New York State Museum Bulletin

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The University of the State of New York

New York State Museum

John M. Clarke, Director

THE MINING AND QUARRY INDUSTRY OF NEW YORK STATE

REPORT OF OPERATIONS AND PRODUCTION DURING 1915

BY

D. H. NEWLAND

ALBANY

THE UNIVERSITY OF THE STATE OF NEW YORK

1916

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The University of the State of New York
Department of Science, July 17, 1916

Dr John H. Finley
President of the University

Sir:

I beg to communicate to you herewith the manuscript of the *Mining and Quarry Industry of New York State: Report of Operations and Production During 1915,* prepared by David H. Newland, Assistant State Geologist, and to recommend its publication as a bulletin of the State Museum.

Very respectfully
JOHN M. CLARKE
Director

THE UNIVERSITY OF THE STATE OF NEW YORK
OFFICE OF THE PRESIDENT

Approved for publication this
24th day of July 1916

President of the University

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JOHN M. CLARKE, *Director*

THE MINING AND QUARRY INDUSTRY OF NEW YORK STATE

REPORT OF OPERATIONS AND PRODUCTION DURING 1915

BY

D. H. NEWLAND

INTRODUCTION

The mineral industries of the State, as represented by the branches engaged in mining and quarry operations, were not very prosperous during 1915. The conditions in certain restricted lines were fairly good and generally the tendency was toward improvement as the year advanced, but on the whole they did not conduce to activity and large outputs, as was the case in many allied lines of metallurgy and chemical manufacturing. The slump that developed out of the foreign situation still manifested an influence upon many of the industries.

The poorest showing of all was that made by the producers of structural materials — cement, stone and clay wares. There was a slackening in the demand for many of these materials, and prices consequently fell off sharply from competition among sellers for trade.

A feature of more than passing interest in the year's record of events was the inauguration of active ore shipments by the newly opened zinc mines at Edwards, St Lawrence county. The ore is included for the first time in the list of local mineral products. As yet there has been no extended development undertaken aside from that by the Northern Ore Co., at Edwards, although there are many showings and prospects in the district which as now defined extends from Edwards to the vicinity of Sylvia lake.

From the summary of the year's reports rendered by the individual enterprises it appears that the value of the total production of ores and mineral materials amounted to $35,988,407. This represented a slight gain over the corresponding figure for 1914, which was reported as $35,870,004. The increase, however, was more apparent than real for it did not equal the actual increment arising from the entrance of new enterprises in the list of producers.

The products on which the valuations noted are based number over thirty, and with few exceptions represent the materials as they come from the mines and quarries without elaboration or manufacture, except so much as is necessary to put them in marketable form. They do not include secondary products like iron and steel, sulphuric acid, aluminum, carborundum, calcium carbide, artificial graphite, alkali products, etc., the manufacture of which constitutes a large industry by itself, with an annual output of a much greater value than that returned by the industries covered in this report.

Among the metallic minerals, iron ore ranks first in importance as regards value of output. The gross amount of ore hoisted from the mines last year was 1,365,064 long tons, which after allowance for shrinkage in concentration — practised by the Adirondack magnetite mines — left 944,403 long tons of shipping product valued at $2,970,526. In the preceding year the amount of ore hoisted was 1,122,221 long tons and the output of furnace ore and concentrates 751,716 long tons valued at $2,356,517. The market for iron ore improved rapidly during the year and there is every prospect of an active demand for the current season.

The clay-working industries are first in importance in regard to value of the annual production. Last year they returned an aggregate output valued at $10,002,373, compared with $9,475,219 in the preceding year. Most of the gain indicated was contributed by the potteries, whereas the manufacture of structural materials in most cases was smaller than in 1914. Another branch that reported a decline was the paving brick industry, which experienced a diminished demand for the material owing to temporary conditions.

Cement production was on a reduced scale, but this was partly accounted for by the shutdown of one of the larger mills for several months owing to a disastrous landslide. The market was fairly active, but prices were so low as to afford little profit to makers. The output of portland cement amounted to 5,219,460 barrels valued at $4,175,528, against 5,667,728 barrels with a value of $5,088,677 in 1914. Natural cement did not vary much from the previous year's total, having been 223,564 barrels worth $134,138, against 232,076 barrels worth $115,117 in 1914.

There was a big decrease in stone products which was distributed among practically all branches of the quarry industry. The value of the entire output was $5,162,115 against $5,741,137 in the preceding year. The completion of some of the large engineering contracts on the canal and road systems of the State accounted in a measure for the decrease, although construction work in general was not so active as ordinarily. The granite quarries made the best showing and there is prospect of additional quarries being opened during the current year.

The salt mines and wells reported a record yield of 11,095,301 barrels, which exceeded the largest previous total — that for 1913 — by about 275,000 barrels. The value was reported as $3,011,932. In 1914 the output was 10,389,072 barrels valued at $2,835,706.

In the gypsum industry no material change took place and the output of 516,002 tons was practically the same as reported in the preceding year. The value of the products sold by the mining companies was $1,261,200 as compared with $1,247,404 in 1914.

The natural gas industry which had increased largely in recent years showed a considerable decline in the past season for which the flow amounted to 7,110,040,000 cubic feet against 8,714,681,000 cubic feet in 1914. The falling off was mainly in Erie county, where no new discoveries have been made recently that suffice to counterbalance the declining yield of the old wells. The value of the gas sold was $2,085,324, against a value of $2,570,165 reported for 1914. The oil wells of Allegany, Cattaraugus and Steuben counties contributed a total of 928,540 barrels as compared with 933,511 barrels in the preceding year. Prices showed an upward turn after a precipitate decline of over $1 a barrel, but the change was too late to show itself in the value which amounted to $1,476,378 against $1,773,671 in 1914.

Among the other branches of the mineral industry that shared in the activities were those of talc, graphite, garnet, pyrite, slate, mineral paints, mineral waters, emery, feldspar, quartz, molding and building sand, sand-lime brick, marl and zinc ore. One of the few of these that experienced an enlarged demand for its products were the emery mines in Westchester county which reported an output of 3895 short tons against 763 short tons in 1914. The Adirondack garnet mines contributed 3900 short tons of that mineral as compared with 4026 tons in 1914. The talc mines were adversely affected by market conditions which are largely governed by the state of the paper trade. They contributed a total of 65,914 short tons, or a little less than in the preceding year.

Mineral production of New York in 1914

PRODUCT	UNIT OF MEASUREMENT	QUANTITY	VALUE
Portland cement	Barrels	5 667 728	$5 088 677
Natural cement	Barrels	232 076	115 117
Building brick	Thousands	943 241	4 703 295
Pottery	....	....	2 405 676
Other clay products	....	....	2 366 248
Crude clay	Short tons	7 109	12 424
Emery	Short tons	63	9 105
Feldspar and quartz	Short tons	23 751	117 390
Garnet	Short tons	4 026	134 940
Graphite	Pounds	2 483 339	151 143
Gypsum	Short tons	513 094	1 247 404
Iron ore	Long tons	751 716	2 356 517
Millstones	....	....	12 410
Metallic paint	Short tons	7 321	88 720
Slate pigment	Short tons	1 182	9 620
Mineral waters	Gallons	8 480 669	769 932
Natural gas	1000 cubic feet	8 714 681	2 570 165
Petroleum	Barrels	933 511	1 773 671
Pyrite	Long tons	61 513	266 930
Salt	Barrels	10 389 072	2 835 706
Sand and gravel	....	....	2 212 087
Sand-line brick	Thousands	17 696	111 326
Roofing slate	Squares	4 998	40 650
Granite	....	....	367 242
Limestone	....	....	3 316 063
Marble	....	....	230 242
Sandstone	....	....	1 056 990
Trap	....	....	770 600
Talc	Short tons	74 075	671 286
Other materials *a*	....	....	58 428
Total value	....	....	$35 870 004

a Includes apatite and marl.

Mineral production of New York in 1915

PRODUCT	UNIT OF MEASUREMENT	QUANTITY	VALUE
Portland cement	Barrels	5 219 460	$4 175 528
Natural cement	Barrels	223 564	134 138
Building brick	Thousands	951 329	5 040 306
Pottery			3 064 274
Other clay products			2 234 804
Crude clay	Short tons	13 745	28 684
Emery	Short tons	3 895	42 591
Feldspar and quartz	Short tons	22 196	93 152
Garnet	Short tons	3 900	134 064
Graphite	Pounds	2 500 000	162 000
Gypsum	Short tons	516 002	1 261 200
Iron ore	Long tons	944 403	2 970 526
Millstones			10 916
Metallic paint	Short tons	4 925	45 050
Slate pigment	Short tons	673	5 960
Mineral waters	Gallons	8 636 920	745 530
Natural gas	1000 cubic feet	7 110 040	2 085 324
Petroleum	Barrels	928 540	1 476 378
Pyrite	Long tons	57 241	265 362
Salt	Barrels	11 095 301	3 011 932
Building sand	Cubic yards	4 127 508	1 185 812
Molding sand	Short tons	454 511	415 073
Other sand *a*			1 065 133
Sand-lime brick	Thousands	18 226	115 912
Slate	Squares		45 000
Granite			422 597
Limestone			3 177 700
Marble			120 447
Sandstone			890 411
Trap			550 960
Talc	Short tons	65 914	576 643
Zinc ore	Short tons		*b*
Other materials *c*			435 000
Total value			$35 988 407

a Includes also gravel. *b* Reported under "Other materials." *c* Includes zinc ore, marl and apatite.

CEMENT

BY ROBERT W. JONES

At the beginning of 1915 there was little cement construction work in sight, and manufacturers in general began to cut their rate of production in order to reduce the accumulated stock held over from 1914.

The price of cement in the New York market, allowing for the refund on bags at the rate of 7½ cents a bag with four bags to the barrel, opened at $1.28 a barrel. This was a trifle lower than for the preceding year although the demand was about the same. In February the price dropped to $1.12, although for other sections of the United States it still held at the previous monthly average. During March there was a falling off in demand and prices in general were reduced, though the New York market price remained at the February level. An unfortunate disagreement between the producers of the Hudson River region and the Lehigh district occurred and cement sold in April on the New York market at 92 cents a barrel. This was only a local reduction, and nearby cities were not affected to as great an extent. In May a large amount of cement was sold for future delivery at 93 cents. During June, July and August the market continued at the same low level, with an average price of 92 cents. In September the price rose to $1.12, in October and November to $1.27 and the year closed at the high price of $1.32.

The production in New York State amounted to 5,219,460 barrels with a value of $4,175,528 as compared with 5,667,728 barrels and a value of $5,088,677 for 1914. This drop in production resulted chiefly from the temporary closing of one plant during the entire year and of two plants in the Hudson River region for several months.

There were seven plants in active operation during 1915. In August 1914, the Cayuga Lake Cement Corporation took over the plant of the Cayuga Lake Cement Company at Portland Point, Tompkins county, with the intention of enlarging the plant from a daily capacity of 800 barrels to 2000 barrels. This plant made no production during 1915. The Acme Cement Corporation began the active reconstruction of the plant formerly owned by the Seaboard Cement Company. This plant, which has never been operated, was designed to produce cement by a dry method. Under the new management changes in methods of operation have been made and the production will be by wet method. Several attempts have been made on a small scale to produce cement with potash as a by-product. It is understood that during the present year construction work will be begun on a plant to be operated along this line.

During 1915 there was a decline in the output of natural cement although on account of the portland cement market conditions the price per barrel realized at the New York market was higher than for 1914. The output amounted to 223,564 barrels with a value of $134,138 as compared with 232,076 and a value of $115,117 for 1914. Nearly the entire output comes from the Rosendale region. There were three active plants in the State.

Production of cement in New York

YEAR	PORTLAND CEMENT		NATURAL CEMENT	
	Barrels	Value	Barrels	Value
1895	59 320	$278 810	3 939 727	$2 285 094
1896	260 787	443 175	4 181 918	2 423 891
1897	394 398	690 179	4 259 186	2 123 771
1898	554 358	970 126	4 157 917	2 065 658
1899	472 386	708 579	4 689 167	2 813 500
1900	465 832	582 290	3 409 085	2 045 451
1901	617 228	617 228	2 234 131	1 117 066
1902	1 156 807	1 521 553	3 577 340	2 135 036
1903	1 602 946	2 031 310	2 417 137	1 510 529
1904	1 377 302	1 245 778	1 881 630	1 207 883
1905	2 117 822	2 046 864	2 257 698	1 590 689
1906	2 423 374	2 766 488	1 691 565	1 184 211
1907	2 108 450	2 214 090	1 137 279	757 730
1908	1 988 874	1 813 622	623 588	441 136
1909	2 061 019	1 761 297	549 364	361 605
1910	3 364 255	2 939 818	292 760	147 202
1911	3 416 400	2 930 434	274 973	134 900
1912	4 495 842	3 488 931	287 693	142 165
1913	5 146 782	4 873 807	193 975	95 565
1914	5 667 728	5 088 677	232 076	115 117
1915	5 219 460	4 175 528	223 564	134 138

CLAY

BY ROBERT W. JONES

The year 1915 opened with building activities at a somewhat lower level compared with the corresponding period of the preceding year. This was the condition of affairs, particularly, in and near the city of New York. The smaller cities and villages of the State showed, in most cases, a decided improvement although not enough to bring the average materially above that for 1914. It was not until late summer that any decided upturn was noticed and then the monthly average was carried much higher than the corresponding months of 1914. Due to the greatly increased construction along certain industrial lines, there was a greater demand for electrical ceramic ware.

The following table gives the value of the output of clay materials in the State for the last three years:

Production of clay materials

MATERIAL	1913	1914	1915
Common brick	$5 938 922	$4 597 856	$4 886 734
Front brick	99 736	105 439	153 572
Paving brick	576 970	680 226	382 502
Hollow brick	44 265	38 119	59 683
Fireproofing	276 053	245 034	177 844
Terra cotta	1 113 322	892 630	647 815
Fire brick and stove lining	371 408	331 671	502 478
Drain tile	134 199	92 938	91 221
Sewer pipe	154 646	81 000	*a*
Pottery	3 367 187	2 405 676	3 064 274
Miscellaneous	1 164	4 630	36 250
Total	$12 077 872	$9 475 219	$10 002 373

a Included under miscellaneous.

One hundred sixty-five individuals or corporations reported a production of clay materials, as compared with 190 during 1914. This does not necessarily involve a like falling off in active yards and plants. During the past season there were, in the Hudson River district, several combinations of the larger yards under closer management. Labor troubles also caused a few yards to close early in the season and a few for the same reason made no attempt to produce. There were during the year 79 idle plants situated in 27 counties. Common brick, front brick, common hollow brick, fire brick and stove lining and pottery showed gains over 1914.

The total number of building brick manufactured during the year was 951,329,000 with a value of $5,040,306 as compared with 943,-241,000 and a value of $4,703,295 for 1914. Of this number, 41,896,000 with a value of $290,003 were made by the wire-cut process. Paving brick fell from a production of 46,696,000 to 26,154,000 with a value of $680,226 and $382,502 respectively. Fireproofing fell from $245,034 to $177,844; terra cotta from $892,630 to $647,815; drain tile from $92,938 to $91,221. Even with this considerable falling off in some articles there was a total gain, over 1914, although still far below the production of 1913.

Thirty-four counties reported a production of clay products of which 29 had a production of common building brick. Eight counties reported a production of common hollow brick, 4 of front brick, 8 of drain tile, 4 of paving brick, 6 of fireproofing, 3 of terra cotta, 8 of pottery and 5 of fire-resisting forms.

The total value of clay products including miscellaneous wares but not including crude clay was $10,002,373 as compared with $9,475,219 for 1914. In value of products Onondaga county held first place with a total of $1,293,022 as compared with $1,556,093 for 1914. Ulster county was second with a production of $1,059,377 as compared with $895,126 for 1914. The production from Onondaga county consisted mainly of pottery with a value of $1,132,306, while that of Ulster county consisted entirely of common soft-mud building brick. Livingston county was third in value of production with $724,267. Counties reporting gains during the year were Albany, Cayuga, Columbia, Dutchess, Kings, Livingston, Niagara, Oneida, Ontario, Orange, Richmond, Saratoga, Schenectady, Ulster and Washington.

The following table gives the total value of clay products by counties for the last three years:

Production of clay materials by counties

COUNTY	1913	1914	1915
Albany	$473 325	$369 312	$447 344
Broome	*a*	*a*	*a*
Cattaraugus	275 763	334 557	180 290
Cayuga	5 800	8 765	9 800
Chautauqua	147 451	168 134	128 798
Chemung	*a*	*a*	*a*
Clinton	*a*	*a*	....
Columbia	307 571	198 866	271 672
Dutchess	634 043	430 269	491 156
Erie	1 000 055	819 427	710 101
Greene	290 116	196 889	130 093
Kings	539 002	449 839	489 264
Livingston	200 248	73 775	724 267
Monroe	278 145	168 463	98 863
Montgomery	*a*	*a*	*a*
Nassau	109 051	96 534	92 559
New York	*a*	....	....
Niagara	55 469	38 213	44 188
Oneida	84 714	45 000	159 400
Onondaga	1 613 395	1 556 093	1 293 022
Ontario	470 638	68 762	232 149
Orange	472 465	319 500	461 233
Queens	651 328	472 616	333 904
Rensselaer	151 202	124 152	233 332
Richmond	588 534	454 646	515 600
Rockland	820 475	747 026	446 583
St Lawrence	*a*	*a*	*a*
Saratoga	460 223	255 562	270 950
Schenectady	579 158	354 872	411 018
Steuben	*a*	*a*	*a*
Suffolk	81 000	69 300	66 600
Tompkins	....	*a*	*a*
Ulster	1 077 655	895 126	1 059 377
Warren	*a*	*a*	*a*
Washington	14 625	10 186	59 300
Wayne	*a*	....	....
Westchester	290 256	321 826	303 558
Other counties	406 165	427 509	337 952
Total	$12 077 872	$9 475 219	$10 002 373

a Included under other counties.

COMMON BUILDING BRICK

The building brick industry during 1915 was in a rather unsatisfactory condition. Labor troubles and price cutting in other building materials unsettled the conditions as to markets and selling price. In January the prices in the New York market at the opening ranged from $6 to $6.25 wholesale for the best grades.

A considerable amount of brick was sent to the New York market during the month of February. Building activities increased somewhat during this month and on March 1st the stock in storage, at New York, had been reduced to 3,150,000. Price cutting in other structural materials affected the selling price of brick and during March the majority of sales were at $5.75 wholesale for the best grades. In April there were 300,000,000 bricks in the Hudson river yards. This stock was reduced in May to 117,800,000 with no bricks in storage in New York. The wholesale price was advanced to $6.50 a thousand and remained at this rate until the middle of July when it fell to $5.75. With the end of the Haverstraw labor troubles, in the third week of August, the price advanced to $6 and at the end of the month had risen to $7. Overanxiety to sell brought the price again to $6, which held to the middle of September. In October the price dropped to $5.875. At the end of October, the close of the brick-making season, there were only 60,000,000 bricks in the yards, or 50 per cent below normal. During November the price rose to $7. For the first time in many years the brick-making season, for a few of the larger yards, was carried through the winter months into the season of 1916.

Hudson River region. Labor troubles affected this region to such an extent during 1915 that several of the larger plants made hardly any attempt to operate until September. The following tables give the production of the Hudson River region for the last two years:

Output of common brick in the Hudson River region in 1914

COUNTY	NUMBER OF OPERATORS	OUTPUT	VALUE	PRICE PER THOUSAND
Albany	11	58 625 000	$301 512	$5 14
Columbia	5	44 705 000	198 866	4 45
Dutchess	14	91 580 000	430 269	4 69
Greene	5	25 604 000	123 475	4 82
Orange	6	75 500 000	319 500	4 23
Rensselaer	2	5 025 000	28 000	5 57
Rockland	25	150 183 000	747 026	4 30
Ulster	23	202 366 000	895 126	4 42
Westchester	7	56 289 000	302 656	5 37
Total	98	709 877 000	$3 346 430	$4 77

Output of common brick in the Hudson River region in 1915

COUNTY	NUMBER OF OPERATORS	OUTPUT	VALUE	PRICE PER THOUSAND
Albany	11	68 112 000	$392 344	$5 68
Columbia	4	57 766 000	271 672	4 70
Dutchess	14	108 459 000	491 156	4 62
Greene	5	27 555 000	130 093	4 70
Orange	6	84 997 000	461 233	5 42
Rensselaer [1]	1	....	....	....
Rockland	18	87 917 000	446 583	5 07
Ulster	21	211 230 000	1 059 377	5 01
Westchester	5	47 619 000	278 955	5 85
Total	85	693 655 000	$3 531 413	$5 09

[1] The output of Rensselaer county is included with that of Albany county.

The Hudson River region, which consists of three main productive areas with many isolated plants, has 127 plants available for the production of common soft-mud building brick. During the past season 73 per cent of these yards were operative during all or part of the season. Nine plants do not depend on the New York market for the disposal of their output. Of this number, one makes regular shipments into the New England markets and eight depend upon the local demand entirely.

The Haverstraw district with a rated machine capacity of about 2,950,000 a day made an output of 87,917,000 as compared with 150,183,000 for 1914. This loss was due chiefly to labor troubles, the result of an attempt to raise the working capacity of the machines to the same level as those of other Hudson river yards. Many yards, in the Haverstraw district, made no output until September, and the majority had only one or two machines in operation up to that date. The total value of the output was $446,583 as compared with $747,026 for 1914 with 56.25 per cent of the yards productive as compared with 78.12 per cent for the preceding year.

The Kingston district includes the yards at Port Ewen, East Kingston, Glasco, Saugerties and Malden, a total of 30, of which 21 made a production as compared with 22 during 1914. This is the second largest district of the Hudson River region and has an available machine capacity of 2,900,000 daily. The entire production of Ulster county in 1915 was made in the Kingston district.

The total output for the year was 211,230,000 with a value of $1,059,000 as compared with 202,366,000 and a value of $895,126 for 1914.

The Dutchess Junction district made an output of 101,484,000 with a value of $448,306 as compared with 88,585,000 and a value of $410,769 for 1914. The output of Dutchess county was 108,459,000 with a value of $491,156 as compared with 91,580,000 and a value of $430,269 for 1914. The small output outside of Dutchess Junction, as reported from Dutchess county, is mainly produced by horse-power machines. Of the total number of yards in the Dutchess Junction district, 11 were productive as compared with 9 for 1914.

Outside of the three main districts there were thirty-two productive plants in the Hudson River region with a total production of 295,549,000 and a value of $1,566,797 as compared with 260,723,000 and a value of $1,246,009 for 1914.

Long Island and Staten Island Region. The next district of importance during 1915 was that of Long Island and Staten Island with a total production of 63,224,000 having a value of $330,004 as compared with 57,735,000 and a value of $276,832 for 1914. The increase in this district was due mainly to the production made in Richmond county. As a result of comparative high selling price and short haul to the New York markets the larger yards of this county made a production throughout the winter months.

The entire product of this district consists of soft-mud building brick. There are at present six active plants using clays of Cretaceous and Quaternary age. Two inactive plants have pits opened in the Quaternary clays. There are three methods of mining in use in this district — pit, bench and scraping. The plants operating in the Quaternary clays use the pit method entirely, with hand labor and caving or making use of steam shovels. This clay is a dark brown to bright red tough material heavily overlain with gravel and sand. Owing to the great amount of gravel found with this clay it is necessary to go over it carefully by hand either in the pit or on a picking belt in order to remove the larger pieces of stone. It is passed through a set of rolls and then to rectangular tempering pits or direct to the machine. Where tempering pits are used the usual charge consists of about 108 cartloads of clay to 9 cartloads of sand. Where it is not necessary to add tempering sand the clay is sent direct from the rolls to machines equipped with horizontal pug-mills. The yards operating in the Cretaceous clays have very little trouble with gravel and in one case the material goes direct to a vertical machine without tempering. Other Cretaceous clays require the addition of as much as 20 per cent sand and then careful pugging before being used. The total machine capacity of the district is 409,500 a day for the active plants using nine machines. Five methods of drying are in use — open yard, pallet yard, hot-air car tunnels, steam-heated floors and steam car tunnels. The total drying capacity is divided as follows: open yard 45,000, pallet yard 1,251,150, steam tunnels 208,000, hot-air tunnels 90,720 and steam floor 33,000. The total number of arches of the active plants is 627 with capacities varying from 32,000 to 50,000 each. The inactive plants have 194 arches with capacities of 32,000 and 50,000 each.

Mechanicville region. This section reported a reproduction of 52,390,000 with a value of $261,950 as compared with 50,416,000 and a value of $240,912 for 1914. There are three active plants equipped with six machines having a combined daily capacity of 222,000. Two inactive plants have a daily capacity of 77,500 from three machines. The entire output of the active plants is dried in steam car tunnels. The burning capacity of the plants is about 435 arches. Almost the entire product of this section is disposed of in the New England states. The season is continuous, brick being produced during the entire year.

Erie county. This region reported an output of 28,807,000 with a value of $176,010 as compared with 40,015,000 and a value of $244,116 for 1914. Of this output 15,515,000 were made by the wire-cut process and had a value of $93,169. Due to the small quantity of clay available it is probable that the amount of soft-mud brick made in this section will continue to decrease while the product of the wire-cut machines will increase to a considerably greater amount. There are large quantities of shale and clay available for the manufacture of all grades of building and front brick in Erie county. Cheap fuel and nearby markets should greatly increase this output. There were during the season of 1915 six soft-mud plants and five wire-cut plants in active operation. The soft-mud brick are made under similar conditions as are found in the Hudson River region. There are a total of thirteen soft-mud machines with a combined daily available capacity of 275,000. Each machine, in this district, is usually operated with a daily capacity of 20,000. Three methods of tempering are in use — disintegrator with pug-mill, circular tempering pit and rectangular tempering pit. Four yards are equipped as pallet yards, one is a combined open and pallet yard and one is open. The permanent updraft kiln is in use in the majority of the plants, only one using the ordinary form of scove kiln. Coal is used entirely for fuel. The wire-cut plants use shale or a combination of shale and clay, grinding the crude product in dry-pans, screening, storing in bins, forming with an augur machine, drying in direct-heat tunnels and burning in permanent rectangular downdraft kilns, continuous or semicontinuous kilns. The entire product is disposed of in the local markets.

The following table gives the output of common building brick by counties for the last two years.

Production of common building brick by counties

COUNTY	1914		1915	
	Number	Value	Number	Value
Albany	58 625 000	$301 512	68 112 000	$392 344
Cattaraugus	*a*	*a*	*a*	*a*
Cayuga	820 000	4 740	1 100 000	6 100
Chautauqua	3 740 000	34 726	3 905 000	31 187
Chemung	*a*	*a*	*a*	*a*
Clinton	*a*	*a*	....	....
Columbia	44 705 000	198 866	57 766 000	271 672
Dutchess	91 580 000	430 269	108 459 000	491 156
Erie	40 015 000	244 166	28 807 000	176 010
Greene	25 604 000	123 475	27 555 000	130 093
Livingston	*a*	*a*	*a*	*a*
Monroe	11 330 000	63 650	7 738 000	38 690
Montgomery	*a*	*a*	*a*	*a*
Nassau	15 352 000	88 300	13 783 000	86 747
Niagara	*a*	*a*	*a*	*a*
Oneida	6 450 000	43 000	22 200 000	154 200
Onondaga	21 800 000	147 250	22 635 000	155 376
Ontario	*a*	*a*	*a*	*a*
Orange	75 500 000	319 500	84 997 000	461 233
Rensselaer	5 025 000	28 000	*a*	*a*
Richmond	29 583 000	119 232	38 341 000	176 657
Rockland	150 183 000	747 026	87 917 000	446 583
St Lawrence	*a*	*a*	*a*	*a*
Saratoga	51 916 000	248 412	53 390 000	267 950
Steuben	*a*	*a*	*a*	*a*
Suffolk	12 800 000	69 300	11 100 000	66 600
Tompkins	*a*	*a*	*a*	*a*
Ulster	202 366 000	895 126	211 230 000	1 059 377
Warren	*a*	*a*	*a*	*a*
Washington	*a*	*a*	*a*	*a*
Westchester	56 289 000	302 656	47 619 000	278 955
Other counties	29 076 000	188 700	38 072 000	277 804
Total	932 759 000	$4 597 856	934 726 000	$4 886 734

a Included under other counties.

FRONT BRICK

There were five grades of front brick produced in the State during 1915 — smooth face red, rough face, dry-pressed red, dry-pressed manganese and wire-cut manganese. Owing to the few plants producing front brick it is not possible to give comparative figures of the different grades. There was a small amount of rough face vitrified front brick made as a by-product of the paving brick industry.

There is found along the Hudson river in certain localities a heavy bed of light brown laminated clay having a low fire shrinkage and comparatively high fusing point. This clay, without the addition of any other substance, burns to a dark red color and when formed in the augur machine gives a perfectly smooth surface. It is not necessary to add sand in tempering. With the present mining equipment and a small addition in the way of augur machines and kilns at a few of the present Hudson river yards there could be turned out an immense quantity of first-class smooth face red front brick for the New York market. At present this market depends entirely upon brick produced in Pennsylvania, Ohio and other western states.

The entire output of New York State during the last season amounted to 6,603,000 with a value of $153,572 as compared with 10,482,000 and a value of $105,439 for 1914.

COMMON HOLLOW BRICK

There were ten producers of common hollow brick during the last year with an output of 9,402,000 and a value of $59,683 as compared with 6,402,000 and a value of $38,119 for 1914. Nearly the entire output is made from soft, plastic clays and disposed of in the local markets.. Very little is made for the outside trade and the entire supply for the metropolitan market comes from other states.

It is not necessary to have, for this product, a very high grade of clay. Any plastic clay fairly free from sand and burning to a light brown at about 950° C. produces a good product. Such clays are found in great abundance throughout the Hudson River region and could be used, with a very small extra addition to the present equipment of the soft-mud yards, for the production of common hollow brick and other hollow ware of small size. It is not necessary to change the burning or drying equipment. They can be dried in pallet or open yards and burned perfectly in the ordinary form of scove kiln along with building brick.

FIREPROOFING

Fireproofing was produced to the value of $177,844 by seven companies as compared with $245,034 for 1914. There was no change in the number of producers. The output includes those articles known as hollow blocks and terra cotta lumber, exclusive of common hollow brick. Owing to the large size as compared with common hollow brick, there has been some difficulty in using the ordinary soft plastic clays of the State for the production of fireproofing. It is only those operators who have used a combination of clay and shale or grog that have been able to produce material which would compare favorably with that of the better known grades from other states. At present the production is only that necessary to supply the local demand.

PAVING BRICK

During the last season a considerable decrease took place in the production of paving brick not only in this State but throughout the United States. In general this was caused by a small demand. Many roads are being built of other materials, but with the intention of facing in the future with brick. This is especially true of the long trunk lines. In New York State financial troubles have been the main cause of the small production. Several plants have had to close temporarily on this account and one on account of a poor grade of crude material with high transportation costs. The total production for last year was 26,154,000 with a value of $382,502 as compared with 46,696,000 and a value of $680,226 for 1914. The following table gives the production in New York State during the last ten years:

Production of paving brick in New York

YEAR	QUANTITY	VALUE	VALUE A THOUSAND	NUMBER OF PLANTS
1906	11 472 000	$178 011	$15 51	5
1907	12 296 000	184 306	14 98	4
1908	14 570 000	211 289	14 50	5
1909	12 278 000	207 970	16 27	3
1910	19 762 000	333 511	16 88	4
1911	23 993 000	388 479	16 19	4
1912	18 249 000	382 984	15 78	5
1913	35 666 000	576 970	16 17	6
1914	46 696 000	680 226	14 56	6
1915	26 154 000	382 502	14 62	5

TERRA COTTA

The total production during 1915 had a value of $647,815 as compared with $892,630 for 1914. The material produced in this State is entirely from imported clays with the exception of a small amount for glaze. On this account it is hardly probable that the industry will have a very great growth as compared with other states. The building industry, making use of ornamental terra cotta, had a comparatively poor season and this has helped to a great extent in reducing the production in New York State.

DRAIN TILE

The output of drain tile had a value of $91,221 as compared with $92,938 for 1914. There were twelve active producers operating in Albany, Cayuga, Erie, Monroe, Onondaga, Ontario and Washington counties. With a few exceptions, the entire output is sold in the local markets. The local demand is far ahead of the production and a considerable quantity is imported from other states. There is a large and growing demand for a glazed drain tile as a substitute for the ordinary porous tile such as is made in this State. There is no reason why drain tile should not be produced to a greater extent in New York State as there is any amount of clays and shales which will produce either a porous, glazed or a nonporous unglazed tile. With the present water transportation there should be a great field among the southern agricultural coast states for a large output of drain tile. For the unglazed tile it would not be necessary to furnish much additional equipment to the present soft-mud brick plants in order to produce a large quantity. It would not be necessary to change either the drying or burning arrangement.

POTTERY

The production of pottery for 1915 in New York State had a considerable increase over the season of 1914. The output had a value of $3,064,274 as compared with $2,405,676 for the preceding year. The increase was due mainly to the greater demand for electric porcelain insulators and for American-made porcelains. The table below gives the value of products for the last three years.

Value of production of pottery

WARE	1913	1914	1915
Stoneware	$37 077	$28 888	$70 152
Red earthenware	35 790	31 806	34 031
Porcelain and semiporcelain	1 143 835	1 129 629	1 503 718
Electric and sanitary ware	2 100 985	1 187 506	1 440 373
Miscellaneous	49 500	27 840	16 000
Total	$3 367 187	$2 405 676	$3 064 274

CRUDE CLAY

The total value of crude clay produced during the season of 1915 amounted to $28,684. This was the value placed on 13,745 tons of which 11,012 tons were sold for slip clay. During the preceding season the entire output of slip and red burning clay amounted to 7109 tons with a value of $12,424. There was no production of white or buff burning clay during 1915.

Owing to the scarcity of aluminum sulphate for use in water filtration plants, there was some discussion locally of the utilization of the comparatively high alumina clays of the Hudson River region for the purpose of manufacturing this chemical. At the present time the greatest demand for slip clay comes from the electric porcelain manufacture. It is also used to a great extent as a bonding material in the manufacture of artificial abrasive wheels. In both the abrasive and slip uses it is necessary that the clay should have a quiet fusion and be free from bubbles when cooled. Such clays are found in this State at a few localities near Albany and Troy.

There are four known beds of clay in the Albany region which have furnished material suitable for slip and bonding purposes. The lowest has a thickness of about 8 feet and is fairly uniform in most exposures. At some localities this bed is of rather irregular deposition and composition. The result is that material of uncertain working qualities is sometimes produced. The next higher bed with a thickness of about 4 feet has furnished a great amount of fine slip but at present is not exposed so as to be available for production. It is from this bed that the early production was made. The third bed, which is the main producing one at present, has a thickness of about 14 feet and is very regular in composition and structure. Immediately above this is found a 2 foot bed of gray sand. This sand layer causes considerable trouble, for without the exercise of much care it gets into the clay, and such mixed clay is unsuitable for slip. Above this sand layer comes the uppermost productive layer of slip, a 4 foot bed of very regular composition and which is in greater demand for electric insulator purposes than the next lower bed.

Onondaga county makes the only other production of crude clay. This material consists of a brown banded tough clay used chiefly in the manufacture of red ware.

FELDSPAR

No new quarries of feldspar were developed or worked in 1915, but there was an unusual manifestation of interest in the local feldspar resources by reason of the possibilities they offer for the production of potash.

It is well known that the extraction of potash from silicate minerals offers no special difficulties, so far as laboratory operations are concerned; fusion with some strong base like lime is all that is needed to release the alkalies from combination with the silica and bring them into soluble form. Though the feasibility of applying this process on a commercial scale has been discussed for a long time, no definite steps have been taken toward putting it in practice, and the matter still is in an experimental stage. The recent interest is the result of the curtailment of potash shipments, since practically all the supply of this very essential material is imported from Germany, which in normal times affords most of the requirements of the whole world.

The utilization of feldspar for the purpose has been investigated recently by Cushman and Hall [1] whose work has been given wide currency and has been the means of attracting much atention generally to the subject. Their method is based on the use of calcium chloride as flux. The feldspar is first pulverized and agglomerated with a little lime and then brought to fusion in a furnace with the aid of calcium chloride. By this treatment the alkalies are converted into chlorides which can then be leached from the fused mass with hot water. The solution will contain both potassium and sodium chlorides, the relative amounts varying of course with the proportions represented in the feldspar.

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[1] American Inst. Chem. Engineers, Philadelphia meeting, December 1914. The article is published in full in Metallurgical and Chemical Engineering, 13: 2, February 1915.

It is essential, of course, that the feldspar should have a high content in potash. Of the varieties which occur in nature only two fill this requirement; they are orthoclase and microcline, each having the same chemical composition — silica 64.7 per cent, alumina 18.4 per cent and potash 16.9 per cent. As a matter of fact, the theoretical percentage of potash as given is never attained, since there is always some soda present as a substitute. It is not uncommon, furthermore, to find the potash feldspar intergrown with albite or soda feldspar so as to reduce the amount of potash in the material very largely. In a quarry way, 10 to 12 per cent of potash is about the maximum that can be expected, and this only under the best conditions with the aid of more or less sorting and cobbing for the removal of waste.

It is the writer's experience that pegmatite bodies which will yield a uniform content of 10 per cent potash are extremely uncommon. Not only is the content likely to be reduced by admixture with other sorts of feldspar, but there is always a considerable percentage of quartz and iron silicates which has to be reckoned with, the amount varying with each locality and to a greater or lesser extent in different parts of the same body. Pegmatite is very prone to variation as can be seen in nearly every occurrence that is sufficiently well exposed to afford an estimate of its character. A pegmatite that will yield 75 per cent of potash spar quarrywise is exceptional, at least among the explored bodies of this State.

Pegmatites of such dimensions that they will afford the necessary quantity of material to justify the expense of establishing a works are not very abundant. An available supply of several million tons probably would be required, since the first cost of plants is high and the capacity must be large to afford the necessary margin of profit on the output. It is desirable also that the quarry should be convenient of access, with low freight rates on fuel, and with a supply of limestone nearby. Altogether the conditions are very definite and exclusive, much more difficult to meet than most writers on the subject seem to have realized.

The feldspar resources of New York have been recently investigated and described in detail.[1] Most of the local pegmatites that are of any considerable size are found among the crystalline schists, gneisses and acid igneous rocks of the Highlands and Adirondacks. They occur as dikes or tabular bodies which intersect the country rocks; the largest ones, however, have the form of bosses and

[1]The Quarry Materials of New York — Granite, Gneiss, Trap and Marble. N. Y. State Mus. Bul. 181, p. 154–75. 1916.

stocks, which as seen on the surface present rather irregular boundaries, though broadly considered have a more or less rounded outline, that is, nearly equidimensional. Such bodies may reach diameters of several hundred feet and of course extend for indefinite distances into the earth. Microcline is the variety of feldspar most common in the pegmatites of New York State.

In addition to feldspar, quartz and mica are sometimes produced from pegmatite quarries. The quartz, if pure, may find employment in pottery manufacture, or it is useful as an abrasive, for wood filler, and other purposes. Mica is obtained only in limited quantity from the local quarries.

Production. The production of feldspar, inclusive of unsorted pegmatite, in 1915 was 16,896 short tons, valued at $76,152. This was a decline from the output of the preceding year which was reported as 18,487 short tons, worth $97,192. Although the valuations in the two years seem to indicate a marked drop in prices, this was more apparent than real, since the statistics for 1915 included a larger proportion of the unsorted pegmatite than usual. Such material brings a low price, from $2 to $3 a ton. Selected crude spar of pottery grade is worth $4.50 to $5 a ton, ground spar for enamel and glass manufacture brings $7 to $8, and ground pottery spar from $8 to $10 a ton.

The quarries recently active are situated in Westchester, Essex and Saratoga counties. P. H. Kinkel's Sons and the Bedford Spar Co. operate quarries at Bedford, Westchester county. The Crown Point Spar Co. owns quarries and a mill at Crown Point and the Barrett Manufacturing Co. at Ticonderoga. The quarries near Batchellerville, Saratoga county, once worked by the Claspka Mining Co., but inactive for several years past, have been taken over by the Eureka Mining Co. and again placed in operation. The quarries afford a good grade of pottery material.

GARNET

The abrasive garnet industry experienced no marked changes last year, either as regards technology or its economic position. The Adirondack mines were worked on about the usual scale, though the production fell a little short of the total for the preceding year, amounting to 3900 short tons valued at $134,064. The value of the product was practically as large, however, owing to the increased proportion of high-grade crystal garnet in the total. For a number of years past the production has averaged around 4000 tons, and only twice in recent years has it exceeded 5000 tons. Prices vary with the quality of the product, but the best crystal garnet which comes from the North River district holds steadily at $35 a ton.

The active producers in the Adirondack region last season included the North River Garnet Co. with mines on Thirteenth Lake, H. H. Barton & Son Co., operating on Gore mountain, and Warren County Garnet Mills at Riparius, all in Warren county. The property on Mount Bigelow, near Keeseville, in northern Essex county, recently worked by the American Garnet Company, was idle throughout the year. The resources of garnet in the Adirondack deposits are large and capable of yielding a much greater quantity than is now produced; it is no lack of capital or enterprise on the part of the mining companies that holds the production down to the present proportions, but the market is strictly limited and shows little tendency to growth.

Outside of the Adirondacks, garnet occurs in association with metamorphic rocks along the Appalachians from the New England states south to North Carolina and Alabama. The Highlands of southeastern New York belong to this mountain range, and in the vicinity of Peekskill, Westchester county, there are garnet deposits which have been worked in a small way. New Hampshire, Pennsylvania and North Carolina have yielded more or less of the mineral in recent years, but nowhere except in the Adirondacks has the mining industry attained any great importance.

The use of garnet as an abrasive has not made much headway in foreign countries. Spain is the only country of Europe which produces it in quantity and the output is sent to this country for manufacture. Spanish garnet is obtained from alluvial deposits which are found in the province of Almeria; it is of rather fine grain and only a partial substitute for the American product. The imports into the United States in 1915 were 1343 tons, with a declared value of $24,472; in 1914 they were reported as 1244 tons with a value of $20,277. There is no duty on the mineral and owing to the character of the Spanish deposits the foreign garnet can be shipped into this country at a cost well below that attainable by the domestic producers.

GRAPHITE

A production of flake or crystalline graphite was reported for last year as usual by the American mine at Graphite, Warren county. The output of this mine has long been the chief factor in the local industry, as in fact also it has represented a large share of the product of refined crystalline graphite in the country. The property is worked by the Joseph Dixon Crucible Co. who convert the graphite into various commercial grades and products for the market. The mineral occurs as disseminated flakes in a hard quartzite, constituting only a few per cent of the rock mass, and its extraction and refining require special mechanical treatment, as well as much technical skill, to make the outcome successful from a market standpoint.

A new firm — the Graphite Products Corporation — was engaged last year in developing a property near Kings Station, 4 miles north of Saratoga Springs, on the easterly face of the ridge of crystalline rocks that defines the Adirondack boundary in this region. The property was worked in a small way by the Saratoga Graphite Co. during the years 1912 and 1913, but has since been idle. The latter company erected a small milling plant and made a little output of graphite from rock which was taken from outcropping ledges, of which there are several in the vicinity. The deposits were not sufficiently opened to permit work to be carried on advantageously. The present operations have been on a larger scale, with the view to thoroughly testing the deposits and the methods best adapted for milling the rock. It would appear from the exploratory work that the quartzite exists in beds of considerable thickness and extent which in general have a northeasterly strike parallel with the ridge and southeasterly dip. The first place where the rock shows in force is along the face of the ridge, just northwest of the old mill, where a quarry pit exposes 10 to 12 feet of quartzite, all of it graphitic, in thinly laminated and weathered condition. This pit is not now worked, but supplied much of the material in the earlier operations. The graphite is in finely divided scales, most of them less than 1 mm in diameter, and is mixed with a little brown mica. The outcrop is badly weathered and softened through oxidation of the contained pyrite which is rather plentiful in the unweathered rock. Higher up, near the summit of the ridge, a second outcrop of the graphitic rock was explored in the early operations by an open cut that reveals the quartzite in more massive beds, with a coarser flake. The beds dip to the southeast at a small angle. Along with the usual components, there is more or less pegmatitic material which forms knots and stringers in the quartzite, probably due to injection from a granite magma. The pit, as left by the operations of the first company, was 75 feet long and 30 feet wide. Between the two pits intervenes an area of hornblende gneiss which has the appearance of a metamorphosed gabbro. At present the main work is being done at a point near the second pit but lower down close to a ravine which follows the slope of the ridge in a direction south of east. Tunnels have been driven along the course of the beds at points below the outcrop and the rock is mined underground so as to obtain fresh material, better adapted for mill treatment. The openings show fully 20 feet of rock fairly well charged with flake.

The quartzite here contains less mica than in the more easterly ledges and with the coarser size of the flake affords better material for mill treatment. From the available exposures it would appear that the graphite beds are found at two horizons, at least, within the quartzite, although the latter has been broken up by intrusions of the gabbro and by trap dikes so that the relations of the several outcrops are not readily apparent. Thin beds of crystalline limestone are intercalated in the quartzite, as can be seen in the bottom of the ravine by the old mill where serpentinous limestone forms the bed of the brook for some distance.

The upward trend of prices which has characterized the market for graphite during the past year or so has lent interest to the Adirondack deposits, although no other developments were started during 1915. Occurrences of graphitic quartzite are common in the eastern Adirondacks, and some may be found that appear to be both extensive and fairly rich in graphite as the quartzite of this region runs. Thorough tests are necessary, however, to show the value of any particular occurrence for mining purposes. Many failures have resulted in the business, due to lack of information about the character of the deposits that were to be worked or of the amenability of the material for extraction of the graphite.

GYPSUM

The gypsum industry was conducted on about the same scale as was reported for the preceding two or three years, and without any developments in the field that promise a change in the situation for the current season. The output of crude rock was 516,002 short tons, a few thousand tons more than in 1914 but still somewhat below the mark set in 1913 which was 532,884 short tons.

The market for gypsum products, especially calcined plasters, which had been rather depressed for some time owing to a condition of oversupply and of competition among the producers, showed a little improvement with an encouraging outlook for the immediate future. The production has grown very rapidly, the plaster industry being developed practically within the last decade, so that trade conditions have not become fully adjusted.

New York has a leading place in the gypsum industry, both from the standpoint of the mine product and of the manufacture of gypsum plasters. Its position in the calcined plaster trade is even more important than the output of rock gypsum would indicate, since in recent years large quantities of crude rock have been imported by local mills for calcination. Most of this material comes from the Maritime provinces of Canada, under the moderate transporation rates that ordinarily obtain for water shipments, and is used by calcining plants situated on the lower Hudson and in the environs of New York City. Nova Scotia is the source of most of the imported rock; it possesses large deposits that are conveniently situated for reaching the seaboard markets. In the interior of the State the calcining plants are mostly operated in connection with the local mines, from which they obtain all their crude material.

The production in 1915 was reported from four counties — Onondaga, Monroe, Genesee and Erie — the same that have yielded most of the supply in recent years. The deposits are not confined to these counties, however, since they outcrop at intervals all the way from Madison county on the east to the Niagara river, and extend southward under cover of rock for indefinite distances. The present mine localities possess advantages either as to quality of product or for economical extraction and marketing which have led to the concentration of operations in their vicinity.

The most easterly point at which beds of workable dimensions occur is in Madison county. Here they take the form of rather small lenses, not over 4 or 5 feet thick in most instances, though occasionally of greater thickness and extent, and consist of gypsum intermixed with argillaceous material and the carbonates of lime and magnesia. On the average the rock from this section carries about 70–75 per cent gypsum and is drab or gray in color. It has been employed quite extensively for agricultural plaster, and there are a number of quarries along the line of the Lehigh Valley Railroad to the south of Canastota, and also farther west along the Erie canal between Chittenango and Sullivan, which were worked quite extensively up to 15 or 20 years ago. Of late the substitution of limestone for gypsum in agriculture has restricted the market for the output of quarries of this section, and no active work has been under way for several years.

In Onondaga county around Fayetteville and Jamesville occur beds of large size up to 50 or 60 feet thick that are worked in a small way, mainly for agricultural plaster and for use in portland cement. Some of the product in former years was converted into stucco; the rock is said to make a good strong plaster but rather dark in color, a feature that can be corrected to some extent by admixing with the lighter plasters of other districts. The gypsum occurs in several layers which vary somewhat in purity, color and grain. It is worked mainly by open-cut or quarry methods, operations being restricted to points where the overburden is relatively light.

The Union Springs district, Cayuga county, contains gypsum deposits of similar nature to those in Onondaga county and from 20 to 30 feet thick. They were worked very actively at one time for agricultural plaster, but in recent years have been operated intermittently and then only in a small way.

Gypsum beds appear in Seneca and Wayne counties, but no rock has been mined there in many years. In Ontario county, near Victor, is an old quarry which yielded a very fair quality of gypsum. Drill cores from the vicinity indicate the presence of two beds, of which the lower one is 6 feet thick and light in color. Mr C. L. Tuttle of Rochester intends to make additional explorations in this district during the current season.

Monroe county contains the well-known Wheatland district in which active mining has been carried on for many years. There are two layers, separated by a limestone bed 6 to 12 feet thick. The upper layer above is worked and is followed underground by means of tunnels and shafts. In the average, about 5½ feet of gypsum is excavated. Most of the output is calcined and used in wall plaster manufacture. Some is sold crude to cement mills and a small amount ground to land plaster. The active producers include the Lycoming Calcining Co. of Garbutt, the Empire Gypsum Co. of Garbutt and the Consolidated Wheatland Plaster Co. of Wheatland.

Near Oakfield, Genesee county, are the mines of the United States Gypsum Co. which are very extensive and productive and are based on a layer of white gypsum 4 to 5 feet thick. The output mainly is converted into stucco for wall plasters, hollow fireproofing and plaster-board, that are manufactured locally by the same company. West of these mines lies the property of the Niagara Gypsum Co., which also operate on a large scale, making various calcined products.

Just east of Akron, Erie county, are the mines of the American Gypsum Co. and the Akron Gypsum Products Corporation. They

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supply rock of lighter colors, suitable for the manufacture of calcined plasters, but only the latter company engage in their manufacture. The American Gypsum Co. sells its output in crude form mainly to cement mills. The plan and mines of the Akron Gypsum Products Corporation were taken over in 1915 by the American Cement Plaster Co. The continuation of the gypsum deposits is found to the west of Akron, as shown by explorations with the drill made a few years ago. There are records of the occurrence of white gypsum under the city of Buffalo, but owing to the large flow of water that is encountered in the beds there has been no attempt put forth to develop the deposits.

The production of gypsum for 1914 and 1915 is shown in the accompanying table, which also gives the several forms in which it was sold by the mining companies. Considerably more than one-half is converted into calcined plasters by the latter. A few thousand tons are ground for land plaster, and the remaining is sold crude to portland cement works or to calcining mills outside of the district. There is some fluctuation from year to year in the relative proportions of mined product and the amount of calcined plasters, as the mining companies often hold considerable amounts of rock in stock. The production of calcined plasters from foreign rock is not included in the statistics.

Production of gypsum in New York

MATERIAL	1914		1915	
	Short tons	Value	Short tons	Value
Total output, crude	513 094	....	516 002	....
Sold crude	169 257	$246 804	162 686	$241 511
Ground for land plaster	7 096	15 342	6 536	13 486
Wall plaster, etc., made	297 084	985 258	292 344	1 006 203
Total	....	$1 247 404	....	$1 261 200

IRON ORE

The iron mining industry reversed its course last year and showed a marked improvement in activity as compared with the record for 1914. The latter year was a period of great depression for the eastern mines, with demand and prices on a lower basis than they had been for a long time. The output consequently fell off, the mines reporting the smallest total that had been recorded since the panic times of 1907–8. While the upturn that came in the spring of 1915 was registered in the trend of production for the year, it did not show itself fully in the statistics, inasmuch as the mining companies were not in position to take advantage immediately of the change.

The outlook for the immediate future of the iron industry in the State is encouraging. The curtailment of the shipments of foreign ores, due to the high ocean freights and uncertainties incident to the European War, has created a situation favorable to the local mines whose market is found in the metallurgical centers of New York and eastern Pennsylvania. A further advantage has been the general rise in railroad rates which has created a larger margin between the rates for Lake Superior ores and those from the East.

The production of furnace ores and concentrates, as reported by the different mines that were operative in the State, was 944,430 long tons. In comparison with the total reported for the preceding year, this represented an increase of 192,714 tons or about 25 per cent, but still was smaller than any other year previously since 1908. The value of the product at the mines was $2,970,526, or $3.15 a ton, against an average of $3.13 a ton in 1914.

The total was made up of magnetite, hematite and limonite in the order of their importance. The magnetite mines in the Adirondacks and the Highlands of Orange county contributed altogether 873,422 long tons worth $2,825,176, against 703,670 long tons worth $2,251,656 in 1914. The hematite was from the Clinton belt in Oneida and Wayne counties. The limonite, which amounted to a few hundred tons only, came from Columbia county.

Production of iron ore in New York State

YEAR	MAGNETITE	HEMATITE	LIMONITE	CARBONATE	TOTAL	TOTAL VALUE	VALUE A TON
	Long tons	Long tons	Long tons	Long tons	Long tons		
1895	260 139	6 769	26 462	13 886	307 256	$598 313	$1 95
1896	346 015	10 789	12 288	16 385	385 477	780 932	2 03
1897	296 722	7 664	20 059	11 280	335 725	642 838	1 91
1898	155 551	6 400	14 000	4 000	179 951	350 999	1 95
1899	344 159	45 503	31 975	22 153	443 790	1 241 985	2 80
1900	345 714	44 467	44 891	6 413	441 485	1 103 817	2 50
1901	329 467	66 389	23 362	1 000	420 218	1 006 231	2 39
1902	451 570	91 075	12 676	Nil	555 321	1 362 987	2 45
1903	451 481	83 820	5 159	Nil	540 460	1 209 899	2 24
1904	559 575	54 128	5 000	Nil	619 103	1 328 894	2 15
1905	739 736	79 313	8 000	Nil	827 049	2 576 123	3 11
1906	717 365	187 002	1 000	Nil	905 367	3 393 609	3 75
1907	853 579	164 434	Nil	Nil	1 018 013	3 750 493	3 68
1908	663 648	33 825	Nil	Nil	697 473	2 098 247	3 01
1909	934 274	56 734	Nil	Nil	991 008	3 179 358	3 21
1910	1 075 026	79 206	4 835	Nil	1 159 067	3 906 478	3 37
1911	909 359	38 005	5 000	Nil	952 364	3 184 057	3 34
1912	954 320	103 382	Nil	Nil	1 057 702	3 349 095	3 17
1913	1 097 208	120 691	Nil	Nil	1 217 899	3 870 841	3 18
1914	703 670	47 705	341	Nil	751 716	2 356 517	3 13
1915	873 422	70 147	834	Nil	944 403	2 970 526	3 15

Most of the magnetite shipments consisted of concentrates, which averaged around 65 per cent iron. Lump magnetite was supplied by the mines of Orange county and the two Mineville companies, the average of this material being about 60 per cent iron. In the concentration of magnetite, as practised in the Adirondacks, each ton of finished product represents from a little over 1 to nearly 3 tons of crude ore, the ratio varying with the different deposits. The gross output of magnetite, as hoisted from the mines, was 1,294,056 long tons. The total ore hoisted from all mines was 1,365,064 tons.

The list of active mining companies for the year included the following in the Adirondack region: Witherbee, Sherman & Co., and Port Henry Iron Ore Co., Mineville; Chateaugay Ore & Iron Co., Lyon Mountain. The Cheever Iron Ore Co., Port Henry, and the Benson Mines Co., Benson Mines, were inactive during the year, although they contributed to the output of the preceding year. In southeastern New York the producers were the Hudson Iron Co., Fort Montgomery, and Sterling Iron and Railway Co., Lakeville. The hematite mines were operated by C. H. Borst, Clinton; Furnaceville Iron Co., Ontario Center, and Ontario Iron Co., Ontario Center. The single limonite mine was worked by Barnum, Richardson & Co., who shipped the output to their furnaces at Salisbury, Conn.

Mineville. A revival of activity was reported by the two companies who are engaged in mining at this place. Witherbee, Sherman & Co. continued work in the Old Bed group, where the main operations in the past have been centered and also operated the Harmony and Barton Hill mines. The Barton Hill property, which was recently reopened, has become one of the principal sources of ore supply, the new development uncovering some extensive deposits of milling ore of desirable quality. This ore is the lowest in phosphorus of the Mineville magnetites and has been much in demand during the past year.

The concentrates are used in part in the Port Henry furnace which has been running of late on low phosphorus pig. Besides the properties in Mineville, the company owns a series of deposits which extend for some distance north of these and which include the Smith and the Sherman mines, both equipped for production.

Lyon Mountain. Important improvements have been made in the mining installation of the Chateaugay Ore & Iron Co., which works the magnetite deposits at this place. The principal feature of the improvements is the construction of a new shaft which is designed to provide a hoisting capacity of 3000 tons a day and will take the place of the several small shafts at irregular intervals along the outcrop which hitherto have been in use. The shaft has been extended to about 900 feet depth and levels are now being opened from it; during the past year it has provided some ore for milling, but only such as was taken out in the course of development. With the completion of this important work, the methods of underground mining will be changed so as to effect important economies as well as to increase the production. The next step to be undertaken is the construction of a new mill which is required if the milling capacity is adjusted to the mine output. The company has plans for such a mill under consideration. All the ore is crushed and concentrated before shipment. The concentrates, which carry above 60 per cent of iron, are very low in phosphorus; consequently they are in great demand. They are smelted in the furnaces at Standish and Port Henry.

Benson Mines. No shipments were made from this place last year. Changes in the methods of concentration are to be effected before the mines are again placed in operation.

MILLSTONES

Millstones are quarried from the Shawangunk grit of Ulster county, one of the few sources of these materials in the United States. The industry was established there many years ago, and during the earliest period of its history was in a flourishing state as the product found a wide sale for the grinding of cereals. This market has been greatly curtailed within the last quarter of a century or more by the general use of the roller mill process for making flour, although some mills still make use of stones for grinding the coarse grains. The small corn mills in the South furnish one of the larger markets for the New York product. Besides millstones, the Ulster county quarries also turn out disks of stone known as chasers which are employed in a roll type of crusher, the disks revolving on a horizontal axis in a circular pan that is sometimes floored by blocks of the same stone. This type of crusher is much used in the grinding of minerals like quartz, barytes and feldspar, and paint materials.

The Shawangunk grit of which the stones are made outcrops on Shawangunk mountain, a monoclinal ridge that extends from Rosendale southwesterly into New Jersey and Pennsylvania. The grit forms the top of the ridge, dipping to the west in conformity with the slope of the surface, and in the Wallkill valley along the north side disappears below shales and limestones which belong to the uppermost formations of the Siluric. The grit rests unconformably upon the Hudson River series. In thickness it ranges from 50 to 200 feet. The millstones are quarried within a limited section of the ridge, between High Falls on the north and Kerhonkson on the south, where the grit appears to be best adapted to the purpose. In character it is a light gray conglomerate with pebbles of milky quartz ranging in size from that of a pea to 2 inches in diameter. The pebbles are rounded and firmly cemented by a silicious matrix of gritty texture.

The work of quarrying requires only a small equipment, the stone being pried out by hand bars, after the use perhaps of a drill and plugs and feathers. Sometimes a little powder may be employed, but care has to be exercised in its use to avoid weakening the stone. The spacing of the natural joints determines the size of the stone that may be produced, the joints occurring in two sets approximately parallel to the dip and strike of the formation. The rough blocks thus obtained are reduced to shape by the hammer and point and then undergo a final tool dressing which varies with the use to which the stone is to be put. The hole or " eye " in the center is drilled by hand.

The sizes of the stone marketed ranges from 15 to 90 inches in diameter. The greater demand is for the smaller and medium sizes with diameters of 24, 30, 36, 42 and 48 inches. The chasers are supplied in sizes that usually run from 48 to 90 inches and with widths up to 24 inches. The prices range from $3 for an 18-inch stone to $75 or $100 for the largest sizes.

The production at one time was valued at over $100,000 a year, but within the last decade it has averaged less than $20,000. During 1915 the total sales of millstones and chasers were reported as $10,916 as compared with $12,410, the value of the stones marketed in 1914.

MINERAL PAINT

For the purposes of the present report only the natural mineral pigments are included under this title. In addition to these materials, there is a production in the State of artificial pigments, especially those of lead, but as the substance used in their manufacture is derived from outside sources, they have not been included among the local products.

The crude paint materials that occur within the State include iron ore, ocher, shale and slate. Of the iron ores, the Clinton hematite affords an excellent base for the manufacture of metallic paint and mortar color of red to brownish red colors. The beds with a relatively high iron content are employed, as they possess the softness and uniformity of texture, as well as depth of color which are requisite for such use. The ore is obtained from the mines at Clinton, Oneida county, owned by C. A. Borst, and from those at Ontario, Wayne county, worked by the Furnaceville Iron Co. The hematite from the former locality is of oolitic nature and carries about 45 per cent iron. The ore from Ontario contains about 40 per cent iron and is known as " fossil " ore. In years past the red hematite from the northern part of the State has also been employed, but recently this ore has not been obtainable.

Both shale and slate from the local formations have been used rather extensively for pigments. They occur in various colors depending upon the amount and nature of the iron oxides present.

A large percentage of ferric oxide lends a reddish color which resembles that of metallic paint. Red shale has been obtained from the base of the Salina beds near Herkimer. The red slate from Washington county is another material that has been rather extensively ground for pigment. At Randolph, Cattaraugus county, beds of green, brown and bluish shale occur in the Chemung formations and have been utilized in the past.

Deposits of ferruginous clay, or ocher, are found in many places within the State, but they are not now worked. Sienna, a dark brown variety of ocher, is found near Whitehall where it was produced a few years ago.

MINERAL WATERS

New York has held for a long time a leading position among the states in the utilization of mineral waters. The different springs, of which over two hundred have been listed as productive at one time or another, yield a great variety of waters in respect to the character and amount of their dissolved solids. There are some that contain relatively large amounts of mineral ingredients and are specially valuable for medicinal purposes; Saratoga Springs, Ballston Springs, Richfield Springs, Sharon Springs and Lebanon Springs are among the more noted localities for such waters. Numerous other springs are more particularly adapted for table use, containing only sufficient mineral matter to give them a pleasant saline taste. Both kinds of waters are generally carbonated and sold in small bottles.

Of late there has developed an important business in the sale of spring waters which can hardly be classed as mineral in the common acceptance of the word, but which are extensively consumed for office and family use in the larger towns and cities. Their employment depends upon their freedom from harmful impurities, in which feature they are generally superior to the local supplies. In so far as such waters are an article of commerce they may well be included in a canvass of the mineral water industry. They are usually distributed in large bottles or carboys in noncarbonated condition.

Character of mineral waters. Among the spring waters that contain mineral ingredients in appreciable quantity, those characterized by the presence of alkalis and alkaline earths are the most abundant in the State. The dissolved bases may exist in association with chlorin and carbon dioxid, as in the springs of Saratoga county, or they may be associated chiefly with sulphuric acid, as illustrated by the Sharon and Clifton springs.

The mineral waters of Saratoga Springs and Ballston are found along fractured zones in Lower Siluric strata, the reservoirs occurring usually in the Trenton limestone. They are accompanied by free carbon dioxid which, together with chlorin, sodium, potassium, calcium and magnesium, also exists in dissolved condition. The amount of solid constituents in the different waters varies from less than 100 to over 500 grains a bottle. Large quantities of table and medicinal waters are bottled at the springs for shipment to all parts of the country. The carbon dioxid which issues from the wells at Saratoga at one time was an important article of commerce, but its sale has been discontinued.

The waters at Richfield Springs contain the elements of the alkali and alkaline earth groups together with sulphuric acid and smaller amounts of chlorin, carbon dioxid and sulphureted hydrogen. They are employed for medicinal baths as well as for drinking purposes. The springs issue along the contact of Siluric limestone and Devonic shales. Sharon Springs is situated to the east of Richfield Springs and near the contact of the Lower and Upper Siluric. Clifton Springs, Ontario county, and Massena Springs, St Lawrence county, are among the localities where sulphureted waters occur and are utilized.

The Oak Orchard springs in the town of Byron, Genesee county, are noteworthy for their acid waters which contain a considerable proportion of aluminum, iron, calcium and magnesium, besides free sulphuric acid.

The Lebanon spring, Columbia county, is the single representative in the State of the class of thermal springs. It has a temperature of 75° F. and is slightly charged with carbon dioxid and nitrogen.

Ordinary spring waters. The greater quantity of spring waters consumed in the State belongs to the nonmedicinal, noncarbonated class, represented by such springs as the Great Bear, Deep Rock, Mount View, Sun Ray, Chemung etc. The waters are obtained either by flowing springs or from artesian wells and are shipped in carboys or in tank cars to the principal cities where they are bottled and distributed by wagons among the consumers. The essential feature of such waters is their freedom from noxious impurities. This is generally safeguarded by the care exercised in the handling of the waters which are also regularly examined in the chemical and bacteriological laboratories.

List of springs. The following list includes the names and localities of most of the springs in the State that are employed commercially, as shown by a canvass of the industry:

NAME	LOCALITY
Baldwin Mineral Spring............	Cayuga, Cayuga county
Coyle & Caywood (Arrowhead Spring)	Weedsport, Cayuga county
Diamond Rock Spring..............	Cherry Creek, Chautauqua county
Breesport Oxygenated Spring........	Breesport, Chemung county
Breesport Deep Rock Water Co......	Breesport, Chemung county
Chemung Spring Water Co..........	Chemung, Chemung county
Keeseville Mineral Spring...........	Keeseville, Clinton county
Lebanon Mineral Spring.............	Lebanon, Columbia county
Arlington Spring	Arlington, Dutchess county
Mount Beacon Spring...............	Mount Beacon, Dutchess county
Mount View Spring.................	Poughkeepsie, Dutchess county
Monarch Spring Water Co..........	Beacon, Dutchess county
Elk Spring Water Co...............	Lancaster, Erie county
Mohawk Spring	Amsterdam, Montgomery county
Clinton Lithia Springs, Inc..........	Franklin Springs, Oneida county
Glen Alix Spring....................	Washington Mills, Oneida county
Lithia Polaris Spring...............	Boonville, Oneida county
F. H. Suppe (Franklin Lithia Spring)	Franklin Springs, Oneida county
Orville Risley	New York Mills, Oneida county
Geneva Mineral Water Springs.......	Geneva, Ontario county
Crystal Spring	Oswego, Oswego county
Deep Rock Spring..................	Oswego, Oswego county
Great Bear Spring..................	Fulton, Oswego county
White Sulphur Spring...............	Richfield Springs, Otsego county
Black Rock Spring..................	Rensselaer, Rensselaer county
Mammoth Spring	North Greenbush, Rensselaer county
Shell Rock Spring...................	East Greenbush, Rensselaer county
Madrid Indian Spring...............	Madrid, St Lawrence county
Artesian Lithia Spring..............	Ballston Spa, Saratoga county
Comstock Mineral Spring............	Ballston Spa, Saratoga county
Mohican Spring	Ballston Spa, Saratoga county
Arondack Spring	Saratoga Springs, Saratoga county
Hathorn (Nos. 1 and 2) Springs......	Saratoga Springs, Saratoga county
Coesa Spring	Saratoga Springs, Saratoga county
Geyser Spring	Saratoga Springs, Saratoga county
Minnonebe Spring	Saratoga Springs, Saratoga county
Orenda Spring	Saratoga Springs, Saratoga county
Saratoga Gurn Spring...............	Saratoga Springs, Saratoga county
Saratoga Vichy Spring..............	Saratoga Springs, Saratoga county
Chalybeate Spring	Sharon Springs, Schoharie county
Eye Water Spring	Sharon Springs, Schoharie county
Sulphur-Magnesia Spring	Sharon Springs, Schoharie county
White Sulphur Spring...............	Sharon Springs, Schoharie county
Red Jacket Spring..................	Seneca Falls, Seneca county

NAME	LOCALITY
Setauket Spring	Setauket, Suffolk county
Elixir Spring	Clintondale, Ulster county
Sun Ray Spring	Ellenville, Ulster county
Vita Spring	Fort Edward, Washington county
Vermont Mineral Spring	Granville, Washington county
Briarcliff Lodge Association	Briarcliff Manor, Westchester county
Gramatan Spring Water Co	Bronxville, Westchester county
Orchard Spring	Yorktown Heights, Westchester county

Production. The returns received from the spring water companies for 1915 showed total sales of 8,636,920 gallons with a value of $745,530, which was about the usual quantity. The largest business was reported by Oswego county, which, however, was restricted to the sale of fresh spring waters for family and office supply. Saratoga county led in the output of carbonated and medicinal waters.

NATURAL GAS

Returns received from the producers and distributors of natural gas within local territory show a further drop in the yield for 1915. The continuation of the decline over a period of two years, as has been the case, seems to indicate a serious situation with respect to supplies which are not maintaining equilibrium with the drain resulting from exploitation. This is to be attributed no doubt to the smaller flow obtained from new wells than in the few previous years when some very productive pools were tapped in the western counties. There has been no material enlargement of the productive area since the bringing in of the large wells at Orchard Park. Erie county, in 1912, which reflected itself so markedly in the returns for 1913.

The flow of natural gas in 1915, according to the reports of producers and distributors, was 7,110,040,000 cubic feet, as compared with 8,714,681,000 cubic feet in 1914 and 9,055,429,000 cubic feet in 1913, which is the high mark for the industry. The figures represented a decline of about 18 per cent during the year and of over 20 per cent in the two years including 1913. The loss is traceable mostly to the pools in Erie county, whereas the other counties of importance, like Genesee, Chautauqua, Allegany and Cattaraugus, held their own or showed a very small decrease for the year.

In value, the production last year was reported as $2,085,324 against $2,570,165 in 1914. The value is based on the average prices received for the gas in the different centers of consumption. The mean for the whole State was 29.4 cents a thousand in both years. The actual prices range from 20 cents to over 50 cents a thousand, the latter being reported from the isolated fields in the central counties.

Production of natural gas

YEAR	OUTPUT 1000 CU. FT.	VALUE	NUMBER OF WELLS
1904	2 399 987	$552 197	....
1905	2 639 130	607 000	....
1906	3 007 086	766 579	....
1907	3 052 145	800 014	925
1908	3 860 000	987 775	1 100
1909	3 825 215	1 045 693	1 280
1910	4 815 643	1 411 699	1 340
1911	5 127 571	1 547 077	1 403
1912	6 564 659	1 882 297	1 660
1913	9 055 429	2 549 227	1 750
1914	8 714 681	2 570 165	1 797
1915	7 110 040	2 085 324	2 051

It would be of interest to give the statistics according to counties or districts represented in the production, but owing to the fact that the larger distributing companies may take their supplies from several fields it has become difficult to segregate the output in this way, although the figures for a few of the counties can be stated separately. In all about 200 individuals and firms are represented in the industry. Chautauqua county alone has over 100 producers, but most of them are small with only a single well each, used for family supply. The production of this county in 1915 was 1,210,378,000 cubic feet valued at $335,610. Erie has the largest output but the exact figures can not be stated. The four counties of Allegany, Cattaraugus, Erie and Genesee, which are tributary to Buffalo, contributed a total of 5,580,928,000 cubic feet with a value of $1,631,194. This represented a large decline from the total reported for the preceding year, as the result of the falling off in Erie county. Genesee county increased its flow somewhat and Allegany and Cattaraugus counties contributed about the usual amount. The statistics do not include gas used in the pumping of oil wells in the Allegany-Cattaraugus field. Among other counties, Ontario contributed a total of 158,301,000 cubic feet valued at

$53,801. The remaining counties represented in the industry were Livingston, Monroe, Niagara, Onondaga, Oswego, Schuyler, Steuben, Wyoming and Yates.

The business of distributing the output among the cities and communities within the different districts is controlled by a relatively few companies, some of whom are employed also in productive operations. The largest single distributor is the Iroquois Natural Gas Co. of Buffalo with pipe lines to the principal fields in Allegany, Cattaraugus, Erie and Genesee counties. The Alden-Batavia Natural Gas Co. and the Pavilion Natural Gas Co. are important producers and distributors in the Erie-Genesee county district. In Chautauqua county the larger operators are the Frost Gas Co. and the Silver Creek Gas & Improvement Co. In Allegany and Cattaraugus counties the Gowanda Natural Gas Co., the Empire Gas & Fuel Co. and the Producers Gas Co. have pipe lines. In Ontario county the main producer and distributor is the Ontario Gas Co. Among the smaller companies engaged in the business are the Consumers Natural Gas Co. with wells in the town of Darien, Schuyler county, the Baldwinsville Light & Heat Co. of Baldwinsville, Onondaga county, the Pulaski Gas & Oil Co. of Pulaski, Oswego county, and the Sandy Creek Oil & Gas Co. of Sandy Creek, Oswego county.

The geological occurrence of natural gas in the State has been described in various reports issued by the New York State Museum. The productive gas pools are distributed over portions of sixteen counties, but they are all in the section that lies west of the 76th meridian, which crosses the west end of Oneida lake. Discoveries have been reported from time to time in the eastern part of the State, notably in the sections along the Mohawk river as far east as Albany county; in this region, however, the gas seems to be confined to small pockets which are rapidly depleted.

The most prolific gas pools thus far found are in the sandstones of the Medina formation, near the top of the latter. This formation outcrops in a belt along the south shore of Lake Ontario and consists mainly of shale with sandstones in the upper part, with an aggregate thickness of about 1200 feet. It extends along the lake shore from the Niagara river to Oswego county, and continues eastward for some distance beyond the limits of this county. The strata have been little disturbed or changed since their uplift. They dip slightly toward the south or southeast, the average inclination being about 50 feet to the mile. The dip together with the rising elevation toward the south soon brings the strata under a considerable cover which increases progressively with the distance from the outcrop. The important gas pools of Erie and Genesee counties occur in the Medina at depths of from 1200 to 1800 feet, those in the southern part of Erie county being the deepest. The lake shore gas belt of Chautauqua county also derives its main supply from the Medina which is encountered at depths of 1900 to 2300 feet. The deepest explorations have been in northern Cattaraugus county, where gas sands supposedly belonging to the Medina have been encountered at 2500 to 3300 feet.

Next to the Medina, the most important horizon is in the Chemung sandstones at the top of the Devonic, the same strata that yield the petroleum production of New York. The wells are from 600 to 1800 feet deep and were primarily drilled for oil, but the gas is an important subsidiary product that is utilized in part for pumping the wells. The excess is piped to the communities in the district and as far as Buffalo.

The Trenton limestone affords a small supply of gas which is developed at Pulaski and Sandy Creek, Oswego county, at the east end of Lake Ontario and at Baldwinsville, Onondaga county. At the localities first named the wells are 1200 to 1500 feet deep and at Baldwinsville 2400 feet.

PETROLEUM

The oil wells last year yielded about the average product, as shown by the receipts of pipe-line companies who handle the New York output. The total receipts were 928,540 barrels, against 933,511 barrels in 1914 and 916,873 in 1913. For the last 20 years the production has held steadily at about the same level, fluctuating to a slight extent with the varying market conditions. When prices are low there is less activity in drilling and the increment from new wells falls short of balancing the natural decline in the flow of the older wells, so that the production falls off; whereas a rising market usually results in an increase of output.

While market conditions on the whole have favored the industry during the last few years, they have been subject to remarkable variations, so much so that producers could place little reliance upon their stability from month to month or day to day. Such rapid changes naturally have a tendency to unsettle and discourage plans for new undertakings. The causes for the rapid rise and fall in the quotations for crude oil during 1914 and 1915 have not been apparent from the viewpoint of the refined market.

The range of prices within the period of the year has been from \$1.35 to \$2.50 a barrel. In the early months of 1914 quotations remained steady at \$2.50. During the month of May there was a vertical drop to \$1.90 and by September they had reached \$1.45 where they held to the close of that year. In January 1915 Pennsylvania and New York crude was quoted at \$1.50. No change occurred until April when the price dropped to \$1.35. With the month of August an upward trend began which carried the quotations to \$1.45, to \$1.65 in September, \$1.75 in October, \$2.10 in November and \$2.25 in December.

Owing to the discouraging outlook at the close of 1914, with prices over \$1 a barrel below the quotations at the beginning, there was little enterprise manifested in exploratory work during the first months of the new year. There were fewer wells drilled in 1915 than had been reported for a number of years. The total, according to the monthly compilations of the Oil City Derrick, was 108, as compared with 267 in 1914, 512 in 1913, and 246 in 1912. The increment of production from the new wells amounted to 122 barrels, against 446 barrels in the preceding year, 810 barrels in 1913 and 278 barrels in 1912. There were two dry wells reported, as compared with 17 in 1915, 48 in 1913 and 66 in 1912.

Production of petroleum in New York

YEAR	BARRELS	VALUE
1896	1 205 220	\$1 420 653
1897	1 279 155	1 005 736
1898	1 205 250	1 098 284
1899	1 320 909	1 708 926
1900	1 300 925	1 759 501
1901	1 206 618	1 460 000
1902	1 119 730	1 530 852
1903	1 162 978	1 849 135
1904	1 036 179	1 709 770
1905	949 511	1 566 931
1906	1 043 088	1 721 095
1907	1 052 324	1 736 335
1908	1 160 128	2 071 533
1909	1 160 402	1 914 663
1910	1 073 650	1 458 194
1911	955 314	1 251 461
1912	782 661	1 338 350
1913	916 873	2 255 508
1914	933 511	1 773 671
1915	928 540	1 476 378

The statistics of production for the 20 year period, 1896–1915, are shown in the accompanying table. The figures up to the year 1903 inclusive are those compiled by the *Mineral Resources*, while the statistics of subsequent date have been collected directly from the pipe-line companies and shippers who operate in the New York fields. The list of these companies follows: Columbia Pipe Line Co., Union Pipe Line Co., Fords Brook Pipe Line Co., Buena Vista Oil Co., and Madison Pipe Line Co. of Wellsville; Vacuum Oil Co., Rochester; New York Transit Co., Olean; Emery Pipe Line Co., Allegany Pipe Line Co., Tide Water Pipe Co., Limited, and Kendall Refining Co., Bradford, Pa.

The production of oil comes from three counties — Allegany, Cattaraugus and Steuben. Altogether there are about 11,500 wells in the State, of which 8200 are in Allegany, 3000 in Cattaraugus and 300 in Steuben county.

The Allegany county wells are distributed over six townships situated along the Pennsylvania boundary. The field was opened about 1880 and in the height of its prosperity contributed 30,000 barrels a day. The principal pools are the Bolivar, Richburg, Wirt and Andover; the last named lies partly in Steuben county and is the source of its production of oil. The wells of Allegany county range from 780 to 1900 feet deep, and the oil sands attain a thickness of 50 feet or more in the best territory.

Cattaraugus county contains the extension of the Bradford field of Pennsylvania, with about 40 square miles of oil territory in the towns of Olean, Allegany and Carrollton. The more notable pools are the Ricebrook, Allegany, Chipmunk and Flatstone and are found at depths of from 600 to 1800 feet. The first wells were drilled in 1865.

SALT

A record year in the salt industry was indicated by the returns received from the mines and brine-pumping plants for 1915. The aggregate output of all grades of salt was 11,095,301 barrels, as compared with 10,389,072 barrels in the preceding year, and larger than the highest total previously reported, which was in 1913, by 275,780 barrels. The increase was brought about by enlarged operations of the producers and not by the development of new sources of supply. There were no additions to the list of enterprises either among brine works or mines.

As shown by the detailed statistical tables for 1914 and 1915, the increased output was not accompanied by any notable improvement in the market situation, so far as relates to prices. The average selling price was the same in both years, although minor changes may be noted among the individual grades. In view of the strong upward trend of commodity prices that has been in evidence recently, the salt trade does not appear to be in a particularly prosperous condition.

The industry has experienced a tremendous expansion in the last quarter of a century, in which time the production has increased nearly fivefold. This is not entirely the result of the growth of the salt trade, strictly speaking, within the territory tributary to New York, although there has been a material gain in the trade; but is due largely to the development of chemical industries that consume salt, and especially of alkali or soda manufacture which has grown to large proportions in recent years. It is estimated that the amount of salt that is now converted into sodium compounds by manufacturers within the State amounts to fully one-third of the whole annual production of salt.

Production of salt by grades in 1914

GRADE	BARRELS	VALUE	VALUE A BARREL
Common fine *a*	1 369 071	$543 203	$.40
Common coarse	162 329	74 545	.46
Table and dairy	1 272 629	820 840	.64
Solar	328 700	90 392	.27
Packers	100 186	50 402	.50
Other grades *b*	7 156 157	1 256 324	.18
Total	10 389 072	$2 835 706	$.27

Production of salt by grades in 1915

GRADE	BARRELS	VALUE	VALUE A BARREL
Common fine *a*	1 460 379	$598 193	$.40
Common coarse	126 193	59 077	.46
Table and dairy	1 274 743	829 581	.65
Solar	267 886	93 760	.35
Packers	165 179	83 890	.50
Other grades *b*	7 800 921	1 347 431	.17
Total	11 095 301	$3 011 932	$.27

a Common fine includes a small amount of common coarse.
b Includes rock salt, salt in brine used for alkali manufacture, agricultural salt, and small amounts of brine salt for which the uses were not specified in the returns.

The classification, as given in the tables, is based on the commercial grades, so far as practicable. In case, however, a certain grade is made by a single producer, it is merged with other grades, so as not to reveal the individual figures. Rock salt and the salt in brine converted into soda appear in the last item of the tables, which includes also small amounts of evaporated salt not specially classified in the returns. Table and dairy salt includes the superior grades of artificially evaporated salt that are specially prepared for the table and for butter and cheese making; it brings the highest market prices. Under common fine are listed the other grades of fine, artificially evaporated salt that are not specially prepared. Common coarse represents the coarser product from artificial evaporation. Solar salt is made by evaporation of brine in shallow vats exposed to the sun's heat. The process is employed only by the manufacturers on the old Onondaga Salt Springs Reservation at Syracuse, and can be carried on of course only in the summer months. The product is used practically for the same purposes as rock salt. Packers salt includes the grade sold to meat packers and fish salters.

The salt industry is confined at present to six counties, as follows: Genesee, Livingston, Onondaga, Schuyler, Tompkins and Wyoming. Of these, Livingston county is the sole producer of rock salt; while the others are represented only in the evaporated salt industry, and derive their brines from wells sunk to the salt beds, or, in the case of the Onondaga county solar salt industry, from wells that yield a natural brine.

The following is a list of the active companies in the evaporating industry during 1915: International Salt Co., with works at Myers and Watkins; Worcester Salt Co., Silver Springs; Rock Glen Salt Co., Rock Glen; Remington Salt Co., Ithaca; Watkins Salt Co., Watkins; Genesee Salt Co., Piffard; Le Roy Salt Co., Le Roy; Solvay Process Co., Solvay, and the several makers of solar salt at Syracuse who market their output through the Onondaga Coarse Salt Association of that city. The rock salt mines, of which two were active, were worked by the Sterling Salt Co., Cuylerville, and the Retsof Mining Co., Retsof. One company, the Eureka Salt Corporation of Saltville, who made a production in 1914, was inactive last year.

The salt deposits of the State are widely distributed and of inexhaustible character. Practically all the territory to the south of the outcrop of the Salina formation, west from Madison county, may be considered as within the salt-bearing district, although the deposits are not absolutely continuous throughout the area. Rock salt is not encountered usually at less than 800 feet or so from the surface, since the beds are very soluble and it is only under a protecting cover of considerable thickness that they have been preserved. They are known to continue far to the south of the Salina outcrop where the dip carries them to depths of over 3000 feet. The distribution of the salt beds and the industry based on them have been described by Merrill and Englehardt in Bulletin 11 of the New York State Museum, "Salt and Gypsum Industries of New York." Further and more recent data on the geology of the beds will be found in Luther's "Geology of the Livonia Salt Shaft" in the 13th Annual Report of the New York State Museum and "Salt Springs and Salt Wells of New York and Geology of the Salt District" in the 16th Annual Report of the Museum. Many records of salt wells are assembled in the papers by Bishop, included in the 5th Annual Report of the New York State Geologist and the 45th Annual Report of the State Museum.

The most recent exploration for salt has been in the vicinity of Portland Point, Cayuga county, on the east side of Cayuga lake, south of Ludlowville or Myers where the International Salt Co. has a brine works. According to information supplied by Fordyce A. Cobb, Esq., of Ithaca, the well was started in May 1915, and completed in August of the same year. The locality is about 10 rods north of the Cayuga Lake Cement Works, near the Lehigh Valley Railroad Company's tracks. Rock (limestone) was encountered at 11 feet. The salt bed was reached at 1484 feet. The upper 17 feet of salt was somewhat shaly and impure, but between 1501 and 1548 feet depth a fine quality of rock salt was passed through. No attempt toward development of the deposit has as yet been undertaken. The drill test is of interest as showing the continuation of the Ludlowville beds to the south, over a part of the interval between that place and the next proved territory just north of Ithaca where the Remington Salt Co. has a plant which derives brines from wells 2100 feet deep.

Production of salt in New York

YEAR	BARRELS	VALUE
1890	2 532 036	$1 266 018
1891	2 839 544	1 340 036
1892	3 472 073	1 662 816
1893	5 662 074	1 870 084
1894	6 270 588	1 999 146
1895	6 832 331	1 943 398
1896	6 069 040	1 896 681
1897	6 805 854	1 948 759
1898	6 791 798	2 369 323
1899	7 489 105	2 540 426
1900	7 897 071	2 171 418
1901	7 286 320	2 089 834
1902	8 523 389	1 938 539
1903	8 170 648	2 007 807
1904	8 724 768	2 102 748
1905	8 575 649	2 303 067
1906	9 013 993	2 131 650
1907	9 657 543	2 449 178
1908	9 005 311	2 136 736
1909	9 880 618	2 298 652
1910	10 270 273	2 258 292
1911	10 082 656	2 191 485
1912	10 502 214	2 597 260
1913	10 819 521	2 856 664
1914	10 389 072	2 835 706
1915	11 095 301	3 011 932

SAND AND GRAVEL

The production of sand and gravel should be given consideration as one of the branches of the mineral industry. It is carried on in one or more places in practically every county of the State; but only in a few sections has it become really stabilized so as to be conducted on a more or less permanent basis. For that reason a statistical investigation of the industry is attended with considerable difficulty, and the results may be lacking somewhat in accuracy.

Such is the case more especially with the ordinary building sands and gravels which are so widely distributed that in most places they have little or no intrinsic value, the requirements being supplied from deposits in the immediate vicinity at a nominal expense above the cost of handling. In recent years, however, there has been a manifest tendency toward a standardization of these materials when they are to be employed in important structures or engineering works. It has been found that they have a very direct influence upon the quality of the mortar or concrete into which they enter, a fact that has not received so wide appreciation as it should perhaps, outside of the engineering profession. The need for materials that will meet the modern requirements has made necessary more care in the selection, besides preparation oftentimes by sizing or washing. This development is one that promises to place the industry upon a more settled basis than it has had in the past.

Sand also serves a variety of other uses, such as for glass manufacture, for making of molds for casting metals, as an abrasive, and in numerous manufacturing and metallurgical operations. In most of these applications the sands must meet certain definite requirements as to physical condition, mineral or chemical composition, which greatly limit the available sources of supply. Their production necessitates a degree of skill and technic which makes for permanency in the enterprises.

The sand and gravel beds of the State belong mainly to the Pleistocene formations, accumulated as the result of the great ice invasion which moved from north to south and reached as far south as northern New Jersey and Pennsylvania. This ice sheet swept the rocks bare of their former mantle of disintegrated materials and in their place left a covering of transported bowlders, gravels, sands and clays. These materials when deposited directly by the ice as ground moraine are so intermixed as to have little or no industrial value. Such unmodified drift covers a considerable portion of the area, especially in the hilly country, whereas in the valleys and lowlands it is usually concealed by beds of sorted gravels, sands and clays. These latter were deposited by the waters which issued from the glacier during its retreat. In some of the larger valleys, as those of the Hudson, Champlain and Genesee, as well as in numerous smaller ones, the glacial waters were held imprisoned for a time by dams so that they stood high above the present levels, and the sands and clays were deposited in a series of terraces in great thickness and in well-sorted arrangement.

Beach sands are found on the shores of Long Island and Staten Island and of some of the interior lakes, notably Oneida lake. These are characterized by a degree of uniformity and purity which make them valuable for many purposes. The sands that have been used most extensively for glass making are found on Oneida lake.

Production. The statistics of the sand and gravel industry, as collected from the individual producers, give an approximation of the total business, but it is not claimed that they are complete. The figures for molding sand, however, are full and reliable, since this branch of the trade is on a fairly stable basis, in contrast with the other branches which in general are subject to great changes from year to year. The figures for building sand and gravel, doubtless, understate the actual business, falling short perhaps as much as 15 per cent of the total output in any one year. The operations are so widely scattered and often of so fugitive nature that it is not possible to keep informed of all developments as they take place.

Production of sand and gravel

MATERIAL	1913	1914	1915
Building sand	$1 102 688	$1 151 521	$1 185 812
Molding sand	449 224	310 727	415 073
Fire and core sand	38 571	23 944	24 797
Other sand	75 000	75 000	75 000
Gravel	918 783	650 895	965 336
Total	$2 584 266	$2 212 087	$2 666 018

Building sand and gravel. Building sand is employed in lime and cement mortars, for concrete, artificial stone, etc. It is desirable that sand for this use should be mainly composed of quartz which is the strongest and most durable of the minerals that occur in sands, but ordinarily the sands supplied consist of quartz mixed with considerable percentages of silicate minerals, especially feldspar, mica and hornblende. Silt and clayey matter are also present in most sands, especially those of glacial or stream origin.

For small structures where little stress is laid upon the elements of strength and permanency the silty mixed sands, if not too inferior in quality, may serve well enough, as in fact large quantities of such material are thus utilized with satisfactory results. It is also true that the tendency in building construction is toward a closer scrutiny and control of all the materials, inclusive of the sand and coarser aggregates. The strength of mortar and concrete is dependent quite as certainly upon the character of the sand as upon that of any other constituent, and in important works like highways, bridges and large buildings it is the practice now to require certain standards of texture and composition. Hence there has arisen an increased demand for the better grades which is serving to stabilize and centralize the industry. The requirements are such that the supplies are obtainable only from certain restricted areas or through artificial benefication of low-grade sands by washing and sizing.

The most important deposits from a commercial standpoint are those found on the northern shores of Long Island. These are dredged from shallow waters or excavated along the exposed beaches, and prepared by screening. Enormous quantities are taken each year from the northern shores of the island within the limits of Nassau county. The sand is shipped in barges to New York and the environs for use in buildings, street work, etc.

Some of the lake beaches in the interior of the State afford excellent building sands. Oneida lake is bordered by extensive sand beaches from which quartz sands, some of high quality, are obtained.

The output of building sand in 1915 was returned as 4,127,508 cubic yards, worth $1,185,812, a little over the output reported for the two preceding years. The output included some sand used for water filtration, which is obtained from the same beds as building sand.

Molding sand. The Hudson valley from Fort Edward south to Poughkeepsie contains extensive areas of fine sands which represent the last deposits formed in glacial Lake Albany.[1] They overlie the blue and yellow clays, deposited during the same period of flood waters, but have a rather variable vertical distribution owing to effects of wind erosion which in places has swept them away to heap them up elsewhere in dunes. The sand normally contains considerable shale, but through weathering the shale is resolved into clay with the release of some iron. The weathering is also marked by a change of color, from grayish to yellow. This yellow weathered sand is a pure quartz sand and is remarkable for the angularity and even size of the particles. It usually possesses also a fine grain. The combination of qualities makes it a valuable molding sand, especially for small castings like stove-plate and other iron work which require a smooth surface.

The business of excavating and shipping the sand of this district is extensive and is carried on by a number of concerns, each of which usually has several banks under operation so as to be in a position to supply the various grades in demand. The output in recent years has ranged from 300,000 to 500,000 short tons. In 1915 it amounted to 454,511 short tons valued at $415,073, which represented a large gain over the product reported in 1914 when the industry felt the effects of the general depression in the metal trades.

[1] A detailed account of the molding sands of this region will be found in a paper by D. H. Newland in Trans. Amer. Foundrymen's Association, v. 24. 1914.

STONE

The products of the stone quarries form a large item in the total mineral production of the State. The last few years have witnessed, however, some notable changes in the relative importance of the different branches of the stone industry. The use of cement and terra cotta in architectural work has curtailed the demand for cut stone, so that this branch no longer occupies the prominent place that it once had. Similarly the market for flagstone and curbstone has fallen off, especially for flagstone, as a result of the favor shown for cement construction. On the other hand there has been a tremendous development of the crushed stone industry, which has practically counterbalanced the declines in the other departments. Altogether the changes that have taken place have meant a loss industrially, since the preparation of crushed stone requires a minimum of labor of the unskilled sort, while the cut stone business once gave employment to large numbers of highly trained workmen.

The statistics of stone production which have been supplied by the quarry operators throughout the State indicate that the year 1915 was a period of great depression for practically all branches of the industry. The decline in production coming after a period of such radical curtailment as shown by the returns for the preceding year in comparison with those for 1913, was significant of a reaction such as the industry has not experienced previously for a long time. The total value of the quarry materials amounted to $5,162,115 against $5,741,137 in 1914 and $6,763,064 in 1913. This represents a decline of 10 per cent for the past year and of 24 per cent in the output for the two years since 1913. The depression caused the closing of some quarries. There is little doubt that the decline has reached its lowest point, and hereafter an improvement may be expected, as in fact there has already been some change for the better.

The granite quarries made the best showing of all, but this was due largely to the product of a single quarry in southeastern New York which supplied stone for a large contract. The output of crushed stone and paving blocks is expected to increase during the current season through the addition of new producers to the list.

Limestone, as heretofore, constituted more than one-half of the total output in value. The product was but little smaller than that for 1914, the principal decrease being in the item of crushed stone.

Marble showed a drop of nearly 50 per cent which was distributed nearly proportionately between building and monumental stone. The active quarries were in the Gouverneur district and in Dutchess county.

The production of sandstone continued to decline as it has done for several years past. The depression affected the bluestone industry more especially, which supplies stone for street work. The Medina district fairly held its own.

The quarrying of trap was influenced by conditions other than those of supply and demand. The quarries along the face of the Hudson Palisades have been in process of condemnation, and it is expected their operations will be definitely terminated before long, while some properties have already been closed.

The production of the different kinds of stone for the last three years is shown in the accompanying tables.

Production of stone in 1913

VARIETY	BUILDING STONE	MONUMENTAL	CURBING AND FLAGGING	CRUSHED STONE	ALL OTHER	TOTAL VALUE
Granite	$45 911	$17 013	*a*	$236 650	$36 068	$335 642
Limestone	101 198	....	$6 546	2 386 632	1 358 302	3 852 678
Marble	127 556	81 330	....	....	43 406	252 292
Sandstone	285 645	....	682 984	46 267	306 376	1 321 272
Trap	....	....	....	1 001 170	....	1 001 170
Total	$560 310	$98 343	$689 530	$3 670 719	$1 744 152	$6 763 054

a Included under "All other."

Production of stone in 1914

VARIETY	BUILDING STONE	MONUMENTAL	CURBING AND FLAGGING	CRUSHED STONE	ALL OTHER	TOTAL VALUE
Granite	$79 903	$10 952	....	$259 750	$16 637	$367 242
Limestone	81 409	....	$3 877	2 156 503	1 074 274	3 316 063
Marble	142 223	70 797	....	8 000	9 222	230 242
Sandstone	217 508	....	490 222	36 143	313 117	1 056 990
Trap	....	....	....	770 600	....	770 600
Total	$521 043	$81 749	$494 099	$3 230 996	$1 413 250	$5 741 137

Production of stone in 1915

VARIETY	BUILDING STONE	MONUMENTAL	CURBING AND FLAGGING	CRUSHED STONE	ALL OTHER	TOTAL VALUE
Granite........	$261 091	$19 926	$1 165	$61 965	$78 450	$422 597
Limestone.....	63 121	....	1 627	2 072 852	1 040 100	3 177 700
Marble........	61 601	37 074	....	....	21 772	120 447
Sandstone.....	198 743	....	317 986	77 368	296 314	890 411
Trap..........	....	....	....	497 660	53 300	550 960
Total.....	$584 556	$57 000	$320 778	$2 709 845	$1 489 936	$5 162 115

GRANITE

Granite is both a specific and a general term. When used in the restricted scientific sense it means an igneous rock of thoroughly crystalline character in which the chief constituents are feldspar, quartz and mica. Such a rock has a massive appearance; that is, the constituents are uniformly distributed in every direction, and owing to the predominance of the feldspar and quartz the color is rather light, commonly gray or pink. As a variation to the uniform distribution of the minerals, the latter may develop a plane parallel arrangement through the influence of compression when the mass was still deeply buried in the earth's crust. A granite with this parallel or foliated texture is known as a granite gneiss.

The commercial definition of granite is much broader than that given and includes almost any of the crystalline silicate rocks (usually igneous) that possess the requisite physical qualities for use as architectural or monumental stone. In most cases the commercial product is actually a granite in the true sense, but not infrequently it may be a syenite which lacks quartz, or a diorite consisting of plagioclase, feldspar and hornblende, or anorthosite which contains little else than basic plagioclase feldspar. So-called black granites are mainly gabbros and diabases with a large proportion of the iron compounds — pyroxene, hornblende and magnetite.

The broader usage will be followed in the present classification, as all the above-named rocks are quarried in this State. The only silicate rock not included under granite is diabase or trap which, on account of the special features surrounding its production and uses, is classified by itself.

Granites and the associated crystalline silicate rocks are restricted in New York to two well-defined areas — the Adirondacks in the north and the Highlands in the southeast. A detailed account of these materials, their characters, distribution and economic development is given in "Quarry Materials of New York," issued as Bulletin 181 of the New York State Museum.[1]

The quarrying of granite has never attained the importance which seems commensurate with the resources and large markets of the State. Much of the output reported in recent years has been by contractors on local engineering works, rather than by permanent enterprises established for the supply of stone to the general market. The value of the product thus is difficult to establish. In the last year or two there has been manifest a more general interest in the industrial development of the granite resources which promises to give a new impetus to the production.

The output in 1915 was valued at $422,597 and consisted of building stone, $261,091; monumental, $19,926; paving blocks, $78,450; crushed stone 74,050 cubic yards, $61,965; other kinds, $1165. A large part of the building stone was quarried by a single firm for the construction of the Kensico reservoir at Valhalla, N. Y., which is built of cyclopean masonry.

Activity in the St Lawrence River district was confined to the operations of J. Leopold & Co. at their Alexandria Bay quarries where paving blocks were made. The quarries of the Picton Island Red Granite Co. were closed down. The Wisconsin Granite Co., one of the largest firms in the granite trade, has secured property on Wellsley island, where it will quarry stone for paving blocks, and has erected a crushing plant at Alexandria Bay.

The syenite quarries at Ausable Forks, which supply monumental stone of dark green color, were operated on about the usual scale. The Champlain Green Granite Co. and Fred A. Carnes were the producers.

The anorthosite quarries in the northern Adirondacks are among the properties that should contribute materially to the output, once the stone becomes familiar to the public. The material is nearly pure feldspar, white to grayish green on the rock face and a beautiful lustrous green on polished surfaces. A dark gray gneissic granite was quarried by E. F. Edel near Gloversville, principally for paving blocks.

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[1] January 1, 1916.

The Mohegan Granite Co. continued work in its quarries near Peekskill, from which are obtained yellow and light gray granites adapted to building and monumental work.

H. S. Kerbaugh Co., Inc., operated the Valhalla quarries in the Yonkers granite. This is the largest enterprise in the State, most of the product being used locally in engineering work, although some of the output was sold. The stone is well suited for general building purposes.

LIMESTONE

The stone classified under the heading of limestone consists for the most part of the common grades of limestone and dolomite, such as are characterized by a compact granular or finely crystalline texture and are lacking in ornamental qualities.

A smaller part is represented by crystalline limestone and by the waste products of marble quarrying which are sometimes employed for crushed stone, lime-making or flux. Limestone used for the manufacture of portland and natural cement is, however, excluded from the tabulations so as to avoid any duplications of the statistics.

Limestones have a wide distribution in the State, the only region which is not well supplied being the southern part where the prevailing formations are sandstones of Devonic age. The microcrystalline varieties occur in regular stratified order in the Cambric, Lower Siluric, Upper Siluric and Devonic systems. In most sections they occupy considerable belts and have been little disturbed from their original horizontal position. On the borders of the Adirondacks and in the metamorphosed Hudson river region, however, they have been more or less broken up by faulting and erosion and in places have a very patchy distribution.

The Cambric limestones are found in isolated areas on the east, south and west of the Adirondacks. They are usually impure, representing a transition phase between the Potsdam sandstones below and the high calcium limestones above. The lower beds of the Beekmantown formation as originally defined are now known to belong to the Cambric system. The Little Falls dolomite is perhaps the most prominent member of the Cambric limestones and is extensively developed in the Mohawk valley with quarries at Little Falls, Amsterdam, and other places. It is a rather heavily bedded stone of grayish color, suitable more especially for building purposes. In Saratoga county the Hoyt limestone is in part the equivalent of the Little Falls dolomite; it has been quarried for building stone just west of Saratoga Springs. On the west side of the Adirondacks the Theresa limestone is described by Cushing as a sandy dolomite which may in part belong to the Cambric system. It is comparatively thin and has no importance for quarry purposes.

The Beekmantown limestone, which is now taken as including the middle and upper beds of that series as earlier defined, is mostly restricted to the Champlain valley. It occurs on the New York shore in rather small areas, usually downfaulted blocks, that are the remnants of a once continuous belt. It is also doubtless represented in the basal portion of the limestone area that extends across Washington and Warren counties. The only place where it has been extensively quarried is at Port Henry where the purer layers have been worked for flux. In the Lake Champlain region it is a bluish or grayish magnesian limestone occurring in layers from a few inches to several feet thick.

The Chazy limestone is found in the same region as the Beekmantown in discontinuous areas along the eastern Adirondacks from Saratoga county north to the Canadian boundary. It attains its maximum thickness in eastern and northeastern Clinton county, and has been quarried around Plattsburg, Chazy and on Valcour island. The Chazy is the earliest representative of the Paleozoic formations characterized by a fairly uniform high calcium content; it analyzes 95 per cent or more of calcium carbonate. It has a grayish color and finely crystalline texture. The fossiliferous beds afford attractive polished material which is sold as "Lepanto" marble. It is used also for lime and furnace flux. There are old quarries on Willsboro point, Essex county. On the west side of the Adirondacks the Pamelia limestone, described in the areal reports of that section, belongs to the Chazy series. It covers a considerable area in Jefferson county between Leraysville and Clayton, and has been rather extensively quarried for building stone and lime, though of subordinate importance to the Trenton limestones of that section.

In the Mohawkian or Trenton group are included the Lowville (Birdseye), Black River and Trenton limestones which have a wide distribution and collectively rank among the very important quarry materials of the State. They are represented in the Champlain valley but are specially prominent on the Vermont side; from the latter area a belt extends southwest across northern Washington county to Glens Falls in Warren county and is continued into Saratoga county. Another belt begins in the Mohawk valley near Little Falls and extends northwesterly with gradually increasing width across Oneida, Lewis and Jefferson counties to the St Lawrence river. There are isolated areas of Trenton limestone in the Hudson valley south of Albany. The limestones vary in composition and physical character according to locality and geologic position. They are often highly fossiliferous. In the northern section they are mostly gray to nearly black in color, contain little magnesia and run as high as 97 or 98 per cent calcium carbonate. The lower part of the group is heavily bedded and well adapted for building stone; the upper beds commonly contain more or less shale. They are used for various purposes including building and ornamental stone, crushed stone, lime, portland cement and flux. In the Champlain valley quarries are found near Plattsburg, Larabee's Point and Crown Point; in Washington county at Smith's Basin; in Warren county at Glens Falls where there are extensive quarries that supply material for building purposes, portland cement and lime. The well-known black marble from Glens Falls is taken from the Trenton. Numerous quarries have been opened in Herkimer, Oneida, Lewis and Jefferson counties. The output of the last named county is specially important, including limestone for building and road construction and lime for manufacture of calcium carbide. The principal quarries in Jefferson county are at Chaumont.

The next assemblage of limestones in the order of stratigraphic occurrence includes the Clinton, Lockport and Guelph members of the Niagara group. The Clinton limestone has a variable importance in the belt of Clinton strata that extends from Otsego county a little south of the Mohawk river across the central and western parts of the State on the line of Oneida lake and Rochester to the Niagara river. East of Rochester the limestone is relatively thin, usually shaly and split up into several layers, but on the west end in Niagara county it becomes the predominant member and has a more uniform character. Large quarries have been opened recently at Pekin, Niagara county, for the supply of flux to the blast furnaces of the Lackawanna Steel Co., at Buffalo. The upper beds of bluish gray fossiliferous limestone from 10 to 12 feet thick are the purest and analyze from 90 to 95 per cent calcium carbonate. The Lockport is a magnesian limestone, in places a typical dolomite, and is rather silicious in the lower part. It outcrops in a continuous belt, several miles wide, from Niagara Falls east to Onondaga county and then with diminishing width across Madison county. The upper layers are rather heavy and yield material suitable for building purposes, road metal and lime. There are quarries around Niagara Falls, Lockport and Rochester. It is worked to some extent in Wayne, Onondaga and Madison counties. The Guelph, also a dolomite, occupies a limited area in Monroe and Orleans counties and is worked near Rochester.

The Cayugan group includes among its members the Cobleskill, Rondout and Manlius limestones, which are economically important. They have furnished large quantities of material for the manufacture of natural cement, being the source of the cement rock in the Rosendale district and in Schoharie and Onondaga counties. The cement rock of Erie county is found in the Salina formation. The Manlius limestone is used for portland cement in the eastern part of the State.

At the base of the Devonic system appears the Helderbergian group which is very important for its calcareous strata. Limestones of this age are strongly developed along the Hudson river in Albany, Columbia, Greene and Ulster counties. The Coeymans or lower Pentamerus and the Becraft or upper Pentamerus limestones afford material for building, road metal, lime and portland cement. The limestone for the portland cement works at Hudson and Greenport is obtained from Becraft mountain, an isolated area of limestones belonging to the Manlius, Helderbergian and Onondaga formations. The works at Howes Cave use both the Manlius and Coeymans limestones. Extensive quarries are located also at Catskill, Rondout and South Bethlehem.

The Onondaga limestone, separated from the preceding by the Oriskany sandstone, has a very wide distribution, outcropping almost continuously from Buffalo eastward to Oneida county and then southeasterly into Albany county, where the belt curves to the south and continues through Greene, Ulster and Orange counties to the Delaware river. It is in most places a bluish gray, massive limestone with layers and disseminated nodules of chert. The chert is usually more abundant in the upper beds. The limestone finds use as building stone and the less silicious materials also, for lime-making. Quarries have been opened at Kingston, Split Rock (near Syracuse), Auburn, Waterloo, Seneca Falls, Le Roy, Buffalo and other places.

The Tully is the uppermost of the important limestone formations and likewise the most southerly one represented in the central part of the State. Its line of outcrop extends from Ontario to Madison county, intersecting most of the Finger lakes. Its thickness is not over 10 feet, and on that account can not be worked to advantage except under most favorable conditions of exposure. For building stone it is quarried only locally and to a very limited extent. It finds its principal use in portland cement manufacture, being employed for that purpose by the Cayuga Lake Cement Co., in its works at Portland Point, Tompkins county.

Marl is a useful substitute for the hard limestone for some purposes and is rather extensively developed in the central and western parts of the State. It is found particularly in swampy tracts and old lake basins associated with clay and peat. In the Cowaselon swamp near Canastota the marl underlies several thousand acres and is said to be 30 feet thick. The Montezuma marshes in Cayuga and Seneca counties contain a large deposit which at Montezuma is 14 feet thick. In Steuben county the marls at Arkport and Dansville have been employed for lime-making. Until recently marls have been used extensively for portland cement and plants were operated at one time in the marl beds near Warner and Jordan, Onondaga county; at Montezuma, Cayuga county; Wayland, Steuben county; and Caledonia, Livingston county. Their principal use at present is for agricultural and chemical purposes.

Production. As already noted in a previous paragraph, limestone ranks first among the quarry materials of the State. The value of the output is larger than that of all other kinds together, and has gained in relative importance within the last few years. Its main use is as crushed stone for concrete and road work; most of the stratified formations, except those in the Upper Devonic, contain limestones that are adapted to that purpose. It is also employed as building stone, though not so extensively as formerly, and considerable quantities are consumed as reagent in chemical manufacturing and as flux in the iron and steel industries. Of late there has been a growing demand for finely ground limestone and burnt lime for agricultural uses. Lime manufacture still holds a prominent place in the industry.

The production of limestone, like that of other quarry materials, showed a decline in 1914 owing to the general dulness in building and other trades. The reaction continued into 1915 and brought about a further diminution in the output, although before the close of the year a distinct improvement had set in. The total value of limestone quarried was $3,177,700, against $3,316,063 in 1914.

Altogether 87 quarries reported as active, or 4 less than in the preceding year, distributed among 29 counties of the State. The accompanying tables give the statistics for the last two years, divided as to principal counties and the different uses for which the stone was sold.

Erie county has the largest industry of any; the value of the output quarried in the county in 1915 was $601,465. Its products chiefly are crushed stone, furnace flux and dimension stone. The quarries are situated in North Buffalo, Clarence and Akron. The Kelley Island Lime and Transportation Co. sold its quarry at Akron to the General Crushed Stone Co.

Onondaga county is second in rank as a producer and last year reported an output valued at $495,004, which was larger than in 1915. The quarries are situated in the Onondaga and underlying formations which stretch across the county south of Syracuse. One of the largest quarries is that of the Solvay Process Co. which uses the product largely in their alkali works at Solvay near Syracuse.

Other counties reporting values of over $100,000 in 1915 were Niagara, Dutchess, Genesee, Rockland, Ulster, Warren and Westchester, named in order of their rank.

Crushed stone. This item includes road metal, railroad ballast and concrete. The larger quarries supplying these materials are in Erie, Genesee, Onondaga, Dutchess, Ulster, Rockland and Westchester. The "fines" from some of the crushing plants are sold for agricultural use, the sales being entered under "other uses." The value of the crushed stone for 1915 showed a small decrease, as compared with that reported for 1914, and totaled $2,072,852, against $2,156,503. The total does not include stone crushed by contractors on the highway system, but the value of such stone is relatively small. The quantity of stone reported by the crushing plants was 2,985,347 cubic yards, against 3,306,325 in 1914.

Lime. The value of the lime made for the market last year was $387,083, as compared with $370,377 in 1914. In quantity the product amounted to 83,627 short tons, against 82,944 short tons in 1914. The greater part of the output was building lime, but a considerable proportion consisted of material for paper and chemical purposes and agricultural lime. A new feature of the trade was the inquiry for magnesian limes to supply the place of imported magnesite, especially for the manufacture of refractory furnace linings. The supply of magnesite which formerly came from Austria and Greece has been practically cut off by the European War, and manufacturers have resorted to dolomite as a substitute. One quarry in the Adirondack region made a speciality of magnesian lime for the purpose named. The principal lime burners are in Warren, Washington, Clinton, Fulton, Lewis and Dutchess counties.

Building stone. A further decline in the output of dimension stone is noted for 1915. The reported value of $63,121 was smaller than for any year previously covered by detailed statistics and represented about one-third of the value of such stone quarried 10 years ago. The decline can be traced largely to the change that has taken place in methods of building construction, whereby such materials as concrete, tile and terra cotta are substituted for cut stone. Artificial stone which produces the effect of the natural material is also now coming into use. It is made usually from selected aggregates like crushed pegmatite, marble, etc. with a minimum of cement as binder, and being formed in molds is given any desired shape without the expense of cutting.

Furnace flux. The metallurgical establishments of the State, notably iron and steel works, consume large quantities of fluxing limestone, which is obtained largely from local sources. Calcium limestones are mainly used, and the principal requisite is that they contain little of siliceous or aluminous impurities, and be free of phosphorus and sulphur. The larger flux quarries are in the Onondaga limestone of Erie and Genesee counties; the Clinton limestone of Niagara county, the Chazy limestone of Clinton county; and the Precambric crystalline limestones of the Adirondack region. The production of flux in 1915 was 822,729 short tons, valued at $440,237, a slight increase in quantity but a decrease in value as compared with the output for the preceding year. Niagara and Erie counties lead in this branch of the industry.

Agricultural lime. The sales of lime for agricultural use have become in the last few years an important factor in the quarry business. The actual quantities thus marketed are not stated separately in the tables, for the reason that many of the quarries have no record of the amount that is so used. Some of the material that finds employment as land amendment is really a by-product of which little account is taken, as in the case of the fines and dust of the crushing plants which are sometimes marketed, and also the inferior grades of burnt lime. It is estimated that over 100,000 tons of agricultural limestone in crushed or calcined state were sold last year by the quarries of the State.

The possibilities of the trade have received much attention in the last few years, and quarry lands favorably situated with respect to markets have been in request. Inasmuch as the material must be delivered to the consumer at a low cost to make it economically available, the tendency is to develop local sources of supply in so far as they are at hand.

The resources in limestone suitable for agricultural use are rather widespread, but they are not always within easy reach of markets. They are most abundant in the northern section, particularly on the borders of the Adirondacks and the adjacent regions to the south, where they occur in the Precambric and early Paleozoic formations. The crystalline limestones or marbles of St Lawrence, Jefferson, and Lewis counties and the Trenton and Chazy stratified limestones of the Champlain and Mohawk valleys are among the best high calcium rocks. Some agronomists hold the view that magnesium above a small amount is detrimental, while others are of the opinion that it may perform a useful function or at least have no harmful effect if not existing in a proportion of more than about one-half that of lime. Supplies of magnesian limestones occur in Highlands and Taconic sections and also in the central and western counties. The southern tier of counties on the Pennsylvania border are devoid of carbonate rocks.

Production of limestone by counties in 1914

COUNTY	CRUSHED STONE	LIME MADE	FURNACE FLUX	BUILDING STONE	OTHER USES	TOTAL
Albany	$101 022					$101 022
Cayuga	49 860			$14 124		63 984
Clinton	14 917	$61 462	$12 423	3 500	$10 616	102 918
Dutchess	322 970	26 050				349 020
Erie	478 127		177 764	44 939	4 035	704 865
Genesee	156 302		40 000	600		196 902
Greene	4 039					4 039
Herkimer	700					700
Jefferson	10 992	11 600			2 700	25 292
Lewis	3 700			217		3 917
Madison	43 498	55 896				99 394
Monroe	20 027	4 898		1 021		25 946
Montgomery	6 400			4 576	744	11 720
Niagara	6 780		190 334	300	5 700	203 114
Oneida	74 741					74 741
Onondaga	148 106			6 193	231 036	385 335
St Lawrence	3 937	4 500	22 172	2 440	274	33 323
Schoharie	108 241			416		108 657
Ulster	208 720	7 740				216 460
Warren	18 406	129 281		1 708	5 343	154 738
Washington		40 000		1 000		41 000
Other counties	375 018	28 950	4 184	375	449	408 976
Total	$2 156 503	$370 377	$446 877	$81 409	$260 897	$3 316 063

3

Production of limestone by counties in 1915

COUNTY	CRUSHED STONE	LIME MADE	FURNACE FLUX	BUILDING STONE	OTHER USES	TOTAL
Albany	$92 003	....	....	....	....	$92 003
Cayuga	33 003	....	....	$7 060	....	40 063
Clinton	31 853	$47 373	$17 373	....	....	96 599
Dutchess	236 106	40 365	....	....	....	276 471
Erie	469 374	....	90 707	39 590	$1 794	601 465
Genesee	196 964	11 560	38 000	....	13 500	260 024
Greene	1 920	....	....	....	....	1 920
Herkimer	8 866	....	....	....	1 975	10 841
Jefferson	18 153	10 145	....	319	17 165	45 782
Lewis	3 300	30 000	....	80	....	33 380
Madison	17 166	....	....	....	13 762	30 928
Monroe	14 132	....	....	590	....	14 722
Montgomery	31 500	....	....	2 977	300	34 777
Niagara	24 847	....	267 845	1 660	19 199	313 551
Oneida	48 190	....	....	....	....	48 190
Onondaga	357 600	....	....	5 300	132 104	495 004
St Lawrence	13 334	4 725	25 762	285	1 365	45 471
Schoharie	76 034	402	....	2 763	6 787	85 986
Ulster	145 794	19 017	....	....	300	165 111
Warren	13 713	138 381	....	1 247	4 930	158 271
Washington	....	60 000	....	1 250	....	61 250
Other counties	239 000	25 115	550	....	1 226	265 891
Total	$2 072 852	$387 083	$440 237	$63 121	$214 407	$3 177 700

MARBLE

Marble, in the commercial sense, like granite, includes a variety of rocks that lend themselves to building or decorative uses. Most commonly, the name signifies a crystalline aggregrate of calcite or dolomite, as distinguished from ordinary limestones which at best are of indistinctly crystalline nature. At the same time it implies the feature of attractiveness by reason of color and the ability to take a lustrous polish. Rocks possessing all these features are marbles in the strict sense to which the name may be applied without qualification. Some compact or granular limestones that lack the elements of thorough crystallinity make, however, a handsome appearance when polished, and such are commercially classed as marbles. Fossil marbles, black marbles, and a few other kinds are commonly of the noncrystalline type. Serpentine marble, or verde antique, is made up for the most part of the mineral serpentine, a silicate of magnesium and iron, and is therefore not related to the varieties already described. Ophitic limestone, or ophicalcite, is a crystalline limestone or dolomite carrying grains and nodules of serpentine scattered more or less evenly through its mass. Its ornamental quality lies in the speckled or mottled pattern and the sharp contrast between the clear white mass and the greenish serpentine inclusions.

Marbles belonging to those various types find representation in the geologic formations of the State and are quarried on a commercial scale or have been so quarried in the past.

The true or crystalline varieties are limited in occurrence to the metamorphic areas of the Adirondacks and southeastern New York. They are of early geologic age, antedating the period of crustal disturbance and metamorphism which in the Adirondacks was brought to a close practically before Cambric time and which in southeastern New York was completed in the Paleozoic. This thoroughly crystalline character is in fact a development of the strong compression accompanied by heat to which they have been subjected; having been originally, no doubt, ordinary granular or fossiliferous limestones similar to those so plentifully represented in the undisturbed formations outside the regions.

The crystalline limestones of the Adirondacks are most abundant on the western border in Jefferson, Lewis and St Lawrence counties where they occur in belts up to 4 or 5 miles wide and several times as long, interfolded and more or less intermixed with sedimentary gneisses, schists and quartzites. They are found in smaller and more irregularly banded areas in Warren and Essex counties on the eastern side, but have little importance elsewhere. The ophitic limestones that have been quarried at different times belong to the same series. The marbles of the Adirondacks comprise both the calcite class with very little magnesia and the dolomite class containing high percentages of magnesia. No definite relations is apparent in regard to the occurrence of the two and both may be found in the same area and in close association.

The southeastern New York marbles occur in belts which follow the north-south valleys, east of the Hudson, from Manhattan island into Westchester, Dutchess and Columbia counties. They range from very coarsely crystalline to finely crystalline rocks, are prevailingly white in color and belong to the dolomite class. They are interfolded with schists and quartzites, the whole series having steep dips like those of strongly compressed strata. The geologic age of the southern belts is probably Precambric, but on the north and east within range of the Taconic disturbance, they may belong to the early Paleozoic.

Bodies of practically pure serpentine of considerable extent are found on Staten Island and in Westchester county near Rye; they represent intrusions of basic igneous rocks whose minerals, chiefly pyroxene and olivine, have subsequently changed to serpentine. They are not important for quarry purposes, owing to the frequency of fissures and joints and the rather somber color of the exposed part of the masses.

The microcrystalline or subcrystalline limestones that are sometimes sold as marbles include members of the regularly bedded unmetamorphosed Paleozoic limestones, which locally show qualities of color and polish that make them desirable for decorative purposes. They range from dense granular varieties to those having a more or less well-developed crystalline texture and are often fossiliferous. Inasmuch as they have never been subjected to regional compression or been buried in the earth deep enough to become heated, the crystalline texture, when present, may be ascribed to the work of ground waters. These circulate through the mass, taking the carbonates of lime and magnesia into solution, and redeposit them in crystalline form. Originally, the limestones were accumulations of lime-secreting fossils or granular precipitates, for the most part of marine origin. Some of the localities where these unmetamorphic marbles occur are on the west shore of Lake Champlain, around Plattsburg and Chazy (Chazy limestone), Glens Falls (Trenton limestone) and Becraft and Catskill (Becraft limestone).

Production. The marble quarries reported a very poor business in 1915, the output amounting to about one-half that of the average for previous years. The depression affected both building and monumental quarries. The number of firms reporting a production was seven, distributed among Dutchess and Westchester counties in southeastern New York and St Lawrence and Warren counties in the Adirondack region. In the Gouverneur district the St Lawrence Marble Quarries and the Gouverneur Marble Co. alone were active. The Northern New York Marble Co. of that place went out of business. The quarries of the South Dover Marble Co. at Wingdale were worked as heretofore, though on a reduced scale. In Westchester county the old "Prison" quarry at Ossining was reopened for the purpose of getting out dimension stone for the remodeling of the State Hall at Albany, which is constructed of marble from this quarry.

The production of marble altogether was valued at $120,447 against $230,242 in 1914 and $252,292 in 1913. Of the product, building stone, rough and dressed, accounted for $61,601 and monumental for $37,074 against $142,223 and $70,797 respectively in 1914. Other kinds of marble quarried had a value of $21,772 against $17,222 in 1914.

SANDSTONES

Under sandstones are included the sedimentary rocks which consist essentially of quartz grains held together by some cementing substance. Among the varieties distinguished by textural features are sandstones proper, conglomerates, grits and quartzites.

Of the sedimentary rocks which occur in the State, sandstone has the largest areal distribution, while in economic importance it ranks second only to limestone. Nearly all the recognized stratigraphic divisions above the Archean contain sandstone at one or more horizons. The kinds chiefly quarried are the Potsdam, Hudson River, Medina and Devonic sandstones. A few quarries have been opened also in the Shawangunk conglomerate and the Clinton and Triassic sandstones.

The Potsdam of the Upper Cambric is the lowest and earliest in age of the sandstones that have a fairly wide distribution and are utilized for building purposes. The most extensive outcrops are along the northern and northwestern borders of the Adirondacks, in Clinton, Franklin, St Lawrence and Jefferson counties. Other exposures of smaller extent are found in the Lake Champlain valley and on the southeastern edge of the Adirondack region. These latter areas represent the remnants of a once continuous belt that has been broken up by folding, faulting and erosion. The Potsdam sandstone has in many places the character of a quartzite, consisting of quartz grains cemented by a secondary deposition of quartz, and then is a very hard, tough and durable stone. The quartzite from St Lawrence county has sustained a crushing test of more than 42,000 pounds to the square inch. The color varies from deep red to pink and white. The principal quarries are near Potsdam and Redwood, St Lawrence county, and Malone and Burke, Franklin county. Besides building stone, which is the chief product, there is some flagstone sold, mainly by the quarries at Burke, for shipment to Montreal.

The so-called Hudson River group is essentially a group of sandstones, shales, slates and conglomerates, ranging in age from the Trenton to the Lorraine, but which have not been sufficiently studied to permit the actual delimitation of the various members on the map. The group is exposed in a wide belt along the Hudson from Glens Falls southward into Orange county and also in the Mohawk valleys as far west as Rome. The sandstone beds are usually fine grained, of grayish color and rather thinly bedded. Over wide stretches they provide practically the only resource in constructional stone and consequently they have been quarried at a great number of places to supply the local needs for building and foundation work. Some of the stone is crushed for road metal and concrete.

The Medina sandstone is found along the southern shore of Lake Ontario from the Niagara river east to Oswego county; in central New York it is represented by a coarse conglomeratic phase called the Oneida conglomerate. As developed in the western part of the State, where it is principally quarried, it is hard fine-grained sandstone of white, pink and variegated color. The pink variety is specially quarried for building stone and has an excellent reputation. Many of the larger cities of the country and most of the important towns and cities of the State contain examples of its architectural use. The large quarries are situated in Orleans county, near Albion, Holley and Medina, along the line of the Erie canal, but there are others at Lockport and Lewiston, in Niagara county, and at Brockport and Rochester in Monroe county. The Medina sandstone also finds extensive applications for curbing and flagging and for paving blocks. It is employed more extensively for the latter purpose than any other stone quarried in the State.

The Shawangunk conglomerate is more widely known for its use in millstones than for constructional purposes. It outcrops along Shawangunk mountain in Ulster county and southwesterly into New Jersey, with an outlier near Cornwall, Orange county. The quarries near Otisville have supplied considerable quantities of stone for abutments and rough masonry.

The Clinton sandstone is mainly developed in central New York, being absent from the Clinton belt in the western part of the State. It forms ledges of considerable extent on the south side of the Mohawk valley from Ilion to Utica and beyond. It consists of reddish brown and gray sandstones, of medium texture and hardness. The stone has been used for foundations and building in Utica and other places in the vicinity.

Of the Devonic formations which cover about one-third the whole area of the State, the Hamilton, Portage, Chemung and Catskill contain important sandstone members serviceable for quarry operations. These sandstones are popularly known as bluestones, a name first applied in Ulster county where they are distinguished by a bluish gray color. They are for the most part fine grained, evenly bedded, bluish or gray sandstones, often showing a pronounced tendency to split along planes parallel to the bedding so as to yield smooth, thin slabs. For that reason they are extensively used for flag and curbstone, and a large industry is based on the quarrying of these materials for sale in the eastern cities. Most flagstone is produced in the region along the Hudson and Delaware rivers, where there are convenient shipping facilities to New York, Philadelphia and other large cities. The Hudson River district includes Albany, Greene and Ulster counties, but the quarries are mainly situated in the area that includes southern Greene and northern Ulster, with Catskill, Saugerties and Kingston as the chief shipping points. The Delaware River district includes Sullivan, Delaware and Broome counties; the shipping stations are along the Erie and Ontario & Western Railroads. The sandstone of this section ranges from Hamilton to Catskill age. In the area to the west the quarries are confined to the Portage and Chemung groups, with the most important ones in the Portage. There are large, well-equipped quarries near Norwich, Chenango county, and Warsaw, Wyoming county, which produce building stone for the general market. Numerous small quarries are found in Otsego, Chemung, Tompkins, Tioga, Schuyler, Steuben, Yates, Allegany, Cattaraugus and Chautauqua counties.

Production of sandstone. Sandstone, by reason of its adaptability and its wide distribution, is extensively quarried in the State, ranking next to limestone in commercial importance. The larger part of the output is employed in street work in the form of curbstone, flagstone and paving blocks, but an important quantity is also used as building stone. It finds very little application as crushed stone on account of its platy fracture.

The Devonic sandstones, which are collectively known as bluestone, are more widely quarried than the other kind; this production is carried on throughout the southern part of the State by a large number of individuals and companies. With few exceptions, the quarries are small, giving employment to only two or three workmen each and having very little in the way of mechanical equipment. Such small enterprises are particularly characteristic of the Hudson River and Delaware River regions where much of the flagstone and curbstone is produced. Many of the quarries are worked intermittently by farmers in the off season of their usual occupation. The stone is hauled down the hillside to the railroad sidings or the river docks where it is purchased by middlemen who ship it to the eastern markets. The stone from the Hudson River district is mainly shipped by barges from Kingston and Saugerties. In the interior it is shipped by rail. A statistical canvass of such small enterprises is a matter of great difficulty and is likely to afford very unreliable results. Consequently, it has been the practice in the compilation of this report to secure the information so far as possible from dealers who purchase the stone for shipment to the large wholesalers and consumers in the cities.

The production of sandstone during the last two years is shown in the accompanying tables which give its distribution also among the leading districts.

The combined value of all the sandstone quarried in 1915 was $890,411 against $1,056,990 in 1914, indicating a decline of about 16 per cent in the amount of sales for the year. This was a smaller output than in any recent year previously and is largely accounted for by the falling off in the bluestone industry. The totals are exclusive of sandstone quarried by contractors for use on the state highway system, for which it is impossible to assign any accurate value.

Of the combined value given, considerably less than one-half was returned by the quarry companies operating in the bluestone districts, whereas in previous years this branch of the industry was much the more important. The reported value of the bluestone actually was $339,779, as compared with $546,314 in 1914. Most of the decline may be attributed to the conditions in the curb and flagstone trade which has had to meet increasing competition from other materials, notably concrete and granite, in street work. This is indicated by the fact that the total value of curb and flagstone made from bluestone was only $155,288 as compared with $337,488 in 1914. A small decrease may be noted also in building stone, the value of which was $178,577 in 1915, against $191,239 in the preceding year.

Sandstone other than bluestone represented a value of $550,632, a gain over the figure for 1914 which was reported as $510,676. Orleans county by itself accounted for a value of $449,620 as compared with $439,635 in 1914. There was a good demand for paving blocks which constitute the principal product of this district.

Altogether the general situation last year was not very favorable for the quarry companies in the sandstone districts. Only a few new operations were reported, the more important being quarries for crushed stone production in Albany and Ulster counties. On the other hand, several quarries that were active in former years were closed without any prospect of immediate reopening.

Production of sandstone in 1914

DISTRICT	BUILDING STONE	CURBING AND FLAGGING	PAVING BLOCKS	CRUSHED STONE	RUBBLE RIPRAP	ALL OTHER
Bluestone						
Hudson river	$5 500	$153 436	....	....	....	$1 559
Delaware river	20 196	177 200	....	....	$1 425	9 865
Chenango county	69 255	5 812	....	....	960	2 337
Wyoming county	92 201	1 000	....	$48	1 393	....
Other districts	4 087	40	....	....	....	....
Total bluestone	$191 239	$337 488	....	$48	$3 778	$13 761
Sandstone						
Orleans county	$15 926	$147 970	$266 775	....	$1 319	$7 645
Other districts	10 343	4 764	12 912	$36 095	6 927	....
Total sandstone	$26 269	$152 734	$279 687	$36 095	$8 246	$7 645
Combined total	$217 508	$490 222	$279 687	$36 143	$12 024	$21 406

Production of sandstone in 1915

DISTRICT	BUILDING STONE	CURBING AND FLAGGING	PAVING BLOCKS	CRUSHED STONE	RUBBLE RIPRAP	ALL OTHER
Bluestone						
Hudson river	$3 235	$44 243	....	....	....	$500
Delaware river	12 281	96 402	....	$237	$2 394	1 800
Chenango county	50 661	9 643	....	....	....	....
Wyoming county	104 829	....	....	15	720	248
Other districts	7 571	5 000	....	....	....	....
Total bluestone	$178 577	$155 288	....	$252	$3 114	$2 548
Sandstone						
Orleans county	$13 926	$160 441	$254 081	$19 931	$1 000	$241
Other districts	6 240	2 257	11 276	57 185	5 500	18 554
Total sandstone	$20 166	$162 698	$265 357	$77 116	$6 500	$18 795
Combined total	$198 743	$317 986	$265 357	$77 368	$9 614	$21 343

TRAP

Trap is not a distinct rock type, but the name properly belongs to the fine-grained, dark-colored igneous rocks that occur in intrusive sheets and dikes. In mineral composition it differs from most of the igneous rocks that are classed in the trade as granite by the prevalence of the basic plagioclase feldspars and the higher percentages of the iron magnesia minerals, while it contains no quartz. Some of the so-called "black granites," however, are trap. The name is sometimes applied to fine-grained rocks of granitic or syenitic composition and sometimes even to rocks of sedimentary derivation, but such usage is misleading and indefensible.

The particular value of trap is due to its hardness and toughness. Its fine, compact, homogeneous texture gives it great wearing powers and it is eminently adapted for road metal and concrete of which heavy service is required. The principal product, therefore, is crushed stone. It has been used to some extent, also, as paving blocks, but these are rather difficult to prepare, since trap very seldom shows any capacity for parting comparable to the rift and grain structures of granites. As a building stone it finds very little application, probably on account of its somber color. The expense of cutting and dressing trap is also an obstacle to its employment for building or ornamental purposes.

The trap quarried in New York State is properly a diabase. Its mineral composition varies somewhat in the different occurrences, but the main ingredients are plagioclase, feldspar and pyroxene, with more or less of amphibole, olivine, magnetite and sometimes biotite. The texture is characteristic, for the feldspar forms lath-shaped crystals which interlace and inclose the pyroxene and other ingredients in the meshes, and it is this firmly knit fabric which gives the stone the qualities of strength and toughness.

The largest occurrence of trap in New York is represented by the Palisades of the Hudson and the continuation of the same intrusion which extends southward through New Jersey onto Staten Island and is also encountered in the interior of Rockland county. The Palisades are the exposed edge of a sill or sheet of diabase that is intruded between shales and sandstones of Triassic age. The sheet is several hundred feet thick, in places nearly 1000 feet, and in general seems to follow the bedding planes of the sedimentary strata which dip to the west and northwest at an angle of from 5° to 15°. The outcrop is narrow, seldom over a mile, and in places is limited to a single steep escarpment. The principal quarries are near Nyack and Haverstraw at the base of the cliffs. Other quarries have been opened near Suffern, Rockland county, on an isolated intrusion, and also near Port Richmond, Staten Island, at the southern end of the Palisades sill.

Trap occurs in numerous places in the Adirondacks, but mostly as narrow dikes. It is especially common in Essex and Clinton counties where there are many thousands of dikes that range from a few inches to 20 or 30 feet thick. On the southern border of the region are a few dikes of notable size, such as that in the town of Greenfield, Saratoga county, and at Little Falls in the Mohawk valley. A quarry has been opened in the Greenfield occurrence for the supply of crushed stone.

For many years the leading trap quarries have been those situated along the river front of the Palisades from Haverstraw to Nyack. Their output during the height of the industry amounted to over a million cubic yards annually. Since 1910 negotiations have been in progress for the acquisition of the quarry properties in connection with the Palisades Interstate Park which is designed to include the lands lying between the river line and the top of the ridge. The completion of the plans for the park is now in prospect and it is unlikely that quarry operations at the present sites will last much longer. The quarries of the Rockland Lake Trap Co. and of the Manhattan Trap Rock Co. have already been closed. The final extinction of the industry will involve an increase in the price of trap in the lower Hudson district, inasmuch as there is no other place where it can be obtained so conveniently and at so low cost.

The output of trap in 1915 amounted to 683,700 cubic yards valued at $550,960. Of this quantity 409,100 cubic yards valued at $331,280 consisted of crushed stone for roads. The figures showed a decrease in comparison with the totals for 1914 which were reported as 975,000 cubic yards valued at $770,000.

TALC

The dulness in the talc trade which prevailed during the later months of 1914 continued into the following year and caused some reduction in the mining and milling operations, although there were no producers that withdrew from business. The depression was caused more particularly by the curtailment of demand in the paper industry which supplies the principal outlet for the local product. The market showed some improvement during the last six months of the year, when paper makers began to experience difficulty in filling their requirements of white clay which had been obtained, hitherto, from England and Germany and consequently turned to talc as a substitute.

The output for the year amounted to 69,514 short tons valued at $576,643, or a little less than in 1914, but fully up to the average of earlier years. The list of active firms included the Ontario Talc Co., the International Pulp Co. and the Uniform Fibrous Talc Co. in the Gouverneur district and the St Lawrence Talc Co. of Natural Bridge.

There was a cessation of exploratory work during the year on the part of development enterprises and no new additions to the list of producers is in prospect for the current season.

The talc industry occupies a position of considerable economic importance in the limited field in which it is carried on. The labor item is the principal element of cost in production, and a large quota of the local population find employment in one or another of the branches of the industry. The mining operations of themselves are not so extensive in their requirements, but in addition there is the milling which involves a process of gradual reduction continued over several hours and the haulage necessitated by the fact that some of the mines are situated at a distance from the railroad which serves the district.

The Gouverneur talc began to enter the market about 1880. Shipments of some importance were made before that date, but from that time they have been continuous and in large volume. Since 1900 the average annual output has exceeded 60,000 tons. Altogether the production has amounted to about 1,700,000 tons valued at $15,000,000.

Production of talc in New York

YEAR	SHORT TONS	VALUE	YEAR	SHORT TONS	VALUE
1883	6 000	$75 000	1900	63 500	$499 500
1884	10 000	110 000	1901	62 200	483 600
1885	10 000	110 000	1902	71 100	615 350
1886	12 000	125 000	1903	60 230	421 600
1887	15 000	160 000	1904	65 000	455 000
1888	20 000	210 000	1905	67 000	519 250
1889	23 476	244 170	1906	64 200	541 600
1890	41 354	389 196	1907	59 000	501 500
1891	53 054	493 068	1908	70 739	697 390
1892	41 925	472 485	1909	50 000	450 000
1893	36 500	337 625	1910	65 000	552 500
1894	50 500	454 500	1911	65 000	552 500
1895	40 000	320 000	1912	61 619	511 437
1896	46 089	399 443	1913	63 000	551 250
1897	57 009	396 936	1914	74 075	671 286
1898	54 356	411 430	1915	69 514	576 643
1899	54 655	438 150			

ZINC

The progress of the interesting developments in zinc mining at Edwards, St Lawrence county, has been described in previous issues of this report, and a brief account of the ore occurrences and their geological surroundings was included in the issue for 1912 (Museum Bulletin 166). During the past year productive operations were begun, resulting in the first shipments of zinc ores on a commercial scale that have been made by any enterprise within the State.

The source of the production, which amounted to a few thousand tons of blende concentrates, was the mine of the Northern Ore Co., situated just outside the village of Edwards on the road leading to Trout lake. The property, with showings of ore at the surface but unprospected at the time, was acquired by the company over ten years ago. Owing to the unusual character of the deposits, scarcely comparable in their geological relations to any other bodies of zinc ores now mined in this country, the conduct of the early exploratory work could hardly be guided by experience with similar ones elsewhere, and it was essential to adopt a conservative policy in the development and equipment of the property. In the past year the workings have been extended to a depth of about 500 feet, following a lens of ore that is inclined 25°–60° from the horizontal. There are no indications on the lowest level of any change in the geological conditions which might lead to the interruption of the ore-bearing ground and the discontinuance of the deposits; on the contrary, the conditions seem favorable to the extension of the ore beyond the depths attained up to the present time.

So far the Northern Ore Co. has worked only one shaft, near the south line of the Edwards property, that follows a vein or lens of solid blende and pyrite, about 5 feet thick at the surface, swelling to 14 feet at the 150 foot level and thinning again where seen in the 300 and 400 foot levels. The longest levels are about 600 feet on the strike of the ore. The ore body to the south of the shaft curves around in a broad arc, so that at the extreme end of the working stopes the direction of dip is southwest or at right angles to that of the shaft itself. Swells and pinches occur frequently, and stringers of ore occasionally branch off from the main body. There is much resemblance in the shape of the deposit to the form assumed by some of the magnetites in the harder crystalline rocks of the Adirondacks. A second lens of ore shows at the surface to the west of the shaft in the hanging wall and is tapped underground by cross cuts from the main levels. This body is smaller, about 4 feet thick at the surface and 150 feet wide in the drift at the 200 foot level. The ore is intersected by small slips or faults. One fault is seen on the second level at the south end where it is accompanied by a sheeted zone of limestone that apparently terminates the ore; it lies near the edge of the limestone and is concealed at the surface by the alluvial beds that floor the adjacent valley. Evidences of faulting are found on the surface northeast of the shaft in the occurrence of a fracture zone which cuts across the bedding of the limestones; the zone is 3 feet or more wide.

About 800 feet northeast of the working shaft, on the opposite side of the limestone ridge, an outcropping lens of ore has been prospected at the surface and for some distance underground, but has not been actively worked. The sulphides here occur in bunches, bands and as disseminations, intermixed with secondary silicates and limestone. The shape of the deposit is like a thick lens or shoot, but is less well defined than the bodies previously described. There is evidence of crushing and differential movement within the ore, which may be partially accounted for perhaps by the greater amount of silicates that have undergone hydration and swelling. The ore shades away at the edges into the country limestone.

The ore from the property is rich as compared with the usual grades of zinc blende that are now mined in this country. The product of the present openings is a mixture of sphalerite and pyrite with variable but usually small amounts of gangue. The sphalerite predominates over pyrite, but samples may be gathered which show the two minerals in nearly equal proportions. The texture is very compact, with no vugs or openings of any size, the grains being firmly interlocked. The individual particles have rounded and irregular outlines. The grain varies from rather coarse to fine, the coarser ore being found in the larger and richer bodies; the disseminated sulphides are usually finely divided. The ore now mined probably averages 25 per cent or more in zinc. The sphalerite is dark, almost opaque, as seen in the hand specimen, indicative of considerable combined iron, which is confirmed by its magnetic permeability. In one part of the Edwards mine, ore of light brown color has been uncovered. Galena occurs in small amount, less than 1 per cent, but is seldom discernible in the hand specimen. The presence of barite in the gangue was determined from specimens taken by the writer several years ago from the outcrop. It is of subordinate importance. The principal ingredients of the gangue are dolomite and lime-magnesia silicates, with serpentine and talc as alteration products of the latter.

The Edwards mine has a peculiar place in the zinc-mining industry at the present time, being the only representative of its type in the country. Similar deposits of sphalerite occur in the Precambric limestones of eastern Canada and have contributed small quantities of ore for smelting, but so far as known this is the only active enterprise based on such deposits within the United States.

The operations of the Northern Ore Co. are in charge of Justice Grugan as manager.

The belt of crystalline limestones in which the deposits lie stretches to the southwest of Edwards in unbroken continuity into the town of Fowler and is traceable beyond Sylvia lake, which occupies a bowl-shaped depression in the same limestones. Prospecting has been active in the district during the last year or two, and many new localities for zinc ores have been discovered.

Between Edwards and Fullerville there are showings of blende on the farm of Woodcock Brothers, south of the highway, in a ledge of limestone that contains bands of white quartz. Where uncovered the blende is seen in streaks and disseminations that follow the strike of the wall rock and occupy a zone several feet wide. The outcrop is marked by rusty, hornblende material which, however, is of slight depth. The gneiss that limits the limestone belt occurs within 50 feet of the ore.

The McGill farm, next on the southwest, has a prospect that shows 2 or 3 feet of light brown blende, free of pyrite. The hanging side of the deposit, in contact with the limestone, shows differential movements, with the formation of slip-fiber asbestos.

On the H. Webb place the ore appears at approximately the same horizon, close to the gneiss, along a ridge of limestone that follows the general strike of the beds. It has been uncovered in several places which seem to mark a more or less well-defined zone of mineralization carrying sulphides in bands and as disseminated grains. Shallow holes have been blasted into the ridge, following the dip of the ore, which is 40° to 60° northwest. The richer bands are fairly well marked on the borders and attain a thickness of 6 to 8 feet. Altogether the ore outcrops and prospects cover a distance of 800 feet along the face of the ridge. The blende is light in color and is admixed with less than the usual amount of pyrite. A. J. Moore of Edwards has explored this part of the district.

On the McGill farm farther southwest is a prospect with some showings of blende in scattered bunches and disseminations. The opening is close by the road, somewhat distant from the limiting ridges of gneiss. Messrs Finch and Potter of Gouverneur have a lease of the property.

The occurrence of zinc on the Balmat, Streeter and Tamlin places east of Sylvia lake has been known for some time. The Balmat property was prospected over 75 years ago for lead, which is found as a larger ingredient of the ore than elsewhere in the district. The presence of so much zinc, however, proved an obstacle to its utilization, which apparently could not be overcome by the methods then employed, and little ore was mined. The property is now owned by the Northern Ore Co. which is holding it as a reserve for the future. The Streeter property has a good showing of ore which forms a well-defined band, much like the deposit now being worked at Edwards.

In the vicinity of the Balmat property a deposit of zinc has been uncovered by the Dominion Company in the extension of an old shaft which was once worked for iron ore for use in the furnace at Fullerville, now dismantled and in decay. The iron is present as hematite of soft, paintlike texture, which deeper down changes to a harder siliceous ore in which sulphides are found. It would appear probable that the hematite is simply the oxidized outcrop of the sulphides. The latter occur in finely divided particles, with a quartz gangue. The deposit seems to be a pipe or shoot, rather than a lens.

Northeast of Sylvia lake, between there and the hamlet of Little York, are several small showings of sphalerite and pyrite, mostly of disseminated character. Some of them are on the Austin place. The limestone of this section of the district is characterized by a larger proportion of impurities than is usually found; vitreous quartz, chert and serpentine make up a large part of the mass. On the weathered surface the limestone is ribbed by the quartz which has a tendency to aggregate in parallel bands that are brought into prominence by the solution of the included carbonates.

A showing of blende is found on the cemetery lot, near Balmat corners, just off the Gouverneur sheet. It has been prospected by Arthur C. Scott of Fowler and occurs on the east side of a limestone ridge that parallels the road. The limestone is seamed with white quartz which stands out in prominent ledges and also contains much serpentine and talc. The ore forms a band that is exposed by the opening only for 10 or 12 feet on its course along the hill, with a stringer making off at right angles into the hanging wall.

The blende and pyrite are segregated, instead of being intergrown as in most instances, while they are accompanied by secondary calcite and other unusual features.

J. C. Finch reports to the writer the occurrence of zinc on the west branch of the Oswegatchie, near the falls, about 3 miles above Fullerville. This locality is rather remote from the main district and indicates the extension of the limestone farther south than has been indicated on the maps. It appears quite certain that a narrow tongue of the limestone extends south on the east side of the West Branch at least to the locality named, which is just off the limits of the Gouverneur quadrangle.

The Davis farm, northwest of Pleasant Valley school, is one of the new localities for blende that has been under prospect. It is held under lease by Gouverneur parties, with B. J. Hatmaker in charge. The ore occurs in disseminated grains within a zone of impure limestone, but had not been explored to any extent at the time of the writer's visit in August 1916.

Across the Oswegatchie river from the mine of the Uniform Fibrous Talc Co. is a ridge of impure limestone in which an old talc shaft was sunk years ago. Nearby an opening shows 3 to 4 feet of fairly rich blende, with some pyrite, having a mottled appearance from inclusions of carbonates. The ore appears to run about north and south and dip steeply to the west, but it has not been explored sufficiently to reveal fully the extent and attitude of the body. Another outcrop is found on the south side of the ridge, nearly in line with the first. The locality is on the Freeman farm now leased by the Dominion Company.

Nature of ore occurrence. Two types of ore bodies may be distinguished on the basis of the methods of aggregation. In the one type the zinc and iron sulphides form a well-defined band, shoot or lens within the limestone. The contact is sharp and shows little evidence of a true gradation between the ore and wall rock, although if the two are frozen the ore may send out stringers from the main body for a little distance into the limestone. In this type, however, it is rare to find both foot and hanging wall tightly cemented; more often the ore breaks clean from one wall and is separated from the limestone by a gouge of talcose decomposition products. This type of deposit averages high in metallic content, the blende and pyrite together forming more than 50 per cent of the mass, and specimens may be found that are practically solid sulphides. The visible gangue minerals are chiefly serpentine and talc which occur as nodular particles surrounded by the sulphides, and are of the same nature as the silicate inclusions in the limestones. It is rather evident that they were formed before the ore, representing the unreplaced matter in the process of mineralization.

In the second type the sulphides are disseminated through the limestone, usually within a more or less restricted zone which itself constitutes a band or lens that on the borders shades off into the country limestones. The percentage of sulphides is much smaller than in the other type, in most examples constituting but a small per cent of the whole mass. The individual grains of pyrite and blende are surrounded by those of dolomite; and silicate minerals abound, often constituting nodular bodies that measure several inches to a foot in diameter. The size of the metallic particles averages much smaller than it does in the richer ores illustrated by the first type.

As to the general distribution of the ores in the limestone it can be said that they favor the border zone more often than otherwise. Although some showings have been found within the middle of the belt, they are mainly of the disseminated form of occurrence which has not yet been proved to be of commercial value.

It is also noticeable that the limestone in the vicinity of the deposits is always impure, owing to the presence of silicates. In their original form these consisted of tremolite and diopside but they are now mostly altered to serpentine and talc. The association of the ores with the silicated layers is too constant to be merely accidental, but points to a genetic relationship which need not be explained, however, in this place. The vicinity of the talc mines offers favorable ground for prospecting for zinc. The fact that the sulphides have not been penetrated in the mines themselves is to be explained by the fact that the openings are carried always within the talc, never reaching out into the country rock in the ordinary course of operations. The writer discovered some good specimens of zinc blende in the dump of one of the mines in which exploratory work for the purpose of finding a possible continuation of the talc had been carried into the overlying limestone.

Another suggestion for the guidance of prospecting operations is prompted by the occurrence of the hematite deposits which at one time were actively worked for the supply of the Fullerville furnace. The hematite, not unlikely, may prove to be the gossan or oxidized outcrop of the sulphides, as was suggested by the writer in an earlier account of the deposits. This has been actually found to be the condition in the old iron mine on the Dominion Company's property near Sylvia lake. There the unaltered zinc and iron sulphides were encountered at less than 100 feet from the surface, although the material above was a soft hematite. There is no certainty of course that the same result would be obtained by deepening the other iron-ore pits, but from a prospecting standpoint the localities seem to be worthy of consideration.

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The University of the State of New York
New York State Museum
JOHN M. CLARKE, Director

GEOLOGY OF THE VICINITY OF OGDENSBURG

(Brier Hill, Ogdensburg and Red Mills Quadrangles)

BY H. P. CUSHING

ALBANY
THE UNIVERSITY OF THE STATE OF NEW YORK
1916

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The University of the State of New York

Science Department, July 6, 1916

Dr John H. Finley

President of the University

SIR: I beg to communicate herewith a manuscript entitled "The Geology of the Vicinity of Ogdensburg" with appropriate maps. This manuscript has been prepared by Prof. H. P. Cushing, temporary member of this staff, and I recommend its publication as a bulletin of the State Museum.

Very respectfully

JOHN M. CLARKE

Director

THE UNIVERSITY OF THE STATE OF NEW YORK

OFFICE OF THE PRESIDENT

Approved for publication this 11th day of July 1916

President of the University

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GEOLOGY OF THE VICINITY OF OGDENSBURG

BY H. P. CUSHING

INTRODUCTION

The chief purpose in mind in undertaking the areal mapping of the district here reported upon was to make a careful study of the Beekmantown formation in the district of the upper St Lawrence, in order to see how fully it was represented and how it compared with the formation in the Champlain valley. Between Ogdensburg and Morristown excellent sections of the formation are shown so that, in so far as the lower portion of the formation is concerned, the work was very successful. Down the river from Ogdensburg, however, the glacial drift is very widespread and heavy, and rock exposures are infrequent and scant; so much so that it is highly questionable whether a satisfactory idea of the higher beds of the formation can be obtained.

Prof. G. H. Chadwick was engaged in mapping the Paleozoic rocks of the Canton quadrangle, at the same time that our work was in progress, giving opportunity for us to keep in touch with each other, and to make a definite comparison of results. This has proved of especial help since, owing to heavy drift, the rocks east of Ogdensburg on the Ogdensburg quadrangle are almost completely covered up, and a formation wedges in there and appears strongly on the Canton quadrangle, where Professor Chadwick recognized it, which would probably have entirely escaped our notice on Ogdensburg.

In 1913 both Dr E. O. Ulrich and Dr R. Ruedemann spent two or three days with me at Ogdensburg, looking over the section with me and giving indispensable assistance. They have also spent much time in determination of the fossils collected, hence a large part of such merit as the report may have is owing to their aid.

LOCATION AND CHARACTER

The district here reported upon comprises the Brier Hill, Ogdensburg and Red Mills quadrangles of the topographic map sheets. The southwestern margin of the Brier Hill sheet overlaps by a trifle the northeastern corner of the Alexandria Bay sheet, so that the mapping is a continuation, down the river, of the work done in the Thousand Islands region.[1] In the latter territory the Paleozoic rocks found are chiefly those to the south of the Frontenac axis, as the belt of crystalline rocks which comes down to and crosses the river at the Thousand Islands is called. In the Ogdensburg district the Paleozoics are those to the north of this axis, and the contrast between the two will be subsequently shown.

The mapped area extends from longitude 75° 15′ to 75° 45′ W. and from latitude 44° 30′ to the St Lawrence river. It is of triangular shape, since the river flows northeast. At the west edge of the Brier Hill sheet the river crosses the parallel of 44° 30′; at the east edge of the Red Mills sheet the south bank of the river is about at latitude 44° 52′. The area included is about 320 square miles.

The district lies entirely in the topographic province of the St Lawrence plain, though its southern margin might be said to belong to the northwest edge of the Adirondack highland. On the northwest there is not the sharp junction between these two topographic provinces that there is farther east, but a very gradual drop from the one to the other.

The district lies also on the boundary between two geologic provinces, which correspond in a general way with the topographic. The crystalline rocks of the Adirondack highland descend to low levels in this vicinity, and cross into Canada at the Thousand Islands in a narrow belt, furnishing an isthmianlike connection between the great area of these rocks in the Adirondacks, and the vastly greater area in Canada. Below the Thousand Islands the river flows through a country of low altitude whose rocks are flat-lying formations of early Paleozoic age, and crystalline rocks do not reappear along the river west of Quebec. The general breadth of this Paleozoic plain of the St Lawrence valley, which separates the Adirondack highland from the Canadian highland, is from 60 to 70 miles, but three-fourths of this breadth, and of the plain, lies on the Canadian side of the river.

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[1] N. Y. State Mus. Bul. 145.

GENERAL TOPOGRAPHY

The mean level of Lake Ontario and of the St Lawrence through the Thousand Islands is 246 feet above tide. At Ogdensburg it is only 2 feet lower than this, but on the 12 miles of river across the Red Mills quadrangle there is a rapid drop at the Galop rapids, from 244 feet above the rapids to 228 feet at Rockaway point, 16 feet in 8 miles. The levels of the river are the lowest levels in the area mapped.

The highest land on the Ogdensburg quadrangle is around Dekalb Junction in the extreme southeast corner where an elevation of 470 feet is reached. This gives for the quadrangle an extreme of relief of only 225 feet, a very small amount; and the bulk of the quadrangle lies between 300 and 400 feet altitude. On the Brier Hill quadrangle it is even less, since 400 feet is exceeded in only two places, and 440 feet is the highest point, only 200 feet above the river.

The minor relief on the Brier Hill sheet is considerable, much of the surface consisting of slopes; there are many rock exposures, and hence very little guess work is necessary in working out the geology. But the entire northern half of the Ogdensburg quadrangle consists of a plain with little relief, and so covered with glacial drift that rock exposures are very infrequent, and the mapping of formation boundaries is a very uncertain matter.

Drainage. The mapped area drains entirely into the St Lawrence, the chief stream being the Oswegatchie river, which is one of the five good-sized streams which drain out from the Adirondacks to the northwest, the others being the Black, Grass, Raquette and St Regis. Five miles south of Ogdensburg, Black lake, which is nothing but an expansion of the waters of the Indian river into a lake, empties into the Oswegatchie. The Indian river is a considerable stream, but not comparable to the others in size.

The general slope of the district is to the northwest, toward the St Lawrence. This is, however, at right angles to the geologic grain of the country which trends northeast. Most of the preglacial valleys of the district have this northeast trend. Black lake lies in a preglacial valley; and the adjacent valleys of Fish creek and Beaver creek have the same trend and are small preglacial valleys. South of Rensselaer Falls the Oswegatschie is now occupying the preglacial valley of a small stream; but below that point its course seems entirely postglacial, and it has no valley worthy of the name, but flows in a shallow trench cut chiefly in glacial deposits, with rock seldom showing, and with rapids in the stream wherever it is on bedrock.

The St Lawrence, in its course across the Brier Hill sheet, seems to be occupying an old valley; at least there is a well-defined valley rock wall on the New York side. But below Ogdensburg it has the same characteristics as the lower Oswegatchie, no well-defined valley, low banks of drift with no rock showing, and rapids in the river whenever it discovers rock ledges in its bed, as at the Galop rapids.

GLACIAL DEPOSITS

All the surface of the district is below the levels of the bodies of standing water which existed in the region during the closing stages of the Glacial Period, and practically all of it is beneath the level of the marine waters which invaded the St Lawrence valley when the final melting away of the ice sheet cleared a way for their passage. On the Brier Hill sheet the wave action of these water bodies swept away most of the glacial deposits from the higher rock surfaces and into the old depressions, which are deeply filled with them. The low grounds which comprise all the north half of the Ogdensburg are so drift-covered that rock outcrops are exceedingly scarce, but the drift has comparatively little surface relief, was probably all laid down under standing water, and has since all been wave-washed.

A well-defined morainic belt extends across the Ogdensburg and Red Mills sheets, parallel to the river. It has a breadth of several miles and seems to be broadening eastward, with the widening of the Paleozoic plain. But the moraine has a very subdued relief, the knobs being low and of gentle slope, with seldom a relief of as much as 40 feet above the low grounds. Nor does the material appear to be particularly thick; we doubt if it would average 40 feet thick.

This moraine does not extend far west on to the Brier Hill sheet, on which rock exposures abound and drift is heavy only in the preglacial valleys. On the south half of the Ogdensburg sheet, also, there is no widely spread drift cover. The rock relief is greater there than to the north and the drift is solely in the depressions. The depressions are often marshy.

The morainic belt is, to a considerable extent, drowned beneath the clay plain formed by deposit in the standing waters, so that the general surface is a clay flat, above which the higher knobs of the moraine project.

The only considerable drift hill in the whole mapped district is the rather boldly projecting ridge known as Mount Lona, about 2 miles south of Heuvelton, midway of the Ogdensburg sheet. Its north front is at the river edge, at the sides it rises rather abruptly from low, flat country, it trends southwest, parallel with the general direction of ice motion, has a length of about a mile and one-half, and a breadth of one-half of a mile. Its summit has an elevation of 466 feet, the highest point on the map with the exception of one or two of the granite knobs near Dekalb Junction, which are a few feet higher. It towers 160 feet above the country on the north and east, and 100 feet above that on the southwest.

The ridge is entirely composed of bouldery drift, probably morainic. It stands on a sandstone plain, with rock near the surface, and occasionally outcropping around the margins of the knob. A low moraine stretches from it toward the southwest, but a moraine of no particular bulk or prominence. The hill somewhat suggests a drumlin, though somewhat more abrupt, more prominent and more elongated than the usual drumlin. The lack of other hills of the same type in the district tends to throw doubt on such a classification also. We were unable to devote any particular attention to the drift deposits of the region, and simply chronicle this hill as an interesting point for study. Because of its prominence it was thought that perhaps shore line features would be shown upon it, but we could detect none, and apparently the marine waters must have overtopped it somewhat.

A much smaller and less conspicuous hill of similar type is that at Lost village, 5 miles south of Ogdensburg, on the west side of the Oswegatchie at the point where Black lake outlet empties into it; this is also a purely morainic hill, resting on bedrock, and with no particular connection with a morainic belt.

Though the general surface of the Ogdensburg quadrangle consists of a clay plain, above which low, morainic summits rise, locally considerable sand rests upon the surface. Much of the sand is in the lee of the moraine knobs, in the fashion of sand spits, similar to the many occurrences of the same sort on the Theresa and Alexandria Bay quadrangles. But there is also much sand as knolls mingled with the moraine knobs, which seem to be of the kame type, and the chief moraine is probably a kame moraine, its features masked because of its subaqueous formation.

GENERAL GEOLOGY

The rocks of these three quadrangles consist of (*a*) crystalline rocks of Precambrian age and (*b*) early Paleozoic rocks of the St Lawrence trough which lie upon the Precambrian rocks. The Precambrian rocks are the characteristic rocks of the Adirondack region, are as old as any rocks of which we have knowledge, consist in part of sediments and in part of igneous rocks, and have but small extent on the sheets here reported upon, occupying about one-fourth of the area of the Ogdensburg sheet, and occurring in the southeast corner of the Brier Hill sheet. On the Hammond and Gouverneur sheets, next south, however, they occupy most of the territory. The overlying Paleozoic rocks extend solidly along the St Lawrence in a strip a few miles in breath, and the lowermost member, the Potsdam sandstone, is also found in outlying patches within the area of the crystalline rocks. The crystalline rocks are much older than the Paleozoics, venerable as the latter are, and in the time interval between the two sets of rocks the region existed as a land area for a very long period, during which time much rock material was slowly worn away from its surface. It is upon this worn and somewhat irregular surface of the crystalline rocks that the Paleozoic rocks rest. They have remained comparatively undisturbed since their deposition, and still lie nearly flat and unbroken, as laid down, presenting the strongest kind of a contrast to the greatly deformed Precambrian rocks.

DESCRIPTIVE GEOLOGY

PRECAMBRIAN ROCKS

The Precambrian rocks of northern New York comprise an old series of sedimentary rocks, known as the Grenville series, which are the oldest known rocks of the region, and various masses of igneous rocks, all of which cut the Grenville rocks intrusively and are therefore younger than they are. The older set of these intrusives consists chiefly of granite, while a younger set consists of granites, syenites, gabbros and anorthosites. Where both sets are present and in contact with one another, as is the case in the Thousand Islands region, it is possible to class them in their appropriate groups, on the evidence of their structural relations to one another. But where such contacts can not be found, such classification is a difficult and hazardous matter. To the older set of these intrusives the name of Laurentian is applied; for the younger set certain of the Canadian geologists have recently suggested the name "Algoman." It is not certain to which of these groups the granites in Dekalb and in Macomb belong. But both granites and syenites are well represented in the small Precambrian area which the maps contain.

Much later in Precambrian time came renewed igneous intrusion, and black, heavy lavas, so-called trap rocks, rose toward the surface. Such traps are well represented in the Thousand Islands, but in the district here mapped but two small dikes of this rock have been seen.

The Grenville rocks in considerable diversity are found in the southern part of the Ogdensburg quadrangle. They are cut by granitic, syenitic and gabbroic eruptives, and by trap dikes.

The Precambrian rocks exposed within the mapped area cover such a trifling amount of territory, being the mere northern fringe of the great and well-exposed areas of these rocks on the Gouverneur and Hammond sheets next south, that it seems unwise to attempt any elaborate investigation of them until these sheets have also been studied. Since it is our present plan to commence study of the Gouverneur area, the detailed report upon the Ogdensburg Precambrian will be left until that work is completed.

Grenville series. The Grenville series in the Adirondacks exhibits an enormous but unknown thickness of limestones, quartzites and various sorts of schists and gneisses. These are water deposited rocks and were unquestionably deposited in great thickness over the entire region. Not long after their deposit, however, they were invaded from beneath by huge masses of molten granite; and at a subsequent time by even greater masses of a variety of igneous rocks. This action broke up the old series into a group of disconnected blocks and patches, separated by masses of the intrusives, so heated and compressed the sediments as to cause complete recrystallization of their constituent parts, and vastly changed their appearance. The pure limestones were changed into white marbles, with scales of yellow mica and of graphite always present. The less pure limestones are full of other silicates in addition, chiefly pyroxenes and scapolite. The sandstones were changed into quartzites and quartz schists. The shales were altered to schists of various sorts. Contact rocks were produced at the contacts of many of the igneous rocks, and these also have been recrystallized to schists and gneisses. Often there is great difficulty in determining just what the nature of the original rock may have been.

Limestone. An unusually large proportion of the exposed Grenville on the Ogdensburg sheet consists of limestone. A great belt of limestone comes on to the sheet at its southwest corner and the rock is magnificently exposed along the east side of Mud lake, and runs northeast from there in a prominent belt more than a mile in width, its western portion overlapped and covered by Potsdam sandstone. The Grenville limestone is a weak rock in its resistance to erosion, tends to form low grounds and to be heavily covered with soil, so that outcrops are scarcer than in most of the Grenville rock belts, that is, belts of other rock. To the east of this belt are two narrower belts, one east and one west of the Oswegatchie, but in these the limestone is less pure and alternates with thin bands of quartzite and of schists. The areal distribution of the limestone suggests a series of folds pitching to the northeast.

Frequent knobs of granite are found cutting through the limestone, especially in the belt which borders the Oswegatchie on the east. These are more resistant to erosion than the limestone and form the more prominent outcrops in the limestone belts; in fact the great majority of the limestone outcrops are found on their borders. These granite knobs in every case consist of *white* granite, though the granite masses elsewhere are red. It seems to be the same sort of bleaching of the granite at limestone contacts as has been described in the Thousand Island region.

Quartzite. There is no considerable belt of quartzite in the Grenville series of the Ogdensburg quadrangle, though there are narrow belts of it involved with impure limestone in alternating layers, too narrow to map on this scale as separate from the limestone. There is still more of it in narrow bands interbedded with amphibolite and rusty gneiss, all too narrow to map separately and hence mapped simply as Grenville schist. The quartzite is thin bedded, is really quartz schist, and exhibits everywhere minute folding and puckering, showing these features much better than any other rock in the district (plates 1 and 2).

Schists. The larger portion of the area which is mapped as Grenville schists is occupied by the dark-colored rock conveniently known as amphibolite, and made up chiefly of feldspar and hornblende, often with some pyroxene as well and commonly with black mica in addition. When the mica becomes prominent the rock cleaves readily and becomes rather weak. From these thinly

Plate 1

H. P. Cushing, photo, 1913

Closely folded Grenville quartzite, two miles south of Kindrews Corners

Plate 2

H. P. Cushing, photo, 1913

Closely folded Grenville quartzite, two miles south of Kindrews Corners

foliated mica schists there are all gradations into a solid, massive black rock, fairly coarse grained, and with a poor foliation, which is a rather typical amphibolite.

The amphibolites found in the Adirondack Precambrian look much alike, but have originated in at least three quite different ways and from rocks which were originally unlike. In part they represent metamorphosed calcareous shales, which occur in beds within the Grenville series and are an integral part of that series. They are also produced from somewhat impure limestones as a result of the contact action of granitic intrusion upon these limestones. Such amphibolites are found only at such contacts, and should show a gradation back into limestone as we recede from the contact. In still other parts the amphibolites are produced from original basic igneous rocks, gabbros, due to recrystallization under the conditions of heat and pressure which have so profoundly changed all these old rocks from their original condition.

There are probably amphibolites of all three origins within the Ogdensburg quadrangle, but much uncertainty prevails in regard to most of the occurrences. The belt of schists at the eastern margin of the sheet, between the granite and the Potsdam, consists of a jumble of thin beds of many sorts of rock, much folded and contorted and following one another in rapid succession. Thin limestones and quartzites are interbedded with impure limestones, garnet schists, amphibolites and other schists in such wise that they could be separately mapped only on a very large scale map with the aid of multitudinous exposures. The amphibolites here, however, seem certainly to be metamorphosed shales.

Midway of the southern margin of the Ogdensburg sheet is a broad belt of Grenville amphibolite much involved with porphyritic granite. The granite occurs in long, narrow tongues in the amphibolite, but these hold many inclusions of amphibolite. The amphibolites are cut by a multitude of narrow dikes from the granite, and in places are much granulated and soaked by the granite, with the production of mixed rocks. The granite also carries much black mica, and is thoroughly foliated, so that, in the places where the porphyritic crystals of feldspar fail, it looks not unlike some phases of the amphibolite. The main granite tongues can be mapped, and the chief amphibolite masses are readily differentiated from them, but there remains much mixed material, here mapped with the amphibolites, which forms a very puzzling combination. The amphibolite itself also varies greatly. The central part of the mass, that between the two inner granite tongues, is a solid, massive rock which we can interpret only as an intrusion of altered gabbro. It shows two phases, a fine-grained, pepper and salt combination of feldspar and hornblende in about equal quantities; and a coarser, more blotchy looking rock, of similar composition. This central area has been definitely mapped as gabbro, though its boundaries are very indeterminate. The marginal portions of the mass are more micaceous, much better foliated and less massive, much cut up by granite and quartz veins and dikes, and locally soaked by the granite. Here much of the rock is so exactly like the amphibolites interbedded in the Grenville and considered to be metamorphosed shales, that we are in doubt how to class them. They have the gabbro on one side of them, and Grenville limestones on the other. All are cut by, and therefore older than, the granite.

All the granites of the region contain frequent inclusions of the Grenville rocks, and in almost every case these inclusions consist of amphibolite, and inclusions of limestone are never found. Beyond doubt some of these amphibolite inclusions represent altered limestone fragments; but with this exception no amphibolite was seen within the mapped area which definitely suggested such an origin.

In the variety of other schists shown in the region, mention may be made of the garnetiferous schist, for the reason that Doctor Martin has found this rock in considerable quantity on the Canton sheet, next east, and has separately mapped the belts of it there found. But two exposures of this rock have been found on Ogdensburg, one near the east margin, which is in direct prolongation of the belt on the Canton sheet, and the other in a disconnected patch near the south margin. The rock is a heavy, solid one, chiefly composed of feldspar of greenish-gray color, some quartz, much graphite in small flakes, a small quantity of black minerals, and very numerous purplish-pink garnets, averaging one-quarter of an inch in diameter.

Rusty gneiss. A very characteristic Grenville rock in all districts where they are exposed is a peculiar, weak gneiss, which weathers rapidly to a rusty-looking rock of a peculiar yellowish shade. It is usually a highly quartzose rock, holds much pyrite, whose decomposition is chiefy responsible for the peculiar appearance of the weathered rock, contains considerable graphite, as do many of the Grenville schists, and in addition certain rarer minerals, such as sillimanite. Thin bands of this gneiss are found in many places associated with the limestones, on the Ogdensburg quadrangle, but the bands are quite too thin to map separately on this scale.

Associated with the limestones, especially as marginal phases, are dark-colored, heavy gneisses, composed largely of pyroxene, usually with much graphite also, which apparently represent rather impure limestones. These rocks, when heavily metamorphosed, lose their carbon dioxide to a large extent, and the lime combines instead with the silica present to form various lime silicates, mostly pyroxene.

IGNEOUS ROCKS

Three different varieties of igneous rocks have been mapped on the quadrangle, namely, granite, syenite and diabase. The rock mapped as syenite is really a granite, but because it differs markedly from the general granite of the region and is precisely like rock which elsewhere occurs as a marginal phase of the general syenite of the region, it is so mapped here. It occurs in long, narrow tongues which may be dikelike projections from a larger syenite body to the south on the Gouverneur sheet which is not yet mapped; or there may possibly be such a body to the north, under the Paleozoic rock cover.

A fourth variety of igneous rock should be added, namely, the solid variety of the amphibolite, already described, which is regarded as probably a metamorphosed gabbro.

Granite. Two considerable areas of granite-gneiss are exposed within the mapped district, the one in Dekalb, in the southeast corner of the Ogdensburg sheet, and the other in Macomb, in the corresponding corner of the Brier Hill sheet. A third small area is shown in Hammond, on the south margin of the Brier Hill sheet, and this is of interest as being the extreme northeast prolongation of the granite mass described as the Alexandria bathylith, in the description of the geology of the Alexandria quadrangle in the Thousand Islands report.[1] From Chippewa bay this granite extends to the northeast, up the valley of Chippewa creek, flanked by Potsdam sandstone on both sides, across the northwest corner of the Hammond sheet to the Brier Hill sheet, before the adjacent Potsdam closes around it from the sides and hides its further extent. It shows on Brier Hill in but a single outcrop, but the particular interest which it has for us here is that it is a part of

[1] N. Y. State Mus. Bul. 145, p. 36–38.

the granite mass whose relations to other rocks on the Alexandria sheet seemed to indicate a Laurentian age for it. Its termination here is due to its disappearance under the Paleozoics, which have bordered its sides all the way from Chippewa bay, and which here meet over it. Its further extent to the northeast is purely problematical. It is, however, quite possible that the granite mass in Macomb, east of Black lake, is a part of the same bathylith. The Macomb granite runs out to the northeast in the same manner, namely, by having the bordering Potsdam close around and cover its prolongation. It is, however, very like the rock of the main Alexandria bathylith in character; we regard it as quite probably a part of it, and are disposed to class it as of Laurentian age, along with the Alexandria rock. Even without including it, the Alexandria granite extends for 25 miles in a northeast-southwest direction, to which must be added at each end an unknown amount under the Paleozoic cover which hides its continuation. This continued extent enables us to state that, on the Brier Hill sheet, a granite is present whose proved relations to other rocks strongly suggest its Laurentian age. Evidence of similar sort on the Ogdensburg sheet itself regarding the age of the granites there present, is lacking.

The Macomb granite, which we regard as very probably a part of the Alexandria bathylith, is in large part a fine-grained, red orthogneiss, composed chiefly of feldspar and quartz, but with a variable amount of black mica. Exposures are very frequent in the entire rugged district which it occupies. Coarse phases appear, especially at the margins, and there are frequent pegmatite and quartz veins. In the vicinity of limestone its color is bleached from red to white as described for the granites on the Alexandria sheet, and the granite knobs and dikes found cutting the limestone are all of white color. Inclusions are frequent, especially at the east and south, on approach to the bordering Grenville belts there, and, as usual, the inclusions are always of amphibolite, no matter what the nature of the bordering Grenville rock is. In this particular area, however, most of the inclusions are sharply bounded and show little sign of becoming soaked by the granite and converted into mixed rocks, as so many of the inclusions in the granites of the Alexandria Bay region do. This we take to indicate that we are here comparatively near the margin of the bathylith, and that the inclusions had been incorporated in the igneous mass in its late stage, when its fluidity was much diminished.

A narrow belt of Grenville gneiss margins the Macomb bathylith on the south and just beyond appears the northern edge of a mass of granite, which runs widely to the south on the Gouverneur sheet and which must be studied there. It is a coarser granite than the other, holds but few inclusions, and quite probably belongs to the later intrusives which we have mapped as syenite. Its precise relations must be determined by work on the Gouverneur area.

The Dekalb granite, which occupies the southeast portion of the Ogdensburg sheet, extends to the northeast onto the Canton quadrangle, where it has been mapped and studied by Martin, and also runs southwest for an unknown distance on Gouverneur. Its full breadth of about 4 miles is shown, as Grenville rocks adjoin it to the southeast just at the sheet corner.

In so far as most of the granite is concerned it is a fine-grained, red orthogneiss, quite like that at Macomb and Alexandria, chiefly a feldspar-quartz rock, with very little mica, and with inclusions of amphibolite solely, so that we should have little hesitation in correlating it also with the Laurentian, except for two things. At the western edge it becomes fairly coarse grained and, though quite gneissoid, is a quite different looking rock from the ordinary orthogneiss. At the extreme southeast outcrop on the sheet also the rock is of different character, much more micaceous than normal and resembling a mashed porphyry; in other words, bearing some resemblance to the porphyritic granites here mapped as syenite and regarded as belonging unquestionably to the later group of intrusions. One of the peculiar things about the Precambrian geology of the Ogdensburg sheet is the manner in which these long tongues of porphyritic granite appear cutting the Grenville rocks, but, so far as observed, never invading the adjacent granite-gneiss bodies. It is one of the problems on which we hope to get some light from the study of the wider exposures on the Gouverneur sheet to the south. We are in doubt as to the age of this particular granite, as to whether it should be classed with the earlier or the later group of intrusions.

The bulk of the Dekalb granite consists of finely granular orthogneiss, composed almost wholly of quartz and feldspar, and very similar to the Macomb and Alexandria rocks. Along its western margin, where it is coarse, it directly adjoins a belt of solid Grenville limestone, yet it remains of red color and shows no indication of the bleaching to white which the general Laurentian granites show in like situation. Nor does it show any bleaching near the long limestone tongue which lies within the granite. The coarser phase of the rock is that portion which lies between these two limestone belts, and it may be a wholly different mass from the orthogneiss which lies east of it. In our experience with the two granites of the region, the older or Laurentian is the one which loses its red color at limestone contacts, and we have not yet met with the younger one affected in the same way. Nor, in our laboratory experiments on the question, did we succeed in bleaching it.[1] We are here simply trying to marshal the arguments for and against an age classification of this granite, and, as stated, we are in doubt. If it consists of two separate granites we should have no hesitation in correlating the western portion with the later, and the eastern portion with the earlier granite. But we have little direct evidence of an age difference between the two masses.

In the eastern portion of the mass we came upon evidence of bleaching of granite adjoining amphibolite inclusions, evidence chiefly obtained from a quarry opened near Dekalb Junction to obtain material for use on the state road under construction. It may be remarked that such granite gneiss makes about the poorest possible rock for road making, being exceeded in badness among the local rocks only by the Potsdam sandstone. In this quarry the granite was bleached for a few inches around many of the amphibolite inclusions. This is not a common feature of granite-amphibolite contacts and suggests that these particular inclusions are altered limestones.

Syenite. The rock mapped as syenite and regarded as a member of the later group of intrusives is, so far as its occurrence within the Ogdensburg quadrangle is concerned, not a syenite at all but a granite, and its classification is based solely on its lithologic character, as compared with rocks elsewhere in the Adirondacks. It is a porphyritic granite of a peculiar and definite type, a rock which is of fairly common occurrence in the Adirondack region and which, in our experience, occurs only as a marginal, granitic phase of the syenite bodies of the region. It is because of this that it is mapped as syenite here, and separated from the other granites, and because of this that it is regarded as belonging to the later set of intrusives. In the region here the two sets are not in contact and there is no direct evidence of their relationship to each other.

These peculiar granites are always porphyritic and often coarsely

[1] N. Y. State Mus. Bul. 145, p. 177–80.

so, feldspar crystals of an inch or more in length being not uncommon. They are always prominently gneissoid, with a conspicuous development of black mica, the feldspar crystals are strung out parallel to the foliation, and are themselves often granulated or mashed, sometimes completely, sometimes only partially. The mashed feldspars are always red, while the unmashed are lighter colored, usually gray. The rock is therefore usually a mottled looking, red and black rock, the drawnout, mashed feldspars furnishing the red constituent, and the intervening, fine-grained, micaceous portions the black. The rock is not so siliceous as the usual granite of the region, usually running about 68 per cent of silica as against some 72 per cent for the other. There is considerable quartz in the rock, but probably the quartz and much of the mica develop from recrystallization of original feldspar during metamorphism.

As they occur on the Ogdensburg sheet, the distribution of these syenite masses is peculiar. They occur as a series of disconnected, tonguelike masses, drawn out parallel to the general trend of the neighboring Grenville rocks through which they cut. Eight such separate tongues are mapped within a comparatively small area on the southern part of the Ogdensburg sheet, and there are others to the southwest on the Gouverneur and Hammond sheets. They have not been traced to any connection with a mass of ordinary syenite. Such a mass may be found on these sheets when they are mapped, from which these tongues may be dikelike offshoots. But they do not produce the impression of dikes, nor are their contacts with the Grenville of the type which would normally come with dikes. These contacts are not sharp, but exceedingly blurred. The adjacent Grenville rocks are cut by a multitude of narrow dikes running out from these tongues, so that there is a considerable intermediate zone of mixed rock around each one of them. The relations suggest the influence of a large mass of hot molten rock, much larger than indicated by the present surface exposures. It is therefore quite possible that these tongues are mere upshoots from a large mass of syenite beneath, hidden from view by the Grenville cover, but not far beneath the present surface. This suggestion is, of course, speculative, but would explain the present surface relations, and is opposed by no facts known to us.

Diabase. Only one trap dike has been seen within the mapped limits. This is found in Dekalb, about 2 miles south of Kindrews Corners and just west of the Oswegatchie. It is a large dike, 45 feet wide where measured, bears N. 25° E. and seems quite vertical. No very fresh material could be obtained from it and the alteration which it has undergone has changed its original black color to a dark green. Like all the wide dikes it is of sufficiently coarse grain so that the different minerals may be made out by the eye. Very fresh, glittering, lath-shaped feldspar crystals are abundant, along with much coarser feldspar which is somewhat altered and dull. No olivine can be seen, and the rock is the ordinary feldspar-augite-magnetite mixture usual in these dikes.

The dike does not trend with the rock strike of the adjacent rocks which, at the locality, is north-south. Where seen it cuts across Grenville quartzite and amphibolite and adjacent syenite.

Structures of the Precambrian Rocks

The Precambrian rocks are exposed over such a comparatively small area that study of the structures shown leads to little that is of value and nothing that is new. Their most prominent structure is foliation. The Grenville rocks are believed to be greatly folded, but little that is definite concerning the folds can be made out from the study of such a small area.

Foliation. In the Ogdensburg region the foliation cleavage which has been developed in the Grenville rocks under metamorphism is closely parallel to the bedding, and this seems to be the case throughout the Adirondack region. Strike and dip readings on the one therefore correspond to those on the other.

The general strike of the Grenville rocks of the district is northeast-southwest. But there is much local variation from this general direction. Our readings vary from N. 10° W. to N. 85° E. Often there is rapid local variation due to folding. Along the Oswegatchie nearly north-south strikes prevail; along the east margin of the Ogdensburg sheet the strike has swerved to the northeast and beyond, and so continues on to the Canton sheet; passing westward toward and on to the Brier Hill sheet, it has gone back to the northeast. This is also its general direction in the Thousand Islands region.

The general dip is to the northwest. It is usually steep, in excess of 45°, and locally becomes vertical. Locally also it varies, passing from northwest to southeast and back again within narrow limits, indicative of local plications. The only part of the area within which southeast strikes prevail is a narrow belt on the east side of the Oswegatchie, on the south margin of the Ogdensburg sheet.

Folds. If the Grenville rocks are folded, as they assuredly are, the folding must be of the close and overturned type in order to give rise to dips so prevailingly in one direction as they in general present in northern New York. The general northwesterly dip in this district, for example, seems to us to imply that the folds are all tipped over toward the southeast, so that the dips on both limbs incline to the northwest. The distribution of the limestone on the Ogdensburg quadrangle suggests that we are dealing with one great bed of limestone, pinched into a syncline, the two sides diverging southward, meeting and joining on the north, and hence indicating that the syncline pitches to the southwest, and that the inclosed amphibolite is younger. But the mapped area is too small, the adjacent area too little known, and the structure too complicated, to warrant anything more than this suggestion, to be confirmed or disproved by later work.

The very contorted and complex crumpling and plication which certain beds of the Grenville show, is of itself indication of larger scale folding. Of all the rocks of the group the thin-bedded quartz schists best exhibit such plications. Plates 1 and 2 are from photographs of such quartzite, 2 miles south of Kindrews Corners.

Close folding is also shown in the combination of thin-bedded impure limestones, pyroxene schists and garnet gneisses which occur north of the Dekalb granite on the east margin of the Ogdensburg sheet.

PALEOZOIC ROCKS

General statement. The Paleozoic formations found within the mapped area are the Potsdam and Theresa formations, of upper Cambric age, and the Tribes Hill and Ogdensburg formations, of Lower Ordovician (Beekmantown) age. They rest with marked discordance on the irregular surface of the Precambrian rocks. There is some evidence that still another formation will have to be separated from the upper part of the Theresa, including what we have mapped as the Heuvelton sandstone lentil of the Theresa formation, the beds between this sandstone and the base of the Tribes Hill, and the 30 feet (more or less) of sandy beds just under this sandstone. But the evidence is not yet decisive, and lithologically the beds are much like those of the Theresa, with which they form a convenient lithologic unit.

It is quite possible that beds of later Ordovician age, Chazy, Black River, even Trenton and Utica beds, may have once been deposited in the district, but if so, erosion has left no trace of them.

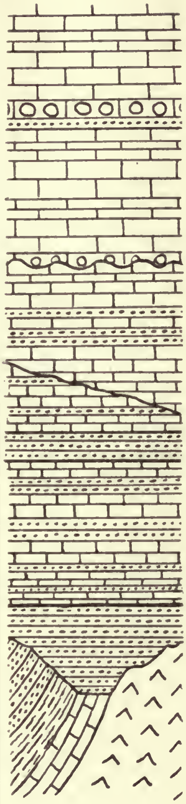
SYSTEM	FORMATION	SYMBOL	SECTION	THICKNESS	CHARACTER OF FORMATION
Ordovician (Beekmantown)	Ogdensburg formation	Oo		120′ +	Alternating beds of massive, blue-gray, granular dolomite, and thin-bedded, iron-gray, fine-grained dolomite: with an occasional bed of gray, calcareous sandstone
	Tribes Hill formation	Ot		0′–40′	Thin-bedded, blue, sandy limestones above and below, with an intermediate, more sandy member
Cambrian (Ozarkian)	Theresa formation	Ch Ct		(20′) 120′	Alternating beds of white sandstone, gray calcareous sandstone, and blue sandy limestone, with a 20′ sandstone member, the Heuvelton sandstone, near the summit
	Potsdam formation	Cp		0–60′	Mostly white, vitreous sand stone
Precambrian	Grenville series and igneous rocks	Gl Gs gr sy			

Fig. 1 Generalized columnar section of the rocks of the Brier Hill, Ogdensburg and Red Mills quadrangles

Character of the Precambrian surface under the Paleozoics. It has been shown in many of the recent New York reports that Paleozoic deposition commenced upon a Precambrian surface which was characterized by considerable irregularity. This irregularity seems to have been most pronounced on the northeastern margin of the Adirondacks, in Clinton county, and to diminish in amount both to the south and to the west. On the southwest, in

Herkimer county, the irregularity is least, and there, in fact, the surface is quite smooth. Because of abundant rock exposures the phenomena are much better exhibited in the Thousand Islands region than elsewhere, and were described at length in the report on that district.[1] These irregularities amounted to differences of altitude of at least 100 feet in the various parts of the Precambrian surface, the limestones and weaker schists forming the depressions, and the granites and quartzites projecting as the knobs and ridges. This irregularity in surface is just about equal to the greatest thickness of the Potsdam sandstone, the first Paleozoic formation to be deposited upon it, so that the sandstone is very thin on the higher parts of this surface, and the very highest may even project through it.

Since the Alexandria Bay quadrangle corners on Brier Hill at the southwest, it is to be expected that these phenomena will be repeated in the Ogdensburg region. But they are by no means so well shown. The Potsdam seems no thicker here than there, and the irregularity in Precambrian surface seems somewhat greater here. On the Brier Hill sheet, near the river and 3 miles southwest of Morristown, is a small exposure of Precambrian rock, a hard, pyroxenic Grenville quartzite, entirely surrounded by exposures of the Theresa formation, nearly 40 feet above the summit of the Potsdam. This is the only observed case within the limits of the map of Theresa beds on Precambrian, but the Potsdam is very thin, not over 20 feet thick, on the Macomb granite, and it also seems to be thin as the Canton sheet is approached. On the other hand, through Depeyster where it lies on Grenville limestone, it seems at least 80 feet thick.

CAMBRIAN (OZARKIAN) FORMATIONS

Potsdam sandstone. The Potsdam occurs in two different situations, the one as a continuous belt of sandstone bordering the Precambrian rocks on the north, and the other as outliers of sandstone, within the Precambrian area. As the rock characters differ somewhat in the contrasted situations, they are best described separately.

The belt which borders the crystallines is a very irregular one, because of the irregular surface on which it was deposited. The thickness varies greatly, only the upper beds overriding the Pre-

[1] N. Y. State Mus. Bul. 145, p. 54–60.

cambrian ridges, while the lower beds are limited to the depressions. The bulk of the rock is a hard, white, sugary-looking sandstone, locally with a brown tint, composed of nearly pure, quartz sand, thoroughly cemented by silica. The majority of the exposures are of low, flat, glaciated surfaces, and cliffs, or exposures showing any considerable thickness of the formation, are very exceptional. Excellent exposures may be seen to the south of Brier Hill Station, and these expand into a broad sandstone platform to the south on the Hammond sheet. There are excellent exposures also along the west shore of Black lake, above the narrows. Good exposures also occur at the northeast end of the Macomb granite mass, though here the formation shows only the upper 20 feet. Here also are the only actual contacts with the underlying Precambrian which were seen within the map limits. On the Ogdensburg quadrangle, great, bared exposures occur 2 miles south of Heuvelton, and from there run southwest for 3 miles, or rather for several miles, for the same belt continues down into Macomb, giving way to Precambrian just about at the southern edge of the map.

Interbedded with the sandstone on the Alexandria quadrangle is a peculiar conglomerate, whose pebbles are large sized cobbles rather than pebbles, which may reach a foot in diameter and often show a diameter of 3 inches. The pebbles are almost exclusively of Grenville quartzite, and are usually subangular, though well-rounded ones also occur. They are set in a matrix of sand, and the whole is bound together by a cement which is more often calcareous than siliceous, though both sorts occur. Where the cement is calcareous, as it is in the cliff along the St Lawrence below Chippewa bay, the cobbles weather out rather rapidly; where it is siliceous the rock is very resistant. This conglomerate is usually not basal in the formation, but has a varying thickness of ordinary sandstone underneath it. It is a most astonishing formation and difficult of explanation.

This river cliff, containing the conglomerate, continues on to the Brier Hill sheet, in Hammond, as far as Oak Point, beyond which it also appears intermittently. There is a fine exposure of it near Point Comfort, 3 miles southwest of Morristown, where a small fault runs east from the river bank and brings up the conglomerate on its north side, well above the river. It shows precisely the same characters as in Alexandria. Not far beyond the Potsdam dips beneath the bed of the river, after which the Theresa beds are at the river level for several miles. Underneath the conglomerate at

Point Comfort is a 25 foot thickness of Potsdam sandstone to the river level, with the base not reached, a greater thickness of sandstone than was noted anywhere under the conglomerate on the Alexandria sheet. It seems to vary in horizon, instead of being a persistent band, and to exist in the sandstone after the fashion of large channel-fillings. Above it there is a 20 foot thickness of Potsdam sandstone, making altogether a 50 foot section of the sandstone, with the base not seen. This is the thickest continuous section of the formation that we have seen within the map limits.

There is locally a little hard, red sandstone, mixed with the ordinary white and buff rock, more particularly in the exposures along Black lake, but there is no great amount of it anywhere.

At the extreme summit of the Potsdam a thickness of some 10 feet of beds is slightly calcareous. The calcareous cement occurs in rounded patches which have a light, pinkish gray tinge in contrast with the dead white of the rest of the rock, in fresh specimens. But in the ordinary exposures this cement has been leached out, leaving brown-stained spots in the rock. This brown-spotted sandstone is a characteristic feature of the upper beds. It is also characteristic of the sandstones of the Theresa formation above.

The Potsdam sandstone of the occasional outliers in the Precambrian rocks frequently shows phases quite unlike those of the general mass of the rock in the continuous belt. In this respect it accords closely with the outliers on the Alexandria and Theresa sheets which have already been described.[1] Occasional patches of a red, very quartzitic sandstone were found, resting upon Grenville rocks, usually limestone, and extending down into the limestone along joint cracks which had been widened by solution. Other patches of basal conglomerates of the Potsdam were found which contained, along with numerous pebbles of Grenville quartzites, pebbles of this red, quartzitic sandstone. There is no rock in the Precambrian series which is anything like this red sandstone, and the occurrences distinctly suggested a sandstone, older than the ordinary Potsdam, which had largely been eroded away before ordinary Potsdam deposition began.

The Potsdam outliers on the Ogdensburg sheet, which are rather remote from the main mass of the formation, are chiefly found on the surface of the Grenville limestone belt which the Oswegatchie follows for the first 4 miles of its course on the quadrangle. Two

[1] N. Y. State Mus. Bul. 145, p. 61–63.

or three of these outliers consist of red, flinty sandstone quite like that on the Theresa and Alexandria sheets. There are also associated masses of very flinty conglomerate, full of pebbles of Grenville quartzite, and quite like the conglomerate previously described, except for their more excessive induration. These beds certainly appear somewhat older than the Potsdam of the border belt. But there is as yet no decisive evidence of any material difference in age.

No fossils have been noted in the Potsdam of the mapped area. The nearest point at which we have collected them is at Clayton, where Lingulella acuminata was found.

Theresa Formation

General statement. A series of "passage beds" of alternating sandstone, calcareous sandstone and dolomite beds overlies the Potsdam everywhere in the circum-Adirondack region. To these beds we have been applying, for mapping purposes, the name of the Theresa formation. In the eastern sections these beds have large thickness, 150 to 200 feet, and are followed by the Little Falls dolomite, the three together forming the upper Cambrian (Ozarkian) series of northern New York. Deposition was seemingly continuous between these formations, and they grade into one another, without sharp boundaries, so that their separation from one another is largely a matter of convention, though they constitute three contrasted, lithologic units.

In mapping the Thousand Islands region we encountered difficulties with this classification. The Potsdam was, as usual, followed by a series of passage bed character, to which we gave the name of Theresa, but no representative of the succeeding Little Falls dolomite is present. In the lower half of the Theresa we found Lingulella acuminata in several localities. In the upper half, however, we did not find this fossil but did find in several places a coiled gastropod and occasional cystid plates. These Ulrich identified with forms found in the Tribes Hill limestone of the Mohawk valley, a formation which there lies unconformably on the Little Falls dolomite, and which Ulrich regards as the lowest formation of the New York Beekmantown. The beds containing these fossils were quite similar to the lower ones containing the Lingulella and we were unable to detect any break between the two, and hence mapped them together as a single lithologic unit, the two together not exceeding 60 to 70 feet in thickness.

This statement is regarded as necessary here since, in following these beds on to the Brier Hill and Ogdensburg sheets, and tying them up with Professor Chadwick's work on the Canton sheet, it is found that they have greatly thickened, have changed somewhat in character, and that apparently another formation has wedged in between the lower and upper parts of the formation, as shown in the Thousand Islands region. Furthermore the upper part, the Tribes Hill, is shown very sparingly and erratically in the district here, but reappears on the Canton sheet in even greater force than on Theresa. We seem to be dealing with the thin, near-shore edges, of several formations, very similar lithologically, whose thorough discrimination and description is going to be a very difficult matter, and can not yet be successfully attempted, chiefly because of the lack of well-preserved fossils.

Description. As here mapped, the Theresa formation contains at least two different elements. The lower portion of the formation consists chiefly of thin-bedded calcareous sandstones and sandy limestones, blue-gray and very hard when fresh, but weathering rapidly to yellow-brown, porous rocks, such as usually appear in outcrop. Occasional thin beds of white sandstone, usually brown-spotted after the fashion of the uppermost beds of the Potsdam, occur with the others. This material has a general thickness of from 25 to 30 feet, and seems to be the exact equivalent of the typical Theresa of the Theresa quadrangle. It is on the same horizon and looks the same. But we have found no fossils whatever in it in this district, though it should hold Lingulella acuminata if our correlation is correct. The zone is, however, seldom well exposed here, and good opportunity for search for fossils is therefore lacking.

Above this thin-bedded zone there is a recurrence of thick-bedded material, with much increase in the amount of sandstone. This is quite foreign to our experience with this passage bed zone elsewhere in New York. In general there is a steady diminution in the amount of sandstone, going up in the section. But here the increase is so marked that, in many exposures, it would be an exceedingly difficult matter to discriminate these beds from the Potsdam, were not the horizon definitely determined. Midway of the zone is a solid mass of sandstone, 20 feet thick, which is so prominent a feature in the geology of the district that we have given it a separate mapping. Professor Chadwick had independently recognized this sandstone on the Canton quadrangle and has suggested the name of Heuvelton sandstone for it. It is, however, but one out of several thick sandstones zones in the formation; there are three or four others with a thickness of from 8 to 10 feet, which may readily be mistaken for the other where outcrops are poor. Nevertheless the Heuvelton is far the thickest and most prominent of these sandstones, and forms a conspicuous bench wherever rock outcrops are at all plentiful, so that it is readily mapped all across the district, except for that part of its course across the Ogdensburg sheet northeast of Heuvelton, where heavy drift conceals all rock.

Above the 20 foot (Heuvelton) sandstone, beds of sandstone are not so prominent and thick as they are below it, though they persist to the summit of the formation. The chief constituent here, however, is massive beds of hard, blue, coarsely crystalline limestone, full always of sand grains, and of irregular, black seams, or films, of uncertain nature.

Direct contacts of the Theresa with the Potsdam are to be seen at several points along the river cliff above Holmes point and on the south margin of the sheet 3 miles southwest of Brier Hill, and also on the hillside above Black lake, 2 miles west of Kings Corners, at the west edge of the Ogdensburg sheet. These show, in every case, the thin-bedded, alternating sands and calcareous beds of the typical Theresa, with a thickness of about 30 feet. In the latter instance the Heuvelton sandstone directly follows these thin beds. In the other sections a thickness of from 20 to 30 feet of the more sandy, heavy beds lies between. In still other sections this is increased to 40 feet or more. This considerable variation in the thickness of the beds between the Potsdam and the Heuvelton, together with the fact that, in the thinner sections, the beds which are absent are the upper ones, suggests a break between the thin-bedded zone and that which overlies; and it is our belief that such a break exists. But it is a difficult one to locate satisfactorily and, in most sections, we are unable to fix it definitely.

Of the many sections in these upper, sandy beds, containing the Heuvelton sandstone, much the best and most complete one we have seen is the one along the river road, as it climbs the hill just out of Morristown going east. Recent road-making operations there have resulted in exposing an almost continuous section in the road gutter. Necessarily it will show less well as the years go by, but just now it is a very satisfactory exhibition. As our work and that of the road makers was in progress at the same time we had the additional advantage of having a large quantity of freshly thrown-out rock material to examine. From the river level to the summit of the hill, one mile east of Morristown, a 90 foot thickness of rock is shown in the section, but only the upper 60 feet is in the continuous section. The whole is so homogeneous in its alternations of sandstone, calcareous sandstone, and sandy limestone, that it seems better to generalize and simplify it, than to give the entire, detailed section.

Generalized section at Morristown

7.	6′	Thin-bedded, light-gray, somewhat magnesian limestone, with frequent sand grains; finely granular; frequent nodules of flesh-colored crystalline calcite, usually small and elongated parallel to the bedding, but sometimes an inch or more in diameter; top not seen; an occasional thin layer of hard, calcareous sandstone is interbedded with it.
6.	8′	Thick-bedded, dark blue-gray, very sandy limestone, alternating with grayish white calcareous sandstone, both showing frequent cleavage surfaces of calcite, due to crystalline orientation of the calcite cement; the blue beds are full of thin black films of uncertain nature, irregular but roughly parallel to the bedding; the sandstones are full of fucoidal markings, and both show occasional, large, coiled gastropods.
5.	7′	Limestone similar to that above, but alternating with beds of white sandstone which are only slightly calcareous; the calcareous cement is present only in spherical spots, and elsewhere the cement is siliceous; the calcareous cement weathers out, leaving brown, discolored, weathered spots on the otherwise white surface; at many horizons the sandstone is full of films of fine-grained, greenish material resembling clay.
4.	20′	Thin-bedded white sandstone, siliceous, but with spots of calcareous cement which weather out leaving round, brown spots; Heuvelton sandstone.
3.	10′	Alternating white sandstone and blue calcareous sandstone, the former much in excess; a bed of calcareous sandstone at the base of the 20 foot sandstone, and three others in the interval; remainder all white sandstone.

2.	20′	Similar to the division above but with the calcareous sandstone much more prominent, so that it forms half of the thickness; the two alternating in divisions which average 5 feet thick.
1.	20′	Alternating hard, white sandstone, softer, brown-spotted sandstone, gray, calcareous sandstone, and blue, sandy limestone, in part thin-bedded; less sandy than the divisions above; complete section nowhere shows; this division seems to represent the upper half of the 30 foot division of thin-bedded material at the base of the Theresa; at least it seems to grade into this when followed up the river.

In this section the basal 30 feet of thin-bedded material can not be made out, and the precise horizon of the base determined. But study of the exposures up the river from Morristown suggest that division no. 1 in this section represents the upper half of the 30 foot division, somewhat changed in character and more massive, and that the base of the sections is about 20 feet above the Potsdam.

Judging from the fossil evidence, the upper part of this section should represent a different formation from the true Theresa, and also a different formation from the Tribes Hill, which directly overlies the Theresa in the Theresa region. It is, however, very like the Theresa lithologically and was classed with it while the field work was in progress. In this section our notion is that the 20 feet of beds of no. 1 would be classed certainly as Theresa; that beds nos. 2–6 likely belong to this new formation, and that no. 7 is perhaps Tribes Hill. The large gastropods which are the characteristic fossils of this new division have been found in beds nos. 3–6, so that really the only doubtful division is no. 2. In this connection it is of interest to note possible evidence of a break at this horizon, shown in a railroad cut one and one-half miles southeast of Morristown. The cut shows a 12 foot thickness of beds belonging apparently to the horizon of division 2 of the Morristown section; massive calcareous sandstone at the base, followed in turn by white sandstone and by thin-bedded, calcareous sandstone, and capped by coarse, white sandstone. Following around to the north face of the exposure, these beds are seen to be cut out by a mass of coarse conglomerate, full of sandstone pebbles up to 2 inches in diameter (figure 2). In the field we interpreted this as a channel-filling, but, when taken together with the varying thickness of the beds between the Heuvelton sandstone and the Potsdam, the 30 feet of divisions 3 and 4 being absent at Black lake, a break is suggested, and probably will be demonstrated on further search.

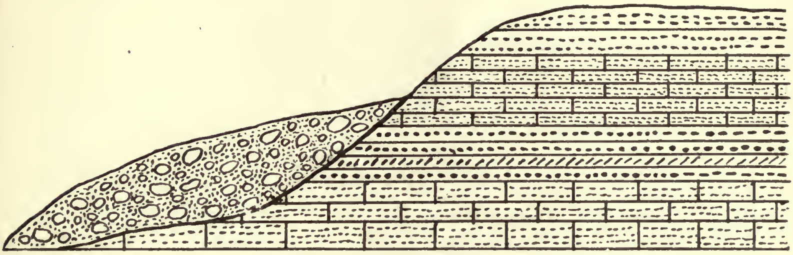


Fig. 2 Exposure in upper Theresa formation 1½ miles southeast of Morristown, showing the sandstones and calcareous sandstones cut out by a coarse conglomerate. Only one side of this channel-filling can be seen, as the exposure gives out to the east, only a small portion of the original mass of the conglomerate showing.

The fossils. As has been stated, not only the Heuvelton sandstone, but also the beds both above and beneath contain large but poorly preserved gastropods sparingly. So far as our evidence goes, the same fauna runs through all of them. We are much indebted to Dr E. O. Ulrich for the examination of these fossils, upon which he reports as follows:

"The fossils in zones 1–3 (the Heuvelton sandstone and the beds just beneath and above) though poor, indicate at least three, and possibly five species of gastropods: (1) a fragment of a Sinuopealike shell suggesting nothing else so much as a new species of *Sinuopea* from the Upper Ozarkian, Chepultepec dolomite of east Tennessee. Nothing like it is known to me from the Lower and Middle Ozarkian; (2) a narrow, whorled gastropod belonging to a new genus allied to *Liospira*. This species resembles the "Pleurotomaria hunterensis" but has a flatter top. A more similar, possibly identical, shell, occurs in the Chepultepec, and in the corresponding Gasconade and Oneota formations, respectively of Tennessee, Missouri, and Minnesota-Wisconsin; (3) a second Liospiralike shell, closely simulating a Chepultepec-Gasconade fossil. It also recalls a species of the Beekmantown and Cotter (both Canadian, the latter a new Arkansas-Missouri formation); (4–5) two other, both wider-whorled, Liospiralike shells are indicated. Both may be compared with Gasconade species, but similar types also occur in the Canadian and Ordovician."

"As it stands, the faunal evidence indicates almost conclusively that zones 1–3 can not correspond in age to the typical Theresa. The former can scarcely be older than the Gasconade-Chepultepec-Oneota (=Upper Ozarkian), while the latter is surely not younger than early, or early Middle Ozarkian. Apparently zones 1–3 belong to the Little Falls dolomite rather than to the Theresa. If Little Falls — or better, late Ozarkian — overlap took place in the Ogdensburg region, the ensuing sediments would naturally partake of and simulate the sandstone land there prevailing." [1]

According to this report of Ulrich's, the fossils point to a late Ozarkian (or Upper Cambrian) age, or else to a Canadian (earliest Ordovician) age. But the remainder of the section here definitely affirms the former as the true solution, since these beds are unconformably overlaid by beds of Tribes Hill age, the Tribes Hill formation being the oldest known formation of the New York Ordovician. Though we have mapped the beds with the Theresa, the Heuvelton sandstone and the beds over that all belong in this new division, as well as a varying thickness of the underlying beds, from 0 to 30 feet in thickness. It will probably be wise to extend the name Heuvelton to include the whole. This division occupies the same interval as that occupied by the Little Falls dolomite of the Mohawk valley, but it is as yet premature to say that it should be correlated with that. The Little Falls follows the Theresa without a break, while there seems to be a break between this Heuvelton and the underlying Theresa.

It is, however, not certain that the Little Falls itself is a single, indivisible formation. The upper, cherty beds at Little Falls and eleswhere contain occasional fossils, especially in the cherts. It was these upper cherts which furnished the fossils described by Hall in volume 1 of the New York Paleontology. The beds contrast rather sharply with the great mass of unfossiliferous dolomite below, and also with the Tribes Hill above. An unconformity separates them from the Tribes Hill. Ulrich has a suspicion that these cherty beds are separable from the Little Falls proper as an upper division, and that a break may occur between them and the main mass of the Little Falls. He is also disposed to correlate the Heuvelton beds with these upper, cherty beds of the Little Falls, because of similarity in the fossils. We have seen all the sections together and I think that this view of Ulrich's has much

[1] Letter of October 17, 1914.

to commend it. But additional work needs to be done before this can be put forward as anything more than a working hypothesis. As such, however, it needs to be kept in mind by future workers in the field.

ORDOVICIAN FORMATIONS

Tribes Hill formation

General statement. Blue, sandy limestones containing as fossils "Pleurotomaria hunterensis" and cystid plates, identical with forms found in the Tribes Hill formation of the Mohawk valley, were found, with a thickness of some 30 feet, in the Thousand Islands region, and correlated with the Tribes Hill. We were accordingly on the lookout for this formation, while the work on the Brier Hill sheet was in progress, and were much surprised to find little or no trace of it in the excellent sections east from Morristown, while we found instead the considerable thickness of sandy beds containing the Heuvelton sandstone, which have just been described. The small thickness of gray, calcareous beds, no. 7 of the section described on page 31, suggested Tribes Hill, but no fossils were found, and the zone was very thin. Scraps of limestone were also found in poor exposures in the heavily drift-covered portion of the Ogdensburg sheet, also with no fossils. Hence we came to the conclusion that the formation had nearly or quite disappeared in the interval between Theresa and Morristown. In his work on the Canton quadrangle, however, Professor Chadwick found a considerable thickness of beds at this horizon, from which he collected fossils, and for which he suggested a Tribes Hill age. His fossils were determined by Doctor Ruedemann, and subsequently Doctor Ulrich also examined a portion of his collection, and both gentlemen agree in their determination of these beds as of Tribes Hill age. We have therefore mapped a belt of this formation across the Ogdensburg quadrangle, to include the scattered outcrops of limestone. The mapping is, however, of the most perfunctory character since, in that drift-covered belt, no accurate mapping is possible, and geologic boundaries can be delineated only in a most general manner. On the Brier Hill sheet the formation, if present, is so thin and so patchy in distribution that it is impossible to map it on this scale.

This variable distribution of the formation definitely suggests one of two things: either the Tribes Hill shore line in this part of the State was irregular, setting back into embayments on the

Theresa and Canton sheets while the Brier Hill sheet was barely reached by its waters; or else it was deposited on the Brier Hill sheet, and eroded away before deposition of the Ogdensburg division of the Beekmantown commenced. The evidence for deciding between these two views is not at hand. But certain facts do suggest the first view rather than the second. The first of these is that the lithologic character of these beds differs quite materially on Theresa and on Canton; the second is the considerable difference in thickness, coupled with the fact that the beds at Theresa more strongly resemble the middle division of the formation at Canton than they do the basal; whereas if they represented parts of a continuous formation whose summit had been eroded away to varying degree, the remnant left at Theresa should be the basal portion. Our preference therefore is for the view that the Tribes Hill formation is absent from the Brier Hill sheet because it was not deposited there. It should also be noted that Chadwick describes the Tribes Hill base on the Canton quadrangle as coming down almost, locally quite, to the Heuvelton sandstone, while on Brier Hill, 15 to 20 feet of calcareous Heuvelton beds overlie the sandstone. In other words, the Tribes Hill base rests on quite different beds as it is followed across the district, so that the evidence of a considerable break at its base is quite clear. At Theresa it rests on the normal Theresa; at Morristown a considerable thickness of the Heuvelton beds rests on the normal Theresa, and the Tribes Hill, if present at all, rests on the Heuvelton; on the Canton quadrangle it rests on the Heuvelton sandstone, the upper Heuvelton beds being absent, presumably because of erosion antedating the Tribes Hill deposition.

Since the Tribes Hill formation on the Ogdensburg sheet is almost completely drift-covered, a description of the formation can not be written from the exposures here present, and hence we present a short account of the formation as shown on the Canton sheet, which we owe to the courtesy of Professor Chadwick.

Three divisions of the formation are recognized. The lower division consists of mostly thin-bedded, more or less calcareous sandstones, gray when fresh, but weathering to rusty rotten stone. They are ripple-marked, have fucoidal markings on their surfaces, are fine-grained, and vary considerably in the amount of lime, some beds having very little, and some having the characteristic "sand crystal" cleavages which characterize all the rocks from the Theresa up, when the calcareous cement is abundant. Their thickness runs from 15 to 25 feet.

No such beds as these have been seen anywhere on the Brier Hill quadrangle, and they are believed to be totally absent there. It is quite possible that they may exist on the eastern half of the Ogdensburg quadrangle, but no outcrops have been seen, and they are probably wholly covered by drift.

The middle division consists of more massive, less sandy beds, some of which are blue and strongly dolomitic, suggesting the character of the overlying Ogdensburg formation, though everywhere more sandy than the Ogdensburg beds. These beds have a thickness of some 10 feet, and are capped by a hard layer of white vitreous sandstone. Fossils are most numerous and varied in this division.

The upper division consists again of thin-bedded, fucoidal, sandy and siliceous dolomites, quite similar to the beds of the lower division, but more magnesian and less calcareous. They also contain fossils, but less abundantly than the middle division. They have a thickness of at least 25 feet.

In the Raquette river section, at Hewittville, Professor Chadwick finds an additional thickness of some 9 feet of somewhat argillaceous, firm, fine-grained, light-gray limestones and dolomites, with sand grains only in streaks, quite different looking beds from the Tribes Hill beneath, and lying beneath the Ogdensburg beds. They have furnished no fossils. They seem to wedge in toward the east and to be absent in the remainder of the district. It may be suggested that here is the extreme westerly edge of that portion of the Champlain Beekmantown which underlies the Ogdensburg division in those sections.

Ogdensburg Formation

General statement. As has been stated in the preface to this report, the study of the Beekmantown formation of the region was the principal object of the field work. The other formations appearing were known to be those which had already received detailed study elsewhere. But none of the Beekmantown of New York has ever been studied in the desirable detail requisite to furnishing a good idea of its history and its fauna, and almost no study whatever had been previously given in the State to the formation as shown in the St Lawrence valley. It was known to be less fully shown here than in the Champlain valley, and we had predicted that the lower beds would be absent, on the basis of the belief that the formation overlapped into the district from the east.[1] This proves to be true, in a way, but in a way somewhat more complex than was supposed, owing to the unexpected appearance of the Tribes Hill formation, which we believe to be of oldest Beekmantown age. We do not yet know whether the Tribes Hill formation gets into the Champlain valley at all or not. It is certainly absent at Saratoga, and is apparently absent at Ticonderoga. On the other hand, the lower divisions of the Champlain Beekmantown, division B, division C and the lower portion of division D, are certainly absent at Ogdensburg, as we had predicted.

Nomenclature. The type region for the New York Beekmantown is the Champlain valley, and the work of subdividing and naming the Beekmantown formations of the State should be done in that valley. The work of Brainard and Seely, recognizing five divisions of the formation, which they lettered from "A" to "E," was done a quarter of a century ago, and we do not known whether those subdivisions fulfil modern requirements or not; the faunal zones have not been thoroughly worked out, and the formations have not been named. It was therefore our purpose in this report simply to call the Ogdensburg exhibition of the formation by the group name "Beekmantown," and to leave the application of a name to the future, when it was hoped that a Champlain valley name would be available and applicable. This laudable purpose was defeated by the unexpected presence of the Tribes Hill formation, a Beekmantown formation which had already received a name. In other words, there are two Beekmantown formations here at Ogdensburg, requiring separate mapping and separate designation. Since both are Beekmantown it would be incongruous to apply that name to but one of them. We therefore are proposing the name "Ogdensburg formation" for the upper and more important of the two formations; though we do it most unwillingly, with a premonition that the name will arise to plague us, when the Champlain valley work is done.

Description. By far the best and most complete section of the Ogdensburg formation is that shown along the river west of Ogdensburg, more particularly along the river road, and reaching to within 4 miles of Morristown, where its base is exposed. The most westerly section, shown just north of the roadway, 4 miles northeast of Morristown, is as follows:

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[1] N. Y. State Mus. Bul. 145, p. 78, footnote.

3.	15″	Gray, granular dolomite, capped by a 3-inch layer of dark blue, magnesian limestone which contains many gastropods; the 3-inch layer is solidly welded to the gray bed beneath.
2.	13″	Dark blue, sandy limestone, very full of rounded quartz grains, with calcareous cement showing frequent "sand crystal" cleavages; nearly half of the rock consists of quartz sand.
1.	12″	Gray dolomite, with frequent sand grains, and with some calcareous cement.

These appear to be the very basal beds of the formation. The contact does not show here, but undoubted beds of the Heuvelton calcareous sands come in not far below and, as the Ogdensburg beds are more resistant to erosion, it is probable that this is the very bottom. The sand grains in the two lower layers show that it is near the base, at least. Furthermore, outcrops of the upper Heuvelton in the road gutter, a short distance to the west, show a slightly irregular upper surface, in the depressions of which are patches of sandy dolomite, which are precisely like the basal bed of the section, and which contain, in addition, pebbles of the underlying Heuvelton. These relations indicate an erosional unconformity between the two formations. And this would naturally be expected since, farther east, the Tribes Hill formation wedges in between the two, with indication of a break between it and the Ogdensburg. The so-called upper Heuvelton here consists of a three or four foot thickness of thin-bedded, sandy dolomite which may possibly be itself of Tribes Hill age. No fossils were seen in it and the reference is uncertain. If really Tribes Hill it is but a trifling wedge of the formation, and the break indicated by the exposures is the one between the Tribes Hill and the Ogdensburg, rather than one at the summit of the Heuvelton.

These first exposures of the Ogdensburg formation are about 4 miles northeast of Morristown. Following along to the east no exposures appear within the next mile, owing to a thin, morainic covering, after which they reappear and, except for occasional short gaps, continue all the way to Ogdensburg. The first outcrops, north of the road, show a thickness of 16 feet of the basal beds of the formation, above the Heuvelton, but the actual base is not well shown. Beyond, the road has an up grade for a mile and an additional 30 foot thickness of higher beds is shown, bed by bed, in the road gutter. Then a rapid down grade, about half way between Morristown and Ogdensburg carries us back through the same beds and, at the foot of the grade a considerable quarry has been opened in the formation, enabling accurate measurement of the beds. The section in the quarry and just above is as follows:

7. 12′	Thin, to very thin-bedded, gray, flinty dolomites, with occasional thin bands of blue, crystalline dolomite; occasional fossils, chiefly Ophiletas.
6. 5′	Thin-bedded, gray, flinty dolomite, weathering yellow-brown; often laminated though somewhat irregularly; often thin partings of blackish shale between the beds.
5. 2′ 1″	Two massive beds of gray, subgranular dolomite with frequent nodules of coarsely crystalline white and gray calcite.
4. 3′ 10″	Thin-bedded, gray dolomite quite like no. 6 above.
3. 1′ 4″	Gray, granular dolomite, similar to no. 5 except that the calcite nodules are of smaller size.
2. 7′ 4″	Dark-blue, finely granular dolomite, often with calcareous cement, "sand crystal" fashion, and with nodules of flesh-colored, coarsely crystalline calcite, often of large size; thick-bedded, seven beds in all; thin partings of blackish shale between the beds.
1. 1′ 9″	Gray, finely crystalline dolomite; base not seen; lowest layer contains sand grains; irregularly laminated.
33′ 4″	total thickness

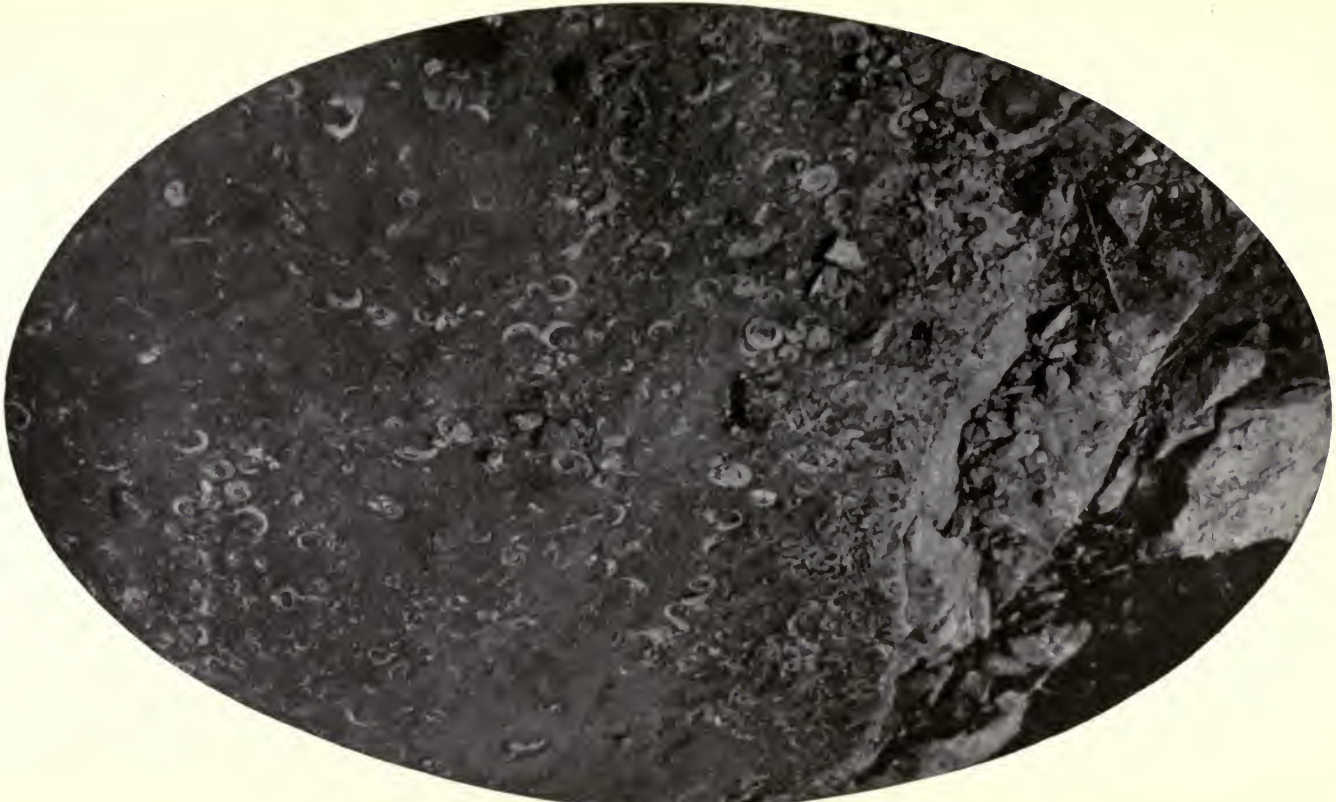
Plate 3 is a view of the beds at this quarry, the massive beds below, and the thinner-bedded material above.

Plate 3

H. P. Cushing, photo, 1913

Quarry showing the lower beds of the Ogdensburg formation, river road, half way between Ogdensburg and Morristown. Beds 1 to 5 of the section in midview, beds 6 and 7 above at the left

Plate 4



H. P. Cushing, photo, 1913

Weathered surface of Maclurea layer in Ogdensburg formation in beds just above those shown in plate 3; river road half way between Ogdensburg and Morristown

The actual base of the formation is not here reached, but the sand grains in the lowest layer distinctly suggest nearness to the base, certainly not more than 10 feet above it. All the beds contain fossils, the massive blue beds much more abundantly than the thin-bedded gray ones. But the quarry sections are much less favorable places for their observation and collection than are the ledges along the roadway and in the fields. The thin-bedded, gray dolomites at the summit of the quarry contain occasional Ophiletas, and are followed above by beds of granular, blue dolomite, some of which are crammed with Maclureas and other gastropods, usually in a bad state of preservation (plate 4). They are vastly more fossiliferous than the gray, thin-bedded material beneath. These upper beds are well shown along the road both east and west of the quarry.

It is hardly worth while to describe all the outcrops along the road, and we shall pass over the intermediate ground to a group of quarries, situated about one mile west of Ogdensburg, at varying levels above the river, which when taken together give a nearly complete section of the formation at that point. The two lower quarries are north of the Pythian Home, between the roadway and the river. Beds in the road and near by at the south are added for completion of that part of the section. The other two quarries lie to the east of these and nearer Ogdensburg, and their sections overlap the others.

Section at the Pythian Home

23.	2′ 6″	Exceedingly massive bed of finely granular, gray dolomite, banded and laminated; forms a massive bench back in the field well to the south of the road; no fossils seen.
22.	8′ 0″	Gap, with beds unexposed, except that midway of the interval is a bed of finely granular, gray dolomite with calcite cement, weathering light brown, and full of small gastropods, Hormotoma and allied forms, the only horizon of these seen in the formation; the bed was not seen in place but the material was excavated from a post hole, around which it lay.
21.	9″	Coarsely granular, dark-blue dolomite with calcite cement of extraordinary coarseness of crystallization, forming "sand crystals" often 2 inches in diameter; the layer is full of rounded masses of Cryptozoon, which weather more rapidly than the surrounding rock, leaving circular holes which imitate pot holes; the bed is very

	fossiliferous above the Cryptozoon, chiefly Eccyliopterus, and the fossils are unusually well preserved.
20. 2′ 6″	Light-gray to white dolomite, full of quartz sand grains, and with a small amount of calcareous cement; fairly thick-bedded.
19. 1′ 8″	Massive layer of granular, blue dolomite, with calcite cement and fossiliferous.
	These upper beds are shown in the road gutter and the field south of the road, just west of the Pythian Home; the beds below are shown in the quarry directly north of the road; the Cryptozoon bed at the summit of the quarry section shows also in the road gutter, and ties the two together.
18. 1′ 3″	Very finely granular, blue-gray dolomite, with very little calcareous cement; frequent small nodules of coarsely crystalline calcite; full of masses of Cryptozoon, a different species from the Cryptozoon of the Eccyliopterus bed above.
17. 1′ 1″	Solid white sandstone with calcareous cement; it will be noted that each Cryptozoon bed is directly underlaid by sandstone.
16. 6′ 0″	Massive 18 inch beds of blue, granular dolomite, with calcareous cement, weathering sandy-looking, and showing irregular lines and bunches on weathered edges.
15. 3′ 8″	Massive blue, granular dolomite quite like that above; nodules of crystalline calcite; weathers sandy looking; has an irregular upper surface with a shale parting between it and the beds above.
14. 1′ 9″	Thin-bedded, very finely granular, blue to brown dolomite, with wavy lamination; weathers irregularly.
13. 1′ 11″	Massive, white sandstone, only slightly calcareous; cross-bedded; irregular upper and lower surfaces, and welded to the dolomite both above and below.

Plate 5

H. P. Cushing, photo, 1914

Higher beds of the Ogdensburg formation in quarry near Pythian home, showing beds 10 to 16 of the section; the sandstone bed, no. 13 is the second above the quarry floor

Plate 6

H. P. Cushing, photo, 1914

Nearer view of the quarry shown in plate 5, showing beds 11 to 16, the sandstone in midview

12. 2′ 5″	Massive blue, granular dolomite, weathering brown.
11. 11″	Thinner layer of gray, flinty dolomite.
10. 2′ 3″	Massive gray, granular dolomite, to base of quarry.

Views of this upper quarry are shown in plates 5 and 6. Directly beneath it, and extending down nearly to the river level is another quarry, carrying the section down.

9. 13′	Estimate of gap between last, and exposures beneath.
8. 2′ 6″	Heavy bed of gray, finely granular dolomite; weathers brown, with lined edges.
7. 1′ 2″	Thin-bedded dolomite and shale, poorly exposed.
6. 1′ 9″	Massive bed of hard, iron-gray, finely granular dolomite, weathering thin bedded.
5. 7′ 6″	Very solid, massive beds of dark-blue, granular dolomite, beds splitting when weathered; near base a laminated bed, and a shale parting at base.
4. 2′ 1″	A single massive layer like that above, also with a 1 inch shale parting at base.
3. 2″	Thin layer of flinty, gray dolomite, fucoidal markings on surface, and an irregular base with a shale parting.
2. 1′ 2″	Layer of blue, finely granular dolomite, with Ophiletas; a thin shale parting beneath.
1. 2′ 6″	Massive, blue, granular dolomite, to bottom of quarry.
68′ 6″	total thickness.

We are unable definitely to tie up this section with that 4 miles to the southwest, and given on page 40. We miss here the 20 foot thickness of the flinty, thin-bedded dolomites at the top of that quarry. Beds 3 to 9 of this section may represent this thin-bedded zone, on the supposition that the thinness of the bedding is only apparent, and due to splitting on weathering, instead of being original. If this be correct, then bed no. 1 of this section corresponds to the upper part of no. 2 of the previous section. In an effort to demonstrate the equivalence, these lower beds were traced southwest for 4 miles along the river and railroad, but a drift-covered belt a mile or more in width intervenes between the two sets of exposures. The heavy blue beds of the base of the section are, however, shown to have a thickness of from 6 to 8 feet and to be full of fossils, chiefly Maclureas, and to be underlaid by thin, flinty gray beds, which seem to be the same as those in the quarry section given on page 40, though the full thickness is not shown. Also the Maclurea zone above seems to correspond with the very fossiliferous beds above the thin beds of that section, yet it is the summit of this Maclurea zone that forms the basal layer (no. 1) of this Pythian Home section. Our opinion therefore is that the one section is entirely below the other, and that the base of the Pythian Home section is some 40 feet above the base of the formation.

In the quarries to the east of the Pythian Home, and on the west edge of Ogdensburg, yet higher beds appear, and the following section was measured:

18. 2′ 6″	Thin-bedded, finely crystalline, sandy-looking dolomite, of light color slightly tinged with pink; small drusy cavities with tiny quartz crystals; summit beds of the southerly quarry, and above anything in the other.
17. 1′ 1″	Thin-bedded, blue, granular dolomite; summit bed of the northerly and largest quarry.
16. 6′	Thin-bedded, finely crystalline, gray dolomite with calcareous cement of the sand crystal type; many of the beds contain nodules of varying size of white, coarsely crystalline calcite.
15. 1′ 9″	Massive layer of dark-blue, granular dolomite, calcareous cement of sand crystal type and dark colored.

14.	2′ 1″	Light-gray, finely granular dolomite, with calcite nodules.
13.	1′ 1″	Massive bed of dark-gray, granular dolomite with irregular upper surface.
12.	5′ 10″	Massive beds of dark-blue, granular dolomite with calcareous cement of coarse "sand crystal" type; nodules of coarsely crystalline calcite in most of the beds which reach very large size in the top bed, many of 8 to 10 inches in diameter, of very coarsely crystalline calcite, much of which is of brown color; holds Eccyliopterus.
11.	4″	Thin bed of flinty, gray, laminated dolomite with very bunchy, irregular upper surface; forms floor of upper division of quarry.
10.	1′ 1″	A 5-inch bed of blue and an 8-inch bed of gray, flinty, brittle dolomite.
9.	6″	Cryptozoon layer of dark-blue, granular dolomite with coarse sand-crystal cleavages; undersurface very irregular and welded to bed beneath.
8.	1′ 10″	White sandstone with calcareous cement, also with very irregular lower surface, making a 6 inch variation in thickness.
7.	2′	Two 1 inch beds of light-gray, granular, porous dolomite.
6.	9″	Thin beds of gray dolomite like that just above.
5.	2′ 2″	Subcrystalline dolomite, iron-gray color and full of ramifying streaks of light gray with a reddish tinge; very brittle and massive; fucoidal markings on upper surface; shale parting beneath.
4.	1′ 11″	Massive bed of dark-gray, finely granular dolomite.

3.	1′ 6″	Light-gray sandstone with a slight reddish tinge; full of round, floated sand grains set in calcite cement; the layer above should be a Cryptozoon horizon, but none shows here.
2.	1′ 2″	Dark-blue, granular dolomite, calcareous cement, occasional sand grains.
1.	2′ 1″	Massive, dark-blue, finely granular dolomite, resting on a bunchy-surfaced layer which forms floor of quarry.
	35′ 8″	total thickness.

It is believed that these two sections, the one just given and the one at the Pythian Home, can be definitely correlated by means of the two sandstone horizons. The upper sandstone, with the overlying Cryptozoon bed, nos. 8 and 9 of this section and 20 and 21 of the Pythian Home section, seems a definitely identifiable horizon. The lower sandstone bed is not so certain, as the thickness of intermediate beds is not the same in the two sections. The sandstones are very irregular and seem to shift horizon. Bed no. 13 would seem to be the same as the gray bed at the summit of the Pythian Home section, though thinner here, and there is a thickness of some 13 feet of higher beds, giving a measured thickness of 82 feet for the formation, plus the amount, estimated at 40 feet, which is lacking at the base, but appears in the more westerly sections.

Generalizing the section it may be said that it consists chiefly of three types of rocks, the granular, dark-blue beds with calcareous cement, and with the most frequent fossils, the finer grained, dark-gray beds, and the thin-bedded, flinty dolomites. A small thickness of basal, sandy beds is followed by a thickness of some 15 feet of the blue beds, above which is a prominent zone of thin-bedded dolomite some 20 feet thick, while the remainder of the section consists chiefly of alternations of the dark-blue and dark-gray beds, together with an occasional thin sandstone, generally in association with a Cryptozoon bed. The zone of these sandstones, and the 20 foot zone of thin-bedded dolomites near the bottom, are the only ones of sufficient definiteness to be used in horizon determinations. For the remainder the beds are very uniform in their character and their alternations, and the horizon of isolated outcrops is invariably a very uncertain matter.

In regard to their fossil contents also, the comparatively few forms which are abundant seem to run through the whole section, and fossil zones which are sufficiently restricted and sufficiently individualized to serve as markers for a particular horizon in the formation do not seem to be common. Ulrich went over the section from Morristown to Ogdensburg with us, collected fossils from it which he has compared with the material in his own large collections from Missouri and elsewhere, and generously contributes the following report upon them.

Zone 1 (zone 4 of Ulrich's section, zones 1–3 being in the Heuvelton beds below) of fossils from the quarry section of the lower beds, given on page 40, and chiefly from the thin-bedded, upper portion:

Lingula sp. undet.

"Ophileta" grandis Ulrich. A widely distributed species marking the Roubidoux (basal Canadian) formation in Missouri. Shell larger, whorls expand more rapidly, and carina more nearly peripheral in position than in O. compacta Salter (=O. complanata Whitfield, not Vanuxem).

Generically undetermined trilobite. (Collected by Chadwick, only one specimen seen.)

This is not the lowest fauna of the formation, since the heavy, blue beds beneath contain a fairly abundant fauna, which is, however, difficult of collection and determination, since seen only on glaciated surfaces. The species seem the same as those of zone 2. My own collection shows that "Ophileta" compacta Salter occurs in zone 1, in addition to the forms listed. "Ophileta" grandis Ulrich is the commonest fossil, however.

Zone 2 (zone 5 of Ulrich), the blue beds which follow above the thin-bedded dolomites of the previous zone, and are crammed with fossils, usually poorly preserved (plate 4).

Tryblidium cf. ovatum Whitfield

Maclurea (?) cf. transitionis Billings

Maclurea (?) cf. oceana Billings

Maclurea (?) cf. affinis Billings

Liospira (?Ophileta) aff. hunterensis Cleland

Liospira (?Ophileta) sp. cf. Raphistoma praevium Whitfield

Liospira sp. 3 (has more rapidly expanding whorls and smaller umbilicus than two preceding species)

"Ophileta" compacta Salter

In addition, a few feet above the most fossiliferous bed of this zone is a thin bed (zone 2a, 5a of Ulrich) filled with Syntrophia lateralis Whitfield.

Above zone 2 fossils are comparatively scarce, though apparently of these same species through a thickness of some 30 feet of beds, when the two Cryptozoon horizons are reached (beds 18 and 21 of the Pythian Home section). From bed 18 we collected no fossils aside from the Cryptozoon. But bed 21 contains the best preserved fossils obtained from the entire section, lying above the Cryptozoon masses, and evidently inhabiting the reef. Good material can be collected only from somewhat weathered rock. In freshly quarried material the fossils break across.

Zone 3 (zone 6 of Ulrich) Eccyliopterus zone.

Cryptozoon sp. undet. (cf. C. minnesotensis Winchell)
Eccyliopterus planidorsatus Ulrich
Eccyliopterus planibasalis Ulrich
Endoceras montrealense Billings
Cameroceras (?) (siphuncle only, strongly annulated)
Involute cephalopod of undetermined genus

Of this fauna E. planidorsatus is the common form, outnumbering E. planibasalis by 5 or 6 to 1. Annulated cephalopod fragments are not scarce, but the Eccyliopterids are the abundant fossils.

Zone 4 (7 of Ulrich), Hormotoma zone, only a few feet above zone 3.

Hormotoma gracilens Whitfield,
Turritospira cf. anna Billings and confusa Whitfield.

This thin layer is crammed full of these small gastropods, and likely several other species can be identified when the fauna is thoroughly studied.

Ulrich comments on the fossils as follows: "Apparently all these zones belong above division C and beneath division E of the Champlain section. Stratigraphically then, they occupy the position of division D. The fauna of division E is not even suggested, while none of the species are of those which particularly characterize the fossil beds at Fort Cassin. The latter, I believe, belong between typical D and E. Hence the Ogdensburg dolomite seems to correspond exactly, or at least essentially, to division D."[1]

[1] Letter of January 13, 1915.

It was our hope that, by carrying our work down the river below Ogdensburg, this section could be extended upward. In this respect we were completely disappointed. The drift is so heavy below Ogdensburg, and the outcrops so rare and so poor that, with the lithologic similarity of the beds, no certainty as to their position could be arrived at. The best section seen east of Ogdensburg is at Red Mills, 6 miles farther down the river, where a 20 foot thickness is exposed, the basal layer appearing in the river bed and causing the Galop rapids in the river. The section here is:

10.	4′ 8″	Four solid layers of blue, finely granular dolomite, weathering on edges in horizontal, wavy lines; small calcite nodules; much coarser grained than the beds below.
9.	1′ 8″	Blue-gray, hard, flinty dolomite, thin-bedded, upper 2 inches very shaly.
8.	2′ 4″	Two beds of massive dolomite, otherwise like that above.
7.	2′ 1″	Light-gray, hard, *very* finely granular dolomite, with small drusy cavities containing calcite; weathers drab; two beds.
	1′ 6″	Unexposed.
6.	1′ 3″	Light-gray, flinty dolomite, excessively fine grained.
5.	3′ 4″	Dark-blue, flinty dolomite, of very fine grain, in 6 inch layers.
4.	10″	Gray, fine-grained dolomite, weathering yellow-brown; irregular surface.
3.	1′ 1″	Hard, dark-blue dolomite, like no. 5; finer grained than no. 4.
2.	1′	Unexposed.
1.	1′ 1″	Single layer of thick, hard, *very* finely granular, gray dolomite at river edge and in river; base not seen.
	20′ 10″	total thickness.

This section does not correlate with any of the beds seen in the Ogdensburg section, where there is nothing resembling such a thickness of thin-bedded, flinty dolomites, wholly unmixed with the granular, dark-blue beds with calcite cement which make the larger part of the upper section there. We are therefore forced to conclude that this section lies above anything seen at Ogdensburg, and that it can not be much higher. The dip in the district is to the north, as will be shown; but it is not high. Red Mills is about 3 miles farther north than Ogdensburg, and 6 miles farther east. The summit beds of the section at Ogdensburg are 80 feet above the river. Judging from the rate at which the Heuvelton and the lower Ogdensburg beds pass beneath the river level between Morristown and Ogdensburg, and assuming that the rate remains the same below Ogdensburg, the upper beds of the Ogdensburg section should have just about reached the level of the river at Red Mills. We feel therefore reasonably secure in stating that this thin-bedded dolomite zone at Red Mills almost directly overlies the beds of the Ogdensburg section, and that their 20 foot thickness should be added to the thickness of the formation.

Elsewhere on the Red Mills sheet outcrops are exceptional and show no great thickness of rock. But all the outcrops seen are of the same type of rock as at Red Mills, hard, flinty, fine-grained dolomite. The rock is very unfossiliferous, not a sign of a fossil having been seen on the Red Mills quadrangle. In this respect also the rock differs from the lower beds shown west of Ogdensburg. The most northerly exposure seen, on Rockaway point, north of Tilden, is nearly 5 miles farther north than the section at Red Mills, and should therefore represent a considerably higher horizon. A single, massive bed of gray, flinty dolomite is, however, all that is shown.

Summary of section of Ogdensburg formation. The reporting of detailed sections furnishes a dreary job for the general reader, hence the details are here briefly summarized.

Between Morristown and Ogdensburg all the beds of the lower portion of the formation are shown, with a thickness of some 120 feet. The base lies unconformably on the underlying beds, and the lower beds contain sand grains. Some 15 feet of granular, blue, calcareous dolomites follow, then 20 feet of thin-bedded, fine-grained, gray beds, weathering brown. Above come 80 feet of alternating dark-blue, granular beds, and dark-gray, more finely granular beds, of dolomite with calcite cement. All the beds are fossiliferous, sometimes abundantly so. Above these, separated by an unknown but probably small interval, follow the gray, flinty beds of the Red Mills quadrangle, very unfossiliferous and of unknown thickness. The section shown seems to correlate with division D of the Champlain section. Further work down the river may show somewhere a good section of the higher beds, so that the section may be completed and the full character of the Beekmantown group of this district shown, but the whole valley is so heavily drift-covered that we are not sanguine that this can be successfully done. The formation extends down the river for many miles more before the overlying Chazy beds appear, the Ottawa basin Chazy. It is very doubtful if these beds get over into New York at all. But in any event the indications are that a considerable thickness of Beekmantown beds higher than those in the Ogdensburg region must be present.

In New York State Museum Bulletin 145 we made certain predictions concerning the age of the Beekmantown formation of the St Lawrence valley based on the results of the Thousand Islands work and of our much earlier reconnaissance work farther east, particularly around Potsdam.[1] The results just outlined in the discussion of the Ogdensburg formation seem to us to fulfil those predictions. We argued that the first Beekmantown to appear down the river from the Thousand Islands should not be the lowest division of the formation in the Champlain valley, but of higher beds. The basal beds prove to be of the age of division D, with divisions C and B entirely lacking. There is also a break between them and the beds directly underneath, as we argued should be the case, a break not only shown by a basal conglomerate and sand grains in the basal dolomite, but also by the fact that the beds just underneath vary much in horizon across the district. So far the results of this study accord with expectation. The unexpected results are the continued presence of the Tribes Hill formation underneath, and the entirely new division represented by the Heuvelton beds. Our work has shown an unconformity between the Ogdensburg and the Tribes Hill, and Chadwick's work on the Canton sheet shows a break between the Tribes Hill and the underlying Heuvelton. We have not demonstrated a break between the Heuvelton and the underlying Theresa, and have mapped them together, but it is quite likely that a break exists. The work of

[1] Pages 92–96.

the past fifteen years on the Paleozoic rocks which rim the Adirondacks has shown clearly that they consist largely of the thinned, near-shore edges of a great number of formations, and that there is a great lack of correspondence between the formations on the different sides of the region. The Heuvelton division found here adds yet another unexpected member to the group. Or, as Ulrich writes, "Evidently the western flank of the Adirondack uplift carries more of these thin wedges than we supposed." No doubt yet others remain to be found.

Structures of the Paleozoic rocks

Dip. The dips of the Paleozoic rocks of the Ogdensburg region are low, seldom exceeding 5°, and are in a general northerly direction. On the Brier Hill quadrangle they average somewhat to the west of north; on Ogdensburg they are more nearly north. Along the river between Morristown and Ogdensburg the Heuvelton and Ogdensburg beds disappear under the river at a rate of from 25 to 30 feet a mile; that is, a mile in a northerly direction; in the northeasterly direction of the river's course the rate is slower. This is not a high dip, but a very low one, and has no particular interest except in its contrast with the southwest dip which the Paleozoic rocks of the Theresa and Clayton quadrangles, on the other side of the Frontenac axis, possess.

Folds. In the Thousand Islands report it was shown that the gently inclined Paleozoic rocks of the region had been somewhat folded, and that there were two sets of gentle folds whose axes cut one another almost at right angles, the one set trending somewhat east of north, and the other somewhat north of west.[1] The effect of this double folding was to produce an alternating series of low domes and low basins in the rocks, domes at the intersections of anticlines, and basins at the intersections of synclines of the two sets of folds.

This same type of folding carries over into the Ogdensburg region, though the evidence is not so clean-cut here because of less frequent exposures. But low domes of rock, from the summit of which the dip falls away to all points of the compass, are of quite frequent occurrence. The corresponding basins, occupied by outliers of younger formations, which were such a feature of the geology of the Theresa and Clayton sheets, are not easily detected

[1] N. Y. State Mus. Bul. 145, p. 112–15.

about Ogdensburg, partly because sharply contrasting, thin formations are not present here, and partly because of drift-covering. The areal mapping suggests that the axes of the folds have swung to northeast and northwest directions, and that the northeast set is much more prominent than the northwest set in the Ogdensburg region.

Faults. Faults are scarce in the Paleozoic rocks of this northwestern region, though they increase in number and importance in passing to the east. In the Ogdensburg region we have noted but one fault of any prominence, at Point Comfort, 3 miles up the river from Morristown, Brier Hill sheet. The fault bears east and the south is the downthrow side. Above Point Comfort the river cliff is composed of the Potsdam and Theresa formations, 10 feet of Potsdam which has increased to 20 feet at Oak point, overlaid by the thin-bedded, calcareous sandstones of the typical Theresa. This is the section south of the fault, the downthrow side. North of the fault the Potsdam extends up to 50 feet above the river, with a great bed of its characteristic coarse conglomerate, the same bed that occurs in the river cliff in Hammond township. At the fault 25 feet of sandstone show below it, and 20 feet above it, followed by the Theresa. The throw of the fault here is about 40 feet. The fault zone shows no outcrops but is occupied by a drift-filled depression, as is apt to be the case. It can not be definitely traced inland, away from the river because of infrequent outcrops and of similar Theresa beds on both sides. But 2 miles to the east, along its supposed trend, there is evidence of misfit in the strike of the bed of 20 foot (Heuvelton) sandstone, on the two sides of the line, so that in all likelihood the fault extends east at least to this point.

A very trifling fault is shown along the river road 2½ miles below Morristown, where the road runs over a shallow gully and small stream. The 20 foot sandstone of the Heuvelton is dropped in level about 15 feet on the east side of the gully as compared with its level on the west side, and is apparently faulted down. It is a trifling break and can not be traced to the south.

Except for these two, no faults have been noted.

HISTORICAL GEOLOGY

PRECAMBRIAN TIME

Recorded geologic history began in New York with the deposition of the Grenville series. That this was not the actual beginning of the history of the region is shown by the fact that the Grenville, a series of water-deposited rocks, must have been laid down on some floor of preexisting rocks. So far as we can find, no trace of this floor remains and we are in entire ignorance as to its nature. That there must have been a long period of time anterior to this in the earth's history, we are certain, but we entirely lack direct evidence regarding it.

The Grenville is an enormously thick sedimentary series, comprising masses of limestone, of shale and of sandstone. It is so thick and so varied that it is quite probable that it comprises more than one formation. To deposit such a thick accumulation of sediments must have required a very great lapse of time. The Grenville is as old a rock series as is anywhere known.

Following the Grenville the region was invaded from beneath by enormous masses of molten rock which were working their way upward toward the surface. They badly broke up the Grenville deposits, thrusting their way through them, pushing them aside, and likely wholly engulfing great masses of them. This intrusion, and those which followed, are no doubt chiefly responsible for the disappearance of the old floor of deposit of the Grenville. The intrusive consisted of granite. It greatly added to the pressures and the temperature of the invaded rocks, and was an important factor in changing them into the crystalline rocks of which they, today, consist. The Grenville rocks today invariably rest upon these intrusives, which are nevertheless younger, in spite of the fact that they underlie them.

The Grenville rocks and the Laurentian granites (as these early granitic intrusives are called) are early Precambrian. Elsewhere, in Ontario and the States which border on Lake Superior, other and younger Precambrian formations are found; at least three great series of formations younger than the Grenville, aggregating many thousand feet in thickness, and separated from one another by profound unconformities, representing times of uplift and of erosion, times apparently as long as those in which the deposits were being laid down. Erosion is a slow process; so is deposition; yet thousands of feet in thickness of deposits were formed, and a vast amount of material was eroded during that part of the Precambrian which followed the Grenville.

These younger Precambrian rocks, that is, younger than the Grenville and the Laurentian granite, are, in their turn, accompanied by, or cut by, intrusives, which are younger than they are. Younger intrusives are also present in the Adirondacks, though the sediments are lacking. A great series of intrusives, anorthosite, syenite, granite and gabbro, have wide extent in the Adirondacks, particularly on the east and south. They aided in altering and metamorphosing, as well as in breaking up and destroying, the older Grenville and Laurentian. The small masses, mapped as syenite, on the Ogdensburg quadrangle, we refer to this second period of eruptive action.

The latest of the Precambrian rock series of the upper lake region is accompanied by great flows and sheets of trap. The trap dikes of late Precambrian age in the Adirondacks are of similar rock and are naturally correlated with them. Only one such dike has been found in the Ogdensburg region, but they are abundant farther up the river, in the islands. Not only do they cut all the other Precambrian rocks, but they are entirely unmetamorphosed, indicative of a long time gap between them and the older rocks.

There is no evidence that any of these later series of Precambrian sediments were ever deposited in the Adirondack region, though it is entirely possible that some of them may have been laid down, and subsequently completely removed by erosion. There is no evidence to controvert the statement that the Adirondack region was a land area throughout all the great lapse of Precambrian time following Grenville deposition, and that this portion of its history is one of erosion rather than of deposition. A great thickness of Grenville and of igneous rock was worn away, and the region was reduced to the condition of a comparative plain, whose surface irregularities were of a minor sort, and seem not to have exceeded 200 feet in amount. Within this minor degree, however, the surface was fairly rough, the weak rocks worn down into valleys and the more resistant ones projecting as low hills and ridges. The intrusion of the traps came toward the latter end of this long period.

CAMBRIAN TIME

The erosion period just mentioned involved the greater part of Cambrian time in addition to the long Precambrian interval. But in the latter part of the Cambrian all four sides of the Adirondack region became depressed and deposits began to form on the old erosion surface. Deposit began on the northeast, with coarse conglomerates, followed by sand, forming the initial deposits of the Potsdam sandstone. These early deposits have furnished no marine fossils and strongly suggest continental formations. In their lack of thorough decay they also suggest climatic aridity. As time went on the deposits gradually extended to the south and the west of the initial region, up the Champlain and the St Lawrence troughs. And these upper beds of the formation are marine in origin, as their fossils show. In the Ogdensburg region only a thin, upper portion of the formation was deposited, its thickness barely equalling the irregularity of the floor on which it was laid down, so that is does not appear at all on the higher parts of the old, Precambrian surface.

The passage to the Theresa was a gradual one, the sand supply lessening, and calcareous matter increasing. The fauna remained substantially the same.

The Theresa *seems* to graduate upward into the Heuvelton without any break; at least we have, so far, failed to detect one. But there is a prominent change in the fauna, which Ulrich compares to that of the uppermost portion of the Little Falls dolomite of the Mohawk valley. We are still in doubt as to just what the history was at this stage. The fauna is a comparatively unknown one in New York, and there is nothing in the St Lawrence region which can be directly correlated with the thick Little Falls dolomite of the Mohawk and Champlain valleys, which there follows the Theresa without a break. Whether the Heuvelton is a thinned representative of the Little Falls, of quite different lithologic character because of deposit in a separate basin, whether it is younger than most or all of the Little Falls and represents a deposit of an age hitherto unknown in the New York section with a break between it and the Theresa representing Little Falls time, or whether there is no break, and the Potsdam and Theresa of this region were being deposited at the same time that the dolomite was forming in the Mohawk region, can not yet be told. One or the other of the three no doubt represents the true condition of affairs.

ORDOVICIAN TIME

There is a distinct break between the Heuvelton and the overlying Tribes Hill formation in the Ogdensburg region, and such a break seems everywhere to mark the close of the Cambrian in New York. We are therefore justified in concluding that marine waters were completely withdrawn from the region for a time. Slight warping of the surface took place and a very moderate amount of wear occurred, so moderate as to indicate that the land was of low altitude. Then the sea returned and Tribes Hill deposition commenced. This formation runs all through the Mohawk valley with considerable prominence. It is absent in the Black river valley, but reappears as a thin wedge in the Theresa region, is absent on Brier

Hill and again returns with increased prominence east of Ogdensburg, running at least as far as the Raquette river. How much farther down the St Lawrence valley it may go, is today unknown. The formation is not known in the Champlain valley, though it may exist there. But it is now certain that the Tribes Hill waters bordered the Adirondacks on the south, west and north sides.

At the close of the Tribes Hill there was oscillation of the district, bringing the whole above sea level following which the Champlain valley region alone was depressed, and deposition of Beekmantown divisions B and C began there. As Beekmantown time went on this Champlain depression began also to involve the St Lawrence trough, extending westerly up that trough until the Ogdensburg region was reached, and deposit of the Ogdensburg formation, division D, began. This depression no doubt continued through the remainder of Beekmantown time, the Champlain and St Lawrence valleys below, the Black and Mohawk valleys above sea level, all Beekmantown formations other than the Tribes Hill being absent on the south and west sides of the Adirondacks. At the close of the Beekmantown the sea was withdrawn from the whole region.

There is no direct evidence of the deposit of any of the later Ordovician formations in the Ogdensburg region, but it is highly probable that the thinned edges of several of them were laid down here. The Pamelia formation of the Theresa region may have come as far east as this; outcrops of the Ottawa Chazy come in above the Beekmantown not a great many miles down the St Lawrence on the Canada side, and may well have reached farther west. Some of the various Black River and Trenton formations may likewise have been laid down, and this is also possible in regard to the upper Ordovician shales. But the Frontenac axis was early outlined as a barrier between the St Lawrence and Black river troughs of deposit, and it is not believed that any of these formations could have had any large thickness in the Ogdensburg region. So far as now known there is not a scrap of reason for believing that any Paleozoic marine rocks younger than the Ordovician were ever laid down here.

LATER PALEOZOIC HISTORY

During Silurian, Devonian and Carboniferous times the region no doubt experienced oscillations of level, as during its previous history. But the downward movements do not seem to have carried it below sea level. It seems to have persisted as a low altitude area, so low that erosion of its surface was but slight, but not low enough for marine invasion. From time to time it may have received a coating of continental deposits, in fact the Oswego sandstone may have been deposited here in considerable thickness; but all trace of these is now gone. We are, however, obliged to assume the original presence here of formations younger than the Beekmantown for the reason that some considerable thickness of rock has certainly been eroded away from the region in the vast lapse of time since the Ordovician. The most probable of such formations are those whose present-day outcrops lie nearest the region, such as the Pamelia, Chazy, Black River and Trenton, Lorraine and Oswego.

During all of Paleozoic time the Adirondack region seems to have persisted as a continuous land area, submerged frequently on one or more sides; seldom or perhaps never on all four sides at once, and the interior probably never submerged at all.

No doubt the district participated in the considerable uplift of the eastern part of the continent at the close of the Paleozoic, the so-called Appalachian revolution, when it may for a time have had an altitude of many hundreds of feet above sea level. But the St Lawrence valley has always had a tendency to sag, as compared with the territory to the north and south. How much this inherent tendency may have counteracted that uplift, it is impossible to say.

MESOZOIC HISTORY

In common with all the eastern portion of North America, with the exception of a narrow, marginal strip along the Atlantic and Gulf coasts, the Ogdensburg region was a land area and undergoing wear. In this long interval the erosion was so great that the entire area was apparently worn down to a comparative plain, or peneplain. No trace of this peneplain remains in the Ogdensburg region, as subsequent wear has entirely obliterated it; but there is strong probability that it was produced here.

TERTIARY HISTORY

Uplift of the region followed after its peneplanation, and erosion began the development of another peneplain. During the Tertiary there was more than one such oscillation, during which the district underwent partial peneplanation. A great peneplain level is today discernible in the even levels of the hilltops of the western Adirondacks, of the Oswego sandstone plateau, and of the plateau region of southern New York. This may represent the Cretaceous peneplain; or it may represent one of the later ones. Much work remains to be done before more definite statements regarding the history of the region during this long lapse of time will be warranted.

QUATERNARY HISTORY

Another upward movement of the region occurred toward the close of the Tertiary and the present low grounds of the region have been worn down below the level of the previous peneplain, since that occurred. Glaciation of the region followed, a series of ice sheets invading it, advancing, reaching a maximum, waning and disappearing, and separated from one another by long, interglacial intervals. There were certainly three such ice sheets, and very probably five or even six, which followed one another over the district. The later ones largely obliterated the traces of the earlier. The glacial deposits of the region consist chiefly of those left by the last retreating ice sheet, and the polish and striation of the underlying rock are chiefly also of that date, though in some places the rocks bear two sets of striae, the one superimposed on the other.[1]

The last ice sheet retreated from the district toward the northeast. It vanished from the Ogdensburg vicinity while it still remained blocking the St Lawrence valley lower down. The district also had sagged in level during the Glacial Period and was at a level some 400 feet or more below its present-day altitude. The lake waters which collected behind the retreating ice front could not pass down the St Lawrence valley because of the ice blockade lower down, and they rose until they found an outlet down the Mohawk valley to the Hudson. This lake, known as Lake Iroquois, occupied the Ontario basin, extended east to Rome, N. Y., where its outlet began, and extended itself down the St Lawrence valley behind the retreating ice wall. It has left a well-defined shore line all around Lake Ontario, distinctly recognizable as a continuous beach to a point some 5 miles east of Watertown, Cape Rutland, where its altitude, a terrace and cliff on the limestone nose of the promontory, is at 733 feet above sea level. This old shore line has

[1] The glacial striae which have been observed in the region are indicated upon the geologic maps. The usual direction shown is south, from S. 10° W. to S. 10° E. showing that to be the general direction of the latest ice motion. The older striae, however, trend from S. 40° W. to S. 30° W. Whether these were produced by an earlier ice sheet, or during an earlier stage of the last ice sheet, is not yet definitely established, though quite probably it was the former. There is considerable evidence to the effect that the action of the last ice advance in the region was very feeble, erosively.

been tilted since its formation, rises in elevation toward the north, and Fairchild estimates its altitude at some 900 feet at the south edge of the Brier Hill sheet. East of Cape Rutland, owing to the broken and uneven character of the country along the north side of the Adirondacks, this shore line is much broken and difficult to trace. But even the altitude at Cape Rutland is far above any elevation on the Brier Hill and Ogdensburg quadrangles, which were therefore covered for a time with the fresh waters of this lake, waters over 500 feet deep on these quadrangles. The moraines left by the retreating ice were deposited underneath these waters.

As the ice retreated down the valley and neared the Champlain region, the lake waters began to find outlets to that valley between the ice front on the north and the valley walls on the south, and the level of the lake began to fall. Successive stages were passed through until finally the ice entirely unblocked the valley, and the waters fell to an altitude estimated at some 450 feet, using Fairchild's figures.[1] Even this altitude would carry the water to the very top of Mount Lona, the highest point on the Ogdensburg quadrangle. And at this level, and the lower ones which succeeded it, the whole surface of the district would have been subjected to the leveling effect of wave action, laying bare surfaces of hard rocks, and filling hollows with water-laid clays.

At this stage the fresh waters of Lake Iroquois were succeeded by the brackish waters of a marine estuary, the lower altitude of the region permitting the marine waters of the Gulf of St Lawrence to extend up the valley to Lake Ontario, involving the lake itself in this marine extension. The marine fossil shells buried in the deposits of these waters have been found as far west as Ogdensburg, and farther east are abundant. Those found near Ogdensburg have all been on low grounds, only 30 to 40 feet above the river, but at Norwood, Woodworth reports them at elevations of from 335 to 360 feet.[2] The clays and sands containing these shales were obviously laid down below the marine level. The lack of these fossils west of Ogdensburg is likely due to the water not being sufficiently salty there.

In the few thousand years that have elapsed since the marine waters were in the region at their highest stage, a slow uplift has been in progress, an uplift most prominent at some point well to the northeast of Ogdensburg. This uplift not only slowly brought this

[1] N. Y. State Mus. Bul. 145, p. 139.
[2] N. Y. State Mus. Bul. 84, p. 208–9.

district above sea level, and carried the end of the St Lawrence estuary eastward to its present position, but also tipped the old shore lines of the vanished bodies of water, so that today they are no longer horizontal, but have a slowly increasing altitude as followed northeast. The entire Ogdensburg quadrangle is too low to exhibit any of these main shore lines.

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