, the strata of which are filled with the fossils of

(165) B.M., Vol. XII., pp. 142-43.

the Trenton formation. The lowest beds of the cliffs are from 4 to 8 inches thick, the surfaces being thickly studded with black weathered fossils, chiefly an Orthis. Above these beds is a strong one about 3 feet thick. . . The rest of the exposure consists of dark grey or blackish and blue limestones, alternating with dark green calcareo-argillaceous shale. These beds are very fossiliferous. . . . From Crow Bay to Ramsay's falls, on the ninth lot of the sixth range of Seymour, a distance of about four miles and a half, the measures accumulate at the rate of about 40 feet in a mile; and at the latter place they rise in vertical cliffs on each side of the river to the height of 40 or 50 feet. All the beds are filled with Trenton fossils, and some are almost a mass of Leptaena sericea . . .

"Between Peterborough and Rice Lake, the Otonabee nowhere exhibits a rock section, nor was there one observed at any place between Rice Lake and the shore of Lake Ontario at Cobourg; but at the latter place and between it and Port Hope, there are some small exposures of blackish-grey thin bedded nodular limestone and shale, which, among other Trenton fossils, hold Lingula Canadensis and Asaphus megistos." (166)

"From the Moira river the Trenton [formation], continues along the north side of the bay of Quinte, and is well seen in low-lying ledges in rear of the town of Trenton." (167)

Ontario

The following paragraphs dealing with the limestone exposures of Ontario county are taken from the Reports of the Geological Survey :

"The farthest up exposures of Trenton limestone, near the lake shore, occur about a mile south of the village of Oshawa, in Whitby, where the dip is N. < 5 degrees." (168)

"Between Balsam Lake and Lake Simcoe, a distance of nearly thirty miles, the detailed distribution of the outcrop of the formations [Trenton group], which we have been tracing, has not been ascertained. The base of the series is supposed to be limited northward by the south branch of the Black River, a tributary of the Severn. It comes upon the east side of Lake St. John, in the fifth range of Rama, and continues from the west side to a cove in Lake Couchiching, on the thirtieth lot of the lake front. Crossing this lake, it would strike the fifth lot of the tenth range of Orillia, where it is concealed, and pass to the mouth of the Coldwater in Matchedash Bay.

"On Lake St. John the lowest Silurian beds, not far removed from the Laurentian gneiss, consist at the base of a yellowish fine-grained and somewhat arenaceous limestone, passing in a few feet to a drab-colored, compact limestone with a conchoidal fracture, some of the strata resembling the Marmora lithographic stone. The thickness seen is about twenty feet. Fossils are rather scarce in the rock, and somewhat obscure. . . In one of the beds. the fossils are coated with a leek-green mineral, and the same substance invests what appear to be very small fissures in the rock. On Lake Couchiching there is exposed above the water nearly the same thickness of a similar limestone, which is quarried for building and lime-burning, for both of which purposes it is well suited. . .

"On the east side of Lake Couchiching these beds reach the line between the townships of Rama and Mara, where they become covered over with drift, so that their precise summit has not been determined. Proceeding southward, the strata, after an interval of concealment, are again exposed in Mara, striking to the northward of east, and coming upon the banks of the Talbot River, about three miles and a half from the lake shore. The sections are seldom over five feet in thickness, and a better display exists at the northern extremity of Canise Island, opposite the mouth of the Talbot, where the beds present an aggregate of ten feet over the water's edge. The upper layers are thin, coarse, and irregularly deposited, but the lower ones are thicker, and afford good limestone for burning. This locality, with those on the Talbot, is very fossiliferous, the species being such as characterize the Trenton formation.

"A ridge of the Trenton formation is met with near the Beaver River in Thorah, and on Graves Island, which is considerably to the south of Canise, are to be seen some calcareous rocks, which are probably pretty high up in the series. Southeastwardly, similar beds strike the main shore on the twenty-second lot of the first range of Thorah, not far from the lake corner of Brock; and it is said that similar limestone is met with on the twenty-third lot of the eighth range of the last-mentioned township. On the former lot, the beds are from three to eight inches thick, and constitute an aggregate of ten or twelve feet over the surface of

(166) G.S.C., 1863, pp. 187-189.

(167) Ibid, 1901, Sum. Rept. p 178.

(168) Ibid, 1863, p. 189.

Lake Simcoe. They yield excellent lime when burnt, and are occasionally fit for building. At this place a favorable opportunity is afforded to determine the dip. It would appear to be south-westerly, and as the strata seen on the lake shore crop out about half a mile from it, where they stand at a height of thirty feet over the lake, the difference between this and their height at the margin would be about eighteen feet so that the slope may be taken as something between thirty and thirty-five feet in a mile. This would give a volume of about 150 feet for the Birds-eye and Black River formation on Lake Couchiching, and from 500 to 600 feet for the Trenton formation on Lake Simcoe. The country to the southward of the exposures mentioned being covered over with drift, it is difficult to say whether this would comprehend the total thickness." (169)

"Prof. E. J. Chapman has described bright green streaks and markings in beds of a silicious limestone of the Black River formation in the township of Rama. The green matter is said, in some cases at least, to be collected around minute crystals of decomposed iron pyrites. It was supposed from its color to be a compound of copper, but according to Prof. Chapman, it contains no traces of this metal. Silica, oxide of iron, and water were however detected in its composition, so that it is probably related to glauconite." (170)

"A dove-colored limestone of the Black River formation from Lake Couchiching is fine-grained, homogenous, compact, with a conchoidal fracture, is translucent on the edges, and resembles in aspect some hornstones. It is a nearly pure carbonate of lime, containing however 1.27 per cent. of carbonate of magnesia, and 1.17 per cent. of insoluble matter, of which .8 per cent. is soluble silica." (171)

Marl

"From Chalk Lake, lots one and two of the first, and lot one of the second concession of the township of Reach, ... The lake has an area of about seventy-five acres. The marl, which forms the bottom of the lake, is apparently of considerable thickness, but its exact measure has not been ascertained.

"The air-dried material is earthy, somewhat coherent; color, yellowish-white. It contains root-fibres and some shells.

"An analysis by Mr. F. G. Wait showed it to have the following composition: (after drying at 100 degrees C.—Hygroscopic water, = 0.01 per cent.):

Lime	51.88
Magnesia	0.07
Alumina	0.09
Ferric oxide	0.08
Potassa	traces.
Soda	"
Carbonic acid	40.86
Sulphuric acid	0.06
Phosphoric acid	0.01
Silica, soluble	0.05
Insoluble mineral matter	2.11
Organic matter, viz., vegetable fibre in a state of decay and products of its decay, such as humus, humic acid, etc., and possibly a little combined water	4.77
	99.98

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 92.64 per cent. carbonate of lime.

"The insoluble mineral matter was found to consist of: (172)

Silica	1.57
Alumina and ferric oxide	0.38
Lime	0.06
Magnesia	0.02
Alkalies (?)	0.08
	2.11"

Longford Quarries

The Longford are among the most important limestone quarries in the Province. Formerly quarries were operated here by a number of companies or individuals, but they were consolidated under one management in 1901. The quarries are on lots 20 to 28, front range, of the township of Rama. The stone has been used in the King and Queen street subways in Toronto, the date stone in the former being from the yellow layer mentioned below. It was also used in the foundations of the Parliament buildings and city hall, Toronto, and in the Hamilton tunnel of the Toronto, Hamilton and Buffalo railway. It is being constantly used by the Canadian General Electric Company of Peterborough as they extend their works. The Grand Trunk railway uses the stone for their work in Toronto and Hamilton. It has also been employed as a flux at the Midland blast furnace. A small amount of the rock from the top layer

(169) G.S.C., 1863, pp. 191-3.

(170) Ibid, p. 488.

(171) Ibid, p. 621.

(172) G.S.C., 1894, p. 26 R.

is used for burning into lime at the quarry.

The company operating the quarries is known as The Longford Quarry Company, Limited, the officers of which are J. B. Tudhope, president, G. Thomson, vice-president, and A. McPherson, secretary-treasurer. The company advertise "all kinds of building, bridge and dimension limestone always on hand." The following are given as the results of crushing tests of the stone from these quarries, made by the Department of Public Works of Canada, November, 1895.

"Sample No. 1 :—"Area exposed to crushing, 2.9 inches by 3 inches, equals 8.7 square inches.

"Height of sample, 3 inches.

"Ultimate crushing load, 181,000 pounds.

"Crushing strength per each square inch, 20,805 pounds.

"Sample No. 2 :—"Area exposed to crushing, 3.4 inches by 3.4 inches, equals 11.56 square inches.

"Height of sample, 3 inches.

"Ultimate crushing load, above 200,000 pounds."

(Note.—The strength of No. 2 was beyond the capacity of the machine, 200,000 pounds.)

As to the size of stone produced here it may be stated that one block prepared for the King Edward Hotel, Toronto, measured 9 feet by 4 feet by 16 inches.

The following represents a section, in descending order, in one of the quarries: Top, rotten or weathered bed 20 inches; thin layer; 30 inch bed, succeeded by beds having the following thicknesses, in inches: 21, 16, 14, 4, 3, 12, 12, 12, two thin layers, 14, 2 1-2, 20. The top layers are fossiliferous and brittle and are not used for cut stone. They, however, make the best lime.

Analyses

	1.	2.	3.
Lime	53.42	52.42	34.28
Magnesia	.72	.85	16.25
Carbon dioxide	42.68	42.00	44.70
Ferric oxide }	.62	.22	.54
Alumina }		.41	.72
Sulphur trioxide	.17	.30	.....
Alkalies	.05	.....	.....
Silica	.....	.....	.....
Insoluble residue	2.78	1.38	2.80
Loss on ignition	.....	1.78	.....
Water	.72	.....	.06
Sulphuric acid	.....	.....	.44
	101.16	99.36	99.79

1.—Sample taken from 30-inch bed.

2.—Sample taken from brittle or rotten bed, 20 inches

3.—Sample taken from yellow bed, which has a thickness of 24 inches in one of the quarries. This is a good cutting stone, and letters well. The date stone, mentioned above, was taken from this layer.

Oxford

Quotations describing the limestone beds of Oxford county are made as follows from Reports of the Geological Survey and Bureau of Mines:

"An outcrop of the Corniferous limestone occurs near Woodstock, nearly on the axis of the main east and west anticlinal of the peninsula. To the north of this exposure, the western boundary of the formation is traced by the abundant fossils, which are found loose on the surface, in Wallace and Elma." (173)

"In Dereham, where only clay and sand overlie the Corniferous limestone, natural springs are found, yielding small quantities of oil; but neither the wells sunk in the clays of these regions, nor the borings into the limestones beneath, have as yet furnished any large amount of petroleum. Small portions of it are, however, still escaping at these points; which are on the lines of anticlinal fold and fracture, and are thus the natural localities both for the accumulation and the discharge of the petroleum contained in the subjacent upraised strata. . . . Near Tilsonburg, in Dereham, two wells were sunk in 1861. In one of these, after passing through thirty feet of clay, a boring of ninety-six feet was made in the Corniferous limestone. A fissure yielding petroleum was met with at twenty-five feet in the rock, and another at thirty-eight feet, which discharged small quantities of oil, with abundance of water and of gas at intervals. Some oil was also obtained beneath the clay, at the surface of the rock." (174)

"Masses of crystalline travertine [calcareous tufa] occur in fissures in the gypsiferous rocks at Oneida and elsewhere. Recent deposits of a similar nature, from calcareous springs, are abundant in many parts of western Canada, as at Dundas, Niagara, Woodstock and near Toronto. These travertines are sometimes solid and crystalline, like alabaster; and at others porous and tufaceous. They often enclose or incrust mosses, leaves and branches of trees" (175).

"Westward from Paris rock is next exposed at the Grand Trunk railway bridge at Woodstock. This outcrop resembles the cherty coralline limestone of the Corniferous as already described; it contains beautifully preserved examples of Favosites hemispherica as well as F. polymorpha (Billings), numerous Diphyphyllidae and Cyathophyllidae and Bryozoa. . .

(173) G. S. C., 1863, p. 371.

(174) Ibid, p. 787.

(175) Ibid, p. 455.

"Below this are about eight feet of thin-bedded blue fossiliferous limestone more or less cherty and bituminous throughout. . . .

"More of the above corals in fewer numbers and very numerous impressions of Bryozoa, particularly the Fenestellidae. The substance of those forms is unfortunately entirely gone and their only remains are the impressions on the flinty nodules.

Quarries

"Occasional exposures are seen in the valley of the Thames towards Beachville, where a number of quarries are operated on a rock of decidedly different general appearance from that at Woodstock. East of the village and north of the river a quarry has been opened, the surface layers of which are somewhat coralline, while the underlying rock is of a whitish color and carries bitumen. Across the river an extensive quarry shows this white layer with fucoids, Conocardium trigonale and numerous Athyris spiriferoides, with a less abundance of Zaphrentis prolifica. This white rock gives an excellent analysis as below:

	Per cent.
Water	0.20
Silica	0.13
Alumina	trace.
Ferrous oxide	0.22
Calcium oxide	53.71
Magnesium oxide	trace
Sulphur trioxide	0.35
Ignition loss	43.92

"Three feet below this bed are a few feet of friable rock, followed by eight feet of thick-bedded (10 to 12 inches) limestone suitable for building purposes. Traces of petroleum are found in the corals and other porous parts of these beds. Below the village Mr. Jas. Bremner is carrying on extensive quarrying operations on beds which are higher (?) than the above. The quarries are not opened to any depth as, at about seven feet, a water-bearing stratum is cut which renders operations below this level more difficult. The stone being quarried is more massive than at the upper quarries and shows less petroleum and fewer fossils. This rock also makes a good lime, of particular value for chemical purposes owing to its freedom from magnesia.

"Assay of limestone from the Bremner quarries·

	Per cent.
Water	0.55
Silica	0.46
Alumina	7.42
Ferric oxide	1.50
Calcium oxide	49.97
Magnesium oxide	trace.

"About twenty-five men are employed in the various quarries at Beachville.

"Returning to Paris, and continuing the section northward we find surrounding Paris rolling hills of glacial detritus bearing isolated boulders of limestone (sometimes of considerable size) which are collected and burned to lime at various small kilns" (176)

Parry Sound District

Silurian strata are almost absent from the territory embraced in this district.

The limestone occurrences noted in the district are thus described :

"A group of islands situated about Georgian Bay, between Parry Sound and Franklin Inlet, and designated on Bayfield's chart as the Limestone Islands, very probably belongs to the series of rocks [Trenton group] under description" (177). I am told these islands possess no good harbor, and stone can only be transported from them with difficulty.

The following analysis of a sample of the Cambro-Silurian rock on the Limestone islands was made by a chemist in the United States for Mr. J. B. Miller, of Parry Sound:

	Per cent.
Calcium carbonate	94.48
Magnesium carbonate	4.03
Alumina and ferric oxide	0.52
Silica	0.76
Total	99.79

This is equivalent to 52.91 per cent. of lime and 1.92 of magnesia.

Crystalline Limestones

"The crystalline limestones of the above region [between Georgian bay and Lake Nipissing] belong to at least three distinct bands, and it is probable that some of the exposures belong to a fourth, and others, possibly to a fifth band. With the exception of one locality, mentioned by Mr. Murray, more than 20 years ago, these limestones have not hitherto been noticed in any of the reports of the Survey, and their existence does not yet appear to be generally known by the inhabitants of the district itself, although for many reasons they are of much importance in relation to the settlement of the country. I shall now give the principal facts ascertained in regard to each of

(176) B.M., Vol. XII., pp. 148-49.

(177) G.S.C., 1863, p. 193.

these bands during the short time at my disposal near the end of the season. The greater part of this region is still in a state of wilderness, and difficult to explore for geological details, but towards Parry Sound itself it is becoming settled, and the roads which are being made in that vicinity gave us facilities which did not exist a few years ago.

Burton Band

"The most western band of limestone of which I could get any information is reported to be well developed in the vicinity of Wa-wash-kaise (Little Deer) Lake, in the townships of Burton and McKenzie, and Ka-wa-shaig-amog (Clear Water) Lake, the position of which is not yet definitely located, but which appears to be near the northeast corner of Wilson. On Iron Island, in Lake Nipissing itself, Mr. Murray has described a crystalline limestone of Laurentian age which would lie in the course of the northward continuation of the band under consideration. About a quarter of a mile west of the southern expansion of Lake Wa-wash-kaise, the limestone of this band is said to come out in great force around a small lake in the eastern part of the township of Burton, from which circumstance I propose to give the band this name. It is stated to be nearly white in this locality, and to be worn into numerous caves. An exposure of crystalline limestone was reported to exist on the southern part of Shibaishkong Island, a few miles northwest of Parry Sound, and if this be a fact it may represent a southward continuation of the Burton band.

Parry Sound Band

"The band of crystalline limestone, on which the most exposures were found was traced from the southwest corner of the township of McDougall, near Parry Sound village, in a general bearing of N. 14 degrees E (ast.) for a distance of about forty miles, or into the township of Ferrie. The courses of the other Laurentian limestone bands of this region appear to be nearly parallel to this, which, I may mention, is also the general bearing of many of the similar bands which have been traced out by Sir Wm. Logan, in the country north of the Ottawa. The band under consideration, which I propose to call the Parry Sound band, must have a thickness of upwards of one hundred feet in many places. It consists, for the most part, of a very pure, coarsely crystalline limestone, which is usually white or very light grey, but is often tinged pink, green or yellow. On burning it yields an excellent lime. Among the minerals which I found associated with it were graphite and serpentine; the former as scales, disseminated through the mass, and on Manitouwabin Lake occurring in lumps of two or three inches in diameter; and the latter in grains and masses of an inch or two in diameter, on lot 32, concession A, Hagerman, at the east end of Lorimer Lake. Along with the serpentinous portion of the limestone at this locality there is a fine-grained and semi-crystalline rock, having, on fresh fracture, very much the appearance of a dolomite, but which Dr. Harrington finds, on examination, to consist of fine grains of quartz in a matrix of lime feldspar. This rock contains spots a few inches in diameter, stained to a beautiful purple tint by some compound of iron. Its position appeared to be near the western limit of the band, which is flanked on this side by gneiss, composed principally of quartz and lime feldspar. The limestone near the junction of the gneiss contains crystals of pyroxene and specimens of yellow mica, having the laminae arranged in a radiating form, or at right angles to the greater diameter of the mass. About the line between Lots 33 and 34, of the Northern Road in this vicinity a natural culvert, excavated in the limestone, passes under the road, and conveys a small stream which runs into the head of Lorimer Lake. The rock is here coarsely crystalline and nearly white, and does not crumble under the influence of the weather.

"On Lot 28, Concession 1, McDougall, about one mile east of Parry Sound village, where this band is quarried for lime-burning, it is very much reduced in thickness, and appears to be pinched out entirely a short distance to the northward. At the lime kiln it dips westward at a high angle, and consists of 12 feet of pure friable light pink and green, coarsely crystalline limestone, underlaid by twenty or thirty feet of similar limestone, interstratified with gneissic beds, and holding pebbles, and concretions. The latter appear to be made up principally of pyroxene, while the pebbles, which, are partly rounded and partly angular, consist of quartz with layers of crystalline hornblende. The largest pebble observed was about a foot in diameter, and most of them were under three inches.

"The rock which is here immediately associated with the limestone is a remarkable looking diorite, consisting of a white ground, thickly mottled with patches of dark green or blackish hornblende, having their longer diameter arranged parallel to the general bedding. This appears to be the rock which Mr. Vennor has described in the Hasting, Lanark and Renfrew region under the name of "blotched diorite." I found the same rock along the face of the hill on the north side of the brook, at the head of Partridge Inlet, which runs parallel to Long Inlet, at a distance of two or three miles south of it, both inlets being between the two northern mouths of the Muskoka River. I should not be surprised if it should be found that it forms the western flank of a band of limestone concealed in the valley of the brook.

"Crystalline limestone is said to occur at the head of the bay, about one mile west of the Indian village on the south side of Parry Island, which would be the most southern known exposure of the Parry Sound band. It is reported as occurring next on Lot 30, Concession XI. of Foley. The lime kiln above mentioned is a mile further to the northward. The next locality at which it is seen is said to be on the northern part of Lot 22, Concession 1, of McDougall. It is well exposed on Lot 18, Concession II., of the same township, on a small pennisula at the east end of Mill Lake, where it consists of about sixty feet of creamy-white and light-pinkish coarsely crystalline limestone, with some included lenticular bands and smaller masses of hornblende. The dip is eastward, at an angle of 35 to 40 degrees. It next appears at the edge of the water of this lake, under a cliff on Lot 18, Concession III., and again forming the surface of a hill on Lot 17, Concession III., and dipping eastward at an angle of 60 to 70 degrees. Here it is full of pebbles and concretions, like those at the lime kiln, and it is underlaid by the mottled diorite above described. The latter rock is cut by veins of coarse granite, holding masses, a few inches in diameter, of black magnetic iron ore, which contains traces of manganese and titanium.

"The coarsely crystalline limestone of this band is largely exposed about the outlet and eastern extremity of Manitouwabin Lake, in Concessions VI., VII. and VIII., McKellar. Between this lake and the localities which have been described about the eastern extremity of Lorimer Lake, it is said to occur on Lot 19, Concession I, Hagerman, and beyond the latter lake, about Lots 43 and 44, Concessions A and B, on the Northern Road in the same township. Mr. D. F. McDonald of Parry Sound, to whom I am indebted for many useful facts in reference to the Parry Sound district, informed me that a coarse, whitish, crystalline limestone, which would be on the run of this band, is well developed on Lot 60, Concession B, and Lots 59 and 60, Concession A, in Hagerman, and I have been assured that a similar limestone is found on Lot 35, Concession XI., Croft. This brings us close to Maple Island on the Maganatawan River, in the southeastern part of McKenzie, from which Mr. Murray traced this band for three miles to the northward. He describes it as dipping eastward at a high angle, and as holding graphite, yellow mica and iron pyrites. The thickness is not stated, but, according to his accompanying plan, it would be at least 300 feet. Further on, the limestone occurs on the Northern Road, about the centre of the Township of Ferrie, and at the intersection of this road with Deer River. Beyond this, crystalline, whitish limestones, in which caverns are formed, are known to occur abundantly in the rear of Ferrie and in the unsurveyed township to the north of it, and also on Lake Minisegog; but it is uncertain whether these represent a continuation of the Parry Sound band or not. It is possible that the band, which appears to run in the same course from the eastern part of the township of Pringle to the south Bay of Lake Nipissing, is a continuation of the band under consideration; although it is equally probable that it belongs to the one to be next described.

Nipissing Road Band

"A band of crystalline limestone is traceable by numerous exposures on and near the Nipissing Road, from the township of Chapman all the way to South Bay, on Lake Nipissing, a distance of about thirty miles, the bearing of its general course being about N. 6 degrees E. (ast). I propose to call this the Nipissing Road band. Its whole width was not seen at any of the exposures which came under my notice, but it is, probably, not less than one hundred feet. In general character it is a light-grey or whitish, moderately coarsely crystalline limestone. It crops out at the following localities (stated in order from south to north), which are given partly from my own observation and partly from information which appeared reliable:

"Lot 24, Concession IX., township of Chapman, on the Distress River. Lots 110, 112, 114 and 120, Concession B, in the same township. Opposite the ends of Lots 126 and 129, Concession B, township of Lount. Lots 137 to 142, Concessions A and B, in Lount. On the road between Concessions VI. and VII., on Lot 6, Pringle. Lot 202, Road Range, township of Nipissing, near Muckwabi Lake. About Lot 215, Road Range A, Nipissing. About the western corner of Lot 218, Road Range B, Nipissing. On the peninsula between Namannitigong River and South Bay, Lake Nipissing, opposite "the landing," or the termination of the Nipissing Road. Similar limestone is said to occur on one of the Manitou Islands in the eastern part of Lake Nipissing, which lie in the continuation of the strike of this band to the northward.

"Southward this band may, perhaps, be represented by an exposure of crystalline limestone, said to occur at Goff's Mill, in the Township of Foley; and it is not impossible that the limestones of Robert's Bay (about to be described) may belong to the same band." (178)

"Among the most interesting rocks at Parry Sound are the crystalline limestones, which were studied somewhat carefully for a few days in the hope that they would provide a clue to the stratigraphical arrangement of the rocks of the region. A general account of the limestone bands of the region has been given by Dr. Bell.

"It was thought that if they were regularly interbedded with the schists the general relations of the schistose rocks might be made out by following the easily-recognized band of limestone. In general these limestones are white, gray or flesh-colored, coarsely crystalline, sometimes pure, but often containing darker grains of various silicates, and usually also fragments of adjoining schists, twisted and curled in an extraordinary way, as if the limestone had torn them off like an eruptive.

"The limestones near Parry Harbor were visited under the guidance of Mr. Adair, who observes such things carefully, and had already studied their distribution. Near Parry Harbor there are apparently two parallel bands of limestone, one with a strike of 55 degrees to 60 degrees and a dip of 25 degrees to the southeast, and a quarter of a mile southwest of this another band with a strike of 65 degrees or 70 degrees and a very gentle dip to the northwest. The direction, as well as the angle of dip is variable, and no outcrop can be followed more than a few hundred yards, though a succession of outcrops following the same general direction can be recognized. The thickness, too, is very irregular, being sometimes more than a hundred feet, and then rapidly thinning out till the band is lost among other rocks. There is no distinct stratification, and we may suppose that any traces of bedding have been obliterated by the process of crystallization, or by the squeezing to which they have evidently been subjected. As limestone is the softest rock of the region. it has been forced to adapt itself to the forms of the other rock masses. The accompanying schistose rock, gray, fine-grained gneiss or hornblende schist, is always much contorted and crumpled, and the proximity of the limestone may be recognized in this way, as noticed by Mr. Adair. The various outcrops of limestone near the town, if continuous, would make one or two bands a mile and a half long, probably extending at least four miles to the northeast, since limestone occurs again on the shore and on an island of Mill lake. Whether it continues on in the same direction is uncertain, but several bands will be noted later suggesting this. A small outcrop of limestone is found also at Depot Harbor, on Parry Island, four miles west of Parry Harbor." (179)

Peel

Exposures of strata of the Medina, Clinton and Niagara formations are found in this county. The following quotations are the only descriptions I have met with concerning the limestones:

"Two of the main indentations [in the escarpment] are on the Credit in Caledon" (180).

"The river Credit, in Caledon, is flanked on both sides by the cliffs of the Niagara limestone, in some places a hundred feet high; these in ascending the valley meet on the ninth lot of the fourth range of the township near Bellefontaine, and from a crescent-shaped precipice, over which the river falls in a cascade" (181).

"Prof. Chapman notes the occurrence of a very large block of Black River limestone in Albion, on the highest part of the Oak Ridge" (182).

Perth

The following quotations show the distribution of the Corniferous in this county. There are now important quarries at St. Marys, where very pure lime is produced. The stone is pure enough to use in beet sugar manufacture.

"An outcrop of the Corniferous limestone occurs near Woodstock, nearly on the axis of the main east and west anticlinal of the peninsula. To the north of this exposure, the western boundary of the formation is traced by the abundant fossils, which are found loose on the surface, in Wallace and Elma" (183).

"In the south-western area, which includes the region between the lakes Erie and St. Clair, the Corniferous limestones appear to become somewhat lighter in color, and more granular in texture than they are to the east. In this respect they approach in character to the rocks of the same formation in Ohio and others of the western States of the Am-

(178) G.S.C., 1876-77, pp. 202-207.

(179) B.M., Vol. IX., p. 166.

(180) G.S.C., 1863, p. 315.

(181) Ibid. pp. 327-8.

(182) Ibid, p. 895.

184 Ibid, p. 371.

erican Union. A section of about twelve feet of the formation is displayed on the banks of the north branch of the Thames at the village of St. Marys between the sixteenth and eighteenth ranges of Blanshard. The rock is exposed for about a mile and a half above, and for the same distance below the bridge, which here crosses the river. Its color is a light drab, occasionally weathering to a greenish tinge; it is very bituminous, and holds numerous fossils" (184).

Borings at Stratford

"Continuing northward from Ayr, via Dundee, no exposures were seen, the country being rather uneven with light stony land of morainic origin. At about the point where the road from Dundee joins the main line to Hamburg the character of the country changes, the rough morainic deposits giving place to more level clay soil, which continues as far north as the section was carried, that is to Stratford and St. Marys. Some years ago a well was sunk at Stratford in the hope of obtaining gas; the following record was kept, which unfortunately is of doubtful interpretation: (185)

	Feet.
Drift	143
Limestone	90
White flint	117
Limestone	38
Flint	58
Limestone	100
Slate	40
Limestone	716
Medina	368
Hudson River and Utica	676
Trenton	40
Total	2,386"

Quarries

"The heavy deposit of drift reaching, as above noted, a depth of 143 feet at Stratford, is cut by the Thames at St. Marys, exposing the underlying limestones. The first outcrop of rock is seen about three miles east of St. Marys, where a tributary stream has eaten through the drift. A small quarry has been opened and about ten feet of thin-bedded, jointed, whitish-gray limestone exposed. The fossils are very poorly preserved; among them were noted Athyris spiriferoides and Spirifer gregaria.

"Lying north and east of the town of St. Marys, and at some elevation above the river, are a series of whitish limestones very similar to those on the Stratford road, but containing even fewer fossils. The two beds are doubtless analogous and represent the highest members of the Corniferous as here exposed. The rock is being extensively quarried and burned by Mr. J. Sclater. An analysis follows:

	Per cent.
Water	00.14
Silica	2.32
Ferric oxide	0.88
Alumina	0.17
Calcium carbonate	94.24
Magnesium carbonate	2.10

"On the south side of the river, at a distance of about a half-mile, the so-called Horseshoe quarry is being opened. Here the rock dips perceptibly to the west, and is somewhat fractured by local folding. The upper bed is a thin limestone weathering red, and filled with shells of Chonetes hemispherica and other species of the same genus. In less abundance are found Spirifera gregaria. Below this bed friable silicious limestones occur with Conocardium trigonale which seems to be more or less confined to this bed. On descending, more heavily-bedded rock is found in which, at a depth of four feet, specimens of the rare species Panenka grandis were obtained. Along the river south and west of the Horseshoe quarry extensive operations have been carried on for years. Apparently the above described Chonetes bed is about eight feet down at these quarries, being overlaid by a series of shaly friable rocks bearing Orthis (Rhipidomella) livia, Athyris clara, Athyrias maia, Lucina elliptica and other lamellibranchs. Two feet lower is the bed which, as at the upper quarry, is characterized by the presence of Panenka grandis. It consists of a heavy blue limestone overlaid immediately by a thin bed. The Panenka limestone gives on analysis the following result:

	Per cent.
Water	0.41
Insoluble residue	4.49
Alumina	0.47
Calcium carbonate	90.22
Magnesium carbonate	2.09

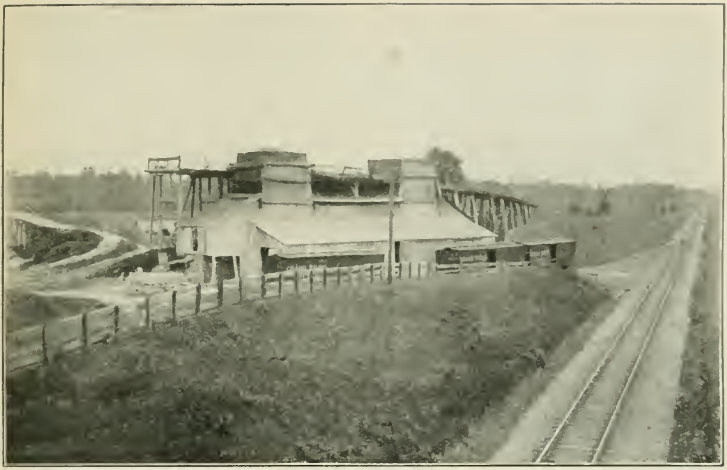
"Below the Panenka bed is found a stratum characterized by the nautiloids Gomphoceras eximium, Gyroceras sp., Nautilus sp. and by Aviculopecten princeps. A very distinct horizon is marked by an abundance of fucoids lying at a depth of about 14 feet, below which the rock is more heavily bedded, of a bluer color and decidedly less fossiliferous. Although a few corals such as Zaphrentis prolifica, Favosites hemisphærica, etc., are met with at St. Marys, the general series is not comparable with the highly coralline rocks to the southward" (186).

(184) G.S.C., 1863, pp. 377-8.

(185) B.M., Vol. XII., p. 150.

(186) Ibid, p. 151.

Limestone blasted out at Ryan and Haney's quarry, near Meldrum bay, Manitoulin island.



Beachville lime kilns. Oxford County.

Horseshoe Quarry, St. Mary's. Product used for building—rubble, sills and courses ; and waste rock for road metal. Perth County.

Elliott's limestone quarry, St. Mary's. Product used for building, and waste rock for road metal. Perth County.

Grand Trunk Railway bridge, St. Marys: piers built of limestone. Perth County.

Sclater's lime kilns, St. Marys. Perth County.

Sclater's quarry, St. Marys. For lime burning only. Ten feet of earth and gravel overlying limestone. Perth County.

The production from the Horseshoe quarry alone amounts to from 15 to 18 carloads (400 to 500 tons) a day, three-quarters of which is used in the crushed state for flux in the Hamilton blast furnaces, for road-metal in the cities and for the beet-sugar refineries. The remainder is used for building stone, principally as rubble and courses, some of it, however, being cut and dressed. The quarrying and crushing plant is quite elaborate, comprising two rock crushing houses, hoists, derricks, etc.

Physically this limestone, both here and in the adjacent quarries to the south and west, is tough and compact, and of a grayish drab color on freshly broken surfaces, which changes, after exposure, to a most pleasing bluish gray. The strata are well marked, easily separable and of various thicknesses, according to the bed to which they belong, ranging from 2 or 3 inches, suitable for flagging, to 2 feet for heavy dressed building blocks. The largest quarry in the district is amongst these older workings at the foot of the hill near the river and measures about 200 feet by 400 feet area by 20 feet depth, with a perfectly flat floor on the plane of stratification.

Peterborough

Palæozoic and crystalline limestones, together with marls, are found in various parts of the county. The Lakefield cement works use marl, and Portland cement has been used in some very important structures in the county, notably in the lift-lock near the town of Peterborough and in the building of the beet sugar factory. Palæozoic limestones, which are found in the southern part of the county, have been used extensively. Analyses are given below of samples from three or four localities. The insoluble matter in these is a little high for cases where a nearly pure calcium carbonate is required. The samples, however, represent surface material in which this matter is apt to run higher than in stone freshly broken in a quarry. Crystalline limestone is found in many localities in the northern part of the county.

"In their western run from Healy's Falls the escarpments [of the Trenton group] we have been following approach Stony Lake; the main one presenting an abrupt rocky cliff from two to three miles from the south margin of the lake, and the other, of small elevation, approaching the margin to within about a mile. After sweeping round a small sheet of water called White Lake, in the township of Dummer, the two escarpments partially unite, striking Salmon Trout or Clear Lake at about the fourth range of that township, keeping the south shore of the lake to its western extremity. The corresponding escarpment rises on the northwest side of Salmon Trout Lake, and then follows the sinuosities of the chain of lakes and the river up to Buckthorn Lake, keeping the south side at a distance seldom exceeding a quarter of a mile. It crosses Buckthorn Lake at the strait about two miles and a half above Buckthorn Falls; and then, again separating into two parts, the main one strikes nearly straight by Sandy and Pigeon Lakes to the head of Balsam Lake, the inferior escarpment keeping about a couple of miles to the northeast. In the general course westward from Belmont Lake, the rocks composing the lowest escarpment thin out and disappear before reaching the western end of Salmon Trout Lake. Here the base of the series is composed of very regular beds of buff colored limestone, bearing the lithological characteristics of the succeeding portion, while the upper tier of beds contains black chert and silicified corals of those species which peculiarly distinguish the Birdseye and Black River formation. The whole height of the escarpment, from this, seldom exceeds fifty feet.

"On the Otonabee the thick bedded coral-bearing stratum with chert . . . crops out on the twenty-second lot of the sixth range of Douro, where the river opens into a small lake called Kawchewahnook. Below this, assisted by the effect of a gentle undulation on the axis of which the river runs, there is a continued section of limestone and shales all the way to Peterborough, holdng many characteristic fossils of the Trenton formation. Between Peterborough, and Rice Lake, the Otonabee nowhere exhibits a rock section. .

"The limestone escarpment south of Burleigh Falls, in the township of Smith, is about eighty feet high. On the summit, thin beds of limestone and shale occur. . . . Except at the top, the rock is more or less covered by moss and small trees; but about twenty or thirty feet below strong beds of limestone occasionally come out in points, and probably represent the cherty beds of the Birdseye and Black River formation." (187)

"The lock on the Otonabee canal is constructed of massive beds of limestone, from the lower part of the Trenton group, which was quarried near Warsaw in Dummer; and good beds of

(187) G.S.C., 1863, pp. 188-9, 190.

similar stone are to be obtained in many other places in this region." (188)

Palaeozoic Limestones

The composition of some of the Palæzoic limestones of Peterborough county is shown in the following table :

PALÆOZOIC LIMESTONES OF PETERBOROUGH COUNTY

—	1	2	3	4	5	6	7	8	9
Insoluble residue	....	6.50	1.54	4.99	1.76	2.18	2.20	3.60	6.24
Silica	1.96	....	....	....	....	....	....	....	....
Ferric oxide	.61	.40	.30	.55	.38	.32	.50	.56	.54
Alumina	2.37	.54	.10	.20					.96
Lime	51.22	50.60	53.14	51.10	53.40	52.76	53.08	52.30	50.30
Magnesia	.70	.65	.65	.69	.57	.60	.60	.41	.97
Carbon dioxide	40.75	40.41	42.37	42.44	42.50	41.93	42.16	41.47	40.52
Loss	2.29	....	....	....	1.34	1.83	1.18	1.91	1.22
Sulphur trioxide	.24	.31	.10	.11	.13	....	.23	.39	.26
Alkalies	....	....	....	....	....	.18	....	....	....
Total	100.14	99.41	98.20	100.08	100.08	99.80	99.95	100.64	101.01

1.—Small quarry just east of Havelock. 2.—From Clear lake, near Burleigh falls. 3.—Bed just below top of cliff, lot 42 or 43, concession 16, Smith. 4.—About same locality as 3, but different bed. 5.—Topmost layer cliff near hotel. 6.—Quarry, lot 44, concession 16, Smith. 7.—Top of cliff, lot 45, concession 16, Smith. 8. Lots 1 and 2, just south of Lakefield boundary. 9.—Between 2nd and 3rd locks.

Prescott

Economic uses have been made of limestones of the Chazy, Black River and Trenton formations in this county. The following notes taken from reports of the Geological Survey describe briefly the distribution of these formations, and references are made to some of the more important quarries.

"The Chazy limestones also appear along the road in East Hawkesbury between ranges IV. and V., and are well seen on a road southwest from Barb postoffice between lots 22 and 23. They here contain certain fossils and have a low southerly dip. Similar rocks show along the road to St. Eugene.

"West of L'Orignal the country is largely clay-covered for several miles. About 3 miles from the village several rock outcrops appear along the south side of the river road and in these a number of quarries are located. Some of these are in rocks of Black River and Trenton age, and the presence of the fault which was noted on the road south of L'Orignal is recognized in the tilted attitude of some of the strata. Outcrops of Chazy shales overlain by limestones of the same formation however appear and these are highly fossiliferous. The rocks are nearly horizontal or with a low dip to the south, and on a road leading from the village of Alfred to L'Orignal, known as the L'Ange Gardien road, Black River and Trenton limestones appear with low undulations. . . .

"The Black River limestones can be well studied at . . Murray's quarry, about one and a half miles south of L'Orignal, and several others to the south of this in East Hawkesbury. The formation [Black River] is important as furnishing some of the best building stones of the Palæozoic series. . . .

"A large quarry in the upper portion of the formation [Black River] is found at the crossing of a road over the Riviere a la Graisse, on lot 15, range VII., Hawkesbury East. . . .

"The Trenton limestones are extensively developed throughout the townships of Cumberland, Clarence, Plantagenet, Alfred, Caledonia and Hawkesbury west and east. In the southern portion of most of these they are overlain conformably by the Utica shales which form the central part of the great Palæozoic basin. In the eastern part of the area the strata are affected in the same manner as those of Black River and Chazy age by the great Rigaud fault. They are well seen along the road from L'Orignal to Vankleek Hill, and southwest from the contact with the Black River formation at the fault near Murray's quarry they have a surface breadth till they are overlapped by the Utica of not far from 8 miles.

"West of L'Orignal they are well exposed along L'Ange Gardien road towards Alfred for about a mile, in low undulations. They occupy the upper part of the big escarpment south of Brown's wharf and thence are seen along the Nation river in the direction of Plantagenet village in large exposures,

(188) G.S.C., 1863, p. 816.

the rocks are filled with characteristic fossils of the formation, and the dip is to the south at angles of 3 to 5 degrees" (189).

"The limestones of the Chazy, Black river and Trenton formations have long been noted for the excellence of their material for building purposes, and large and valuable quarries exist in the areas occupied by these rocks. Among these may be mentioned the Ross quarry, in the township of East Hawkesbury, in limestone of Chazy age, and from which a very large amount of excellent stone was taken for construction work on the Grenville and Carillon canals. Near L'Orignal also quarries are found in the Black River and Trenton formations (Murray's), the stone from which has been used for the same purpose. Butler's quarry in the Chazy limestone about three miles west of L'Orignal, near the river road, and several others in the Black River or Trenton limestones of adjoining lots are well-known and the quality of the stone is excellent. These are in the western part of the township of Longueil" (190).

"Gray beds of the Chazy formation, thickly marked by small bivalve shells filled with white calc-spar, have been wrought to a small extent near L'Orignal, but the stone is not well fitted for a marble, inasmuch as the shells are readily detached from the rock." (191).

"About two miles from the mouth of the South Petite Nation, the Birdseye and Black River formation crosses the stream, dipping southward at an angle of four degrees. Trenton beds are seen resting on it, and they underlie the road up the valley for more than a mile, in which they appear to be quite horizontal. These rocks are seen in the same relation on the east side of the township, in an escarpment below the road, crossing the line between Plantagenet and Alfred, about two miles from the Ottawa. The escarpment and the road keep in the same relation for two miles and a half farther to the south-eastward, up the valley of the brook flowing into George Lake ; but three miles farther east, on the second range of Alfred, the escarpment is south of the road, and on the summit there occurs a bare triangular surface of Trenton limestone of a mile and a half long. In the township of L'Orignal, the escarpment approaches nearer the Ottawa, being about a mile from it on the west side, and a mile and a half on the road, which runs back from the village. In the rear of Hamiltonville in West Hawkesbury, it is two and a half miles from the margin. Its position in East Hawkesbury is not so well ascertained, but the base of the series very probably reaches the boundary between the western and eastern divisions of the Province, in sweeping round the extremity of the trough north of the Rigaud anticlinal. On the south side of the trough, limestone beds are met with at McDonald's Mills, on the Riviere a la Graisse, in the fifteenth lot of the seventh range of East Hawkesbury. These are at the base of the Trenton, and very nearly in the strike of these beds, there is an exposure of Trenton limestone in the thirty-second lot of the ninth range of the Lochiel" (192)

"At about one mile and a half south of Vankleek Hill, there is a small quarry in fine gray, very brittle and bituminous Trenton limestone, with partings filled with bituminous matter and joints coated with white crystallized calcite. The beds here are somewhat folded" (193)

"Another Black River quarry is seen on the River à la Graisse, in the south-eastern portion of Hawkesbury East, where they have a dip to the south-west at an angle of about 10 degrees. They are here separated by a heavy fault from the Potsdam sandstone, about two miles west of the village of St. Anne de Prescott" (194).

(189) G.S.C., 1899, pp. 85-87 J
(190) Ibid, p. 136 J.
(191) Ibid, 1863, p. 827.
(192) Ibid, p. 171.
(193) Ibid, 1895, p. 72 A.
(194) Ibid, 1899, p. 135 A

Prince Edward

Trenton limestones underlie this peninsular county and crop out on its shores at points convenient for shipment. At the outlet of the lake of the Mountain, for example, in the shore of the bay near the entrance to Picton harbor, the perpendicular rock cliffs are upwards of 200 feet in height.

The writer has met with no detailed description of the outcrops of limestone in the county or around its shores, but it may be said that the chemical composition of the rock is pretty uniform in character, carrying a high percentage of calcium carbonate, when flint nodules are absent. Now that there is a growing demand for rock of this kind for use in various industries it would seem that the outcrops near the water's edge may be worked to furnish a supply of stone for use along the upper part of the lake.

The following analyses represent samples from Picton. The residue, insoluble in hydrochloric acid, in 1 was 5.42, and in 2 it was 2.42 per cent. The first sample is from Sullivan's quarry, and the second from the corporation quarry :

	1.	2.
Silica	4.46	2.00
Ferric oxide	1.73	.76
Alumina	.45	.24
Lime	51.08	53.46
Magnesia	.88	.71
Carbon dioxide	40.45	42.32
Loss	.20	.20
Sulphur trioxide	.67	.29
Alkalies	....	.18
	99.92	100.16

The limestones in the other parts of the county, when not containing nodules of chert or flint, have a similar composition.

Sullivan's quarry is near the Catholic cemetery. Its face has a height of 10 or 12 feet and extends along the cliff for some distance. The rock is dark colored, fossiliferous, and rather thin bedded, with shaly seams between the layers. The rock is used for foundations, the thickness of the layers not exceeding 5 or 6 inches. The corporation quarry has a face of 25 or 30 feet in height at the back of the quarry. The beds of limestone are only a few inches in thickness, and are interbedded with thin layers of shale or clayey material. It would be possible if such a mass of rocks were free from magnesia and other deleterious constituents, to use the whole mass in the manufacture of Portland cement, adding more or less clay to the mixture.

Rainy River District

Limestones are rare in this district. The crystalline limestone which is found at Steep Rock lake presents the most prominent outcrops. These have been described by a number of writers. (195) Samples taken from one of these outcrops by the present writer possessed the following percentage composition :

	1.	2.
Insoluble residue	.....	.63
Silica	26.46	.....
Alumina	2.10	.....
Ferric oxide	.....	.30
Ferrous oxide	5.94	.....
Lime	20.34	54.90
Magnesia	9.63	.61
Loss	.....	2.04
Carbonic acid	26.32	41.66
Sulphur trioxide	.....	.13
Alkalies		traces
		100.27

1. The lime and magnesia here shown exist as carbonates. The insoluble silicious residue after treatment with hydrochloric acid is equal to 31 per cent. The lime and other bases were not determined in this, but the total silica in the rock, as shown above is 26.46. The loss on ignition was 30.08 per cent., which includes the carbonic acid, 26.32 per cent. (196)

2. In this analysis the percentage of lime is high. It represents a much purer limestone than does 1. Sample 2 is dark limestone, which is enclosed or surrounded by the lighter colored, which is represented by analysis 1. The darker appears to have been the original rock, which has been brecciated and partly dissolved. The lighter colored rock formed from the darker chiefly by solution and reprecipitation, contains fragments of the latter.

In the following notes taken from reports of the Geological Survey reference is made to the occurrence of boulders of Silurian limestone in the district. These are of economic importance as large lime-kilns often make use of "field" stone. Marl deposits also occur in the district, and may be made use of in the production of lime, and for other purposes.

"In the post-glacial formations of Rainy River, the clays, sands and limestone boulders are all of economic value. Some of the lower blue clay seen on the banks of the river appeared to be very pure and capable of being worked for pottery. Other clays would make good bricks. Much of the sand intercalated with the clays would be serviceable for building purposes, and some of that at the mouth of Rainy River would be good for glass making. The limestone boulders are occasionally burned for lime by the settlers." (197)

"In valleys tributary to Rainy Lake, such as the basin of the Seine River and that of the Turtle River, there are local deposits similar to those on Rainy River which may perhaps be regarded as having been formed in arms or bays of Lake Agassiz. These deposits appear to lack a feature which is very characteristic of the deposits along Rainy River, viz., the presence of pebbles of cream-colored or yellow Silurian limestones. The northern limit of the distribution of this limestone drift has been noted by Bigsby, Dawson and myself, and it appears to be coincident with the line that has been sketched as limiting the northern extension of the post-glacial formations. The limestone pebbles and boulders, while doubtless derived in the first instance from the Silurian rocks of the Red River basin, appear on the Lake of the Woods to come immediately from the post-glacial strata in which they are imbedded. Their glacial origin is attested by the very common and distinct striation observable upon them;

(195) Am. Jour. Science, 1891, pp. 317-331, and B.M., Vol. XI., pp. 131-3.

(196) B.M., Vol XII., pp. 306-7.

(197) G.S.C., 1887-88, part I., p. 182 F.

which fact also attests that they have been very little water-worn since their escape from the foot of the glacier, the inference being that the clayey strata in which they are imbedded were derived largely from the same glaciers. With regard to other isolated patches of post-glacial formations, it is to be noted that those of any considerable extent that are known, such as that near Lake Wabigoon, appear to lie on the north side of the height of land, and may have been formed at a somewhat later stage of the recession of the ice barrier, after Lake Agassiz had shrunken to a fraction of its maximum size. On this assumption the lake in which the deposits around Wabigoon were deposited would have had the height of land for its southern barrier, and probably the ice for its northern. There are few facts, however, as yet to support such speculations, and they are only suggested by the analogies which the results of Mr. Upham's work naturally lead us to look for." (198)

"Between the Laurentians of the Ottawa Valley and of Western Ontario, there is one marked difference, the presence of a series of limestones in the former, and its comparative absence in the latter ; but the absence of a lithological member of a series, as limestone or quartzite, does not militate against the correlation of the members occurring in different districts, and future investigation may prove the Couchiching series to be the stratigraphical equivalent of the Upper Laurentian series of the east, to which as far as may be gathered from published descriptions of the latter, the mica schists would seem to bear a marked resemblance in stratigraphical relationship. But whatever conclusion may be eventually arrived at regarding the origin of Laurentian rocks, or whatever subdivisions of, or re-arrangement of certain members of this system future investigation may justify, the separate areas of granitic rocks referred to in this report present no individual characteristics sufficiently significant to justify the belief that any great difference exists between their respective ages, and the same theory of origin that applies to one applies to all." (199)

"At the narrow entrance to Echo bay [Shoal lake], a four-foot seam of crystalline limestone, containing some copper pyrites, was observed in the sericitic schist. This is not very pure, containing some quartz, etc., but may at some time be of value for lime" (200).

(198) Ibid, pp. 175-6 F.

(199) G.S.C., 1890-91, part I, p. 37 G.

(200) B.M., Vol. V., p. 49.

Renfrew

This county possesses important resources in crystalline limestones or marbles, Cambro-Silurian limestones, and marl deposits. The marble deposits in the vicinity of the towns of Arnprior and Renfrew have been described in several reports, published during the last half century. Quotations from some of these reports are given in the following notes. The only quarries of crystalline limestone now being worked in the Province for marble or decorative building stone are those of the town of Renfrew and one a few miles from Haley station, some distance to the westward. The town of Renfrew is also one of the largest producers of lime in eastern Ontario, the rock used being the crystalline limestone, which is quarried within the limits of the corporation. It will be seen from the analyses given below that this lime possesses a high degree of purity.

Crystalline Limestones

"A marked feature in the formations in the vicinity of the Madawaska, in the area to the south of that river, is the great development of crystalline limestones. In character these differ somewhat from the limestone found in the Grenville district. They are often characterized by the presence of bluish and bluish-gray shades, and by a well-defined banding, which imparts a peculiar striped aspect to the rock over large areas. The limestone is also often highly dolomitic, and in places weathers to a peculiar ochreous brown. Instead of the usual association of grayish and reddish-gray gneiss found north of the Ottawa, the associated rocks are mostly schists, either hornblende, micaceous or chloritic. The characteristic mica-schists are beautifully exposed on the line of the Kingston & Pembroke Railway, between Lavant and Flower stations, as well as along certain portions of the Mississippi River, on the north side of Mud Lake, about a mile below Ardoch. They are also well seen on the south side of Marble Lake, in the township of Barrie. The hornblende rocks, however, have a much greater development, being often massive" (201).

"North of the Madawaska, in the townships of Griffith, Brougham and Bagot, while the surface of the country is often exceedingly rough and broken, great areas of crystalline limestone, often dolomitic, are seen. These calcareous masses occur, not only in the valleys but constituting large hills. In places the rock is highly charged with tremolite, and this character is also well seen in

(201) G.S.C., 1896, pp. 55-56 A.

the limestones to the north of Calabogie Lake, as well as at certain places in the township of Darling, and in South Elmsley. Great areas of these limestones, often well exposed, occur in McNab, Darling, Lanark and Ramsay" (202).

"It is interesting to note the occurrence of unmistakable limestone conglomerates in the Laurentian crystalline rocks of the Grenville series in Renfrew county. These were seen at several widely-separated points, as in the township of Westmeath, along the Rocher Fendu channel of the Ottawa, in the townships of Bromley and Stafford, in Sebastopol, and along the Opeongo road. In these conglomerates, which rest upon the rusty gneiss, are pebbles of garnetiferous, hornblendic and reddish gneiss, quartzite and rusty gneiss, well rounded and water-worn. The grayish quartzose gneiss, in the lower part of the calcareous series, presents all the aspects of an altered quartzose sandstone, and the whole series at these places looks like a succession of altered sediments. . . .

"Very considerable areas of crystalline limestone occur throughout the counties of Renfrew and Pontiac, some of which constitute useful marbles. . . At Renfrew [town], extensive quarries exist, which furnish an excellent quality of stone, both for building and for burning. . . A new deposit of snow-white marble has been opened up on lot 19, concession 6, Ross, on the property of Mr. Chas. Bilson. This is a beautiful stone, highly crystalline, and yields large blocks for monumental or decorative work" (203).

Marble Quarries

Mr. Alexander McLean thus described his marble quarry at Renfrew to the Royal Commission on the Mineral Resources of Ontario :

"We have a marble quarry at Renfrew and one in the township of Templeton, Quebec. We have leased the Renfrew property, and we get from it what is commonly known as the Renfrew marble; it is a crystalline marble. We leased that about three years ago. Since we have had it we have taken considerable out. We do not work it steadily; we just take out the quantity that we require. We use it for monumental material, slabs, copings, window sills, trimmings, and for such purposes. It is an excellent stone, and takes a good polish. It is a degree harder than the ordinary limestone, and is not as liable to stain as the ordinary white marble" (204).

The Commissioners themselves give the following account of the marbles or crystalline limestones at Renfrew and Arnprior :

"The town of Renfrew is situated over a very wide band of crystalline limestones, which crops out at different points, but especially upon a lot in rear of the Roman Catholic church. This latter is well adapted for quarrying into large pieces of solid and massive stone, which is free from checks and dries, and stands working, sawing and trimming for marble purposes. The property is operated by the Canadian Granite Company of Ottawa, and the product is shipped to that city for manufacture. The marble is a crystalline limestone of grayish hue, slightly tinted in places with hornblendic crystals, and in other places small crystals of mica are visible. It is taken out by block and feather, and costs $2.25 per cord for labor. The largest blocks are nine feet long by two feet square, and about 25 per cent. is wasted in the quarrying. It stands the weather better than any stone except granite, and some granites will not stand as well. We saw one building which had been put up nearly forty years ago. No action from the weather was visible, except that the tint had become slightly darker where most exposed, and this change could only be seen upon careful observation.

"There is another wide band of crystalline limestone at Arnprior, upon which several openings have been made, and near which works have been erected for cutting and polishing. At the works the strata dip 30 degrees to the south-west, and the strike is north-east and south-west. This band is of a bluish tint with dark blue wavy lines, and yields marble of excellent appearance and quality. The plant of the mill consists of three sawing gangs, three turning and two polishing lathes, and a rubbing bed, all driven by a 25-horse-power engine. The marble is made chiefly into monuments, but it is also manufactured to a small extent into table tops and mantelpieces, and is used in public buildings for decoration" (205).

The Arnprior quarries are further described by Mr. A. R. McDonald as follows :

"I live at Arnprior, and am a member of the firm of R. McDonald & Son. I am engaged in the marble manufacturing and producing business. One of our quarries is at the corner of Russell and

(202) G.S.C., 1896, p. 57 A.

(203) G.S.C., 1895, pp. 66-67 A.

(204) Roy. Com., 1890, p. 84.

(205) Ibid, p. 76.

Elgin streets in this town; the other is about a mile and a quarter distant, in an easterly direction, on a cove of the Ottawa river. The marble from that quarry is known as Ottawa valley marble, while the other is known as Arnprior marble. We have another quarry here at the mill, but it is the same as the Arnprior. We have three sawing gangs, five lathes, three turning lathes, two polishing lathes, a rubbing bed, and a 25 h.p. boiler and engine. I do not know the total value of the plant. This mill was formerly on the south side of the Madawaska, and was owned by Farquharson, McLaughlin & Hartney; they ran it for about four years. We acquired the property in the fall of 1878, and have been running it since. I cannot tell you what our output is. Our market is altogether in Ontario. It is used for monumental purposes, and to a small extent for ornamental purposes, such as table tops and mantlepieces. It has been used for a number of public buildings, among others, in the House of Commons at Ottawa. I suppose we make about $4,000 or $5,000 worth of monumental marble a year. The Arnprior marble has a dark blue ground with wavy veins, the Ottawa Valley marble has a gray ground with dark wavy veins. I do not know any other marble that will take as good a polish; it cannot be stained; it will not absorb moisture at all, and it stands exposure well. We have not been working this year, one reason being on account of the state of the market. When we are working we employ from fifteen to twenty-five men. The engineer gets $1.50 a day, quarrymen $1.25, polishers $1.25 to $1.50, stone cutters $1.25 to $2.50, and other men $1.20 to $1.25. One of the reasons that we find it difficult to compete with the American marble is that our stock is very hard and difficult to get out, and then it does not come out in the right shape. American mountain blue is a cheap marble. Southern Falls is a good marble; it is light in color, and I think it is as good as this; besides, it can be worked cheaper than ours. The Ottawa Granite Co. get marble at Renfrew, but they don't sell much of it as monumental marble; it is mostly the American that is sold for that purpose. The duty on marble is 35 per cent. sawed on four sides, 25 per cent. on two sides, and in the rough, 15 per cent. I am informed that the Americans sell marble here at $2 and $2.50, while they sell at $3.50 in their own country. They make a slaughter market of ours, and it is mostly inferior marble they sell here. That is the reason we are not running now. The marble dips about 30 degrees, and runs northeast and southwest. About a mile and a half from here we have a marble very like the Gouverneur marble; it is light gray with light brown streaks, and extends about five miles to the south and three miles to the west. There is no granite in this part of the country; it is all marble. Northwest it extends about twenty miles, and east of here about twelve or fifteen miles. In different places it varies in color and texture" (206).

The Renfrew limestones and marbles have frequent mention in the Reports of the Geological Survey, from which the following extracts are made :

"Ferguson's Quarry.—This quarry, on Lot 22, Range IV., of Ross, is in a fine gray crystalline limestone, striking N. and S., with an easterly underlie. In burning, it produces a somewhat granular lime, but makes a hard-setting mortar.

"The kiln has a capacity of only about 300 bushels, which amount is produced about six times a year.

"This stone, on account of its fine texture, might be applicable for building purposes, or would also, I have no doubt, constitute a handsome marble.

"On Lot 7, Range IX., bands of a coarse crystalline white dolomite occur, which is said to burn to a good lime.

"A similar band occurs on Lot 23, Range IV., slightly coarser in texture, and when struck with a hammer shows a momentary red phosphorescent glow.

"Either of these dolomites would be susceptible of a high polish. But, as the outcrop indicates a very limited thickness, it is doubtful whether it could be worked with profit.

"On Lot 20, Range IX., of Bathurst fine terminated crystals of pyroxene, hornblende, orthoclase, scapolite, apatite and titanite occur in a calcareous vein, cutting granite.

"On Lot 23, Range IV., of Ross a band of tremolitic dolomite, traceable across several lots, affords in many places long translucent rhomboidal columns and interlacing blades of tremolite, the former often one foot long and one inch across.

"Small specks of apatite were noticed in a disintegrating limestone, that is occasionally mixed with dolomite" (207).

Palaeozoic Limestones

"A band of crystalline dolomitic limestone, with mica, chlorite and hornblende-schists, also cut by diorites, crosses the river in the vicinity of Arnprior, and has a breadth westward of several miles. . . Portions of their area are also

(206) Roy. Co., 1890, p. 82.
(207) G.S.C., 1882-3-4, p. 15 L.

overlaid by thin beds of Calciferous limestones, on the north shore opposite Arnprior and Braeside. Above this, to Portage du Fort, the rock where exposed is mostly Laurentian limestone, forming a series of synclinals, underlaid by rusty gneiss, the whole cut by frequent intrusions of syenite and diorite. . . At the Portage du Fort village, there is a great development of the crystalline series, the intrusions being particularly well seen, and their action upon the limestone being marked by their alteration of this rock into marble. From certain beds of this locality the marbles employed in the interior of the Houses of Parliament in Ottawa were obtained" (208).

"The Roche Fendue channel, on the south side of Calumet Island, is very rocky, broken by numerous heavy rapids and chutes. The rocks are limestone, underlaid by rusty gray gneiss, but the syenitic and dioritic intrusions are frequent and masses of the limestone are often caught in the intrusive rocks. The rock on the north side of the Ottawa, between Bryson and the foot of Allumette island, is mostly syenite. Occasionally small bands of limestone and gneiss are seen, but their area is small as compared with the syenite portion, and they are much broken up.

"Allumette Island, and the south side of the river opposite, are occupied largely by Chazy rocks. The typical Black River occurs at Paquette Rapids, many of the beds being filled with fossils of that formation, which are beautifully preserved. Much of the island however is low, and large areas of sand and bog occur inland. The northwest portion is mostly syenite. In the north or Culbute Channel, a heavy rapid is overcome by a lock, while in the south or Pembroke Channel, the navigation is interrupted by the Paquette and Allumette Rapids, the latter about three miles below the town of Pembroke. These however can be traversed by steamboats at certain stages of the water. . . .

"The only trace of limestone seen in this portion of the river was a thin crushed band above the narrows about one mile below the mouth of the Swego River, some thirty-five miles above Pembroke.

"Some interesting points of structure were observed at various places. While it is very evident that the syenites or granites as a whole in this section are intrusive in the crystalline limestone, some portions of them are of comparatively recent date. Thus about six miles above the Coulonge, they have apparently disturbed the usually horizontal beds of Calciferous and Chazy, the latter in one place being pushed up along the contact to angles of 36 and 40 degrees." (209).

"Inland, to the south, the Chazy and lower part of the Trenton formation have a considerable development in the valley of the Bonnechere at Eganville, whence they extend eastward to Douglas village. The flat-lying limestones occur for some distance on both sides of that river. Another outlier extends from the east side of Lake Dove eastward to Mink Lake, and thence spreads over the flat area between Douglas and Cobden; while yet another considerable area occurs on the lower west half of Muskrat Lake, which is discharged by the Muskrat River at Pembroke. Along this stream the Chazy beds also show, capped in Stafford township by highly fossiliferous strata of Black River age. A small outcrop of Chazy is again seen in a cutting on the Ottawa and Parry Sound railway about three miles west of Killaloe station, while on Clear Lake, to the south the Trenton and Utica beds are exposed at the southwest corner." (210)

"A new outlier of the Black River was discovered in the low tract to the west of Clear lake, in the township of Sebastopol, and the Palæozoic formations seen around the northwest corner of the lake, comprising the Trenton and Utica, appear to extend westward and to underlie a depression, which continues as far as the road from Brudenell Corners to Killaloe. From the character of the drift and soil on the road leading up the mountain from Castile post office, it is very probable that the Utica outlier of the south side of Clear lake also extends in this direction for several miles, overlying the Trenton and Black river formations. It is probable from this Black River outlier, west of Clear lake, that the large masses observed along the north slope as well as along the top of the mountain, on the Opeongo road have been derived. The direction of the ice movement in this district was a few degrees west of south." (211)

Sand Point Quarries

There are two quarries in the Palæozoic limestone at Sand Point village, and one or more within a distance of a mile or two. At the time of the writer's visit stone was being shipped from one of the village quarries to North Bay, which was to be used in

(208) G.S.C., 1894, p. 59 A.

(209) G.S.C., 1894, pp. 60-61 A.

(210) Ibid, 1895, p. 65 A.

(211) Ibid, Sum. Rep., 1897, p. 61.

the building of the round houses and other structures on the Temiskaming and Northern Ontario Railway. This quarry, which lies east of the station, has a face of about 18 feet, and little earth on top of the rock. The other quarry has a face of over 20 feet, but the rock is here covered by about 15 feet of sand. The stone in one house which is said to be over 50 years old is in a good state of preservation. It retains its color well, not becoming lighter with age like the stone of Kingston and elsewhere. Many door and window sills, having a thickness of 15, 16 or 18 inches, have been taken from these quarries.

There is a small quarry at Braeside from which stone for building and lime burning is taken. The lime is said to be strong and quick-setting.

Following are analyses of samples of the stone taken from these Sand Point quarries:

—	1	2	3	4
Insoluble residue	......	......	......	4.97
Silica	4.20	4.14	2.54	.....
Ferric oxide	.72	.82	.92	1.03
Alumina	1.40	2.04	.74	.99
Lime	46.02	46.24	50.80	29.98
Magnesia	4.37	4.45	2.15	19.03
Carbon dioxide	40.60	41.00	42.00	44.30
Loss	.82	.22	.15	.....
Sulphur trioxide	.36	.66	.36	.10
Alkalies	......	.25	......	......
Total	98.49	99.82	99.66	100.40

1. Quarry at road side, just east of Sand Point station; 2, quarry near hotel, Sand Point station; 3, Barnet's small quarry, Braeside; 4, small quarry across road from Eckford's house, just east of Arnprior.

"Pembroke, O., lot 12, range 1.—The Chazy formation at this locality affords good limestone for building purposes, in beds from three to eighteen inches thick. An analysis of a specimen gave:

Carbonate of lime	83.96
Carbonate of magnesia	9.29
Carbonate of iron	0.69
Insoluble	6.06
	100.00

"The stone is light brownish-grey in color, compact and breaks with a conchoidal fracture

"McNab, Ontario.—The Calciferous formation in many localities affords material which answers for building purposes, and appears to be very durable, though often difficult to dress. In some cases the rock is limestone, but it seems to pass by insensible gradations into dolomite, the prevailing rock of the formation. A specimen of the limestone from near Arnprior, on the 11th lot of the third range of McNab, was found to contain:

Carbonate of lime	81.78
Carbonate of magnesia	13.68

"It is compact and dark brownish-grey when fractured, although when tool-dressed it has a rather bluish-grey tint. When polished it shows sections of fossils and presents a mottled surface of dark-grey, with patches of light-grey and yellowish-brown

"Another specimen from the same set of beds, but considerably lower down in the formation, was light brownish-grey in color, and dotted with occasional crystals of white calcite. When polished it presented a mottled appearance, like the limestone just described, the colors, however, being much paler. As shown by the following determination, it is a dolomite:

Carbonate of lime	53.00
Carbonate of magnesia	43.88

The specimen came from an old quarry on the 9th lot of the 14th range of McNab." (212)

The Lime Industry

The lime industry at the town of Renfrew is larger than that of any other place in the eastern part of the Province. The lime is shipped south to lake Ontario, and for a considerable distance east and west. The quarries, which are referred to on another page, are in crystalline limestone. There are three draw kilns 5 feet in diameter and 20 feet high. They each have a capacity of 150 bushels of lime in 24 hours. Lime is withdrawn from the kilns 36 hours after the first starting afresh, and thereafter every 12 hours. Lime sold in Renfrew during the past summer at 25 cents a bushel.

The limestone from these kilns works best if allowed to slack for some time before using. This prevents the danger of chipping in plaster.

Foundation stone (crystalline limestone), sold at $5.00 a cord, delivered, in the town of Renfrew during the past summer. It may also be added that bricks were $7.00 a thousand, and sand, for building, 40 cents a cubic yard.

Of the following two analyses from Jamieson's quarries, No. 1 was made by J. T. Donald, and No. 2 by A. G. Burrows.

(212) G.S.C., 1876-77, p. 486.

	No. 1.
Calcium carbonate.....	87.32
Magnesium carbonate....	7.87
Ferric oxide and alumina..	0.92
Silica and insoluble....	2.04
Volatile matter........	1.85
Total.....	100.00

	No. 2.
Lime.....	49.23
Magnesia...	3.69
Alkalies....	0.63
Alumina....	trace
Ferric oxide..........	0.76
Silica.....	1.39
Sulphuric acid...	0.26
Carbon dioxide....	41.54
Moisture......	0.28
Organic and volatile matter.	1.89
Total	99.67

and library, and gives a good effect with brick. A stone to be used as a sill in a bank at Coulonge, had been gotten out shortly before my visit. It had a length of nine feet, and in cross section was seven by five inches.

Following are analyses of crystalline limestones from Renfrew county :

1, Arnprior, small island near bridge; 2, sample from opening for road material at McLaughlin's mill, Arnprior; 3, Eckford's larger quarry, east of Arnprior; 4 represents a sample from a smaller quarry on the same property as 3; 5, Jamieson's lime kiln quarry, in town of Renfrew; 6, Leitch's quarry near town of Renfrew; 7, Scott's quarry, near town of Renfrew; 8, Jamieson's second quarry, near Leitch's; 9, Bedford's quarry, east half of lot 9, concession 4, Ross.

Analyses

——	1	2	3	4	5	6	7	8	9
Insoluble residue	....	....	....	....	....	....	2.28	1.69	.10
Silica	.53	1.48	.36	1.86	.96	.73	....	....	....
Ferric oxide	.50	.71	.50	.65	.41	.61	.50	.61	.28
Alumina	trace	.55	trace	.51	.87	.10	trace	.14	
Lime	51.42	50.16	52.50	51.62	46.00	50.74	49.62	50.64	31.10
Magnesia	3.34	2.84	2.23	2.15	7.34	3.98	4.17	3.59	21.24
Sulphur trioxide	....	.07	.30	.04	.25	.10	.06	....	.07
Carbon dioxide	43.68	42.35	43.41	42.16	43.62	42.18	43.44	43.74	47.23
Loss	.16	.65	.20	....	....	1.30	....	....	....
Alkalies	.12	.21	....	....	....	....	....	....	....
Total	99.75	99.02	99.50	98.99	99.45	99.74	100.07	100.41	100.02

Samples for analysis were also taken from two or three other quarries (in crystalline limestone) in the vicinity of the town of Renfrew. Considerable stone from Scott's quarry has been used for foundations and other structures. Large blocks or columns have been taken out of Leitch's quarry. One of these lying on the ground had a length of 12 feet, and a thickness of between eighteen inches and two feet. From a second quarry of Jamieson's, near Leitch's, stone has been shipped to Sudbury for use as a flux.

A quarry, known as Quinn's, about four miles from Haley's station, was visited. It is in the east half of lot 19 in the sixth concession of the township of Ross. The rock is white crystalline limestone, and has been used in the manufacture of tombstones, window sills, building stone and for other purposes. The stone has been shipped to Ottawa, Montreal and Sault Ste. Marie. At the latter place it is used as a "trimming" in the new public buildings, the fire hall

"Dolomite.—From the sixteenth lot of the sixth concession of the township of Ross, Renfrew county, Province of Ontario. Geological position, Laurentian. Examined for Mr. W. P. Hinton. A beautiful, white, translucent, coarsely crystalline dolomite. Its analysis afforded Mr. Wait the following results (after drying at 100 degrees C.—Hygroscopic water equals 0.03 per cent. (213))

Carbonate of lime.......		55.32
Carbonate of magnesia... ..		44.54
Carbonate of iron..		0.11
Carbonate of manganese.......		trace
Phosphate of lime (tribasic)......	0.02	0.47
Alumina....	0.09	
Silica, soluble...... ...	0.17	
Insoluble mineral matter...	0.19	
		100.44"

(213) G.S.C., 1899, p. 35 R.

Marl

"About 700 acres of the lower part of White Lake in McNab, under a shallow depth of water, in some places insufficient to float a canoe, and in others not exceeding two or three feet, present a bottom of shell marl, which, where tried in several spots, was found to possess a thickness of five to seven feet at least. There appears to be no deeper channel through this but a small flow of water escapes, notwithstanding the lake has an area of several square miles. It is discharged over a rim of crystalline limestone, and the bed of the brook falls rapidly after leaving the lake, so that an artificial drain could easily be cut, which would dry a great extent of the marl, a large quantity of which however could be dug out of the lake without draining at all.

"In the upper part of Mink Lake, north of the Bonnechere, near Jessop's Rapids, a deposit of marl extends out upwards of a quarter of a mile, where it has a thickness of more than nine feet, with two feet and a half of water over it, while there are only eight or ten inches of water nearer the shore. Other bays in the lake are also provided with marl bottoms. The length of the lake is about three miles, and a shoal, composed of the marl exists in the middle of it. At the outlet the water runs rapidly over boulders for the distance of a quarter of a mile, and there would be little difficulty in draining a few feet of the lake and laying bare a large quantity of the marl." (214)

"Shell marl is found in several lakes in considerable quantity, and should be of economic importance. Perhaps the most extensive of these deposits is in Mink Lake, Wilberforce township, Renfrew Co. Other lakes holding marl were found in Westmeath, and Ross. . ." (215)

"From a deposit on the twelfth lot of concession A, Coulonge Lake Front, township of Westmeath . . The deposit is about one hundred and thirty-five yards in length and some seventy-four yards in width. It consists of two distinct continuous layers—an upper dark-colored layer, twenty-two inches thick, and a lower light-colored layer, fourteen inches thick.

"(a) The material of the upper layer, in the air-dried condition, is earthy, slightly coherent; color light gray. It contains some shells, and also some root-fibres. A partial analysis of this, by Mr. F. G. Wait, showed it to contain (after drying at 100 degrees C.—Hygroscopic water 0.99 per cent.): Lime, 52.31, which would correspond to 93.41 per cent. carbonate of lime; insoluble mineral matter, 0.88; organic matter—consisting of vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water—5.27; phosphoric acid, 0.04.

"(b) The material of the lower layer, in the air-dried condition, is earthy, loosely coherent; color yellowish-white. It contains some shells, but no visible root fibres.

"An analysis by Mr. F. G. Wait showed it to contain: (After drying at 100 degrees C.—Hygroscopic water 0.29 per cent.)

Lime	51 68
Magnesia	0 51
Alumina	0 12
Ferric oxide	0 09
Carbonic acid	41.18
Sulphuric acid	0.03
Phosphoric acid	0 02
Silica, soluble	0.09
Insoluble mineral matter	4 06
Organic matter, viz., vegetable fibre in a state of decay and products of its decay, such as humus, humic acid, etc., and possibly a little combined water	2 71
	100 49

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are however present in other forms of combination, the amount found would correspond to 92.28 per cent. carbonate of lime.

"The insoluble mineral matter was found to consist of : (216)

Silica	2.55
Alumina and ferric oxide	0 82
Lime	0.14
Magnesia	traces.
Alkalies (?)	0.25
	4.06"

Russell

The distribution of limestones of the Chazy formation and of the Trenton group are briefly described in the following notes :

"On the line of the Ottawa and Cornwall railway, about half a mile south of Embrun station, in a quarry of Black River limestone holding an abundance of fossils, the angle of dip is ten degrees to the northeast, but this formation is overlain by the Trenton limestone a short distance east of Embrun village to the northeast of this point." (217)

(214) G.S.C., 1845-46, pp. 95-96.
(215) Ibid, 1895, p. 67 A.
(216) G.S.C., 1894, pp. 27-28 R.
(217) Ibid, Sum. Rep., 1899, p. 136.

"The lower part of the Trenton does not appear to display any corresponding escarpments succeeding these. But about five miles and a half from the Ottawa, on the south side of the anticlinal, an escarpment of the upper part of the formation, varying from thirty to ninety feet, crosses the road between the eighth and ninth ranges of Cumberland, on the seventh lot. This is traceable in a pretty straight line for between seven and eight miles, to the line between Cumberland and Clarence, on the thirteenth lot, upwards of six miles from the Ottawa. Here it makes a sudden turn to the southward, and has been traced in this direction for about a mile. From 200 to 400 yards southward from the edge of this escarpment, the black shale of the Utica formation can be traced the whole way, presenting a very small dip to the southward until coming to the turn. A mile eastward of the turn a lower escarpment occurs, with another still lower, a mile beyond; both run northwestward for upwards of a mile, and present a small dip to the southward of west, indicating the crown of the anticlinal arch. The thickness in the three escarpments would probably be about a hundred and fifty feet.

"A great swamp extends nearly across Cumberland on the crown of the anticlinal, but on the north side of the anticlinal, limestones, which correspond with those of the uppermost of the escarpments, form a point on the third lot of the sixth range of Cumberland, about three miles and a half from the Ottawa. They present a considerable area of bare rocks, and upwards of a mile to the eastward are divided by a point of black shale. The limestones on the south side of the shale soon become covered up, in their progress eastward; but those on the north present an escarpment of about forty feet, facing the north, which is traceable for a couple of miles to the road from the Ottawa to Dunning's mills, where the road runs through the fourth range of Cumberland. On this road the escarpment is on the second lot; the outcrop of the black shales is about 650 yards southward from it on the third, where they form part of the smallest of the three patches of the Utica formation already mentioned, this smallest one being separated from the largest by the limestones on the Clarence and Cumberland anticlinal.

"Between the black shales and the Ottawa, the road which has been mentioned runs very nearly at right angles across the measures, and the breadth on it of the Trenton formation, with the Birdseye and Black River, is just about 5,000 yards. The dip, which is from the Ottawa, does not on the average exceed one and a half or two degrees, while there is a difference in level of about a hundred feet between the summit and the base. The total volume of the series would thus be between 650 and 700 feet, which accords very well with the supposed thickness both at Montreal and Ottawa.

"About two miles southward from McCaul's wharf in Clarence, the Chazy presents an escarpment of fifty feet, the base of which is occupied by the sandstone of the formation, and a short distance from this step there rises up another, the height of which is about a hundred feet. The lower part of it is occupied by the Birdseye and Black River formation, and the upper by a portion of the Trenton. This escarpment is on the southwest side of the Buckingham and Clarence anticlinal, and is well marked for at least two miles to the southeast. It is not yet ascertained how far the Birdseye and Black River formation is carried in this direction before meeting the dislocation which is connected with this anticlinal; but however far it may be, this formation is thrown northward again, beyond McCaul's mills, by the fault, the rock at the mills being Trenton.

"Freed from the effects of this fault, the same series presents itself in another escarpment, which, from a position about a mile west of McCaul's mills, runs in a nearly straight line to the tenth lot of the fifth range of Plantagenet, the distance being about eleven miles, and the bearing about five or six degrees south of west." (218)

"At the High falls on the South Petite Nation, in the twelfth lot of the sixth range of Cambridge, the river runs northward on the face of a single bed of Trenton limestone for about 300 yards, descending about 20 feet. The position and dip of this rock make it probable that it is on the north side of the main Rigaud anticlinal. The want of exposures in the stream for a considerable distance below the High falls renders it uncertain where the axis of the Templeton and Gloucester, and that of the Buckingham and Cumberland anticlinal would strike the stream." (219)

"Westward of the High Falls, at Cook's Mills, on the Castor, in the eighth lot of the ninth range of Russell, which would be in the strike of the strata at the High Falls, already alluded to, there is a section of about five feet, consisting of dark blue limestone alternating with black shale. Several of the shale beds are very fossiliferous. . . . On the south bank of the Castor, in the next range to the west, thick beds of dark blue limestone dip N. 40 degrees W. < 32 degrees ; and further west, at Louck's mills, on the

(218) G.S.C., 1863, pp. 168-170.

(219) Ibid, p. 170, 171.

eleventh lot of the fourth range, the dip, which, on the south side of the stream, is S. 34 degrees W., at an inclination varying, in the distance of a hundred yards, from sixty to five degrees, is on the north side N. 40 degrees W. 17 degrees. While the north bank is occupied by thick bluish beds of granular limestone, the section on the south is as follows, in descending order :

	Ft.	In.
Black shale	3	6
Bluish-black limestone	1	10
Black bituminous limestone	3	0
Black shale	0	4
Bluish black limestone	1	6
Dark bluish-grey limestone	2	4
	12	6

"These exposures on the Castor, which are in a nearly straight line from the High Falls, and in the direct continued bearing of the Rigaud and Fitzroy anticlinal, are shown by the irregularity of the dips to be probably affected by it. Two of them no doubt belong to the Trenton formation; but it is uncertain whether that at Louck's mill is to be placed immediately beneath the Trenton or at its summit. The thickness of the black shale associated with the limestone, and the fact that superior black shales occur not far to the north of the anticlinal, would seem to countenance the latter supposition, but at the same time the supposed position of the Chazy is not far removed to the west. To perplex the question still farther, a dislocation seems to be connected with the anticlinal near the spot, and it is not certain on which side of the black limestone it may run." (220)

Simcoe

Limestones belonging to the Trenton group, and to the Clinton and Niagara formations, together with calcareous tufa and marls, are found in this county. Excellent building stone is found and likewise material suitable for the manufacture of lime and for furnace flux.

Silurian Limestones

"Westward from Hog Bay, the whole of the peninsula of Penetanguishene appears to be enveloped in drift, but on an island in Georgian Bay beyond it, called the Giant's Tomb, the base of this series of limestone is met with, resting on the Laurentian gneiss, which occupies the northeastern half of the island. The upper members of the series are on the southeast side of Georgian Bay. They there compose the little islands called the Hen and Chickens, and may be observed about eight miles west of the Nottawasaga River, at McGlashan's mills, as well as at Hurontario, in the township of Nottawasaga; and at the contiguous corners of Nottawasaga and Collingwood, where they are seen to pass under the black shales of the Utica formation. The transverse breadth of the series is thus about thirty miles, and the thickness, supposing the dip to be southwestward at the rate of thirty feet in the mile, would be 900 feet: but it is not unlikely that the strata may be affected by very gentle undulations, and it would therefore be scarcely safe to state the amount at more than about 750 feet." (221)

"The upper portion of the Trenton limestone becomes interstratified with thin layers of black shales, which form a transition to the black pyroschists of the Utica formation. Similar black bituminous shales are interstratified a little higher up in the series among the grey and green shales and sandstones which constitute the Hudson River formation. These black shales in Canada, are highly calcareous, and often pass into impure limestones. Of two specimens of this kind from Collingwood, one gave to the dilute acids fifty-three, and another fifty-eight, per cent. of carbonate of lime, with a little magnesia and oxyd of iron. The insoluble snuff brown argillaceous residue from the former, when ignited in a closed vessel, gave off 12.6 per cent. of volatile combustible matter, leaving a coal black carbonaceous residue, which when calcined in the open air, lost 8.4 per cent. additional, and became ash grey. The insoluble residue from the second specimen was digested for some time with heated benzole, which took up from it about one per cent. of a solid brown bituminous matter. It then no longer gave the odor of bitumen when heated, but a smell like that of burning lignite. The matter which had thus been treated with benzole, still gave by ignition, 11.8 per cent of volatile and inflammable matters. It was not attacked by a boiling solution of caustic soda. Portions of this shale, when distilled in close vessels, give from four to five per cent. of oily and tarry matter, besides combustible gases and water." (222)

"Deposits of calcareous tufa occur in many places along the base of the

(220) G.S.C., 1863, pp. 173-4.

(221) G.S.C., 1863, p. 193.

(222) Ibid, pp. 621-622.

Niagara formation in the counties of Grey and Simcoe. The most considerable known is on the banks of the Beaver River, in Euphrasia and Artemisia, which probably covers 1,000 acres. An area of about 300 acres of tufa, with an average thickness of five feet, occurs in a similar geological position at the falls of the Noisy River in Nottawasaga." (223)

Quarries

The composition of samples collected by myself is shown in the following table. Some very thick bedded rock occurs in the ravine near Singhampton. Two quarries were visited at Collingwood. The stone in that of the Cramp Steel Company is lithographic in character, and the quarry has a face of about 4 feet. Similar rock is seen in a quarry in the town. The formation here belongs to the Trenton group and lies little above the water level. A short distance away the escarpment rises and exhibits exposures of various Cambro-Silurian and Silurian formations to the top of the Niagara.

ANALYSES OF PALÆOZOIC LIMESTONES.

	1	2	3	4
Insoluble residue	......	......	......	.28
Silica	7.70	9.50	6.00	......
Ferric oxide	1.32	1.11	1.03	.41
Alumina	2.16	2.99	1.79	.40
Lime	45.52	45.30	48.34	30.06
Magnesia	1.42	1.67	1.61	21.40
Sulphur trioxide	.39	.38	.35	.04
Alkalies	.40	.60	.36	trace
Carbon dioxide	38.82	35.56	39.69	47.20
Loss	.30	2.14	.31	......
Total	98.03	99.25	99.48	99.79

(223) G.S.C., 1863, p. 804.

Sample 1 was taken from the face of the Cramp quarry, Collingwood; 2 represents the loose pieces of stone in the same quarry; 3 is a general sample from Merchant's quarry in the town of Collingwood; 4 represents the rock at J. Gosset's lime kiln, near Duntroon.

The following results of analyses of the rock from the quarry of the Canada Iron Furnace Company of Midland have been kindly furnished by Mr. W Dixon Craig, chemist to the company. The quarry is on lots 19 and 20 in the fifth concession of the township of Tay. The formation is Black River. The quarry is situated on the shore of the bay, and the stone is carried to the furnace by scow, and is used as a flux in the smelting of iron ore. Some of the rock is fine grained and lithographic in character, like that in the township of Marmora and other localities farther east. The quarry has a diameter of about 100 yards and a face 12 or 15 feet in height.

—	Iron.	Silica.	Phos.	Alumina.	Alumina and Ferric Oxide.	Lime.	Magnesia.	Sulph.	Insol.	—
Quarry	......	......	......	......	1.00	......	......	.143	3.38	Near water.
"	......	......	......	......	2.45	40.03	10.36	......	4.39	Stock pile.
"	......	......	......	......	2.45	......	......	......	4.40	Dark stone.
"	......	......	......	......	2.39	42.65	8.14	......	3.46	Bottom layers.
"	......	3.61	.013	......	1.85	39.38	11.44	......	......	Stock pile.
Furnace	.10	4.41	.010	1.62	......	40.61	9.93	.092	......	" "
Quarry	......	4.14	......	......	2.35	39.82	10.09	......	......	S.E. portion—lower.
"	......	6.10	......	......	3.24	37.80	11.22	......	......	" " —upper.
"	......	4.61	......	......	1.67	38.93	11.92	......	......	West end.
"	......	5.58	......	......	1.67	38.07	10.93	......	......	Western half.
Furnace	.40	4.99	......	1.20	......	39.35	......	......	......	Stock pile.
"	.63	4.40	......	1.32	......	39.49	10.68	......	......	" "
"	.55	4.55	......	.68	......	39.42	11.51	......	......	" "
"	.69	4.15	......	.51	......	41.16	10.75	......	......	" "
"	.61	3.94	......	.68	......	42.56	8.51	......	......	" "
"	......	3.82	......	......	2.01	40.60	10.16	......	......	" "
"	......	7.14	......	......	3.66	38.43	10.11	......	......	" "
"	......	......	......	......	1.94	41.57	10.57	......	4.36	" "
"	......	......	......	......	1.90	37.95	......	.153	8.00	" "
"	......	......	......	......	2.06	38.27	10.41	.128	7.40	" "

Stormont

Exposures of limestones belonging to the Chazy, Black River and Trenton formations are found in this county.

"The Mille Roches quarries are in Black River limestones. These quarries are extensively worked for stone for canal construction, and blocks of very large size and of excellent quality are here obtained, one solid layer having a thickness of nearly ten feet. A short distance north of this the limestones of the Trenton come in." (224)

"Not far from Berwick, also, are ledges of dark bluish-gray [Chazy] limestone dip S. 40 degrees E. < 4 degrees. These beds extend northwest

(224) G.S.C., 1899, p. 135. A.

from this place as far as Cannamore post-office, and continue on in this direction." (225)

"The Trenton is also well exposed near Mr. Henry Onderdonk's, a short distance to the northwest of Aultsville. It also appears about Crysler in the township of Finch, Stormont county, and thence eastward towards Moose Creek.

"Near South Finch, the bed of the Payne River consists of Trenton limestone, and there are also fine exposures about South Finch, Lodi and other points in the vicinity." (226)

"On the north shore of the St. Lawrence, at a small point opposite the northeast corner of Barnhart Island, there is a fine exposure of greenish and black Chazy shales. They are very concretionary and nodular in places, but no fossils were observed. The dip is N. 10 degrees W. 2 degrees. These shales are exceedingly thin and splintery and are easily crushed in the hand." (227)

Thunder Bay District

Very little has been done in the limestone industry in this district.

Lime, cement and other products are shipped into the district by water at a low cost for freight. Attempts have been made at various times, as the following notes show, to work some of the limestones for decorative purposes.

The marl deposits, such as those which are found in some of the small lakes along the line of the Port Arthur, Duluth & Western Railway, are likely to be of economic value in the future, other forms of limestone being comparatively scarce.

The calcite vein-material which occurs in considerable abundance in some of the deposits in the silver-bearing areas may also be utilized in metallurgical work.

Lake Nipigon

"Nowhere about the lake [Nipigon] are the sedimentary rocks of the Nipigon series seen in any great volume. The mass of the strata exposed about the shores, and forming high bordering hills, is trap, with only here and there a thickness of from six to fifteen feet of limestone or sandstone underlying it at about the water level. On the southern and south-western sides of the lake limestones are the only sediments met with, and on the southern and north-eastern sides, highly silicious red and white sandstones (which become locally quartzites), take the place of the limestone under the trap. These sandstones lie directly upon the Archaean gneiss, and seem to be littoral beds, which mark the shore limit, in this direction, of the basin in the deeper part of which the limestones were deposited. . . . . Some of the sandstones,limestones, etc., about the lake would afford good building stone." (228)

"On the southern point of the Inner Barn,in Wabinosh Bay, I discovered near the water's edge a section of about ten feet of mottled, green and purple, shaly arenaceous limestone, dipping easterly at an angle of 15 or 20 degrees. Beds of a purer limestone, having a gray and greenish color, mottled with purple patches, are interstratified with the others, and fragments derived from them are strewn in abundance upon the beach, and may prove of value for burning into lime." (229)

Albany River

"All the way from Martin's Falls to the forks, the Albany is flanked by steep banks, either immediately overlooking the water, or rising at a short distance back from it. In descending the river their general height increases gradually from forty to about ninety feet, and they also become more regular and continuous in approaching the forks. They are at first composed entirely of drab-colored boulder clay, capped with sand, but, after reaching the Palaeozoic rocks these deposits are by degrees replaced in the lower part of the banks, by drab and chocolate-colored marls, and shales, the upper part being usually composed of the boulder clay, overlaid by sand. The bed and shores of the river consist of either smooth, flat-lying rock, or small rounded boulders, packed closely together, and all brought by the drifting ice to a uniform surface, so that they bear a strong resemblance to a well-laid pavement.

"Gneiss, with the usual east and west strike, was the only rock seen in situ from Martin's falls to the most northern point of the great bend; but, immediately on passing this, yellowish limestone strata make their appearance in the bed of the river. Similar limestones and others of a gray color, are seen in the bed and banks of the river, here and there, to within about twenty miles of the Forks, where they become replaced

(225) G.S.C., 1896, p. 62 A.
(226) Ibid, p. 63 A.
(227) Ibid, p. 62 A.
(228) G.S.C., 1894, pp. 50, 51 A.
(229) Ibid, 1871-1872, p. 104.

by the overlying drab and chocolate-colored marls and shales. The inclination of the strata towards the sea is greater than that of the bed of the river, so that the line of division between the chocolate-colored and the underlying drab marls and shales becomes gradually lower and lower in the banks, and at length sinks beneath the river bed. Layers of the two colors are interstratified with each other for a certain thickness at the junction, so that for some miles the banks have a banded appearance. In this interval a small quantity of soft, thin-bedded gray sandstone occurs. The few fossils found in these rocks appear to indicate an equivalent of the Niagara formation" (230).

"In the Report of the Survey for 1871-72 Professor Bell mentions (p. 106) an 'indurated, pink-colored calcareous marl' which occurs in horizontal beds on the Pikitigouching River. A specimen which he requested me to analyze was collected by his assistant, Mr. Lount. It contained:

Silica	39.87
Alumina and ferric oxide	9.34
Lime	22.40
Magnesia	6.24
Carbonic acid	23.40
	101.25

"The residue left after treatment with hydrochloric acid amounted to 42.84 per cent. of the rock" (231)

"The Black Bay Mine & Quarry Company has its principal office in Chicago and its western office at Duluth. It has been organized to acquire and work a location of jasper and dolomitic limestone in the township of Dorion, near the north shore of Black bay. The property was not secured until late in 1891, and only specimen blocks have been taken out. Both kinds of stone are beautiful in color, and take a fine polish, but the specimens seen are more or less flawed, owing no doubt to the influence of the weather on rock so near the surface. The following account of the quarry has been furnished by A. M. Stearns of Duluth, manager of the company:

'The company's lands as patented by the Crown are described as the west half of lot 3, concession 4 of Dorion, containing 146½ acres.

'The property lies about one and one-tenth mile from navigable water in Black bay, upon the Canadian Pacific Railway. The outcropping of quarry stone occurs about a quarter of a mile west of the railway, on a gradually-ascending slope, at about 100 feet altitude, and lying between immense granite hills on the northerly and southerly sides.

'It has been noted and commented upon by explorers as a peculiar formation, but it was left to our company to demonstrate that it is a very large and valuable bed of jasper, underlaid with a stone so like mahogany when polished that we offer it to the trade as mahogany stone. The jasper lies at and near the surface, is from three to five feet in thickness, and can be quarried in blocks about three feet wide by five to seven feet long.

'The mahogany stone upon which the jasper rests occurs first in thin beds, which soon thicken to an apparently unstratified ledge, and may be quarried in even larger sizes than the jasper.

'Though harder than marble, the jasper saws readily, and can be satisfactorily reduced with hammer and chisel, taking a polish equal to plate glass.

'If one-third of these measurements be allowed for dressing we shall have net dimensions remaining without flaw suitable for wainscoting, tables, mantels, sideboards and sizes suitable for turned columns and carved pedestals in fine architectural work.

'The whole formation dips slightly to the northwest, and judging from the number and uniformly sloping surfaces of the several exposures and the slight stripping between them, as far as tests have been made, must cover an area of at least forty acres.

'The color and the polishing qualities of stone taken from this location will readily commend it to public favor, and should it, as may reasonably be assumed, prove to be free from flaws when a greater depth from the surface is reached, it ought to find a ready market.'" (232)

Victoria

There is a considerable variety of limestones in this county. They consist of the ordinary stratified rock of Cambro-Silurian age, crystalline limestones or marbles, which belong to the Laurentian system, and marls of recent age. Many of the outcrops of these rocks are well situated for shipping. A sketch of the distribution of the Silurian strata is given below, together with a series of analyses of samples of these rocks from the neighborhood of Coboconk and Burnt River P.O. These analyses show the general character of this group of rocks throughout the county.

"It [the Trenton escarpment] crosses Buckthorn Lake at the strait, about two miles and a half above Buckthorn Falls, and then, again separating into

(230) G.S.C., 1871-72, pp. 111-1?

(231) Ibid, 1874-75, p. 312.

(232) B.M., Vol. I., p. 100.

two parts, the main one strikes nearly straight by Sandy and Pigeon Lakes to the head of Balsam Lake, the inferior escarpment keeping about a couple of miles to the northeast." (233).

"In the continuation of this course westward [from Burleigh falls], the cherty beds [of limestone] with their characteristic corals, are displayed at the top of the cliffs, which rise over the exit of Buckthorn Lake. They are seen too on Pigeon Lake, and at the Bobcaygewan Rapids, near the foot of Sturgeon Lake. On the north part of Balsam Lake, in a great bay on the west side, they occur on the land of Mr. Stephenson in block E of Bexley, where they incline at a very small angle southward. . . .

"The base of the inferior escarpment is seen at the foot of Mud Turtle Lake, near where the continuation of the line between the eighth and ninth ranges of Somerville would cross it, about three miles north from the northeast bay of Balsam Lake. The base consists of pale drab limestone of fine texture, in very regular layers of from three to six inches, without fossils, and over it an escarpment rises a little way south to the height of forty or fifty feet. The upper beds are massive and fossiliferous, but the fossils are very obscure. Among the fossils a small Leptaena was observed to be very abundant, and another bivalve was occasionally found with encrinites and fucoids, but the specimens are too ill defined to be easily identified.

"At the rapids at the outlet of Balsam Lake there are flat surfaces of limestone exposed just over the edge of the water, with fossils weathering in relief. . . . At Fenelon Falls, near the exit of Cameron's Lake, where there is a section of about twenty feet in the gorge of the river below the cascade, the following Trenton species occur : . . . .

"On Sturgeon Lake, opposite the mouth of Scugog River, where the strata are of greenish calcareous shale, with very thin beds of limestone, the fossils in greatest abundance are, etc.

"At the village of Lindsay on the Scugog River, in Ops, there is a small exposure of blue limestone in beds of six or seven inches, interstratified with blue calcareo-argillaceous shale, holding abundance of fossils." (234)

In the township of Somerville escarpments of limestone of Black River age surround a somewhat semicircular area lying to the westward of the railway at Burnt River station. The ledges rise to a height of 40 or 50 feet. Britnell's quarry lies about three-quarters of a mile south of the station, alongside of and to the west of the railway track. In ascending order the layers of limestone in this quarry are as follows : 5 beds averaging 12 inches in thickness; followed by bed of shale and transition sandstone 12 inches; 4 feet made up of thin beds, followed by three beds of lithographic character of 2 feet 9 inches, 6 inches, and 1 foot 4 inches in thickness; then there are 4 layers of 7, 9, 12, and 8 inches respectively; the top layer has a thickness of 2 feet. The beds have a slight dip to the southwest. The stone makes a good building material, and the refuse, after being passed through a No. 3 Gates crusher, is used as a road metal, and for concrete work in Toronto.

There is an important lime industry at Coboconk, where the two kilns in use have a combined capacity of 135 tons (70 lbs. to a bushel), a week. The rock burned here is similar to that in the escarpment at Burnt river. The nine upper beds in the quarry used for lime have an aggregate thickness of 18 or 20 feet; under these beds are layers which are said to be unsuited for lime-burning but make good building stone. They have thicknesses of 14, 2, 4 and 9 inches respectively. They are fine-grained and lithographic in character. The soft wood used in the kilns costs from $1.50 to $1.75 a cord. Coboconk lime is used in the production of acetate of lime, at the Longford charcoal plant.

The results of several analyses of the rock from Coboconk and Burnt river are given in the following table :

ANALYSES OF LIMESTONES FROM COBOCONK AND BURNT RIVER

—	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Insoluble residue	...	...	...	...	...	...	...	...	...	...					
Silica	.97	.98	1.60	1.56	.72	1.68	3.94	11.34	1.00	1.62	1.08	1.70	1.54	1.38	1.44
Ferric oxide	.95	.39	.65	.52	.41	.65	.82	1.52	.40	.57	.30	.40	.49	1.62	.21
Alumina		.30	.11	.39	.80	1.14	1.57	4.72	...	.39	.52	.60	.52		1.00
Lime	54.00	54.40	52.40	51.44	50.31	47.28	45.74	28.10	49.34	52.88	53.06	53.00	52.40	54.00	52.60
Magnesia	.70	.69	.74	1.37	2.72	5.46	4.10	4.92	3.79	.76	.29	1.18	.74	.81	.78
Carbon dioxide	42.95	43.00	40.41	41.80	42.30	43.30	40.84	...	42.78	...	41.82	43.04	...	...	43.49
Water	...	...	...	...	...	...	...	...	...						
Loss	.71	.36	2.55	1.41	1.27	...	...	...	.84	...	1.92				
Sulphur trioxide	.39	.44	.25	...	.37	...	.39	.31	.27	.35	.38	.40	.20	.28	.47
Alkalies	.22	.11	...	...	...	...	.24	...	...	5.05	...	trace	...	...	.05
Total	100.88	100.67	98.71	98.52	98.88	99.51	97.64	...	98.42	...	99.37	...	...		100.04

(233) G.S.C., 1863, p. 189.

(234) Ibid, pp. 190-191.

1.—General sample of rock used for lime burning at the Coboconk kilns. 2.—Lower layer of limestone in the quarry at the Coboconk kilns. I was told that this layer was considered unsuited for lime burning. There is no reason for this, as the composition of the rock is shown by analysis to be almost identically the same as sample 1. A general sample taken from the outcrops just east of Coboconk has the composition shown in column 3. Samples 4, 5, 6, 7 and 8 were taken from Britnell's quarry, Burnt River. 4.—Top layer, 2 feet. 5.—4 feet 10 inches, of the upper part of the face of the quarry, 6-3-feet bed, just below top layer. 7.—4 feet, immediately above silicious layers. 8.—The two silicious beds at the bottom of the quarry. 9.—Lower layers of cliff, lot 11, concession 8 of Somerville township. 10.—Upper 15 feet of the same cliff, facing south. 11.—Upper 15 feet of hill on 7th line. 12.—Lower layer, side line, lot 14, concession 6 of Somerville. 13.—Lower 6 feet on hill. 7th line Somerville. 14.—Second 15 feet, about half way up hill, 7th side line. 15.—Crystalline limestone from marble quarry, near river, said to have been opened by Judge Dean.

It will be seen from the table that the upper parts of the limestone ledges and cliffs in the vicinity of Burnt River P.O. are similar in composition to those of Coboconk. Considering that samples 10, 11, 12, 13, 14, represent surface specimens, and hence would be expected to run higher in silica and lower in lime than if they were taken from rock freshly broken in a quarry, their agreement with 1, 2 and 3 is very close. Samples 4, 5, 6, 7, 8 and 9 represent beds of rock which lie at a lower level than those just mentioned. This accounts for their higher average percentage of magnesia, and the comparatively high percentage of silica in 7 and 8. The last mentioned sample, 8, is a sandy limestone, and apparently represents a transition from the overlying limestones to underlying sandstones or conglomerates which are usually found at the base of the series in this region.

The last sample, 15, considering that it is crystalline limestone, is comparatively pure.

There is a small quarry on lot 8 in the eleventh concession of Somerville, some distance northeast of the station, and near Burnt River. This quarry is in crystalline limestone. It was opened years ago in an endeavor to use the limestone as a marble. An analysis of a sample, 15, from this quarry is given in the table.

Dolomite from Coboconk, township of Bexley. "This stone has a light greenish-grey color, is very fine crystalline, and has a close and uniform texture.

"Agreeably with the results of an analysis, conducted by Mr. F. D. Adams, it contains—after drying at 100 degrees C.: (235)

Carbonate of lime....	50.745
Carbonate of magnesia.. ...	35.532
Insoluble matter..	9.960
	96.237

Marl

"Location at Manilla, Victoria county, Ont. An analysis of this marl runs as follows: (236)

	Per cent.
Moisture........	0.20
Organic matter.....	1.61
Clay and sand......	0.50
Lime (CaO).....	53.27
Magnesia (MgO)....	0.77
Iron and alumina (Fe_2O_3 and Al_2O_3)...................	0.59
Alkalies	trace
Carbonic acid (CO_2).........	42.60
Phosphoric acid (P_2O_5)......	0.28
Soluble silica (SiO_2).........	0.12
	99.94"

Waterloo

The characteristics and relationships of the limestone formations in Waterloo county are described in the subjoined extracts from various Reports of the Geological Survey:

"The fall from the base of the [Guelph] formation, at Guelph, on the Speed, to the bed of the Grand River, at Breslau, as deduced from the levels on the Grand Trunk Railway is eighty-two feet. The distance across the strike of the measures, between Guelph and Breslau, is about nine miles, so that if the dip of the strata be taken at twenty feet in a mile, which is perhaps near the truth, the base of the formation would be one hundred feet beneath the bed of the Grand River. The rocks of the Guelph formation are not seen at Breslau; but at points both to the north and to the south, which would include this place in their strike, strata are met with at a level of about sixty feet above the Grand River. This would give for the Guelph [formation] dolomites, about 160 feet; which we may assume as the approximate thickness of the formation.

"The strata of this formation appear, so far as examined, to be magnesian limestone, having the composi-

(235) G.S.C., 1882-84, p. 2 MM.

(236) Cat. Ont. Min. Exhibit, Buffalo, p. 81.

tion of true dolomites, and are frequently made up of brilliant crystalline strongly coherent grains. The rock is very often porous, and has small drusy cavities besides which are those forming the moulds of fossils. In many cases the shell appears to have been simply enveloped in the rock; and having been afterwards removed by solution, it has left a corresponding cavity. At other times, the interior of the shell was also filled with the dolomite, so that the mould corresponds only to the thickness of the shell; the markings of both the interior and exterior of which are thus preserved. More rarely, the cavities have been subsequently filled up with calcareous matter; so that the substance of the shell appears to have been either replaced or preserved.

"The most southern exposure of the summit of the formation, on the Grand river, occurs just above Middleton bridge, on the twenty-first or twenty-second lot of the sixth range of Dumfries. The rock is a pale drab. Similar beds with others of a pale buff color, continue up to the north end of the fourteenth lot of the sixth range of Dumfries, with a very gentle dip to the southwest; the distance across the measure being probably two miles. . . The rocks of the Guelph formation are again met with, farther up the Grand River, in the vicinity of Galt.

"The highest strata here appear to be the same as those above Middleton bridge. The exposures are chiefly on the right bank of the river, but occasionally on both banks, and they extend for some distance, both below the town and above it, where quarries are wrought in the rock. The greatest vertical section in any of these is thirty-four feet; but exposures of both higher and lower strata would make the whole thickness upwards of sixty feet. At the top of the formation, in this neighborhood there are about eighteen feet of hard, thin-bedded bluish dolomite, beneath which are thirteen feet of pale buff or white dolomite; succeeded by twenty feet of yellowish-white and greyish-white crystalline thick-bedded dolomite, in overlapping lenticular masses. The whole mass holds fossils, but these in the immediate vicinity of Galt are most abundant in the twenty feet of pale buff thin-bedded dolomite in the middle of the section. . . .

"The exposures continue all the way to Preston, which is still higher up on the river. Here the banks exhibit a section of from fifteen to twenty feet of coralline, magnesian limestone, probably equivalent to the thin-bedded pale buff dolomite of Galt, but not so fossiliferous. Exposures continue up the Speed; and at Hespeler strata occur that are lower in the series than those at Galt; their stratigraphical place being probably near the middle of the formation. A cutting at Hespeler, on the Great Western Railway, exhibits fifteen or twenty feet of pale greyish-white strata, which are not so massive as some of those at Galt, but more fossiliferous. . . Both at Galt and Hespeler, quarries are worked in these magnesian limestones which yield excellent building stones, easily dressed and probably durable. Some of the beds are burned for lime, which is often rather dark in color, but makes a strong mortar." (237)

"Exposures of strata belonging to the Onondaga formation, are met with at several places on the Grand river, for a distance of about 15 miles; from Doon, six miles above Galt, to about 2 miles below Glen Morris. Between Galt and Preston, on the west side of the river, on a lot adjoining one where the Guelph formation is exposed, there are seen about 5 feet of brownish shale, interstratified with thin beds of dolomite; in one of which is found an obscure bivalve shell. Similar strata are said to occur 2 miles below Glen Morris; beyond which the rocks of the formation are concealed beneath a great thickness of drift." (238)

At the present time the only large limekilns in this county in continuous operation are at Galt and Hespeler. At the former place there are two draw kilns and at the latter, one, the lime produced at each being white. The same limestone is used locally for rubble and road-metal.

Marl

"From Paris towards Ayr the rough morainic deposits gradually give place to gravel beds, while from Ayr to Galt sand and gravel alternate with clay. Throughout this region are numerous marl beds, many of which will doubtless prove valuable for the manufacture of cement. A cursory inspection was given to a few of these deposits as follows:

"The farm of Walter J. Reid, lot 31 in the tenth concession of North Dumfries, shows about twelve acres of marl and four acres of lake. Clay is seen on the south side of the lake, but fine sand is the predominating superficial deposit.

(237) G.S.C., 1863, pp. 337-340.
(238) Ibid, pp. 350-1.

"The farm of Mrs. McCrone, lot 29 in the eighth concession of North Dumfries, contains ten acres of lake and ten acres of low land covered by marl. Close to the shore, bottom could not be obtained in a continuous mass of marl with a 16-foot pole. The lake is very deep, but notwithstanding this objection a very large quantity of accessible marl doubtless exists here. Another lake lies to the south and west; about thirty acres of low lying land intervenes. I have no doubt that this tract is largely composed of marl. Clay does not appear to be plentiful in this vicinity, light land with many stones being the prevailing soil.

"A small lake of three acres with marl is seen to the northwest of this point on the farm of Mr. Taylor, while southward, on the property of Robert Easton, there is an excellent deposit in and surrounding a lake of ten acres bounded by low land, said to show plenty of clay.

"A glance at the township plans of this vicinity will impress on the reader the large number of small spring-fed lakes in this region; while it was impossible to visit more than a few of these, it is extremely likely that they are of the same nature as those seen, in which case we have here numerous sites for the manufacture of that product for which the demand is increasing with strides and bounds—Portland cement." (239)

Welland

The Clinton, Niagara, Onondaga, Lower Helderberg and Corniferous limestones, which occur in this county are briefly described in the following notes. There is much information available concerning the underground geology of the county, as numerous wells have been drilled in search of gas.

There are important quarries in the vicinity of Port Colborne and Sherkston, in the Corniferous formation, where lime is produced. Rock has long been worked at Thorold and elsewhere in the production of natural cement. The Port Colborne and Sherkston quarries produce rock which has been used as a furnace flux and in the manufacture of calcium carbide.

Clinton Formation

"In Canada for reasons which will be stated in describing the Niagara formation, it is found convenient to limit the Clinton to the strata beneath the Pentamerus band, and to include this band in the Niagara formation. On the Niagara River, the Clinton is thus limited to a few feet, but it gradually augments in thickness to the northward.

"In the cutting of the Welland Canal at Thorold, about seven miles to the west, the Grey band is a white fine-grained sandstone, somewhat irregularly deposited; the beds thinning out, and occasionally coming to wedge-shaped terminations. When of sufficient thickness, they afford excellent material for the purposes of construction, and altogether constitute a mass of about ten feet. Immediately above this band the Clinton appears, consisting of four feet of bluish and greenish argillaceous shale, presenting fucoids on the surfaces of the beds; among which are fine examples of Arthrophycus Harlani, especially near to the underlying sandstone. The shales here show no indication of the fossiliferous iron ore beds.

"At Mr. Goodenow's quarry, about a mile and a half west from the village of Thorold, and immediately above the Grey band, which is there ten feet thick, there occur the following Clinton strata, in ascending order: (240)

	Ft.	In.
Bluish-green argillaceous shale	4	0
Bluish-grey limestone, abounding in iron pyrites for an inch on the top	2	9
Bluish-drab argillaceous limestone, yielding a hydraulic cement	3	1
	9	10

Niagara Formation

"The bluish-black shales which in the state of New York afford a well-marked division between the Clinton and Niagara formations, are available for this purpose but for a short distance in Canada. To the northward these shales thin out and disappear; and it is for the present very difficult to distinguish them in that direction. We therefore propose to include in the Niagara series, the two bands of limestone which underlie the shales, and which, in New York, constitute the upper part of the Clinton formation. So far as they have been examined in Canada, these two limestone bands contain no Clinton fossils, but such as pass upwards into the Niagara; and the upper band here possesses one or two species, which, in New York, are considered to belong to the latter group only. There would thus appear, at present, to be no palæontological reason why these limestones may not be considered the base of the Niagara formation; while geographically

(239) B.M., Vol. XII., p. 149-50.

(240) G.S.C., 1863, pp. 312-3.

they present a very marked feature for a considerable distance, and afford a convenient means of describing the distribution of the two formations.

"Including these limestones, the Niagara strata seen in the cutting of the Welland Canal, near Thorold, in immediate succession to the Clinton formation, are as follows, in ascending order:

"1. Bluish-grey magnesian limestone, with partings of bluish calcareous shale. Concentric rings of discoloration are observable around small cavities lined with calespar, which occur generally at the surface of vertical joints, cutting the strata at right angles. The circles are usually so large as to cross the divisional planes of several beds. Pentamerus oblongus and Stricklandia canadensis occur in abundance; 10 feet.

"2. Grey coarse-grained sub-crystalline limestone, with disseminated iron and copper pyrites; the bed abounds with fossils, among which, on the canal, are Atrypa reticularis, Rhynchonella cuneata, and Athyris cylindrica; 10 feet.

"In the upper five feet of this bed, in Mr. Goodenow's quarry, a mile and a half to the westward, there are fragments of an undetermined species. . .

"3. Bluish-black bituminous shale, with thin bands of impure limestone, holding trilobites and a few shells. Among the trilobites, Dalmanites caudatus is frequent. In some places, thin bands of gypsum occur, giving a riband-like aspect to the shale. Small nodules of gypsum are also sometimes met with, as well as crystals of iron pyrites. This shale constitutes the base of the Niagara group of New York; 55 feet.

"4. Bluish-grey argillaceous limestone, yielding excellent water cement, which was much used in building the locks of the Welland Canal; 8 feet.

"5. Dark bluish bituminous limestone, in some places yielding material fitted for purposes of construction, as at Mr. Keefer's quarry at Thorold. The upper and under surfaces of adjacent beds are often united by suture-like joints; the parts interfitting being sometimes two inches in depth, with vertical columnar sides, usually glazed with a thin pellicle of argillaceous matter. Crystals of galena are frequently met with in these beds, which contain many fossils; 8 feet.

"6. Light and dark grey magnesian limestone, in beds varying from 6 to 10 feet in thickness, constituting a building stone of the best description. It is a cemented mass of encrinites, with a few additional fossils, and in some parts holds geodes filled with snow-white gypsum; 26 feet.

"7. Bluish bituminous limestone well suited for purposes of construction, though inferior to the preceding mass. It holds many fossils, principally corals; 7 feet. Total, 124 feet.

"This section represents all the beds of the series which are crossed on the canal, up to the highest part of the ridge, near Thorold; but it does not reach the summit of the series by probably ninety feet. Proceeding westward, the volume of the black shales diminishes, while that of the limestones beneath them augments." (241) (See under Wentworth.)

Onondaga Formation

"Running parallel with the shore of Lake Ontario, it [the Onondaga formation] diminishes considerably to the westward, until it crosses the Niagara River, and enters Canada, with a thickness which is estimated at between 2[illegible]0 and 300 feet. . . . . . .

"Commencing at the Niagara River, the upper beds of the series are seen near the village of Waterloo, and are traceable to the westward, from the eighth lot of the seventh to the twenty-third lot of the second range of Bertie. Sweeping round towards the shore of Lake Erie, behind Cape Abino, through the influence of an undulation, they are again traceable, from the fifteenth lot of the third range of Humberstone to the Welland Canal, on the twenty-sixth lot of the second range of the same township. Between this outcrop and the Chippewa, the whole of the country is covered by clay. It is probable however that the lowest beds occur somewhere near to Chippewa village, as the clay for a considerable extent in that neighborhood has a red color, such as might be expected from the disintegration of the red shales, which occur at the base of the formation in New York. The same red color also prevails on the Welland Canal, in the vicinity of Port Robinson, though no red shales have yet been seen in place, either there or for upwards of a hundred miles beyond.

"The exposures of the Onondaga formation in Canada, so far as yet examined, appear to belong chiefly to the upper portions, from the summit to a little below the gypsum-bearing beds. These portions consist of dolomites and soft crumbling shales, which are greenish and sometimes dark brown or bluish in color, and are often dolomitic. The dolomites are mostly of a yellowish-brown or drab color, and are in beds which seldom exceed a foot in thickness. They often ex-

(241) G.S.C., 1863, pp. 322-23.

hibit the vesicular or the lenticular cavities just described. Some beds of a bluish dolomite are also met with, and many of the strata, both above and below the gypsum, contain such a proportion of clay as make them fit for hydraulic cement." (242).

Lower Helderberg

"The Water-lime series [Lower Helderberg], as thus defined, enters Canada opposite to Buffalo, and can be traced pretty continuously in a band varying from twenty to forty-five feet in thickness. This series has been found to exhibit its characteristic fossils, in three localities in Canada. One of these is on the fifth lot of the tenth range of Bertie, where the following ascending section occurs: (243)

	Ft.	In.
Dark bluish-grey shaly dolomite	1	0
Light bluish-drab dolomite (water-lime), in beds of from one inch to one foot	3	6
Gray dolomite beds from one to eight inches	10	0
Measures concealed in an escarpment, which rises from the previous bed, but supposed, from fragments by which they are covered, to be of the same character as before	6	0
	20	6"

"Summing up the observations in the region described so far, we find that the lowest rock exposure is the so-called water-lime belonging to the Lower Helderberg formation of the New York geologists. It is mentioned in the Geology of Canada, 1863, page 354, as entering Canada opposite Buffalo, and as being exposed at various points, of which the particulars may be found as above cited. In the Report of the Bureau of Mines, 1902, page 34, Professor Coleman gives an analysis of this rock; his results, as well as others prepared for this Report and already mentioned in previous pages are tabulated below:

"The reader should compare this list with the analysis of the famous Rosendale cement rock, quoted by Professor Coleman in the Report above mentioned. It will be seen that all these analyses agree quite closely except that of the rock from Best's quarry, which shows an unusually high percentage of alumina. This rock seems not to attain a greater thickness than 40 feet, and is overlaid by the Oriskany sandstone, which presents two varieties, as already mentioned, a hard quartzite-like example, and a more friable sort composed of rounded grains of quartz with some feldspar. This rock is found just west of Port Colborne, where it forms a bed not over a foot thick. The position here, which is distinctly between the Water-lime and the Corniferous, is maintained, but with increasing thickness, towards the north, reaching south of Hagersville a maximum of about twenty feet. However, if we have rightly interpreted the well at Stratford, a thickness of 117 feet is attained at that point." (244)

Corniferous

"The formation enters Canada from New York, nearly opposite Buffalo, and is traceable, in a narrow belt, along the shore of Lake Erie, resting on the Oriskany sandstone; or where this is wanting on the Water-lime series. At Horn's quarry in Bertie, two miles below Ridgeway station, on the railway, there is a section of nearly twenty-four feet, and at various points on the lake, or at a short distance inland, sections of from ten to twenty feet have been observed, as far as Woodhouse and Middleton. In many parts it is quarried for building purposes; while some portions abound in chert, which forms beds of from one to four inches, or exists in nodules like flints in the limestone. Many of the beds contain silicified organic remains. These, in some localities, as in North Cayuga, and at Port Colborne, are found weathered out and loose, in great abundance, at the surface of the ground. Some of the beds are little more than an ag-

Locality.	Lime.	Magnesia.	Alumina and Iron Ox.	Silica.	Water.	Carbonic Acid.
Lot 28, Con. II., Humberstone	25.02	16.81	4.94	12.32	0.06	39.13
Best's Quarry	20.09	14.41	25.26	1.14	0.55	....
Quarries south of Hagersville	26.61	17.49	1.20	3.44	0.35	44.96 loss.
Springvale	31.58	17.79	5.18	3.69	0.15	44.73 loss.

(242) G.S.C., 1863, pp. 349-7.
(243) Ibid, pp. 353-4.
(244) B.M., Vol. XII., pp. 152-3.

gregate of silicified organic remains, with so little calcareous matter that the whole mass coheres after the carbonate of lime has been dissolved out. The Corniferous limestones, unlke the great mass of the Middle and Upper Silurian strata, in Western Canada [southwestern Ontario], effervesce freely with acids, and are not dolomitic. Some of the beds are marked with epsomites. as on the lake shore near Port Dover, where these impressions occur between layers of limestone and chert; the latter being apparently the overlying bed. These strata are often highly bituminous: petroleum is found in many places, filling the pores of the corals, and in one case a drusy cavity in a Pentamerus." (245)

"In working Mr. Horn's quarry, which has already been mentioned, on the thirteenth lot of the second range of Bertie, the oil is seen to impregnate particular beds, which are in great part made up of the remains of a species of Heliophyllum. These corals, in various attitudes, are arranged in bands varying in breadth from three to six inches, and in their open cells petroleum is lodged. The intermediate parts of the rock, which contain no oil, are composed of a mass of broken organic remains, chiefly encrinites, while in the coral-bearing beds these comminuted crinoids serve as a paste to fill up the interstices among the corals." (246)

"According to Mr. J. C. McRae, who was good enough to serve as guide to the region, the Corniferous limestone near Port Colborne is not more than 25 or 30 feet thick, the water-lime lying beneath it, and as one may see in Wainfleet township a thin sandstone, probably Oriskany, overlies it. The latter rock is a coarse-textured, pale gray stone, only a few inches or a foot thick where we saw it, fitting into all the fissures of the limestone below, as if the lower rocks had weathered before the sands were deposited.

"The Corniferous furnishes excellent material for lime-burning, and Messrs. Reeb & Sons have five large lime kilns some distance west of Port Colborne, near the shore of lake Erie. The limestone in their quarry is ten to fifteen feet deep, and the stone is unusually pure, containing, it is said, only a trace of magnesia. It is shipped to Hamilton as flux for the iron smelter and also to the carbide works. A large amount of lime is burnt in the kilns by a continuous process, natural gas being used as fuel" (247)

(245) G.S.C., 1863, pp. 364-8.

(246) Ibid, p. 378.

(247) B.M., Vol. XI., p. 25.

Limestone from the quarry in the Corniferous formation at Sherkston is shipped in large quantities to the iron and steel plants at Buffalo. Lime is also produced at the quarry, natural gas being used as the fuel. The cut gives a view of the kilns.

Brown's Quarry

"This quarry is in the township of Stamford, on the line between that township and Thorold, and consists of 11½ acres. It was opened about forty years ago by Messrs. Brown & Zimmerman to procure stone for the old canal, and was worked again in 1874 by Belden & Co, during the construction of the new canal.

"The land is the property of Mr. James Brown, but the three quarries upon it are worked under lease by Messrs. Walker Bros. of Merritton; they have been opened to a depth of eighteen feet.

"There are two bands of limestone, the upper of yellowish-gray and the lower of gray color. Under the gray is a bed of blue limestone, which however cannot be worked for want of drainage. Stone from the upper band is used for curbing, street crossing, flagstones and bridge works, and from the lower for monument bases and window sills.

"The firm have a mill at Merritton, which runs a gang of ten saws, where stone is cut for window sills, flagging, street curbing, etc. Four quarrymen and three stone-cutters are employed at the quarries.

The Mountain Quarry

"The Mountain quarry is on parts of lots 4 and 5 in the township of Thorold, on the town line between Stamford and Thorold, and consists of 28½ acres. It is owned by Mr. William R. Cartmell. and has been worked by him since 1854, a large quantity of stone having been taken out.

"About twelve feet of clay covers the limestone here, which has been stripped from an area of three or four acres.

"The quarry has been worked to a depth of twenty-two feet, yielding two qualities of stone. The upper bed, which is nine to ten feet in thickness, is of dark blue color and poor quality, the courses ranging in thickness from two feet at the top to six or eight inches at the bottom of the bed; the stone is used chiefly for backing work.

"The lower bed is twelve feet in thickness, and is of light gray color. It is a fine-grained stone, and is used for bases of monuments and building purposes" (248).

(248) B.M., Vol. I., p. [illegible]

Wellington

Limestones of the Clinton, Niagara, Guelph and Onondaga formations are found in this county. The quarry and lime industries are important.

Niagara Formation

"It is probable that the whole formation [Niagara] is carried westward, in a narrow spur, on the axis of a small anticlinal. The effects of this are visible in the neighborhood of Rockwood, on the Eramosa, a branch of the Speed, in the fourth lot of the fourth range of Eramosa, where there is a considerable display of the upper part of the formation. On the one side of the undulation, the strata incline nearly north, at an angle of ten degrees, and on the other nearly south, at an angle of twelve degrees. The axis of the undulation would thus run about west, which would be nearly at right angles to the general trend of the strata through this part of the country. The undulation thus appears to be a small ridge running down the general slope of the strata, and producing but little effect on the distribution. Exposures of the rock occupy both sides of the stream, in vertical cliffs. The lower part consists of nearly eighty feet of light grey dolomite, in which divisional planes of stratification appear to be absent. Corals and broken encrinites abound in it, associated with other fossils. . . . On this mass there rest about twenty feet of bluff or drab-colored dolomite, holding nodules and patches of chert; these are succeeded by about five feet of alternating black bitumino-calcareous shale, and dark brown very bituminous limestone. Corals are observed in some of these limestones, and crystals of galena are of common occurrence, both in the limestone and in the shale. In quarrying the dolomite beneath the shales at this locality, there was found a string or small vein of galena, which was followed for a distance of fifteen or twenty feet in one of the beds, to which the ore appeared to be confined. It was accompanied with smaller stringers holding the same mineral, which branched from the main one at irregular intervals; but the whole vein was quarried out without any appearance of a farther quantity of ore.

"Quarries have been opened both in the lower and upper masses of this encrinal magnesian limestone, which has been used in constructing the viaduct over the Eramosa, for the Grand Trunk Railway. That from the upper portion appears to be less porous than the lower, and of a better color for architectural purposes; but both are of excellent quality, and will probably be found durable. Caverns occur in the base of the lower mass. One of them extends about a hundred feet under the cliff, with a breadth of forty feet. The roof, which is eighteen feet high at the entrance, slopes irregularly downwards, and meets the floor at the distance just mentioned, leaving however a passage at either corner. One of these is said to lead to a large space beyond; from which other passages proceed. The roof is studded with small stalactitic incrustations.

"From Rockwood westward, the surface of the country falls at about the same rate as the supposed slope of the strata; so that, on arriving at Guelph, we should still have near the surface the beds of Rockwood, or strata not far removed from them. Exposures occur about five miles southwestward from Rockwood, at McFarlane's tavern, on the second lot of the third range, division C, of Guelph. They consist of about six feet of black bituminous shales, and limestones, similar to the highest beds at Rockwood, succeeded in ascending order by the following section, of which the last three feet belong to the Guelph formation :

"Dark brown strongly bituminous limestone, probably magnesian, in beds of about one foot each, 4 feet.

"Dark brown bituminous limestone, hard, brittle, and nearly compact, in several beds; the color is a shade lighter than the previous beds, 2 feet.

"Dark brown bituminous granular magnesian limestone, 6 feet 6 inches. inches.

"Pale buff or yellowish-white magnesian limestone, 3 feet. Total, 15 feet 6 inches.

"On the north side of the anticlinal, the summit of the Niagara series appears to run from Rockwood towards the east side of the township of Erin; between which and Mulmur it is only by the outcrop of the overlying formation that its western limit can be determined" (249)

Guelph Formation

"In Canada, the Niagara rocks are succeeded by a series of strata, which appear to be wanting in the state of New York. They are largely developed in the neighborhood of Guelph and Galt, and we have designated the series as the Guelph formation.

"The town of Guelph, in the township of the same name, is situated on the river Speed, about eight miles southwest from Rockwood. Here, in the bed of the stream, under the bridge on the

(249) G.S.C., 1863, pp. 330-31.

Brock road, there are exposed several feet of dark brown very bituminous dolomite; succeeded a little way up, on the left bank, by a mass of whitish coralline dolomite, which appears on the side of the road. About half a mile above Guelph, near the right bank of the Speed, there is a quarry in a whitish sub-crystalline dolomite, the strata of which are altogether about twelve feet thick. All the beds contain obscure casts of fossils; chiefly of corals and bivalve shells. . . . The strata are probably a little higher in the series than those of the same color at the bridge. Similar beds are extensively wrought a little below the town, and yield an excellent building stone. Some of the beds are burned for lime.

"Nearly five miles below Guelph, where a bridge crosses the Speed, on the town line between the fifth and sixth ranges of the Gore of Puslinch, there is a section, consisting, at the base, of fifteen feet of black, hard, compact, bituminous dolomite, without observed fossils ; followed by seven feet of brown bituminous strata. On these rest seven feet of buff or pale drab dolomites, holding obscure fossils. These exposures on the Speed are nearly in the strike of the strata. The light colored dolomites, which are here seen to rest upon dark colored bituminous strata. are regarded as the base of the Guelph formation." (250) (See also under Waterloo county).

"About fourteen miles north form Breslau, in Pilkington and Nichol, on the banks of the Irvine and Grand Rivers, near their junction at Elora. perpendicular cliffs of these dolomites occur, varying in height from seventy-five to eighty or eighty-two feet. The upper portion of these strata is probably near the top of the Guelph formation. The beds in descending order are as follows :

"1. Light drab or reddish compact magnesian limestone, in beds of from three to six inches, with small cavities. and cracks, lined with calcspar, 12 feet.

"2. Buff colored coralline magnesian limestone, 14 feet.

"3. Pale bluff or yellowish white compact magnesian limestone with a conchoidal fracture, in massive beds holding fossils, 56 feet. Total, 82 feet.

"At Fergus, which is on the Grand River, at such a distance above the mouth of the Irvine as would give 3 miles across the measures, a section occurs at Mr. Webster's mill, displaying about twenty feet of strata, which would underlie the preceding. About sixteen feet of these are a pale buff magnesian limestone, with casts and impressions of fossils. . . . . The remaining four feet consist of a grey hard magnesian limestone, which rests upon a mass of the same color, but somewhat closer grained, forming the bed of the stream. About a mile farther up the stream, on the land of Mr. James Webster, there are beds of pale yellowish-grey magnesian limestone weathering to a light buff. These would be still somewhat lower than the beds at Fergus. . . . Some of the Fergus beds yield good lime; they range from two inches to two feet in thickness, but are for the greater part thin and irregular, and although some of them are used for rough buildings, the stone for facing is brought to Fergus from Guelph. . . .

"The exposures which have been mentioned between Puslinch and Bentinck. belong to the upper part of the formation, and indicate the strike of its summit northward, as far as the Rocky Saugeen. In this region, with the exception of the space occupied by the westward spur of the Niagara series on the Rockwood anticlinal, the Guelph formation presents a breadth of about twenty-five miles, opposite to Puslinch, which gradually increases to thirty-five miles, opposite to Bentinck. This great breadth is probably due in part to the fact that the country rises with the general slope of the strata, to the edge of the eastern escarpment, though at a somewhat smaller angle; and in part also to a series of north and south undulations, which appear to exist in this region.

"Between Rockwood and Erin, the base of the formation forms a small sinus up the Speed, to Everton; while to the southward, it forms another sinus running down the stream to Eden. These two turns in the distribution of the rock are occasioned by an undulation transverse to the Rockwood anticlinal. Its axis, with a bearing a little east of north, would pass under Eden, Rockwood and Everton, and thence to Orangeville." (251)

"More rarely, the cavities thus formed have been filled up with calcareous matter, apparently replacing the substance of the shell; and in one place, great numbers of encrinal fragments have become replaced by a white sparry dolomite, whose color contrasts with the yellowish hue of the base. This last rock, which came from Strange's quarry, Rockwood, was, however, like the others, cellular, and a pure dolo-

(250) Ibid, 336-37.

(251) G.S.C., 1863, pp. 341-43.

mite. It was submitted to analysis, with another specimen without fossils, from the same locality, a third from Howitt's quarry, Puslinch, and a fourth from McDonald's quarry, Guelph. The first and second gave respectively .90 and .65 per cent. of insoluble sand, while the others dissolved without remainder. All of these were pure dolomites, yielding from fifty-three to fifty-four per cent. of carbonate of lime, with traces of oxyd of iron." (252)

"At Rockwood, in Eramosa, there is an exposure of more than 100 feet of crystalline dolomite belonging to the Niagara formation, in beds varying from a few inches to 10 feet in thickness. Of these, about 30 feet are nearly white, the remainder being of a light grey. This stone, which has not become discolored by exposure, has been used for the piers of the railway viaduct over the Eramosa river." (253)

"The quarries at Guelph are in the Guelph formation, and show a thickness of about fifteen feet of workable beds, which range from a few inches to three feet. The stone, which is easily worked and is of a superior kind for building purposes, has been extensively used in the town of Guelph. These dolomites are frequently somewhat cellular, but are strongly coherent." (254)

Onondaga Formation

In the townships of Maryborough and Peel, on the Canestoga, a branch of the Grand river, abundant fragments of the gypsiferous rocks mark the proximity of the outcrop of this formation.

Lime Kilns

In this county large lime-kilns are in operation at a number of points. Those at Rockwood produce a grayish-white lime from a gray, porous, fossiliferous limestone, used only for this purpose. The kilns in Guelph, at two different parts of the town, make a white lime; but the stone in addition is used for a variety of other purposes, mainly building, certain portions of the beds yielding a soft fine-textured, white stone, very easily cut and dressed. The strata, both narrow and wide, readily break into any desired size of slab for courses and sills. At Fergus and Elora are other kilns, also making white lime. The Fergus stone, at the quarry in the town, is also used extensively for road-making in some of our towns and cities.

(252) G.S.C., 1863, p. 624.
(253) Ibid, p. 821.
(254) Ibid, p. 820.

Analyses

"Dolomite.—From the Wellington quarry, south half of the twenty-ninth lot of the Gore of the township of Puslinch. Geological position,—Guelph formation, Silurian.

"A light-gray, fine crystalline, massive dolomite. It was found to have the following composition: (255)

(After drying at 100 degrees C.—Hygroscopic water = 0.05 per cent.)

Carbonate of lime		54.25
Carbonate of magnesia		45.17
Carbonate of iron		0.22
Sulphate of lime		0.34
Alumina	trace	0.08
Insoluble matter	0.08	
		100.06"

"Dolomite.—From the Priest's quarry, on the bank of the river Speed, township of Guelph. Geological position, Guelph formation, Silurian.

"A light cream-yellow, yellowish-brown weathering, very fine crystalline, compact dolomite. Its composition was found to be as follows: (256)

(After drying at 100 degrees C.—Hygrosopic water = 0.02 per cent.)

Carbonate of lime		53.97
Carbonate of magnesia		45.37
Carbonate of iron		0.16
Sulphate of lime		0.68
Alumina	trace	0.03
Insoluble matter	0.03	
		100.21"

Marl

"From a deposit three feet thick, underlying three feet of peat, in the neighborhood of the Eramosa branch of the Green river, township of Eramosa.

"The air-dried material is earthy, friable; color, light gray. It contains but few shells or root fibres.

"Its composition was found by Mr. F. G. Wait to be as follows:

(After drying at 100 degrees C.—Hygroscopic water equals 0.76 per cent.)

Lime	43.71
Magnesia	0.76
Alumina	0.16
Ferric oxide	0.29
Potassa	traces
Soda	traces
Carbonic acid	34.87
Sulphuric acid	0.34
Phosphoric acid	0.03
Silica, soluble	0.33
Insoluble mineral matter	10.36

(255) G.S.C., 1895, p. 17 R.
(256) Ibid, pp. 16-17 R.

Organic matter, viz., vegetable fibre, in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water	9.79
	100.64

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 78.05 per cent. carbonate of of lime.

"The insoluble mineral matter was found to consist of: (257)

Silica	7.74
Alumina	1.52
Ferric oxide	0.37
Lime	0.24
Magnesia	0.08
Alkalies (?)	0.41
	10.36"

A Drill Section

"A record has also been obtained from a boring made at Guelph, where we find:

	Feet
Drift	15
Blue slate	50
Niagara and Guelph	100
Gray slate	5
Red slate	5
Gray slate	10
Blue slate	2
Clinton	10
Blue slate	20
Hard limestone	7
Blue shale	8
Medina sandstone	12
Blue shale	7
Red Medina	400
Hudson river	500
Utica	300
Trenton	110
Total	1,562

"From the top of the Trenton to the surface of the rock at Guelph is therefore 1,437 feet. Assuming the thickness of the various strata to be approximately the same at St. Marys, we get the surface rock at Guelph to lie in the middle of the 716 feet of limestone recorded at Stratford. This would make 323 feet of Guelph limestone removed by erosion at that place. On the other hand, if we consider the 50 feet of blue shale as analogous to the 40 feet at Stratford, then the 716 feet represent the Niagara and Guelph, showing therefore a considerable increase in thickness towards the west. At Guelph this slaty bed lies 15 feet down, and at Stratford 546 feet. Subtracting these figures from the elevations of the respective places (1057 and 1207 feet above the sea) we find that the dip of the beds is 381 feet in the 40 miles separating the two places. This however must not be considered the true dip, which is in a more southwesterly direction and would therefore be somewhat greater. Quite recently a well was sunk at St. Marys, the record of which, whether by accident or design, seems to have been very carelessly preserved. The following notes are due to Mr. Thomas Cox, who had a certain interest in the drilling:

Water at 550 feet.

Brine at 985 feet.

Sulphur water at 1185 feet.

In gray Medina sandstone at 1510 feet." (258)

Wentworth

In the escarpment which runs through this county representatives of three formations are found. At the base of the escarpment, where not covered by talus, the red shales of the Medina are exposed; above and resting on these is the Clinton limestone, on which rest the shales and limestones of the Niagara formation which forms the summit of the escarpment. The limestones in these formations are magnesian, and are thus not adapted for use in certain industries. In the vicinity of the city of Hamilton, and elsewhere in the county there are important quarries which produce stone for structural purposes. A considerable amount of the stone is crushed and used in the paving of streets and roadways. The limestone for the Hamilton blast furnace is also quarried in the county.

"Proceeding westward [along the escarpment of which the upper part is composed of the Niagara formation,] the volume of the black shales diminishes, while that of the limestones beneath them augments; and in the neighborhood of Hamilton and Ancaster, we have the following succession, in ascending order:

"1. Light grey magnesian limestone, weathering yellowish, and holding Pentamerus oblongus in great abundance; 1 foot 6 inches.

"Grey magnesian limestone, with geodes of calcspar in the lower, and

(257) G.S.C., 1891, p. 29 R.

(258) B.M., Vol. XII., p. 150-51.

broken encrinites in the upper part; 9 feet 3 inches.

"2. Bluish argillaceous and arenaceous shale, with thin bands of sandstone; 5 feet.

"Grey arenaceous limestone; 3 feet 5 inches.

"Bluish shale; 1 foot.

"Bluish-grey argillaceous limestone, with geodes of calcspar; this is probably fit for water cement; 5 feet 7 inches.

"3. Whitish limestone, with geodes of calcspar, containing nodules and patches of chert in considerable abundance; 16 feet 6 inches.

"4. Bluish-black bituminous shale, with thin bands of limestone holding fossils; the shale, which is in very thin laminae, presents surfaces covered with bituminous matter, and nodules of chert are sometimes met with in the limestone; 6 feet.

"5. Grey, strongly bituminous limestone, very unevenly deposited; 5 feet.

"Reddish grey, drab-weathering, bituminous, magnesian limestone, moderately thin-bedded; with partings of bituminous shale. The limestone holds disseminated crystals of galena associated with pearl-spar; 5 feet.

"6. Grey compact tough magnesian limestone; 3 feet.

"Bluish magnesian limestone, weathering into small pits on the surface, and containing small nodules of a carbonaceous matter, resembling coal; 3 feet.

"Blue and grey compact magnesian limestones; 3 feet.

"Gray compact magnesian limestone; 3 feet.

"Bluish magnesian limestone, weathering into irregular pits on the surface of the beds; the rock holds small masses or carbonaceous matter as above; 3 feet.

"Bluish-grey compact magnesian limestone, presenting under the influence of the weather a rough pitted surface, 5 feet.

Total 78 feet 3 inches.

"The limestones, 5, which overlie the black shales, 4, form the upper part of the ridge which extends between the falls of Niagara and the village of Ancaster. They are highly bituminous, and for the most part magnesian for the whole distance; and they abound in fine cabinet specimens of selenite, celestine, pearl-spar, blende and galena. Crystals of the latter mineral exist in greater or less quantity, in nearly all the limestones from the Pentamerus band to the summit of the upper beds; but they are in the greatest abundance in the latter . . . .

"Northward from this the black shale, 4, maintains for a few miles the thickness which it presents in the last section, and it is recognized above the beds already described as composing the Clinton formation, on the sixteenth and seventeenth lots of the first range of Flamborough West, near Dundas. In ascending order these succeeding beds are:

"1. Grey magnesian limestone, with Pentamerus oblongus in abundance; 1 foot.

"2. Blue magnesian limestone, in very even and regular beds, of which the thickest are from sixteen to eighteen inches; separated by partings of bluish-grey shale. The limestone is used for building purposes; 7 feet.

"3. Light grey magnesian limestone in one bed; this is used for building purposes and is known by masons and quarrymen as the five foot band; 5 feet 6 inches.

"4. Bluish-grey calcareo-arenaceous shale, passing into black; it is hard and solid in the bed, but disintegrates and crumbles into a clay when exposed to the atmosphere, with the exception of thin interstratified beds, which resist the weather; 6 feet.

"5. Bluish-grey magnesian limestone, composed chiefly of broken encrinites. The beds are from three to four feet thick, and are separated by very thin layers of buff colored argillaceous shale. This limestone forms an excellent building stone, for which it is used, as well as for burning lime; 19 feet 3 inches.

"6. Dark bluish-grey argillaceous shale; this is a well marked band, and may be traced for some distance on the strike; 1 foot.

"7. Blue and grey limestone, including bands of white, buff and grey chert, and thickly studded with chert nodules; 20 feet.

"8. Brownish bituminous magnesian limestone, with small disseminated crystals of galena, and a few fossils; 10 feet.

"9. Grey bituminous magnesian limestone in rough irregular beds; 5 feet.

"10 Measures concealed; 5 feet.

"11. Black bituminous magnesian limestone in thin irregular layers; 2 feet.

"12. Black bituminous shale; 1 foot.

"13. Dark brown very bituminous magnesian limestone, in thin beds, with rough irregular surfaces; 2 feet.

"14. Dark brown bituminous magnesian limestone, holding disseminated crystals of galena; 5 feet.

"15. Black fissile shale; 2 feet.

"16. Dark very bituminous magnesian limestone, with black shale at the top, and with numerous fossils; 3 feet.

"17. Dark brown bituminous magnesian limestone; 2 feet.

"18. Black bituminous shaly limestone; 1 foot.

"19. Measures concealed; 2 feet.

"20. Black bituminous magnesian limestone, with obscure fossils in the lower part; 8 feet.

"21. Dark grey slaty limestone in thin layers, with an occasional band of six inches ; 4 feet 6 inches.

"22. Dark brown bitumino-arenaceous shale, with fossils; 6 inches.

"23. Brownish bituminous limestone, with partings and thin bands of dark brown bituminous shale; 15 feet.

Total, 127 feet 9 inches.

"In this section the black shale of the Niagara Falls is supposed to be represented by the bed, 4, underlying the massive encrinal limestones, 5; but it produces no marked feature in the form of the surface.

"The rocks of the section in the neighborhood of Dundas, however, form two separate and distinct terraces. The lower and more marked escarpment presents the strata beneath the band of cherty limestone, 7, which caps the precipice at Flamborough West. The upper escarpment,composed of the dark colored bituminous magnesian limestones and their accompanying beds, rises more gradually, in a succession of steps; terminating at the summit in a wide extent of table-land." (259)

Niagara Formation

"Across the whole of the western peninsula, the summit of the Niagara formation is so much covered with drift, that it would be very difficult to trace it with any degree of precision; or to connect in an intelligible manner the scattered exposures of Niagara strata to the westward, with the rocks of the lower escarpment, were it not for the aid afforded by the outcrop of the succeeding rock. Above the east end of the Niagara and Hamilton ridge, the upper limit of the formation probably reaches the lower part of the Chippewa Creek; and passing by Port Robinson on the Welland Canal, it may cross the road between Hamilton and Port Dover, within two or three miles of the former place. It is not, however, certain where it folds over the Dundas anticlinal, there being no exposures whatever upon the axis. The most western appearance of the upper part of the formation, on the south side of the anticlinal, occurs in the vicinity of Ancaster; the most western on the opposite side, about two miles north of Ancaster, on the third lot of the first range of Flamborough West. It may be inferred from the trend of the formation on each side, and from the general shape of the country, that its summit would fold over the axis of the anticlinal, on the line between the townships of Ancaster and Beverley, at about the thirty-fourth lot." (260)

(259) G.S.C., 1863, pp. 323-27.

(260) Ibid, p. 329.

"Between the head of the inclined railway at Hamilton and the village of Ancaster no rock exposures are seen; at this latter point however, we may pass over the edge of the escarpment and encounter Niagara limestones where the main road from Hamilton enters the village. Here several quarries are in operation. One owned by Mr. Middleton is situated on the north side of the road, and presents at the top five feet of so-called honeycomb rock. This is a cavernous limestone the spaces in which are lined by small quartz crystals or filled with gypsum and, in some instances, barite. In the better preserved parts of the honeycomb these cavities are seen to arise from the weathering away of masses of a favositoid coral probably Favosites gothlandica. This rock is said to make a sandy lime and consequently is used mostly as road metal. The next stratum is a heavy limestone bed in which fine crystallization has obliterated all trace of fossils. This bed is somewhat shattered in places by jointing, but still furnishes large quantities of excellent building stone. Underlying the bed are three feet of thin limestones, five feet of well laminated limestone, five feet of solid finely crystalline limestone said to chisel excellently, and eight inches of loose material. On the opposite side of the road quarries have been opened by Messrs. Guest and Hendrie which present practically the same series of rocks. An analysis of the best rock from these quarries shows it to be a typical dolomite with the following composition : (261)

	Per cent.
Moisture	0.23
Insoluble matter	1.60
Carbonate of lime	53.30
Carbonate of magnesia	43.13"

"Dundas, Ontario.—At this locality the Niagara formation also affords a dolomite, a specimen of which proved on analysis to contain much more carbonate of magnesia than was found in the specimen from the same formation at Grimsby. The analysis gave:

Carbonate of lime	51.58
Carbonate of magnesia	41.65
Carbonate of iron	0.62
Insoluble matter	5.88
	100.00

"The specimen was brownish-grey, compact and rather earthy" (262)

Quarries

The limestone from the quarry near Rymal station, used as a flux at the Hamilton blast furnace, is said by the

(261) B.M., Vol. XII., pp. 141-42.

(262) G.S.C., 1876-77, p. 487.

chemists there to have approximately the following percentage composition :

Lime....	30.54
Magnesia....	19.50
Alumnia and ferric oxide	0.94
Silica	0.33

The rock from the quarry at Vinemount, Hamilton, is said to be of about the same character, but tends to possess more sulphur and silica.

Barnes' quarry at Rymal has a face of about 21 feet, with a thin layer of soil at the surface. This stone is better suited for furnace use than that near the face of the escarpment, the upper layers of which contain chert nodules. There are one or two other small quarries near Rymal.

From the drill hole put down to a depth of 200 feet, it is said, from the surface in Barnes' quarry, gas and salty water spout up a short distance at intervals. The gas forces up the water and burns when lighted at the end of the iron pipe set into the hole.

An average analysis of the stone from Barnes' quarry used at the Hamilton blast furnace for a considerable period, is given on a preceding page, in the section devoted to smelting.

York

Rock exposures in the greater part of this county are few in number. The southern part is underlaid by the Hudson River formation, and exposures are seen along the courses of the streams. The Utica and Trenton formations, which run in bands across the northern part, are covered heavily with drift material.

The Bureau of Mines has received returns of lime production from the vicinity of Baldwin, Vachell and Virginia post offices, in the township of Georgina. This lime is apparently derived from drift boulders or "field stone," which have been transported from the northeastward during the ice period.

"Between the river Rouge in the township of Pickering [Ontario county] on the east, and the river Credit in the township of Toronto [Peel county] on the west, sections of the Hudson River formation may be seen on almost all the intervening streams. The formation here consists of a series of bluish-grey argillaceous shales, enclosing bands of calcareous sandstone, sometimes approaching to a limestone, at irregular intervals and of variable thickness. In some instances the bands are of a slaty structure, splitting into thin laminae in the direction of the beds; in others they have a solid thickness of a foot; but in few cases do they maintain either character for any great distance. The sandstones, while in the beds, are hard and solid, and upon fracture exhibit a gray color, with much of the appearance of limestone; but by long exposure to the weather they turn to a dark brown, and ultimately crumble and decay. These sandstones generally abound in calcareous fossils, which in some places predominate so as to give rise to beds of impure limestone; these beds are however rare. . . .

"The banks of the Credit, the Etobicoke, the Minaco, the Humber and the Don, for certain distances from the lake shore, expose sections exhibiting sixty feet or more of these strata; but advancing northward, the formation becomes concealed by the great accumulation of drift, of which the interior of the country is composed. At Weston, on the Humber, near to the townships of Etobicoke and York, some good limestone occurs, and at Fisher's mill, below Dundas Street, on the same river, there is more of the same material. At the latter place, the banks of the stream rise to a height of more than a hundred feet, of which from fifty to sixty are composed of the Hudson river shales and sandstones, while the upper part consists of sand and gravel." (263)

"In the township of York, on a small tributary of the Don, beds of tufa occur from twelve to fifteen feet in thickness, and are overlaid by sand and clay" (264)

It is interesting to know that drill holes, which have been put down in the vicinity of Toronto, in search of gas and oil, after passing through the Hudson river and underlying Palaeozoic formations, have penetrated crystalline limestone of the Archaean system.

(263) G.S.C., 1863, pp. 212-213.

(264) Ibid, p. 455.

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Sclater's quarry, St. Marys; another view. Perth County

St. Marys quarries. Product used for building, and waste rock for road metal. Opening is 200 by 400 feet, and 20 feet deep. Perth County.

Horseshoe Quarry, St. Marys. Product, building stone. Perth County.

Lime kiln at Galt (Standard White Lime Co.) Old "set" kiln, one of a series of three. Waterloo County.

Lime kilns at Sherkston quarry, using natural gas as fuel. Welland County.

One of the crushers at Sherkston quarry. Welland County

E. Harvey's limestone quarries at Rockwood. Wellington County.

E. Harvey's lime kiln. Rockwood. Quarry above and to right. Wellington County.

Roman Catholic Cathedral, Guelph ; built of limestone from Guelph quarries (Guelph formation).

"Kennedy's" quarry and kilns, Guelph. (Standard White Lime Co.) Wellington County.

"Kennedy's" kilns, Guelph, (Standard White Lime Co.) Wellington County.

"Kennedy's" quarry, Guelph, (Standard White Lime Co.) Product used for building, and waste rock burned to lime. When taken out, stone is soft and easily worked, but hardens on exposure.

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Ontario, Legislative Assembly
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Vol. 36, pt. 2, 1904.

Map to accompany
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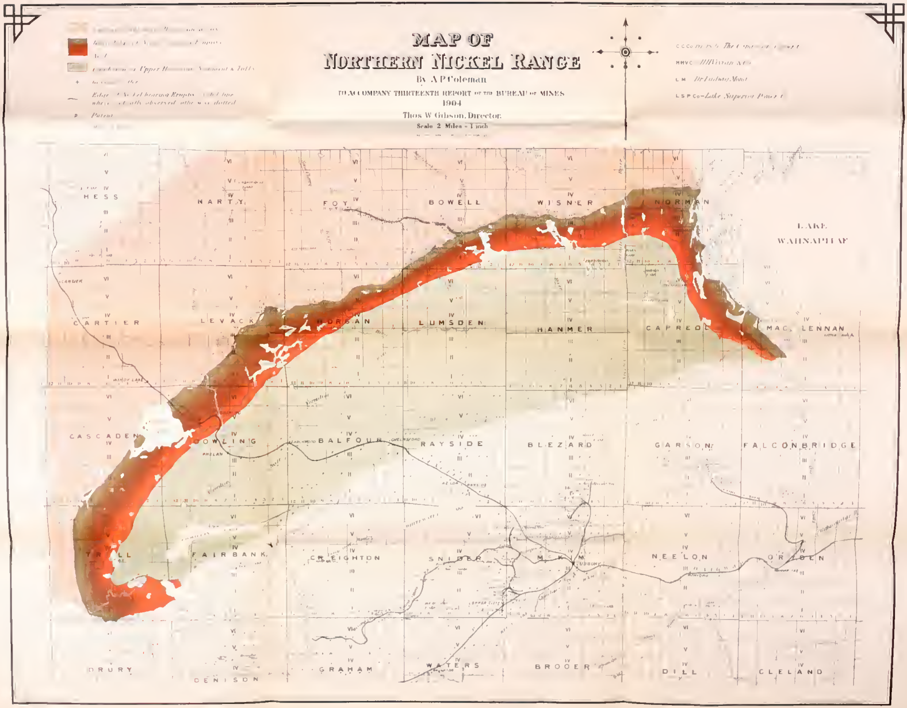
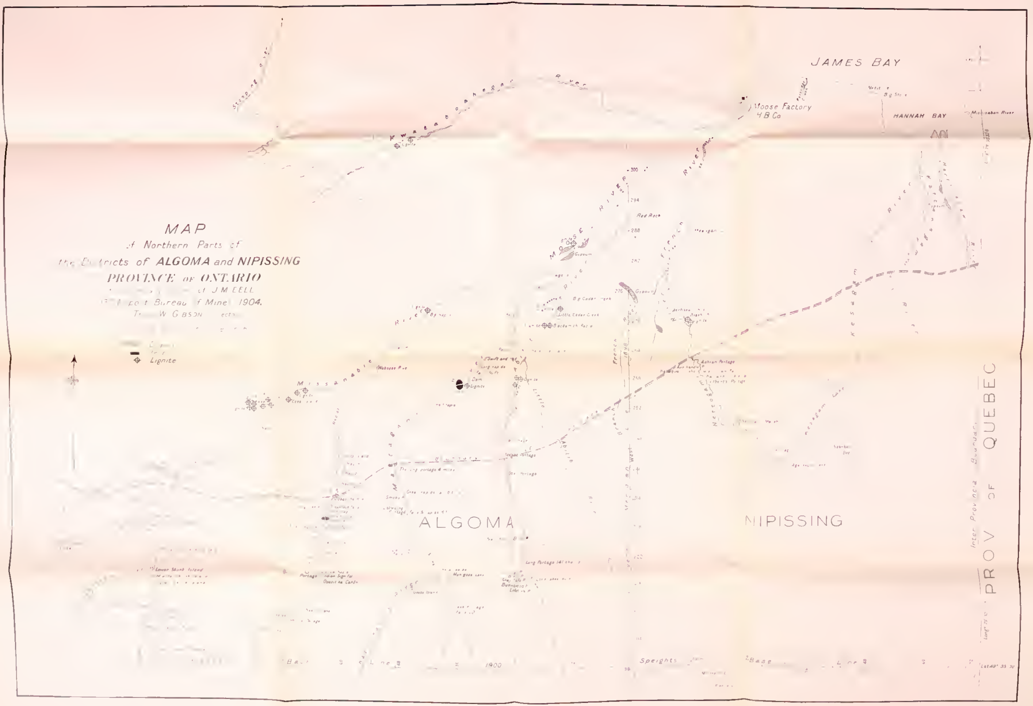


MAP OF
NORTHERN NICKEL RANGE
By A P Coleman
TO ACCOMPANY THIRTEENTH REPORT OF THE BUREAU OF MINES
1904
Thos W Gibson, Director.
Scale 2 Miles = 1 inch
HESS
NARTY
FOY
BOWELL
WISNER
NORMAN
LAKE WAHNAPITAE
CARTIER
LEVACK
MORGAN
LUMSDEN
HANMER
CAPREOL
MAC LENNAN
CASCADEN
DOWLING
BALFOUR
RAYSIDE
BLEZARD
GARSON
FALCONBRIDGE
TRILL
FAIRBANK
CREIGHTON
SNIDER
McKIM
NEELON
DRURY
DENISON
GRAHAM
WATERS
BROOER
DILL
CLELAND


MAP
Northern Parts
Districts of ALGOMA and NIPISSING
PROVINCE OF ONTARIO
J M BELL
Bureau of Mines 1904.
W GIBSON
Lignite
JAMES BAY
Moose Factory
H B Co
HANNAH BAY
MOOSE RIVER
French
Gypsum
Red Rock
Big Cedar Creek
Little Cedar Creek
Lignite
Abitibi
Missinaibi
Mattagami
Adahan Portage
Long Portage 141 chs
Speights
Base Line
1900
ALGOMA
NIPISSING
Inter Provincial Boundary
PROV OF QUEBEC
Lower Skunk Island

Ontario. Legislative Assembly
Sessional papers.
Vol. 36, pt. 2, 1904.

Map to accompany
13th Report of the
Bureau of Mines
(2)

(Ses. Pr. 5
1904)


LAKE IROQUOIS
by
A. P. COLEMAN.
PARTS IN NEW YORK AFTER H. L. FAIRCHILD
Thirteenth Report of the Bureau of Mines 1904
THOS. W. GIBSON, DIRECTOR
Drawn by S. B. Woss
Present Shore Line
Scale
NORTHUMBERLAND
PRINCE EDWARD CO.
Peterborough

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