REVIEWS.

PRE-CAMBRIAN SUMMARIES FOR 1901.

Van Hise[1] describes the geology of the Lake Superior iron ore deposits. The general succession of formations in the iron-bearing districts appears in the following table:

MESABI.	PENOKEE-GOGEBIC.	VERMILION.
Keweenawan: Great basal gabbro and granite, intrusive in all lower formations.	Gabbros, diabases, etc.	Great Gabbro.
Upper Huronian (Mesabi series): Virginia slate (upper slate formation). Biwabik formation (iron-bearing formation). Pokegama formation (quartzite and quartz-slate formation).	(Penokee-Gogebic series): Tyler slate (upper slate formation). Ironwood formation. (iron-bearing formation.) Palms formation (quartz-slate formation).	Animikie series: Upper slate formation. Gunflint formation (iron-bearing formation).
Lower Huronian: Granite intrusive in lower formations. Slate-graywacke-conglomerate formation. (Equivalent to the Ogishke and Knife formations of the Vermilion district.)	Bad River limestone (cherty limestone formation).	Intrusives. Knife slates. Lower Huronian iron-bearing formation. Ogishke conglomerate.
Archean: Greenstones, hornblende schists, and porphyries.	Granite and granitoid gneiss. Schists and fine-grained gneiss.	Vermilion series: Intrusive granites, porphyries, and greenstones. Soudan formation (the iron-bearing formation). Ely greenstone, an ellipsoidally parted basic igneous and largely volcanic rock.

[1] "The Iron-Ore Deposits of the Lake Superior Region," by C. R. VAN HISE, assisted in Mesabi and Vermilion sections by C. K. Leith and J. Morgan Clements respectively, *Twenty-first Ann. Rept. U. S. Geol. Surv.*, Part III, 1901, pp. 305-434; with geological maps.

Marquette.	Crystal Falls.	Menominee.
Upper Marquette: Michigamme formation (locally replaced by Clarksburg volcanic formation). One might divide Michigamme sedimentary formation into three parts: (*a*) upper slate member, (*b*) iron-bearing member, (*c*) lower slate member. Ishpeming formation, consisting of two members; the Bijiki schist (in western part of district), and the Goodrich quartzite, containing detrital ores at its base.	Michigamme formation, containing an iron-bearing horizon not separated in mapping for much of the district, but in a southeastern part having as lower formations (*a*) the Groveland formation, and (*b*) the Mansfield slate.	Upper Menominee: Hanbury slate, bearing in lower portions calcareous slates, etc., containing siderite and iron oxide. Vulcan formation, consisting in descending order of three members: (*a*) Curry member (iron-bearing); (*b*) Briar slate; (*c*) Traders member (iron-bearing).
Lower Marquette: Negaunee formation (the chief iron-bearing formation). Siamo slate, containing inter-stratified amygdaloid. Ajibik quartzite. Wewe slate. Kona dolomite. Mesnard quartzite.	Hemlock formation. Negaunee formation (in northeastern part of the district). Randville dolomite. Sturgeon quartzite.	Lower Menominee: Negaunee formation (in small patches). Randville dolomite. Sturgeon quartzite.
Granite, syenite, peridotite. Kitchi schist and Mona schist, the latter banded, and in a few places containing narrow bands of iron-bearing formation. Palmer gneiss.	Granite.	Granites and gneisses. Quinnesec schist.

Van Hise and others[1] have discussed the geology of the Lake Superior region in previous reports, both general and detailed. The present report is a summary of the earlier reports,

[1] See especially "Principles of Pre-Cambrian Geology," in *Sixteenth Annual Report*, Part I, *U. S. Geol. Surv.*; pp. 571–874; *Bulletin* No. 86, *U. S. Geol. Surv.*; *Monographs U. S. Geol. Surv.*, Vol. XIX, XXVIII, XXXVI; and *Folio U. S. Geol. Surv.*, No. 62.

but it contains in addition many new features of interest. Attention will be directed only to such conclusions as are new or vary from those given in the preceding reports.

In the Vermilion district the great Stuntz conglomerate and equivalent rocks have been found to lie unconformably under the Animikie series, which has been referred to the Upper Huronian by the United States Geological Survey, and thus the Stuntz conglomerate is correlated with the Lower Huronian series instead of with the Upper Huronian, as in former reports. The underlying greenstones, green schists, and iron formation, the latter of sedimentary origin, are thus thrown into the Archean.

In the Mesabi district the Keewatin of the Minnesota Survey, which was in large part classed as "Archean" by the United States Geological Survey and recognized by all as being unconformably below the Animikie, is subdivided on the basis of recent work in the district by C. K. Leith into an upper series of graywackes, slates and conglomerates, correlated with the Lower Huronian, and a lower basement complex, consisting mainly of greenstones and green schists, correlated with the Archean. This correlation is based on the equivalence of the Animikie with the Upper Huronian long maintained by geologists of the United States Geological Survey.

In the Marquette district certain jaspers and associated cherty and slaty rocks found intimately associated with the basement rocks of the Archean, and previously supposed to be Huronian rocks infolded with the Archean, are now themselves called Archean.

In the Michipicoten district of Canada the iron formation, and associated greenstones and green schists, are correlated respectively with the iron formation with associated greenstones and green schists of the Vermilion district, and are therefore classed as Archean.

The iron ores of the Lake Superior region are supposed to have originated from iron carbonate in all districts outside of the Mesabi. In the Mesabi district the ores have mainly resulted from the alteration of a green ferrous silicate in small granules as first shown by Spurr, but the ores have come also in small part from the alteration of iron carbonate which is correlative in origin with the green granules. The ferrous silicate granules are believed not to be glauconite, as they were named by Spurr.

Comment.—The reference to the Archean of sedimentary iron formation rocks in the Vermilion, Michipicoten, and Marquette districts is a source of surprise and comment among many interested in pre-Cambrian stratigraphy. The term "Archean" has been consistently used by the United States Geological Survey for the "basement complex" of the Lake Superior region, consisting essentially of igneous rocks, and all pre-Cambrian sedimentary rocks have been referred to the Algonkian. In survey reports on Lake Superior geology there have been slight variations from this usage, for certain "tuffs" and "gneisses" (Kitchi and Palmer) classed as Archean in the Marquette district have been referred to as partly sedimentary. In the present paper Van Hise has gone a step farther and included sedimentary formations of considerable importance in the Archean. The basal complex rocks of igneous origin are very closely associated with sedimentaries, and in many areas scarcely to be discriminated in the mapping. On the other hand, both igneous and sedimentary rocks are sharply separated by a profound and conspicuous unconformity from sediments called Huronian or Algonkian. In mapping in the Lake Superior region it has been found convenient, and in many cases necessary, to class together all rocks, igneous and subordinately sedimentary, below this well recognized unconformity at the base of the Huronian. Van Hise has chosen to retain the term "Archean" for this structural unit. It is thought by many geologists that it would have been preferable to have extended the term "Algonkian" to include the sediments beneath the well recognized Huronian, thus adding one more series to the Algonkian, keeping in the Algonkian all recognizable sedimentary rocks beneath the Cambrian, and leaving the term Archean for the true igneous basement complex (if there be such a thing). If, because of the close association of the basement igneous rocks and the sedimentary rocks beneath the Huronian, it were found desirable to consider the basal igneous and sedimentary rocks together as a structural unit under one term, the same geologists suggest that some local term might have been applied to the basal complex in the Lake Superior country instead of the general term "Archean."

The correlation of the upper series of the Mesabi and Penokee-Gogebic districts (which are agreed by all to be equivalent to the Animikie series) with the Upper Huronian of the original Huronian area of the north shore of Lake Huron, first worked out by Logan and Murray, is also questioned by certain Canadian and Minnesota geologists, who believe that these series are younger than the true Huronian of the original Huronian area. They would correlate Van Hise's Lower Huronian with the Upper Huronian of the original Huronian area, and thus Van Hise's Archean would in large part fall into their Lower Huronian.

Finally, it is maintained by Canadian geologists and others that the granites classed by Van Hise as Archean are intrusive into the Huronian rocks. Van Hise's position is that the granitic complex contains rocks both older and younger than the Huronian sedimentary rocks; that the fact that certain granites are clearly intrusive into the sediments does not militate against the evidence offered by basal conglomerates that another, and perhaps larger portion, is really unconformably below the Huronian rocks.

It would not be possible in a summary of this nature fully to summarize the arguments and reasons which have led Van Hise to the conclusions outlined in the above paper. He has in preparation a final monograph on Lake Superior geology in which these and allied questions are fully discussed in the light of recent developments. In view of Van Hise's close and exhaustive work in the Lake Superior region, which is in many respects a type pre-Cambrian region, and the long period of time during which this work has been carried on, his final statement of his position with reference to the geology of the area will be awaited with interest.

Coleman[1] reports on an examination of the "Lower Huronian"

[1] "Iron Ranges of the Lower Huronian," by A. P. COLEMAN, *Tenth Report of the Bureau of Mines*, Ontario, 1901, pp. 181–212.

iron ranges at Shining Tree Lake, Clear Lake, Sault Ste. Marie, Aberdeen Additional, Batchawana Bay and northward, Michipicoten Harbor, and the Helen mine, all in Ontario. As a result of this work it is possible to greatly extend the areas of Lower Huronian iron formation rocks in Ontario. Their general distribution is stated by Coleman as follows:[1]

It has long been known that the Vermilion iron range of Minnesota crossed the boundary into Ontario at Hunter's Island, and jaspery iron ores have been found at various points in that region—e. g., by W. H. C. Smith on Jasper Lake, where banded jasper and hematite have a width of forty or fifty feet. Brecciated jasper and iron ore are known from the Mattawin region also, and from a number of points to the north, as noted by Dr. Bell; but in the latter case the deposits may be of Animikie age, and therefore not to be included here.

In the band of Huronian mapped as running eastward from Lake Nipigon in the direction of Long Lake, a deposit of banded jasper and iron ore has been examined by Mr. J. Watson Bain, near the mouth of Black Sturgeon River, and an extension of it is reported from the same stretch of Huronian, north of Long Lake. To the south of this, ten or twelve miles from the mouth of Pic River, the other type of deposit is found, brecciated granular silica with magnetite.

The Michipicoten range is separated from this by a wide area of Laurentian, and the first outcrop occurs about fifteen miles west of Iron Lake, near the headwaters of Dog River. It is jaspery and cherty, with interbanded magnetite and hematite; but on the eastward extension of the line across Dog River one finds the granular variety mixed with magnetite near Paint Lake. A few miles to the north what appears to be a parallel band has been traced by Professor Willmott and has been found to include promising ore deposits. The whole extent of this range, as traced by Professor Willmott, is about twenty-seven miles, the longest continuous stretch in Ontario.

Farther to the east not much has been reported until Magpie River is crossed by Speight's east and west base line, where a range of hills with jaspery and cherty material interbanded with ore runs two or three miles southeasterly. Six or eight miles to the south the iron-bearing rocks are found again near Park's Lake, and can be followed four or five miles west and southwest, including the promising Josephine mine now being developed. In the same direction is Lake Eleanor, where siderite and the banded silica are found; and two miles west is the Boyer Lake property described before, the band having a length of about a mile and a quarter and running east and west. Ten miles to the southwest is the Gros Cap deposit of sandy and

[1] Pp. 200–202.

quartzitic rock interbanded with hematite, sunk upon many years ago, but not developed to any great extent as a mine. Rock of the same sort has been found near Michipicoten Post and Cape Choyé, Professor Willmott having ascertained the latter range to be six miles long, though without ore so far as known.

Once more a wide band of Laurentian intervenes, the next examples of the iron formatian occurring sixty-five miles to the south, near Batchawana Bay, where two bands run nearly parallel to one another, about east and west, each from four and a half to five miles long, with reported finds some miles to the east on Harmony River, and to the west near Pointe aux Mines on Lake Superior. The two bands differ in character, the one to the south being of jasper with hematite and that to the north cherty or quartzitic with magnetite.

The next known locality, about nine miles northeast of the Sault, is of the same character as the last, and is enclosed in Laurentian rocks instead of Huronian or basic eruptives as in most other localities. The wide band of Huronian between the "Soo" and Sudbury is not known to contain any rocks of the iron formation, though the large numbers of bright red jasper pebbles in the conglomerates of the upper Huronian must have a source somewhere in the region.

In the considerable area of Huronian north of Woman River, on the main line of the Canadian Pacific railway, jaspery iron ore has been reported, but no details have been obtained regarding it. To the east of this Mr. Whitson has examined a jasper range running several miles in a southeasterly direction, between the upper end of Onaping Lake and Meteor Lake; and about twenty-five miles to the northeast is a range of jasper, chert and impure siderite with magnetite and limonite of the Shining Tree Lake region, running somewhat west of north and south of east for three and a half miles, and perhaps for double that distance. A few miles farther northeast jasper is reported from one of the chain of lakes belonging to Montreal River, and still farther to the north at Night Hawk Lake.

In the southern portion of this Huronian region rocks of the kind occur on the northwest shore of Lake Wahnapitae as dull red jasper and chert with magnetite, and extend west in the Laurentian in Hutton and Wisner townships. It may be that there are two separate bands here, the southern one east and west and the northern one north and south, the latter the more important, as containing what are said to be large deposits of magnetite.

Of the iron range to the northeast of Lake Wahnapitae, Professor Miller reports that "starting from Lake Temiscaming on the east the first outcrop, which is of small size and was not visited by me, is situated a short distance east of the east end of Rabbit lake. The next outcrops occur along the northeast shore of the east end of the northeast arm of Lake Temagami, the band here stretching from near Snake Lake west to Tetapaga. Outcrops occur also near the end of Matagama Point. A belt lies parallel to these outcrops to the northward and runs, with breaks here and there, from near the west side of Net Lake to Kokoko Lake.

"Then there is an isolated belt stretching from near Cross Lake, north of west, past the southern extremity of the south arm of Temagami to the southwest arm of the same sheet of water, and to the westward outcrops are found on Emerald Lake. A band, more or less broken, runs along the north of Lake Wahnapitae northwest into and through part of the township of Hutton."

He adds that "in nearly all cases the iron ore, magnetite, is intimately interbanded with jasper, which varies much in color in different parts of the field. In some outcrops the magnetite is pretty massive, and if situated near a railroad could apparently be worked profitably. The breadth of the band of interlaminated material is sometimes 500 feet or more. It is at times much bent and fractured, having been disturbed by igneous intrusions, and some of these disturbed bands give evidence of being worthy of more careful prospecting than we are able to do in the limited time at our disposal."

Belts of iron-bearing rocks, like those described in this report, are found also in Quebec, though up to the present little has been done in searching them out. Mr. McOuat has reported from the eighth portage of the Quinze, on the headwaters of the Ottawa above Lake Temiscaming, an ore which forms "layers from the thickness of paper to about an inch, and is interlaminated with similar layers of whitish-gray and dull red fine-grained quartzite. The iron ore constitutes probably from a fourth to a third of the whole, and as the thickness of the whole band is about thirty feet, the total thickness of the layers of iron ore would probably not be less than eight feet." This is evidently the same type of deposit as those described from Ontario.

Mr. A. P. Low describes jaspery iron ores which he compares with those of Michigan, and also cherty iron carbonates from various points in Labrador, and probably some of these occurrences are Lower Huronian, though from his description it is clear that most of them are of Animikie age.

From the statement just given it will be seen that bands of jaspery cherty, or sandstone-like rock interbanded with magnetite, hematite, or limonite and sometimes associated with siderite, occur from point to point across the whole of northern Ontario, with lengths varying from a hundred feet to twenty-seven miles. Almost all of the important areas mapped as Huronian have more or less extensive belts of this rock, and in several cases isolated patches or strips of it occur in the Laurentian, as if these were remnants left when less resistant Huronian rocks had disappeared. These portions contained in the granite are never red jasper, but generally cherty or quartzitic, and the iron ore is magnetite, whereas in Huronian areas we generally find jasper or granular silica with hematite or limonite.

Associated with the iron formation rocks above mentioned, and also in other areas, are conglomerates containing numerous fragments of iron formation rocks, and therefore believed to be of Upper Huronian age. In addition to the conglomerates whose distribution was described in a previous report,[1] conglomerates are known in the following areas:

The Doré[2] river conglomerate, which contains many pebbles of sandstone and chert, has been found to extend within a few miles of the Helen mine, and to be about twenty-four miles in length from the mouth of Dog River on the west where it begins. In sections of some of the pebbles siderite has been found, proving that materials exactly like those at the mine were rolled on the inter-Huronian beach before the conglomerate was formed. Similar conglomerates have been found at other points in this Huronian area; for instance, two or three miles north of Coetz Lake, not far from the Josephine mine.

Conglomerates have not yet been found nearer the Batchawana jasper and chert beds than at the north end of Goulais Bay, fifteen miles to the south, where Murray mapped jasper conglomerate many years ago. The extensive bands of quartzitic conglomerate containing blood-red jasper pebbles in the original Huronian region, extending from Lake George almost to Thessalon, about thirty miles, and found in several different bands, some of them quite to the north of those mapped by Murray, have never been accounted for, since no jasper has been found nearer than Batchawana, more than fifty miles to the northwest, and there the jaspers are much duller in color. The accompanying black chert pebbles, which are equally common, might have been supplied by the cherty iron ore band nine miles northeast of the Sault Ste. Marie, mentioned in a previous part of this report, though this is about ten miles from the nearest of the conglomerates. The region is, however, little known beyond the few miles of settled country along the St. Mary's River and the north shore of Lake Huron, and future exploration may solve the problem.

Numerous conglomerates occur along the same stretch of Huronian to Sudbury, but no jasper or chert pebbles are known in them, though they are found in quartzites and graywackes somewhat farther east on Lake Matagamashing, not far from the jasper iron ore belt north of Lake Wahnapitae. Small amounts of jasper conglomerate have been noted northward from this, and a graywacke conglomerate containing jasper and chert pebbles extends for some miles parallel to the Shining Tree Lake iron range but a mile or two to the west.

East of Lake Wahnapitae conglomerates with jasper are known at various points to Lake Temiscaming, and also on the Quebec shore of that lake

[1] *Bureau of Mines*, 1900, pp. 180-86, and *Bull. G. S. A.*, Vol. XI, 1900, pp. 107–14. See Summaries, JOUR. GEOL., Vol. IX, 1901, pp. 447-9.

[2] Pp. 203–4.

near Baie des Perés. That they extend still further to the east, is shown by Low's report on Labrador, where conglomerates with Laurentian bowlders and jasper bowlders and pebbles seem to be common.

It is not certain, of course, that every one of these rocks containing pebbles of jasper, chert, or sandstone is a basal conglomerate of the Upper Huronian, but many of them undoubtedly are, and in the majority of cases the source of their pebbles is found in adjoining bands of siliceous iron-bearing rocks which may be looked on as belonging to a horizon near the top of the Lower Huronian, Van Hise's Mareniscan.

Willmott[1] describes the geology of the Michipicoten area northeast of Lake Superior. He makes the succession from the base up as follows:

1. Lower Huronian green schists. Some of these are undoubted lava flows showing the characteristic elliptical structure described by Clements as occurring in the Hemlock formation of the Crystal Falls district. At a number of points agglomerates are found, as at Little Gros Cap fish station, north of Goetz Lake, east of Manitowoc, and elsewhere. Commoner occurrences are the various green schists, chlorite, hornblende, mica, and sericite schists. Presumably all these schists are derived from lavas, basic and acidic. The dip of the schists is always nearly vertical and the strike follows closely the line of contact with the granite, to be described later.

2. Lower Huronian sediments. The most characteristic of these is a belt of ferruginous chert, which has been found at intervals for about sixty miles. This rock consists of banded hematite and silica with usually some residual carbonate of iron. The bands vary from one-tenth of an inch in thickness up to several inches. The silica is sometimes very like loaf sugar; again it is like quartzite, chert, or jasper. Red jasper is not infrequent. The hill at the back of the Helen mine is a huge mass of siliceous carbonates. The rocks, as a whole, and the mode of occurrence of the ore, are strikingly like the Lower Huronian iron formations of Marquette and Tower. Besides the iron formation, beds of carbonaceous shales and limestones have been recognized at several points. Shale occurs interstratified

[1] "The Michipicoten Huronian Area," by A. B. WILLMOTT, *American Geologist*, Vol. XXVIII, 1901, pp. 14–19.

with the ferruginous chert at Iron Lake. Near Paint Creek and at Eleanor Lake it has also been found. Whether it always underlies the iron formation is undetermined, but it probably does not. The cherty limestone has been traced in a fairly continuous line from the Helen mine to the east of Park's Lake, a distance of twelve miles.

3. Upper Huronian sediments. These consist of schist-conglomerate. Coleman describes the bowlders as "granites most frequently, then quartzites, or sandstones with pebbles generally small, next green schists, then felsite schists and porphyroids, and finally a few gneisses, but none of the Laurentian type." A thin section of one of the quartzite pebbles showed considerable carbonate, proving that it undoubtedly came from the iron formation. This conglomerate has been traced pretty continuously for thirty-eight miles in a semicircular belt around the central granite boss. At many points, as at Iron Lake, Dog River, Doré River, Wawa Lake, it contains pebbles from the very characteristic iron formation. This fixes its age as Upper Huronian.

4. Laurentian granite, intrusive in the Huronian rock. The granite is in undoubted eruptive relations with the conglomerate along the shore of Superior, for example a few miles west of the Doré. A mile and a half up the Magpie, a boss of granite is in eruptive contact with the conglomerate, and although it may not be of the same age as the larger boss three miles to the northwest, it probably is. In the opposite direction a succession of granite gneiss bosses intrusive in the schists are found, for six miles, after which the granitoid gneiss occurs without interruption for over a hundred miles.

Comment.—Van Hise[1] has referred Willmott's "Lower Huronian" green schist and iron-bearing formation to the Archean, and has referred his "Upper Huronian" schist-conglomerate series to the Lower Huronian. Indeed he would so refer most of the conglomerates described as Upper Huronian by Coleman in the article above summarized. The Michipicoten series show close similarities in structure and lithology to portions of the Archean and Lower Huronian series, respectively, of the Ver-

[1] See summary of Van Hise's report on a preceding page.

milion iron-bearing district of Minnesota. There is little dispute as to the equivalence of the series in the two districts, but there is dispute as to their correlation with the original Huronian series of the north shore of Lake Huron, and thus as to their nomenclature. At the east end of the Vermilion district they have been proven to underlie unconformably the Animikie series of the Mesabi district and its eastward continuation to Thunder Bay on Lake Superior, which has been correlated by Van Hise and others with the Upper Huronian of the original Huronian area, but which the Canadian geologists and others regard as younger than the true Upper Huronian. As already noted, Van Hise has in preparation a final monograph on Lake Superior geology in which the position of the United States Geological Survey with reference to the correlation of these series in the light of recent work will be fully stated.

Bain[1] describes the iron belt of Lake Nipigon, devoting his attention mainly to economic and petrographic features. The stratigraphical features are covered in the general report of Coleman summarized on a previous page.

Miller[2] describes the iron ores and associated rocks of the area adjacent to Lake Temegami and of the Lake Wahnafutae and Hutton areas to the west, all in the Nipissing district of Ontario. The Temegami has been previously mapped and reported upon by A. E. Barlow.[3] Miller's discussion of the general geology of this area follows that of Barlow, with minor additions and corrections.

Winchell[4] publishes a geological atlas of the state of Minnesota with synoptical description of plates. This volume contains maps and general conclusions found in Volumes IV and V of the Minnesota Survey, summarized in this JOURNAL, Vol. IX, pp. 79–86. One additional map is published, a general geological map of the state.

[1] "The Iron Belt on Lake Nipigon," by J. W. BAIN, *Tenth Report of Bureau of Mines*, Ontario, 1901, pp. 212–14.

[2] "Iron Ores of Nipissing District," by WILLET G. MILLER, *Tenth Report of the Bureau of Mines*, Ontario, 1901, pp. 160–80.

[3] *Annual Report Geol. Survey of Canada*, Vol. X, Part I, for 1897, pp. 302. Summerized, JOUR. GEOL., Vol. VIII, 1900, pp. 439–41.

[4] *The Geological and Natural History Survey of Minnesota*, Vol. VI, 1900–1.

Duparc[1] describes the copper-bearing (Keweenawan) rocks of the northwest extremity of Keweenaw Point, Michigan. The article is throughout merely a summary of previous reports on this area by the geologists of the Michigan and United States Survey, and this moreover without a single reference to such reports.

Hall[2] describes the Keweenawan rocks south and southwest from Duluth, along the St. Louis and St. Croix rivers, and shows that a series of alternating lava flows and sediments lie in a synclinal northeast-southwest trough, the western border of which is marked by a profound fault. To the east of the fault the Keweenawan rocks are highly tilted to the southeast, while to the west of it the Cambrian rocks are much broken up. The relations of the fault to the distribution of the flows and analogy with other volcanic regions seem to show that the fault was a plane of weakness along which most of the lavas were originally erupted. The faulting was pre-Cambrian, Cambrian, and post-Cambrian, as shown by the fact that in some places the Cambrian rests horizontally upon the upturned Keweenawan rocks, and in others is much broken up.

Hall[3] describes and maps the slates and associated rocks in the vicinity of Cloquet and Carlton on the St. Louis River, and certain hornblendic and micaceous schists associated with granite and diabase to the west along the Mississippi and Snake rivers. He maintains that the slates and graywackes to the east and the hornblendic schists to the west belong to one and the same series, and that the schists have resulted from the metamorphism of graywacke and slate by the intrusion of granite. Still later intrusions of diabase have cut both the granites and the slates. Accepting Spurr's statement that the Carlton slates are Keewatin or Lower Huronian, the con-

[1] "Note sur la Region Cuprefere de l'extremite Nord-Est de la peninsule de Keweenaw (Lac superieur)," par LOUIS DUPARC, *Archives Sci. Physique et Nat.*, Tome X, 1900, p. 21.

[2] "Keweenawan Area of Eastern Minnesota," by C. W. HALL, *Bulletin of the Geological Society of America*, Vol. XII, 1901, pp. 313–42, Pls. 27–28.

[3] "Keewatin Area of Eastern and Central Minnesota," by C. W. HALL, *Bulletin of the Geological Society of America*, Vol. XII, 1901, pp. 343–76, Pls. 29–32.

clusion is reached that the schists to the southwest are Lower Huronian, and that the intruding granites are post-Lower Huronian. If this conclusion be correct, the granites and schists of the central and eastern portions of Minnesota must be mapped as Algonkian rather than Archean, as in the past.

Ami[1] briefly summarizes the salient features of the geology of the principal cities of eastern Canada, including St. John, Ottawa, Quebec, Montreal, and Toronto.

Ami[2] summarizes the geology of Canada, and indicates the meaning and correlation of the principal terms employed in Canadian geological nomenclature.

Ells[3] sketches the development of geological work in the province of Quebec.

Ells[4] describes and maps the geology of the Three Rivers sheet of the "Eastern Townships" map, Province of Quebec. Archean rocks occupy most of the northwestern portion of the area north of the St. Lawrence River. A portion of this area, including anorthosite masses, has previously been described by Adams.[5]

The great mass of the rocks seen pertain to the Grenville series, rather than to the so-called "Fundamental" gneiss. The composition of the Grenville series, with its crystalline limestones and with rusty gneiss bands, very closely resembles that met with in the lower Ottawa district, but the calcareous members are much less widely developed. There are also large areas of anorthosite, red granite, augen-gneiss and masses of green pyroxenic diabase. Quartzite is an important component of this series, and large areas of this rock, similar to that found along the

[1] "On the Geology of the Principal Cities of Eastern Canada," by HENRY M. AMI, *Trans. Royal Soc. of Canada*, Vol. VI, 1900; sec. iv, pp. 125–64.

[2] "Synopsis of the Geology of Canada," by HENRY M. AMI, *Trans. Royal Soc. of Canada*, Vol. VI, 1900, sec. iv, pp. 187–225.

[3] "Problems in Quebec Geology," by ROBERT W. ELLS, *Record of Science*, Vol. VII, 1898, pp. 480–502.

[4] *Geol. Surv. of Canada, Annual Report*, New Series, Vol. XI, for 1898, pp. 5 J–70 J; with geological map.

[5] *Geol. Surv. of Canada*, Vol. VIII, Part J. Summarized, JOUR. GEOL., Vol. VII, p. 401.

Ottawa, are found associated with the gneiss as far north as the northern limit of the map-sheet.

The definition of the so-called fundamental gneiss is, as a matter of fact, not always possible in this district. If the latter appears at all, it must be along the crests of some of the numerous north-south anticlines, which are generally low, the rocks over a large area being inclined at low angles. The prevailing gneiss is a grayish and hornblendic variety, generally quartzose, and with frequent bands in which garnets are abundant.

The anorthosites are intrusive in the Grenville series. The Grenville series are correlated with the Hastings series and both are equivalent to the Huronian. The Fundamental gneiss is Laurentian.

Bell[1] describes and maps the geology of the Baffin Land shore of Hudson Strait.

The rocks of the northern side of Hudson Strait from North Bay to Chorkback Inlet and inland to Lake Mingo consist of well stratified hornblende and mica-gneiss, mostly gray in color, but sometimes reddish, interstratified with great bands of crystalline limestones, parallel to one another and conformable to the strike of the gneiss, which in a general way may be said to be parallel to the coast in the above distance. The direction, however, varies somewhat in different sections of the coast. All are of Laurentian age.

The distinguishing feature in the geology of the southern part of Baffin Land is the great abundance, thickness and regularity of the limestones associated with the gneisses. At least ten immense bands, as shown on the accompanying map, were recognized, and it is probable that two others, discovered in North Bay, are distinct from any of these. There would, therefore, appear to be twelve principal bands as far as known, to say nothing of numerous minor ones, between Icy Cape and Chorkback Inlet. Their total thicknesses may be 30,000 feet, or an average of 2,500 feet for each of the principal bands. These rocks are correlated with the Grenville.

[1] *Geol. Surv. of Canada, Annual Report*, New Series, Vol. XI, Part M, for 1898, pp. 5 M–38 M; with geological map.

Low[1] describes and maps the geology of the south coast of Hudson Strait and the west and south shores of Ungava Bay. Granite and gneiss of various ages occupy three-fourths of the coastal area. Associated with them are gabbros, diabases and other greenstones, cherts, quartzites, shales, and slates. All are provisionally referred to the Archean.[2] Flat-bedded Cambrian rocks rest with apparent unconformity upon the crystalline complex.

Tyrrell and Dowling[3] describe and map the east shore of Lake Winnipeg. The rocks are all Archean and the great preponderance of gneisses and granites of the Laurentian is the chief feature. Small areas of Huronian greenstones and schists occur in two localities, one on Lac du Bonnet and the other at the mouth of Wannipegow River.

In an account of a trip from Edmonton through Yellow Dog Pass, in the Rocky Mountains, to Canoe River a tributary of the Columbia River, McEvoy[4] describes and maps Shuswap rocks, of Archean[5] age, occurring on Mica Mountain near the western end of the route. The series includes dark glittering mica-schist, easily weathering, thinly foliated garnetiferous mica-schist, with a high percentage of mica and garnet, hard garnetiferous mica-schist in massive beds, bands of dark fine-grained micaceous rock apparently of eruptive origin, and layers of fine-grained gneiss which, in some instances at least, is certainly intrusive. The whole series, while differing somewhat from the Shuswap series of the southern interior of British Columbia, shows the main characteristics of that series and may be classed as such. The age of this series as given by Dr. Dawson is Archean.

[1] *Geol. Surv. of Canada, Annual Report*, New Series, Vol. XI, Part L, for 1898, pp. 5 L–47 L; with geological map.

[2] Pre-Cambrian.

[3] *Geol. Surv. of Canada, Annual Report*, New Series, Vol. XI, for 1898, pp. 5 G–98 G; with geological map.

[4] *Geol. Surv. of Canada, Annual Report*, New Series, Vol. XI, for 1898, pp. 5 D–44 D; with sketch map.

[5] Pre-Cambrian.

Dawson[1] describes the geology of the Rocky Mountain region in Canada. The oldest rocks of the region belong to the Shuswap series of Archean[2] age. The Shuswap series characterizes considerable areas of the Selkirk, Columbia, and adjacent ranges in the southern part of British Columbia. It is known also in the Cariboo mountains and near the sources of the North Thompson and Fraser, about latitude 53°. It is again well developed on the Finlay River, where the country has been geologically examined, between the 56th and 57th parallels of latitude. Northward to this point these rocks appear to be confined to a belt lying to the west of the Laramide range and to come to the surface seldom, if at all, in that range. Further north similar rocks occur in the Yukon district in several ranges lying more to the west, but still with nearly identical characters, in so far as they are known. The Shuswap series includes highly metamorphosed sediments with perhaps the addition of contemporaneous bedded volcanic materials. They are grayish mica-gneisses, with some garnetiferous and hornblendic gneisses, glittering mica-schists, crystalline limestones and quartzites. Gneisses in association with the last mentioned rocks often become highly calcareous or siliceous and contain scales of graphite, which are also often present in the limestones. These bedded materials are, however, associated with a much greater volume of mica-schists and gneisses of more massive appearance, most of which are evidently foliated plutonic rocks, and are often found to pass into unfoliated granites. The association of these different classes of rocks is so close that it may never be possible to separate them on the map over any considerable area. The granites may often have been truly eruptive in origin, but the frequent recurrence of quartzites among them in some regions indicates that they are at least in part, the result of a further alteration of the bedded rocks. The original bedded portions of the series closely resemble those of the Grenville series of the

[1] "Geological Record of the Rocky Mountain Region in Canada," address by the President, GEORGE M. DAWSON, *Bulletin of the Geological Society of America*, Vol. XII, 1901, pp. 57-92.

[2] Pre-Cambrian.

Province of Quebec, and the associated gneisses resemble the Fundamental Gneiss of the same region. The greatest thickness of the Shuswap rocks so far measured, where there is no suspicion of repetition, on Kootenay Lake, is about 5,000 feet, but even here there are doubtless included considerable intercalations of foliated eruptives.

Schrader[1] describes certain granites and schists seen in a reconnaissance along the Chandler and Koyukuk rivers of Alaska. These are referred to as "basal" and certain of the schists are correlated with Spurr's Birch Lake series of schists, but no attempt at further correlation is made.

Brooks[2] describes the Archean of the Tanana-Yukon divide. A broad belt of crystalline rocks extends in a northeast-southwest direction in the region of the Tanana-Yukon divide, embracing a series of gneisses, mica-schists, basic schists, and various intrusives, chiefly of an acid character. Near the middle Tanana this series bends to the west and south, and its continuation is to be sought for in the region of the upper Kuskokwim. To the southeast this belt is probably continued by the granitic rocks on the Pelly River, described by Dawson. What evidence we have goes to show that this is the basal series of the Yukon Basin, and as it contains no recognizable detrital material it can properly be assigned to the Archean. Whatever the original character of the rocks may have been, they are now essentially mica-schists and gneisses, with considerable intrusive material. Their metamorphic condition is the strongest argument for considering them older than any of the sedimentary rocks.

Comstock[3] reviews the stratigraphy of Arizona. Granites, gneisses, and schists, probably of pre-Cambrian age, occur at

[1] "Preliminary Report on a Reconnaissance along the Chandler and Koyukuk Rivers, Alaska, in 1899," by F. C. SCHRADER, *Twenty-first Ann. Rept. U. S. Geol. Surv.*, Part II, 1901, pp. 441–86; with sketch map.

[2] "A Reconnaissance from Pyramid Harbor to Eagle City, Alaska, Including a Description of the Copper Deposits of the Upper White and Tanana Rivers," by A. H. BROOKS, *Twenty-first Ann. Rept. U. S. Geol. Surv.*, Part II, 1901, pp. 331–91; with sketch map.

[3] "The Geology and Vein Phenomena of Arizona," by T. B. COMSTOCK, *Trans. Am. Inst. Min. Eng.*, Vol. XXX, 1900, pp. 1038–1101.

various places, but have not been thoroughly studied. The massive granites are exposed in a limited tract surrounding Prescott, including Granite Mountain, and farther southwest in the Grand Canyon of the Colorado, in the valley of the Colorado in Yuma county, and in the Little Dragoon Mountains, Cochise county. These massive granites form a basement for the other rocks of the region.

In a number of places are found fissile granites which appear to lie between the massive granites and the schistose strata which form the floor of much of the area of western Arizona.

Schists are well exposed in northwestern Arizona, in Mohave county, with E.-W. strike, tilted at high angles. Very similar exposures occur in other districts, as near Oracle and Mammoth, in Pinal county; in tracts in Pima county, and in portions of Yuma county. In Graham and Cochise counties, and, to a less extent, in Gila county, with occasional outcrops near the adjoining boundary of Maricopa and Yavapai counties, the same trend is prominent. Erosion has exposed portions of the same terrane, thrown into the N.E.-S.W. trend, in limited areas in Graham and Yavapai counties, and, possibly, in the northeast portion of Yuma county.

Blake[1] describes the salient features of the geology of Arizona. The Santa Catalina, Rincon, and Rillito mountains consist largely of granitic gneisses and schistose rocks of pre-Cambrian age with a highly complex folded structure, and exhibiting a high degree of metamorphism. Taken together, these mountains may be regarded as the main axis of ancient uplift, and of insular land areas in the pre-Cambrian and Paleozoic periods, the beginning of the "Arizona Land."

The gneiss of the southern side of the Santa Catalina near Tucson is regarded as Archean. It is remarkable for its regularity of stratification and its great thickness, probably over 10,000 feet. It occurs in great tabular masses made up of thin layers which, when seen laterally, give the appearance of evenly strati-

[1] "Some Salient Features in the Geology of Arizona with Evidences of Shallow Seas in Paleozoic Time," by WILLIAM P. BLAKE, *American Geologist*, Vol. XXVII, 1901, pp. 160–67.

fied shales and sandstones. In the same range, but on the northeastern side, facing the valley of the San Pedro, another formation of thinly bedded and highly crumpled mica schist in sharply defined zigzag folds is referred to the Huronian, and is given the name Arizonan.

Hershey[1] describes the schistose rocks of the Klamath Mountains in northwestern California. On the whole it seems impracticable to fix upon any particular part of the time between the Archean and the Devonian as the period of deposition of the Klamath schists, but it is believed that the evidence favors the earlier or Algonkian portion rather than the Cambrian or Silurian portion.

Spencer[2] describes Algonkian rocks occurring in the center of the Rico Mountains of Colorado. They consist of quartzites, quartzitic schists, and biotite and actinolite schists. The exposed thickness of the quartzites is over 350 feet and probably as much as 500 feet. The relations of the quartzites to the schists have not been ascertained. The schists and quartzites of this area are similar in every way to the series of rocks exposed in the upper part of the Animas Canyon and in adjacent portions of the Quartzite or Needle Mountains, where they have been referred to the Algonkian by Emmons and Van Hise. The quartzite of the Rico Mountains is directly along the strike of the great quartzite belt in the Animas Canyon and Needle Mountain area.

Jaggar,[3] in connection with the discussion of the laccoliths of the northern Black Hills, incidentally refers to the structure of the Algonkian. Its lamination abuts abruptly against the hard basal Cambrian quartzite or the conglomerate, and has a fairly uniform strike of north-northwest. The Algonkian surface is seen to be warped.

[1] "Metamorphic Formations of Northwestern California," by OSCAR H. HERSHEY, *American Geologist*, Vol. XXVII, 1901, pp. 225–45.

[2] *Twenty-first Ann. Rept. U. S. Geol. Surv.*, Part II, 1901, pp. 37–78; with geological map.

[3] "The Laccoliths of the Black Hills," by T. A. JAGGAR, JR., *Twenty-first Ann. Rept. U. S. Geol. Surv.*, Part III, 1901, pp. 171–303.

Hills[1] describes the geology of the Walsenburg Folio of Colorado.

The principal mass of the Greenhorn Mountains consists of coarse and fine-grained granites and gneisses, hornblende, mica, and chlorite-schist, and subordinate masses of garnet- and epidote-schist, and occasional vein-like bodies of coarse pegmatite. The schistose rocks are more prominent at the southern extremity of the mountains than elsewhere, while the granite and gneissic rocks are more prominent in the main mass toward the culminating point.

Their origin probably dates back to the Archean period. No further correlation is attempted.

Watson[2] describes the granitic rocks of the Piedmont Plateau of Georgia and concludes that they were not all contemporaneous in origin. Some of them are pre-Cambrian, while others may possibly be later in age. However, the youngest acid intrusives could not have been later than, if as late as, the last great Appalachian disturbance or uplift.

Kemp, Newland and Hill[3] further discuss the geology of Hamilton, Warren and Washington counties, extending the observations noted in previous reports to the west and south.[4] The additional points of interest are the occurrence of anorthosites in Johnsburg, in Warren county, the southernmost exposure yet known in the eastern mountains, and "the increasing certainty of the existence of sedimentary gneisses in Fort Ann and Johnsburg townships."

[1] "Walsenburg Folio, Colorado," by R. C. HILLS, *Geol. Atlas of the U. S.*, No. 68, 1900.

[2] "The Granitic Rocks of Georgia and their Relationships," by THOMAS LEONARD WATSON, *American Geologist*, Vol. XXVII, 1901, pp. 199-225.

[3] "Preliminary Report on the Geology of Hamilton, Warren and Washington Counties," by J. F. KEMP, D. H. NEWLAND, and B. F. HILL, *Eighteenth Ann. Rept. State Geologist of New York*, published in *Fifty-second Rept. N. Y. State Museum*, Vol. II, 1900, pp. 141-62; with geological maps.

[4] For general discussion of classification of geology of these counties see *Rept. of the New York State Geologist* for 1897, published in *Fifty-first Ann. Rept. New York State Museum*, Vol. II, 1899, pp. 499-553. Summarized, JOUR. GEOL., Vol. IX, 1901, p. 444.

Smyth[1] maps and describes the geology of the crystalline rocks in the vicinity of the St. Lawrence River in the towns of Alexander, Clayton, and Theresa, in Jefferson county, together with portions of Rossie and Hammond in St. Lawrence county. The crystalline rocks of the district are discriminated on the map as granite, granite-gneiss, granite-gneiss with much schist and quartzite, schists and quartzites with much granite-gneiss, schists and quartzites of limestone series, and crystalline limestone. This classification indicates the close association of the various rocks in the field. Under the term schists are classed a variety of rocks, such as quartzite, hornblende and mica schists, hornblende, pyroxene, and mica gneisses, etc., of both igneous and sedimentary origin. The gneiss formation is not a unit, but rather a complex, so far as age is concerned. It is the most widespread of the pre-Cambrian rocks. There is abundant evidence that the granite and granite-gneiss are for the most part younger than the schists and quartzite. The granite has a close genetic relation to the granite-gneiss and is identical with a part of the latter. The granite may be the youngest member of the granite-gneiss complex. The quartzite may have a thickness as great as 500 feet.

Kemp and Hill[2] report progress of work on the pre-Cambrian formations in parts of Warren, Saratoga, Fulton, and Montgomery counties.

Cushing[3] maps and describes the geology of Rand Hill and vicinity, Clinton county. The basal rocks are gneisses of the Dannemora formation occurring in the southwestern portion of the area. These are of doubtful origin, but probably mostly

[1] "Geology of the Crystalline Rocks in the Vicinity of the St. Lawrence River," by C. H. SMYTH, JR., *Nineteenth Ann. Rept. State Geologist of New York*, published in *Fifty-third Ann. Rept. N. Y. State Museum*, Vol. I, 1901, pp. 185–204; with geological map.

[2] "Pre-Cambrian Formations in Parts of Warren, Saratoga, Fulton, and Montgomery Counties," by J. F. KEMP and B. F. HILL, *Nineteenth Ann. Rept. State Geologist of New York*, published in *Fifty-third Ann. Rept. N. Y. State Museum*, Vol. I, 1901, pp. 121–135; with geological maps.

[3] "Geology of Rand Hill and Vicinity, Clinton County," by H. P. CUSHING, *Nineteenth Ann. Rept. State Geologist of New York*, published in *Fifty-third Ann. Rept. N. Y. State Museum*, Vol. I, 1901, pp. 139–182; with geological map.

igneous. Intrusive in them are undoubted igneous rocks—gabbro, anorthosite-gabbro, augite-syenite, syenite and dikes of syenite and diabase.

C. K. LEITH.

MADISON, WIS.

THE *Summary Report of the Geological Survey Department of Canada* for the year 1901 is a paper-bound volume of 270 pages, giving a concise outline of the work done during the year. The volume is issued in order to give to the public, without delay, the results of the year's investigations in different parts of the Dominion. The rapidly increasing mining industry of the country makes it very desirable that the information in possession of the Survey should be immediately available, whereas the full annual reports are, as a rule, two or more years behind the field work. During the last three years the Canadian Survey has lost a number of its men by death and resignation. The death of Dr. G. M. Dawson, late director, was a severe loss, and the resignation of such men as J. B. Tyrrel, A. P. Low, J. McEvoy and R. W. Brock leaves places which the younger appointees are not yet able to fill. Dr. Robert Bell, formerly deputy director, has been appointed acting director. The present staff numbers fifty-four.

During the year 1901 thirty-one parties were in the field, and work was done in each of the seven provinces and in the territories of Alberta, Yukon and Keewatin. R. G. McConnel and Joseph Keele continued the work in the Yukon field. Considerable searching has been done in the hope of finding the lodes from which the gold of the placers was derived. Auriferous quartz veins cut the igneous and clastic schists which are so abundant in the Yukon valley. As a rule, the veins, though numerous, are too small and discontinuous to warrant mining operations. The schists are also auriferous in places. R. A. Daly acted as geologist with the Canadian commission co-operating with the United States commission in locating the British Columbia section of the international boundary. The predominant rocks of the Coast Range were found to be metamorphic sediments, of which but few strata were fossiliferous. The mountain forms are regarded as erosional rather than constructional. Erosional features characteristic of the work of Alpine glaciers—cirques, cols, rock basins, ampitheaters, and deep re-entrants—are abundant. The existing glaciers are small, and there is no indication of general glaciation having prevailed in the belt. R. W. Brock worked in the