# THE GEOLOGICAL



AND

# NATURAL HISTORY SURVEY

## OF MINNESOTA.

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*The Twenty-fourth (and final) Annual Report*

*for the years 1895-1898*

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N. H. WINCHELL,
*State Geologist*

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ERRATA.

Page xv. There were added to the books of the survey library, between the date of listing (July, 1898) and Aug. 1, 1899, 112 volumes and 322 pamphlets.

Page 70, 12th line, for rods read paces.

Page 180, 13th line from the bottom, for XXVIII read XVIII.

Page 272, 5th line from the bottom, for 75 read 175.

# ADDRESS.

MINNEAPOLIS, March 1, 1899.

*To the President of the Board of Regents.*

DEAR SIR:—The accompanying report is intended to present a synopsis of the field work done by the geological parties of the survey since the publication of the last annual report which was for the year 1894. As this will constitute the last of the series of annual reports of the survey, it is furnished with an alphabetical index of all the annual reports, in order that the diversified contents of the annual reports may be consulted readily by any one on any subject discussed therein, without the trouble of searching through them all in detail.

Respectfully submitted,

N. H. WINCHELL,

State Geologist and Curator of the General Museum.

## GEOLOGICAL CORPS.

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| L. A. OGAARD, *Draftsman,* | 1896. |
| O. HALVORSEN, *Draftsman,* | 1898. |
| O. J. MIDTHUN, *Draftsman,* | 1898. |
| H. V. WINCHELL, *Economic Geology,* | 1899. |

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## SUMMARY STATEMENT.

The following summary statement covers the years 1895, 1896, 1897 and 1898.

By the writer the year from May, 1895, to May, 1896, was spent at Paris, in the examination of a series of Minnesota crystalline rocks. He there had the cordial and generous aid of Prof. A. Lacroix of the Museum d'Histoire Naturelle, of occasional consultations with Prof. Fouque, of the College de France, and of Michel Levy, of the School of Mines, who is in charge of the construction of the geological map of France. Every facility which their laboratories afforded was placed freely at his disposal. It is through the aid of these French savants, repeated during the first six months of 1898, when another visit was made to Paris, that the methods of modern petrography have been thoroughly applied to the crystalline rocks of Minnesota. The writer, although he personally bore the expenses of this travel and sojourn abroad, is grateful to the regents of the University for the opportunity to satisfactorily go through the subject of Archean petrology as illustrated in Minnesota, and for the respite which he enjoyed from the tedium of office duties and their interruption. These latter were cared for by Dr. U. S. Grant, This was the first and only "vacation" which the writer has had since he began the Minnesota survey in 1872; and as a vacation it was entirely occupied with the legitimate and pressing work of the survey.

The remainder of 1896 was spent in continuation of the microscopical examinations and in caring for vol. iii, part 2, still in the printer's hands. The edition of this volume was partly delivered in 1897, but the principal part of it not till January, 1898. In the fall of 1896 a re-examination was made of some of the important points in the region of Vermillion lake and eastward as far as to Grand Portage. The party consisted, besides the writer, of Messrs. Grant and Elftman, assistants on the survey, and Mr. H. Foster Bain, of the Iowa geological survey.*

In May, 1897, a review was made of some portions of Carlton county with a view to arriving at a final conclusion as to the age of the slates and the greenstones of that county. This

*A preliminary statement of some of the results of this trip is published in the American Geologist, vol. xx, pp. 41-51, 1897, under the title, "Some new features in the geology of Northwestern Minnesota."

trip was extended to Ely for further comparisons with the greenstones lying south of Long lake, especially at the southwest end of that lake. From the northwest corner of Long lake a traverse was made to Burnside lake for the purpose of noting the manner of transition from the greenstones to the mica schists and to the granite.

As the preparation of the final chapters on the geology of the northern part of the state progressed, it became apparent, from time to time, that some points needed farther examination in the field. Hence another small party was made up in August, 1897, consisting of Messrs. Grant, Elftman, and the writer, with Vincent Dufault as general woodsman, and another expedition was made to Snowbank lake with a view to examine the relations of the Animikie to the great conglomerate which has been called Ogishke conglomerate. This re-examination was conducted via Fall lake to Saturday lake, thence to Urn lake, Bassimenan lake, through Pine, Moose and Flask lakes and finally to Disappointment lake. The important results of this re-examination are included in the appropriate chapters of the final report (vols. iv and v).

By January 1, 1898, all the county and special chapters descriptive of the northern one-third part of the state were completed, at least in their first form, and the necessary geological maps were prepared and tendered to the Regents for publication. But the microscopical descriptions of the rocks has not been completed, nor were the generalizations and questions of structural geology and petrology which are based largely on such investigations, even entered upon. The matter ready for publication at that date is substantially what is included in vol. IV of the final report.

The writer again visited Paris, as already stated, taking along the remainder of the microscopical thin sections, and, freed from the interruptions incident to the office and from the corresponcence which it entails, there completed the examination of a large number of the rocks collected by the survey. Dr. Grant, at the same time, while attending to the routine of the office of the survey, was released to conduct the instructional work in geology and petrography in the geological department of the University for one year.

In the summer of 1898 some of the final chapters were revised and still others of the necessary microscopical examinations were made in Minneapolis by Dr. Grant and the writer. Not yet satisfied with the condition of the evidence respecting certain questions that seemed to centre in the rocks about Snowbank and Disappointment lakes, still another visit was made by Dr. Grant and the writer to those lakes in September and October, 1898, by a different route of travel, and some localities were examined which had been reported on by some of the assistants in the earlier years of the survey before the questions now in vogue had arisen, and which therefore were not critically examined in the light of the issues that now present themselves. These later visits were most fruitful in important geological results; and they necessitated the construction and examination of numerous other microscopical rock sections. Perhaps the most important geological results attained by these later examinations can be expressed under two heads: (1) The separation of a large portion of the rocks and the iron ore which have been included in the Animikie as constituent parts of the Mesabi range, from that range and their assignment to the Keewatin. (2) The origination of the gabbro and all its variations, including its bodies of iron ore, from the Keewatin by a process of profound alteration and fusion, causing the resultant molten rock to penetrate every adjacent earlier rock, this taking place after the completion of the Animikie.

The reasons for these changes of classification, and the details of the petrographic and field evidence are included in the final report.

The geology of the state has been furthered by occasional publications by members of the survey corps, and these contributions, based on the facts brought out by the Minnesota survey from time to time since the list published in the 23rd Annual Report, are listed below.

THE FOLLOWING ARE BY N. H. WINCHELL:

The Age of the Galena Limestone. *Am. Geol.* xv., p. 33, 1895.

The stratigraphic base of the Taconic, or Lower Cambian. *Am. Geol.*, xv, 153, 1895.

The paleontologic base of the Taconic or Lower Cambian. *Am. Geol.*, xv, 229, 1895.

The eruptive epochs of the Taconic or Lower Cambian. *Am. Geol.*, xv, 295, 1895.

Canadian localities of the Taconic or Lower Cambian. *Am. Geol.*, xv, 356, 1895.

Historical skstch of investigations of the Lower Silurian of the upper Mississippi valley. Vol iii, part 2, Introduction. *Final report of the Minnesota Survey*.. (With E. O. Ulrich). March 1895.

The discovery and development of the iron ores of Minnesota. *Minn. Hist. Collections*, vol viii, pt. 1, pp. 25-40, 1895.

The source of the Mississippi. *Am. Geol.*, xvi, p. 328, 1895; *Minn. Hist. Coll.*, viii, pt. 2, p. 226, 1896.

Steps of progressive research in the Geology of the Lake Superior region prior to the late Wisconsin survey. *Am. Geol.*, xvi, 12, 1895.

The Keweenawan according to the Wisconsin geologists. *Am. Geol.*, vol. xvi, 75, 1895.

A rational view of the Keweenawan *Am. Geol.*, xvi, 150, 1895.

The snychronism of the lake Superior region with other portions of the North American continent. *Am. Geol.*, xvi, 205, 1895.

The latest eruptives of the lake Superior region, *Am. Geol.*, xvi, 269, 1895.

Comparative Toxonomy of the rocks of the lake Superior region. *Am. Geol.* xvi. p, 331, 1895.

Lacroix' axial goniometer. *Am. Geol.*, xvii, p. 17, 1896.

Microscopic characters of the Fisher meteorite. *Am. Geol.*, xvii, 173, 234, 1896.

The Black River limestone at lake Nipissing. *Am. Geol.*, xvii, p. 178, 1896.

Sur un cristal de labrador du gabbro da Minnesota. *Bul. Soc. Franc. Min.*, t. 19, p. 90, 1896.

Volcanic ash from the north shore of lake Superior (with U. S. Grant), *Amer. Geol.*, xviii, p. 211, 1896.

The Arlington Iron, *Am. Geol.*, xviii, p. 267, 1896.

Sur la metéorite tombée le 9 avril, 1894, prés de Fisher (Minnesota), *Comptes rendus*, t, 122, No. 11, p. 3, March 1896.

L'extension du système taconique ver l'ouest. *Compte-rendu, du Cong. Geol. intern.*, 6th session (1894), pp. 272-308, 1897.

Some new features in the geology of Northern Minnesota. *Am. Geol.*, xx, 41, 1897.

The Fisher meteorite: chemical and mineral composition, *Am. Geol.*, xx, 316, 1897.

The geological chronology of Renevier, *Am. Geol.*, xx, 318, 1897.

The Taconic, according to Renevier, *Am. Geol.*, xx, 405, 1897.

The determination of the Feldspars, *Am. Geol.*, xxi, 12, 1898.

Some resemblances between the Archean of Minnesota and of Finland, *Am. Geol.*, xxi, 222, 1898.

The question of the differentiation of magmas, *Am. Geol.*, xxii, 112, 1898.

Significance of the fragmental eruptive debris at Taylor's Falls, *Am. Geol.*, xxi, 136, 1898.

The oldest known rock, *Am. Geol.*, xxii, 263, 1898.

Note on the characters of mesolite from Minnesota, *Am. Geol.*, xxii, 228, 1898.

Origin of the Archean igneous rocks, *Am. Geol.*, xxii, 299, 1898.

Thomsonite and lintonite from the north shore of lake Superior, *Am. Geol.*, xxii, 347, 1898.

Thalite and bowlingite from the north shore of lake Superior, *Am. Geol.*, xxiii, 41, 1899.

Chlorastrolite and zonochlorite from Isle Royale, *Am. Geol.* xxiii, 116, 1899.

### Papers by U. S. Grant.

The international boundary between lake Superior and the lake of the Woods. *Minn. Hist. Soc. Collections*, vol. viii, pt. 1, pp. 1-10, 1895.

The name of the copper-bearing rocks of lake Superior, *Am. Geol.*, vol. xv, pp. 192-194, March, 1895.

(With N. H. Winchell) Volcanic ash from the north shore of lake Superior. *Am. Geol.*, vol xviii, pp. 211-213, Oct., 1896.

Notes on some water divides in northeastern Minnesota. (Abstract) *Bull. Minn. Acad. Nat. Sci.*, vol. iv, No. 1, pt. 1, pp. 39-40, 1896.

Lakes with two outlets, in northeastern Minnesota. *Amer. Geol.*, vol. xix, pp. 407-411, 1897.

Sketch of the geology of the eastern end of the Mesabi iron range in Minnesota. *Engineers' Year Book*, University of Minn., pp. 49-62, 1898.

*Papers by former members of the survey, on the geology of Minnesota.*

*By A. H. Elftman.*

Geology of the Keweenawan area of northeastern Minnesota. *Am. Geol.*, XXI, 90, 175, 1898.

The St. Croix River valley. *Am. Geol.*, XXII, 58, 1898.

Geology of the Keweenawan area in northeastern Minnesota. *Am. Geol.*, XXII, 131, 1898.

*By Warren Upham.*

Erosion of the St. Croix Dalles. *Am. Geol.*, XVIII, 260, 1896.

The St. Croix river before, during and after the Ice age. A lecture, March 18, 1896.

Interglacial change of course, with gorge erosion of the St. Croix river in Minnesota and Wisconsin. *Amer. Geol.*, XVIII, 223, 1896.

The Glacial lake Agassiz. Mon. XXV, *U. S. Geol. Sur.*, 4to, pp. XXIV, 658, 38pls, 1896.

Glacial lake Hamline. *Am. Geol.*, XIX, p. 423, 1897.

The History of Mining and quarrying in Minnesota. *Minn. Hist. Coll.*, vol. VIII, pt. 2, p. 291, 1898.

Time of erosion of the Upper Mississippi, Minnesota and St. Croix valleys. *Am. Geol.*, XXII, p. 258, 1898.

*By C. P. Berkey.*

Geology of the St. Croix Dalles. *Am. Geol.*, XX, 345; XXI, 139; XXI, 270; 1897-98.

The occurrence of copper minerals in hematite ore, Montana mine, Soudan, Minn. Part II, *Proc. Lake Sup. Min. Inst.*, IV, 73, 1896.

*Alex. N. Winchell.*

Minnesota's Northern boundary. *Minn. Hist. Coll.*, vol. 8, pt. 2, pp. 185-212, 1896.

The age of the Great lakes of North America. *Amer. Geol.*, XIX, pp. 336-339, 1897.

The Koochiching granite. *Amer. Geol.*, XX, pp. 293-299, 1897.

*H. V. Winchell.*

A bit of Iron Range history. *Am. Geol.*, XIII, 164, 1894.

The Iron Ranges of Minnesota. *Proc. Lake Sup. Min. Inst.*, III, 15, 1895.

The Gold fields of the Rainy River region. *Eng. and Min. Journal*, vol. 64, p. 485, 1897.

Reputed Nickel Mines in Minnesota. *Eng. and Min. Journal*, vol. 64, p. 578, 1897.

The Lake Superior Iron Ore Region, U. S. A. *Transactions of the Federated Institution of Mining Engineers*, vol. XIII, pp. 872-895, Sept., 1897.

Characteristic American Metal Mines. The Mines of the Minnesota Iron Company. *The Engineering Magazine*, vol. XII, pp. 872-895. Sept., 1897.

*The Museum and its needs.*

Since the separation of the Museum collections into three museums, by the establishment of independent zoological and botanical divisions of the survey, the writer has had charge only of the geological and archeological portion of the Museum, and he has not been able to devote to it much time, owing to the urgency of the regular survey. The room devoted to the geological specimens, in the east end of Pillsbury Hall, has been kept warm in winter and accessible to the public and to the students. The specimens belonging to the survey have been deposited, in part, in the Museum, and in part they have been kept in other rooms, there having been no suitable cases of sufficient size for their storage, much less for their exhibition, nor time for arranging them.

Recently, however, several new cases have been built, similar to others now in the Museum. A general renovation and rearrangement have been entered upon, including all the specimens. Since the fire which occurred in Pillsbury Hall in December, 1889, the Museum has not been in good condition. The specimens were damaged by soot which fell on all exposed surfaces and even penetrated the drawers and cases. The trays were in many cases ruined, and the delicate specimens could not be cleaned. Nevertheless there was a hasty replacement of most of the specimens, in order to get the Museum into tolerable condition. For the tin e and means that were then available that was all that could be done. It is proposed now (Feb., 1899,) to thoroughly overhaul the whole Museum, rearrange, assort, relabel and clean all specimens that were not cleaned before. Along with this will be involved the arrangement and exhibition of many of the fossils of the state and rocks and minerals from the northern part of the state which have served as basis for the survey reports. The law of the survey also orders the exchanging of typical sets with other institutions and the deposit of specimens in the Normal schools. This will also be done if time and means are afforded.

The type specimens, both rocks and fossils, and all the material on which are founded the investigations and the results of the survey, are valuable as scientific data and ought to be carefully preserved for future use and critical comparison.

The Museum has suffered in the past from untoward circumstances beyond the control of the curator, and it is to be hoped that in the near future such circumstances may be mitigated and that the growth of the Museum along the lines in which such a museum should grow, will be more rapid and more satisfactory.

The writer has entertained the hope that at some place in Minnesota, if not at the University, there might be created a true museum, a source of information and of inspiration, a credit to the scientific enlightenment of the Northwest, and he has on several occasions called public attention to the need of such an institution. With the administration and prosecution of the geological survey on his hands and with no money that could be devoted to it, he has not found opportunity to push this wish to fruition, and the more so because of the adverse circumstances that environed him and his work at the university.

In a lecture delivered at the annual meeting of the St. Paul Academy of Sciences, May, 1891, on "Museums and their Purposes," the writer defined the scope and functions of a true museum of the highest modern type, and concluded with the following summary:

"The ideal museum should have, *first*, suitable permanent quarters for its *local habitation*. These quarters should be adapted to the uses to which they are to be put, and should be planned and erected with constant reference to economy of labor and time for the workmen who are to occupy it. This is so obviously necessary that it seems, at first, that it need not be stated. Yet its neglect is a common mistake. How often are the planning and construction of such a building put into the hands of some professional architect with instructions simply to erect a building of good architectural proportions and fine appearance. In the main, such a building should contain rooms for laboratories, for storage, for exhibition, classification and, perhaps, for lectures.

"*Secondly*. The ideal museum should have materials in the form of multifarious collections, and the ways and means for increasing them, and of exchanging them with other museums. While some of these will be put on exhibition, at least those which have been sufficiently examined and classified, the larger portion will be kept in storage for the use of its collaborators.

"*Thirdly*. Such a museum will be well supplied with apparatus and libraries, and the apparatus will consist of the best makes and of the latest improvements. I wish to emphasize the libraries. There is nothing that the scientific student so much needs, and which he is most frequently without, as a library of those works which pertain to his science. He wishes to know what others have discovered, or what they have failed to discover; what methods others have followed, and what paths are still untrod. It is one of the difficulties of most scientific institutions, especially of new ones, to procure means for the scientific literature pertaining to the sciences which they are supposed to cultivate.

"*Fourthly*. For the efficient working of such a museum there must be a corps of scientific collaborators, sufficiently paid to relieve them from anxiety for their comfortable subsistence and that of their families.

"*Fifth*. Means of publication, either by lectures or by printing. It would be better that both these methods of publication be pursued. The former disseminates information cheaply and quickly. The latter is more formal and more permanent, furnishing means for recording facts and principles with carefulness and thoroughness, with a view to future reference.

"*Sixth*. Such a museum should have its administration unified and harmonized by being under the responsible charge of one man. There should be a plan for its work, outlined by the proper authority, and that plan, with the rules which it should involve for the government of all the collaborators, should be enforced with persistence and fidelity."

Such an institution would be a museum in the highest sense. It is not to be expected that such an ideal museum will be attained at one bound. It will be a result of growth, which sometimes will be slow; but in the writer's opinion it is sure to come and to be realized at some point either in Minneapolis or in St. Paul. The geographical, no less than the political and social conditions, will not be satisfied until there shall be in the state of Minnesota a great centre of scientific light—a point toward which shall gravitate all patrons of science who happen to visit the Northwest, and all citizens who are inclined toward science.

The writer has been hopeful that the Geological and Natural History Survey, and the fund on which it is based, might be the nucleus about which such an institution should be built up at the University. Its collections, its apparatus, its books, its employes, suitably organized, would already constitute such a nucleus. They might be housed in a specially adapted building and, thus individualized and unified, such an institution would be fostered by the Legislature. In the opinion of the writer, it is an opportunity which the University should not let pass, for the remainder of the fund will probably never be recalled by the State, if the State is satisfied that it is being put to the most profitable and most reasonable uses.

The writer has made various fruitless recommendations respecting the development of the museum along these lines, and has striven to lay a satisfactory foundation on which the future might build, but he feels far from satisfied with the success which has rewarded his efforts.

In any case, if the museum be continued on its present plan and scope, it should be put under the exclusive administration of one man, and it should be allowed some means for renewal by purchase. Good specimens can be got only by purchase. Exchanges will extend the variety and donations will increase the volume of the collections, but purchase only will improve the quality. The funds of the Survey have been so limited, and so urgently demanded by the stated work of the geological survey, and the regents have so frequently counseled economy in all survey expenses, that it has been impossible to improve the museum either by the addition of specimens or by the purchase of cases.

*The Library of the Survey.*

In July, 1898, the books belonging to the survey, obtained mostly by exchange with scientific institutions, were inventoried, with the following result:

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|---|---|
| Volumes, foreign, | 895 |
| Volumes, American, | 883 |
| Total volumes, | 1778 |
| Pamphlets, foreign, | 1401 |
| Pamphlets, American, | 981 |
| Total pamphlets, | 2382 |
| Maps, | 75 |
| Miscellaneous, unclassified pamphlets, | 100 more or less. |

Several hundred should be added for arrivals since July, 1898. Seventy-four volumes were lost in a recent fire which consumed the bindery of A. H. Dahl & Co. It has been customary to keep a careful record, in books specially prepared with proper headings and rulings, of all books sent and received by the survey, but since July this registration has been suspended.

The registration and keeping of the library are germane to the keeping of the specimens of the Museum, and it is apparently the most economical method and the most convenient, that the books be in the charge of the same responsible keeper.

The library is not known as a public library. It has no rules. It is consulted by instructors and by students, but it might be made more useful by placing it in a more accessible room, and by the appointment of some young man, with nominal pay, to act as librarian. All the registration and boxing of exchanges sent, and the acknowledgment of those received, as well as the special custody of the whole collection, including the remaining copies of the survey reports, should be kept in a systematized method. It is not likely that the work connected with this department of the survey will be materially reduced by the formal close of the geological survey, for there remain many copies of the reports which ought to be distributed under rules similar to those which have been in force in the past. These will serve to greatly augment the library beyond its present limits.

*The formal official close of the geological portion of the survey*, originated in 1872, may be considered to date from the publication of this statement, although there will remain the publication of the volumes which cover the northern one-third part of the state, the geological atlas of the state, consisting of the collected geological plates with brief explanatory chapters, two important bulletins which have been mentioned in communications to the regents at different times, and a partially prepared bulletin on the Winnebago meteorite. The regents have already executed a contract for the publication of the final volumes referred to, and these will appear in the course of the coming year, in style and size uniform with the three that have already been published. Were it not that the pages of the twenty-fourth annual report have to be referred to in the printing of vols. IV and V of the final report, it would be more appropriate to postpone the publication of the final annual report until the completion and publication of those volumes.

*The cost of the Geological Survey.*

The cost of the geological portion of the survey, made out from the reports of the regents and from the records of the state geologist, can be stated approximately as below. It is a somewhat difficult task, in some cases, to disentangle the strictly geological expenses from others as grouped in the treasurer's reports. But by the aid of records kept systematically since the commencement of the survey by the state geologist, every item of expense incurred by him, or for his work, can be identified; and annually the cost has been separated from the general expenses. Too often, however, in the public press and elsewhere, the cost of the whole Survey, including the museum, has been charged against the "geological survey," and it has sometimes been wrongly accused of being too costly. The average annual cost of the geological portion of this enterprise, for the 27 years during which it has been under the charge of the writer, has been $5,420.64. The following summary of the expenses of the survey is taken from a communication made to the president of the board of regents, Feb. 10, 1897, supplemented by later data to July 31, 1899.

*Summary of the expenses of the geological survey.*

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|---|---|
| Cost of the survey and museum prior to 1879, - - | $ 15,000.00 |
| Cost from 1879 to 1888, inclusive, - - - - - - | 51,051.09 |
| Cost from 1888 to July 31, 1896, - - - - - - | 54,193.35 |
| Special appropriation of 1887, - - - - - - - | 9,640.50 |
| Total cost of the geological survey proper, and of the museum to July 31, 1896, - - - - - - | $129,884.94 |
| Cost since July 31, 1896 to July 31, 1899, including printing, - - - - - - - - - - - - - | 16,472.33 |
| Total cost to July 31, 1899, - - | $146,357.27 |

*The credit side in dollars and cents.*

When the survey began, in 1872, there was in possession of the State, in a more or less uncertain condition as to location and value, a class of lands known as Salt Spring lands. Of this land grant, which came from the United States when the State was admitted into the Union, the Legislature had been induced, under various specious pretexts of developing the brine alleged to exist at Belle Plaine, to part with two large bodies of land. One was granted by the Legislature of 1870. Another was granted by the Legislature of 1871 conditioned on a favorable report by a competent geologist, to be appointed by the governor. Gov. Austin appointed Prof. A. Winchell, who reported adversely, rendering the act inoperative. Still the project survived, and the Legislature of 1872 was induced to make another grant of six sections of Salt Spring lands for the same purpose to the same company, without conditions. This history plainly indicated that the Salt Spring lands were the prey of delusive enterprises, and would in time be frittered away without rendering the State any return. Indeed the present state geologist had no sooner fairly entered upon his duties than he was solicited for aid to the Belle Plaine

Salt Co. with a view to the designation of other salt lands where said company might still further explore at the expense of the Salt Spring lands. And still further, after these lands had been set aside for the expenses of the Geological and Natural History Survey of the state, the Belle Plaine Salt Co. pursued the Board of Regents. A bill was introduced in the Legislature of 1875 (?) authorizing the Belle Plaine Salt Co. to explore for brine on any of the Salt Spring lands of the state, and ordering the regents, after a certain amount of work had been done, to pay said company by deeding to it some portion of these lands. The bill never became a law. But it still further shows the precarious position of the Salt Spring land grant.

The state geologist in his first report (1872) recommended that these lands be used for the prosecution of the survey on which he was engaged. In making this recommendation he had the concurrence of several public spirited and far-sighted citizens, among whom should be mentioned Hon. J. S. Pillsbury, Hon. A. J. Edgerton, Hon. O. P. Whitcomb, Hon. H. B. Wilson and Mr. W. D. Hurlbut. The lands were so appropriated through the activity of Mr. Pillsbury who was then in the state senate.

This history is detailed here, not to show that these lands should be credited to the survey, but to make it plain that, had not the survey interposed at a critical epoch in their history, the State might have lost them entirely by such enterprises as the Belle Plaine Salt Co.

The Salt Spring lands, originally granted to the State, aggregated 46,080 acres, as reasonably computed from the terms of the grant. Of this the State was unable to avail itself of 11,520 acres, that amount being situated outside the area surveyed by the United States government. This reduced the original available grant to 34, 560 acres. It was further reduced by occupancy by settlers 6,752 acres. About 1,600 acres were also previously covered by the terms of the act granting swamp lands to the State. The remainder, 26,425 acres, was certified to the State. The Bell Plaine Salt Co. was granted 7,643 acres on complying with the acts of the Legislature. The rest of the certified lands, amounting to 18,771 acres, were turned over to the regents to carry on the Geological and Natural History Survey.

On making an exhaustive examination of the records in the governor's office at St. Paul, for which search the then governor (Austin) submitted the records of the correspondence of the office since the admission of the State into the Union, the state geologist not only ascertained the foregoing facts, but also discovered *that there was a large deficit to which the State was still entitled.* The report that he made to the regents on the condition of the Salt Spring land grant was printed as a special document by order of the board of regents, at the expense of the board, and was privately circulated to the state officers and to the Legislature, but it never entered into the public documents. It is, however, summarized in one of the reports of the regents to the Legislature.

On conference with Gov. Pillsbury, and largely by his instrumentality, those who were cognizant of the circumstances caused a memorial to be introduced in the Legislature, which was passed, asking Congress to allow indemnity selections for this deficiency. After some delay Congress granted such indemnity lands, aggregating 19,872 acres, and the Legislature of 1885 transferred them also to the board of regents for the purposes of a geological and natural history survey.

It is plain, therefore, that these indemnity lands which were wholly unknown and were procured through the discovery resulting from the voluntary search of the old records by the state geologist, should be credited wholly to the geological survey. At $5.00 per acre, which is the lowest price at which state lands can be sold, they are worth $99.360 as a minimum valuation. The Salt Spring lands already sold have brought an average price over $6.00 per acre.

The reports of the treasurer of the regents, from 1872 to July 31, 1899, show that the total cost of the Geological and Nat ural History survey, since its commencement to the date named, as disbursed by the regents, has been $172,152.33. These figures do not include that $10,000 appropriated by the legislature of 1887 and expended by the state geologist direct, and should be increased by $9,640.50 as stated above. As this includes all expenses, whether for zoology, botany or topography, all of which have been more or less actively prosecuted, especially in late years, the excess of such expense, above that which has been incurred for the geological survey proper and for the museum, should be credited indirectly to the geological survey proper. The funds have all been procured, not for botany nor for zoology; not for a natural history survey, but for a geological survey. The state geologist has borne the burden, *on behalf of geology,* before the legislative committees and before the public, and to this day the public press comments on the survey as a *geological survey*. The lands were appropriated with a view to *completing the geological survey*. It may be questioned whether any lands or any appropriations at all could have been procured for the prosecution of a natural history survey. It is only because we are here considering figures from a strictly geological point of view that this distinction is mentioned. There is a community of interests between the natural sciences and they should not be divorced except when from special circumstances a special inquiry needs to be made. It is reasonable, therefore, that the geological survey should be credited in a general sense with the amount of the total expenses incurred in excess of that incurred for the geological survey proper. This amounts to $25,795.06.

Allowing this general claim, however, to go for nothing, as it might be invidious to estimate it strictly in dollars and cents, it will only be claimed here that those services which have been rendered to the State which can be estimated in dollars and cents, in excess of the regular work of the state geologist and his assistants, should be credited to the geological survey, viz:

| | |
|---|---|
| 1873, appropriation for chemical apparatus, - - - | $ 500.00 |
| Services of the state geologist in charge of the department of geology for six years, apparatus and books for the general library and the department of geology - | 12,510.80 |
| Residue of appropriation of 1887, - - - - - - | 359.50 |
| Residue of appropriation of 1893, - - - - - - | 6.96 |
| Indemnity lands discovered through the agency of the state geologist (1885), 19,872 acres at $6.00 - - | 119,232.00 |
| Total credit in dollars and cents that have entered into the records, - - - - - - - | $132,609.26 |

*Total Summary.*

| | |
|---|---|
| Total cost of the Geological Survey proper, in dollars and cents, 1872 to July 31, 1899,* - - - - - - | $146,357.27 |
| Total revenue to the State, as shown in dollars that can be counted, in excess of the public good that may come from the Survey, - - - - - - - - - | 132,609.26 |
| Balance, (actual cost of the geological survey proper) - - - - - - - | $13,748.01 |

The geological survey proper has therefore in a large measure paid for itself in immediate and direct returns to the treasury af the State.

Nothing is said here of any of the benefits of the survey that cannot be computed as tangible results in dollars and cents, such as the development of the State's resources, nor of the

*Since Jan., 1899, the cost of the Survey, as reported by Accountant Sprague, includes expenses of publication.

credit the State gets for the maintenance of such a scientific and educational agency among the States of the Union. These less observable results, if the trouble should be taken to reduce them to dollars and cents, would far exceed the foregoing, as they constitute at once the chief purpose, and the crowning credit of the survey. Some of the intangible benefits of the survey were summarized by the writer some years ago, in Bulletin No. 1, as they appeared at that date—1889.

Nothing is said above of the cost of printing the reports of the survey, whether economic or scientific, because such expenses have not been incurred under the survey law, and because the reports may at least be considered as worth to the State what it has cost to publish them, notwithstanding excessive irregularities and unnecessary expense under the present methods of public printing.

*The Condition of Geology in Minnesota.*

It ought not to be supposed that by the closing of active work by the present survey, and the publication of its final report, the geology of the state is a finished thing. Geology is a progressive science, and requires continual work. The reports, when published, simply mark halting-places in a research. The halt may be like a comma in a sentence, or like a period. The sense, however, goes on, if the reader does not flag, and it only waits to be expressed. What we know today of the geology of the state is so much truth added to the science of the day. It is more than it was when we began this survey. We began where Owen and Eames had stopped, and we have carried the investigation only to the next period. If we cease here, it is only that, after a time, some one may resume the research and carry the geological story still further ahead. We have built another platform, like that built by Owen. The geology of the state must be pushed beyond this platform, either fast or slow, by those who will come later upon the field in the same way that we have carried it beyond the platform of Owen. There is no county, scarcely a township, but should be more fully examined. All the rocks of the state hold more that is unknown concerning them than all we have found out. The State of Wisconsin began a survey after the Minnesota survey was begun, hurried it to "completion" in a few years, published its report, and has now entered on another survey in which in one year is to be spent more than the average annual cost of the Minnesota survey. Missouri has had several surveys, not completing any. New York closed up its first survey in about 1850, but after a large series of quarto volumes devoted to paleontology has now set to work to describe and map her domain more in accordance with present methods and as demanded by the more advanced geology of the day. Pennsylvania has recently repeated her geological survey, at great expense. Nearly all the States of the Union have found that their first surveys, or efforts at surveys, were far from complete, and have continually added to the knowledge of their territory by fresh and more advanced examinations. Such must be the history in Minnesota. Each report publishes what is known, and usually also indicates what is probable amongst the things unknown. These publications serve as guides, more or less reliable, to the future geologist.

While this is true, in general, of all geological surveys, there are some examinations in special, ordered by the law of the Minnesota survey, which have not been carried out, and it will be well that they be enumerated somewhat seriatim. It is because of the magnitude of the work and the limitations of time and money available that these things have not been done. Several of these neglected examinations are strictly of an economical nature, and bear directly on the natural resources of the state, and their completion would redound immediately to the general acceptability of the survey amongst the citizens of the state. Others are more strictly scientific and technical, but would appeal powerfully to the influential educated classes of the community.

It will be noticed in the chapter on the physical features of the state, published in the first volume of the final report, that the various topics are treated quite summarily. It was the writer's intention, when that chapter was prepared, that each general topic there treated should ultimately serve as the general subject of full research and of illustrated report. Substantially a whole volume would thus be devoted to the physical features of the state. That subject is worthy of such ample description. The materials for such a discussion were then not in hand in detail, but have come into our possession gradually with the progress of the survey. The following would constitute the general topics of such a volume.

1. The distribution and character of the drift.
2. The surface configuration of different parts of the state.
3. The relative elevation of different parts of the state.
4. The kinds and distributions of the soils and sub-soils.

5. The lakes and rivers and the qualities of water of different portions.
6. The nature and distribution of the native forests and their relation to prairies.

While in general the terms of the law are complied with by the brief discussion given these subjects in this chapter of volume i., yet there are some parts which are very insufficient; for instance: the survey law requires the chemical analysis and description of the soils. Not a soil analysis has been made, and there has been no general investigation and description of the soils of the state.

The same is true of the clays which are one of the promising resources of the state, and for which there is a demand for survey and examination. The brick clays are common, and perhaps do not warrant special description, but the kaolin clays of the southern and western counties are worthy of more attention. They have been casually noted in the county reports, but they should have special examination.

The peats were examined into in 1873 and a report was rendered, but it was based on the peats of the southern counties, whereas the northern counties contain much peat that has not been examined, though in much greater quantities.

The brine which exists in large quantities in the northwestern part of the state might be made to produce considerable revenue. According to the slight examination that has been made it is a more pure and concentrated brine than the brines of Michigan which are celebrated for their annual production. Every facility, even artesian overflow, exists in northwestern Minnesota which exists in Michigan favorable for their development, except that of shorter warm seasons for solar evaporation, and it may be that the greater intensity of evaporation during the shorter summer of Minnesota would compensate for its greater brevity.

The mineral waters have not been examined. This topic would naturally fall into the discussion of the "lakes, rivers and qualities of waters" of the state mentioned above.

The marls and limestones have not been examined as such, although specified and required to be examined by the survey law. The limestones, as suitable for building stone, have been carefully investigated and reported in vol. i. of the final report, but for mortar and cement their qualities are an unknown quantity, except for the general experimental knowledge possessed by masons who use them. Their excellences and their limitations should be enquired into officially, and published by the State. They have not been examined in these respects. Several of them have reputed excellent cement qualities, and cement is actually being made at some places. How far this cement-giving limestone extends, and whether the quality is superior or not to those cements that are inported from other states, are questions that the survey is expected to answer, and are specially mentioned in the survey law.

The artesian waters of the state, which are very important in furnishing wholesome water in many towns, and on the prairies in the northwestern counties, and concerning which there is a continued and voluminous correspondence with the survey, have certain laws and fixed principles which govern their distribution and abundance. They have been casually here and there noted in the county reports. As a general subject they have not been examined into, much less explained and set forth so that parties may be guided in making attempts to find them.

The iron ores and the building stones and the gold deposits of Rainy lake are the only economic products that have been thoroughly examined and reported by the present survey, although there remain still unknown possibilities of the iron resources. All other useful materials pertaining to the mineral kingdom, have been subordinated to the general main purpose to ascertain the geological structure. The strength of the survey has been devoted to the discovery of the actual formations, their "number, order, dip and magnitude," and the delineation of the same on the county maps. Special researches into their contents, as to their economic value, have generally not been possible.

Besides this lack of economic research there are important lacunæ in the scientific side of the survey which render it impossible to call the survey of the state finished.

1. The drift features of the state ought to be set forth as a whole, now that the state has been covered and mapped by individual counties, and some further surveying ought to be done to correlate without doubt the various moraines. The retreat of the ice margin across the state of Minnesota, when correctly and fully described, would constitute an important chapter in late geological history. At the present time this remains somewhat in confusion for the lack of some general examination sufficient to adjust some conflicting observations and variant interpretations.

2. Whether some remnants of the Lafayette formation (between the drift and the Cretaceous) exist in Minnesota as rendered possible in the existence of crag and pebbly conglomerates which do not seem to belong to the drift, in Fillmore and other counties, should be determined by special examination.

3. Whether the eastern most outcrops of the Cretaceous belong to the later strata or to the earlier, i. e., whether the Cretaceous ocean withdrew from the state slowly, after a general and prolonged submergence, or rapidly, so as to leave its latest deposits furthest east, is a question which the survey cannot answer. It might be answered by a careful collection of all the data and especially by reconsidering the distribution of the fossils.

4. The Devonian exists in the state, but that is all that is known of it. A few fossils have been collected and hypothetically its area has been mapped. The Devonian has, however, received very little consideration.

5. The Upper Silurian has hypothetically been represented, in the early years of the survey, as entering the state in the southern portion of Fillmore county, but that needs to be verified.

6. The Upper Cambrian has not been fully investigated. There is a large list of fossils belonging to this horizon which have not been described, nor even listed. This is one of the most serious of the gaps in the scientific work of the survey. The material is available, but time and money are lacking.

7. The crystalline rocks of the northern part of the state, i. e. the Taconic and the Archean, have received more attention than all the others. These involve structural problems of the first order, but their great variety and complexity leave it certain that much remains to be found out concerning them, and that some of the conclusions of the final report will have to be considered as tentative hypotheses until reviewed and confirmed or corrected by later research.

8. While some parts of the area of the crystalline rocks have been carefully examined, there are still considerable portions of St. Louis, Lake and Cook counties that have not been sufficiently surveyed, and in such instances not only the geological boundaries but also the geological structure may be different from what has been expressed in the final report and plates which accompany the report. Some of these areas are not yet subdivided by the United States government, but the limitation of the survey in this respect has been owing rather to

shortness of time and funds. It is difficult and costly to conduct geological examinations in such a region, and the observations made in the surrounding country, as well as the conclusions derived from them as to structure, have necessarily been extended hypothetically so as to cover these unsurveyed areas. There is no doubt that many new facts as to the geology of the Taconic and Archean would be learned by extending a careful survey over these regions.

9. The student will also observe a large omission in the petrographical work. There have been collected five series of rock samples by five different geologists. This has been attended by considerable expense, as they are accompanied according to the plan of the survey, by copious field notes. But one of these series has been studied in full, as will be seen by reference to Volume V of the final report. At the same time all the granites and crystalline rocks collected in the central and western portions of the state, numbered and listed and published in the Museum Register (those marked in red) have not been examined at all. It was the writer's plan to make a careful examination of all these rock samples before entering on a final discussion of them, but he has not been able to carry this out. The descriptions and the classification of the crystalline rocks of the state are based wholly on the writer's own series of field samples, although with a few collateral examinations of the series of some of the assistants.

If these rocks be not lost they will yet furnish, along with the published descriptive field notes, for some other geologists a large amount of raw material for further study of the geology of the state. Under proper hands they could be made to furnish to the advanced classes in geology in the University many problems of great interest and importance.

The question may arise—why have all these things been omitted? The answer is because of the necessity of going ahead with the main line of the survey. The people are impatient. Money is hard to get where none exists. Men will not usually work free of all cost for the public, even in the cause of science. Human life is short. The survey has already been continued twenty-seven years. It was a choice between "completing" the survey after a fashion, as first laid out, and leaving it unfinished, and the former alternative was adhered to. The people, the regents and the other professors who have work to do under the same law, as well as the state geologist, were impatient to see the "final report" of the survey done with, in order that a new order of things might be inaugurated.

It appears, therefore, from the writer's point of view, that the State of Minnesota is in the right place to begin a thorough geological survey. Something is now known as to the broad structure; a kind of connoissance has been made. Now should begin a more minute survey, which ought to continue indefinitely, and which ought to make known not only all the possible resources but the more minute geology. Its units of progress should not be geographical, as in this survey, but topical, and a single subject should be followed wherever it might lead. In such a re-examination the chief factors must be the teachers of geology in the colleges and universities, and chiefly those of the State University.

The State of Minnesota has had a geological survey made almost without knowing it. The merely nominal cost entailed by this work, owing to the use of the Salt Spring land, which cost the State nothing, when compared with the appropriations of cash which has been made by most of the other States of the Union, presents a remarkable contrast. The smallness and the slowness of the revenue have retarded the geological work. Had there been enough money available the so-called completion of the survey might have been brought about several years ago, with a satisfactory degree of thoroughness, by the employment of several competent geologists. It has gone along slowly, and that has rendered it possible, and probably to the advantage of the survey, for the state geologist to personally review and decide most of the difficult questions that have arisen in the study of the Archean and the Taconic, thus rendering the final report more uniform in plan and homogeneous in interpretation.

### *Conclusion.*

The writer committed himself to this work unreservedly, in 1872. There have been some difficulties and vexations connected with its progress and administration, sometimes almost sufficient to induce him to relinquish it. The plan, however, which was laid out in the beginning has been adhered to, and with the publication of the last two volumes of the final report, now contracted for and in progress, and the execution of the general atlas, as mentioned, the responsibility and difficulties of this long and arduous enterprise will cease, and its results will be available to the citizens of the state. It is with thankfulness to all who have aided him, and charity for all who have opposed him, that the writer, with a profound feeling of relief, lays down his burden and commits his chief life work to the citizens of Minnesota, and bespeaks for it from all geologists that forbearance which may be due to a difficult task begun under discouragements in a frontier state, and carried on to completion without deviation from the initial plan and with comparatively little cost to the State.

N. H. WINCHELL.

# I

# ROCK SAMPLES COLLECTED TO ILLUSTRATE NOTES OF N. H. WINCHELL IN 1896. WITH ANNOTATIONS.

*The Nature of the Transitions of the Coutchiching.*

Compare rocks 2114-2124.

1980. Ortonville granite, as used in the Hennepin county court house, from the yards at Minneapolis.

1981. Mica schist. Sec. 36, T. 63-7, opposite Avis island on the main land at the shore of Vermilion lake. Here are seen on a rounded dome:

1. Mica schist, the oldest rock.
2. Quartz veins, accompanying upheaval and folding.
3. Crumpling of No. 2 and the schist in which it lies.
4. Later quartz veins uncrumpled.
5. Granite dikes, faulting and crossing the quartz vein No. 4, itself of course existing because of dynamic disturbance that broke the schist.

There is visible also a succession of eruptions.

1982. Greenstone dike, ten inches wide, cutting the next.

1983. Granite, 3 ft. wide, cut by 1982.

1984. Granite, apophysis 8 in. wide, cutting greenstone. The dike is 2 ft. wide.

1985. Greenstone cut by 1984.

1986. Menan island, at the place sketched and illustrated in the 15th annual report, pp. 288, 289. The older granite.

1987. The later granite. Two specimens showing the contact between 1986 and 1987. The older granite is finer grained, and whiter than the younger, which is reddish.

1988. (Number omitted).

1989. An older greenstone cut by the red granite 1987.

1990. Curious gray rock, fine-grained, 6 in. wide, cutting granite (apparently the younger granite) which is cut by a still later greenstone. 1990 also cuts this later greenstone. Shows contact on schist.

1991. NW¼, SE¼, sec. 26, T. 63-17. Supposed to be the same nature and age of dike-rock as 1990, which appears to be the youngest of the eruptive rocks of this vicinity. This exists in the form of a laccolith, or a spreading mass, in the midst of schists and granites, forming the highest parts of a knob a little back from the lake, where the route turns north on the east side of the channel.

1992. Coarse granite or pegmatyte, vein-like, enclosing a mass of 1991, much lighter colored than 1991.

1993. Another supposed condition of 1990, making knobs of eruptive aspect, at the shore—evidently an important rock in the Archean.

1994. NW¼, sec. 23, 63-17. Granite from a dike. Along the high E-W coast can be made a series of important observations. This point was examined cursorily and reported in the 15th annual report (pp. 293-94) in 1886. The mica schist is charged with granitic elements, which appear in various forms. The structure dips north. While some of the granite has distinctly the form and phenomena of eruptive rock cutting the schists, there are irregular nodules and lenticular masses varying in size from a walnut to areas several feet across, but mostly less than six inches, which cannot be referred to that origin. Sometimes these red granite patches assume elongated shapes, their thickness having a tendency to dwindle down to an inch or even a quarter of an inch and their elongation to lie parallel with the schists. They then extend for several feet and appear like inter-laminations in the schists. On close inspection it is apparent, then, that their composition gradually changes, and that they assume the composition and the internal structure of a gray rock which is neither granite nor schist, but which maintains the same general structure and parallelism of direction. This gray rock constitutes a large part of the country rock. It is closely inter-laminated with thin and thick bands of mica schist, and it acquires a red color on weathering. It cannot be separated in the field, by any structural nor any mineralogical distinctions, from the lenticular masses of granite, on the one hand, nor from the main mica schist formation on the other.

That the schists were fractured is evident, and that this granite, which is sometimes very coarse, and quartzose, entered the fissures, is also evident.

1995. Sample of the schist permeated by the granitic elements.

The above stated facts, and further examinations, seem to warrant the conclusion that here the mica schist of the region is itself the source of the granite of the region, through metamorphism and finally through separation, chemical and mechanical, of the granitic rock thus produced, into the inter-laminations and into all openings and areas of weakness; and that this process was accompanied by pressure, heat and moisture sufficient to cause the practical fusion and mobility of the clastics thus affected.

Other phenomena can be briefly given as follows:

1. There is an infinity of the red inter-laminations, some of them interrupted and interchanging or over-lapping with the schist.

2. Sometimes these inter-laminations consist largely or even wholly of quartz.

3. Sometimes they consist almost wholly of coarse red crystals of orthoclase.

4. Sometimes quartz and orthoclase are mingled as in pegmatyte.

5. Sometimes the red color of the rock mass is not separated from the gray by any sharp line, but they fade into each other.

6. There is a dike of red granite (1994) that cuts across the strata. It is 3 inches wide, and in one place the transition is abrupt, but, following it along, the dike loses its individuality by fading out on one side into the schist, and for some inches the two rocks are blended, i. e., on that side, but on the other the contact line continues nearly as distinct. At last the point at which the rocks are blended is marked by an irregular spur, or nodule, of more perfect granite; but associated with this nodule there is a nodule of vein quartz.

1996. Quartz nodule, as above, at the end of a variable place in the mixed rock alongside of the above red dike.

7. The granitic lenticular masses are most numerous in the form of inter-laminations in the schists and dip in coincidence with them.

8. These phenomena occur where the formation is not cut by marked and characteristic granitic dikes, but in a broad area of bare rock where the whole formation is seen to be profoundly and widely altered.

These features, taken together, as they must be, and coexisting in the same rock mass, not far removed from an area of uninterrupted granite where, of course, was still greater activity of the same forces, whatever they were, can hardly be explained except by referring them to the chemical segregation of the elements of granite in the midst of the mica schist itself, due to the heated gases and solutions that penetrated it from below;

and they have a direct bearing on any theory of the origin of all the granite of the region.

1996½. Gray intermediate rock (but rather micaceous) resulting from metamorphism of a clastic rock, similar to 1995 except in color; from a point further west, and further within the metamorphic belt, where many true intrusive dikes of granite, and others of coarse pegmatyte are seen.

There are numerous segregations that consist partly of quartz, and in other places contain also feldspar, and in the latter case having some dark ferruginous mineral in small amount. In some cases the feldspar and quartz surround a quartz nodule, and sometimes quartz surrounds the mixed segregation. They must necessarily have had the same (chemical?) origin.

There are large areas, as already noted, in which the whole rock seems to have feldspar generated in it. It is then still gray and schistose, but coarser and granular and weathers red.

The segregations here are sometimes oval, and roundish, making conspicuous white spots in contrast with the color of the mica schist in general.

In traveling over some of the low, rocky hills about here, many interesting transitions are observed:

1. There is a hardening and crystalizing of all the rock; and it could all be called gneiss, but it is gray except on weathered surfaces, which become red, and on the segregated parts that are of granite.

2. In one large vein which ascends a bluff twenty feet high in a zigzag course in the schist, is a white, coarse feldspar, viz.

1997. Pegmatyte, with red and white feldspar* and quartz, all very coarse.

Passing to the next bay, one side of which is colored on our Vermilion lake map (in the 15th annual report) as schist, and the other granite, along this bay on the north side, NE¼ sec. 22, 63–17, about four rods west of the N–S section line, between secs. 22 and 23, is a knob at the lake shore, which has a dark gneiss in the upper part, dipping north, evidently a more crystalline aspect of the schist, represented by

1998. Dark gneiss, a condition of the mica schist. NE¼ sec. 22, 63-17.

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*In a basal section this white feldspar shows fine, long twinning striations on the albite plan, alternating with broad ones. Extinction on the broad bands is 2 degrees, which indicates oligoclase or andesine. Applying the law of Schuster this extinction is found to lie in the large angle and is therefore positive, and the feldspar is hence oligoclase, for andesine in such a section has negative extinction.

1999. Light-colored gneiss underlying 1998; dense, fine-grained, siliceous, varying from white to gray. Its structure is rudely conformable with that of the dark gneiss which overlies. It has some inclusions of dark schist or gneiss, and these are sometimes in the form of long laminations, agreeing in direction with those of the dark gneiss. This agreement is invariable but the parts or "inclusions" are sometimes not very long. When the dark parts are wanting there is still an internal gneissic variation which is apparent on the weathered surfaces. In this lighter gneiss the segregated pegmatyte is abundant, and is uniformly of coarse grain. There are parts in this lighter gneiss—not inclusions—that are as dark as some of the dark bands in the dark gneiss, but the general tone is as nearly white as the white granitic bands in the schist or in the dark gneiss. These two rocks closely approach granite, but they are evidently only conditions of the same rock mass as in other places further east where it is plainly a mica schist. Throughout both the dark and the light gneiss is evidence of great pressure and dynamic metamorphism. The structure in both is much curved, and often faulted. Long sweeps of these curves maintain a parallelism between the light and the dark gneiss. It is apparent that the original formation differed in acidity in parallel belts, and gave rise, on complete crystallization, in some belts to a lighter colored rock than in others, although the structure is frequently broken, and the light colored rock in some such conditions passes across the structure of the darker gneiss, introducing what might be called an irruptive contact. There are also faults, where the movement was a transverse thrust, while it must be admitted that, in this nearness to the central point of greatest activity, a certain degree of plasticity pervaded the whole. This plasticity, in the presence of such pressure and such intense chemical action, probably accounts for all the appearances of non-conformity and of intrusive relations, the one on the other, which these two gneisses exhibit.

If, on the other hand, one were disposed to ignore the general ensemble, and the associated phenomena indicating a derivation from clastic strata, such as already mentioned, and should accept the occasional minor irregularities of the plane of separation between these rocks as proofs of the "igneous" origin of one or the other, he could be easily convinced that the lower, or light, gneiss is intrusive and igneous, and that the over-lying gneiss was the original clastic, intruded by the light gneiss. The relations would be such as have been fully discussed by Dr. A. C. Lawson, and illustrated by him in the Rainy lake region, where it is plain that a granite in great areas, of later date than the schists, both swells up under the schists and pierces them in the form of dikes. But it is more reasonable to consider the inclusions, indistinct as they are, as mainly conformable remnants of the original schists, they are so long and thin and coincident in dip and direction. If they be real inclusions from the upper gneiss, it is still not incompatible with the supposed original clastic nature of both rocks, that under such movements as they both have incontestably been through, when plastic, or even quite mobile, parts of one should be mingled with the other. As to the difference of mineralogical composition, that is what is to be expected from a continuation of the process which began in the schists, themselves of varying acidity, where many segregations of granite, and a general conversion to gneiss have already been noted. That one part of the schists, when not much moved from its birth-place, should display after crystallization, or even after a period of plasticity, a greater acidity, as here indicated by the lighter color, than another immediately adjacent, is what is to be expected as almost inevitable if the schist was originally of fragmental origin, and such variations in the mica schist of the northwestern part of Vermilion lake are very common.

At a point further west, along the north shore of this bay, the schists are tilted higher and more gneissic. Here, however, is a quantity of more basic rock which existed in the schists before the general granitic upheaval, which is now permeated with acid veins and "dikes." The gneiss here is reddish, with some darker inter-laminations. The strike of the structure from here, if no irregularity supervene, would carry this rock below the light gneiss of 1999, but the interval is hid. This is apparently the last exposure of rock on the north shore of this bay, and is just at the east of a little creek which enters the bay from the north.

On the other side of the bay and westward are outcrops and knobs only of light colored, massive granite, evidently crystallized from a molten condition.* From the nature of the pegmatyte veins in the schists of the region, it may be inferred that this granite will show in thin section the two feldspars orthoclase and oligoclase in predominating amounts.

*The reader may consult, for a preliminary statement of some of the phenomena above mentioned, a paper by the writer in the American Geologist for July, 1897, Vol. XX. pp. 41–48.

2000. A dike of a much more recent diabase, 8 in. wide cuts the granite, running W NW, on the point SE¼, sec. 23, T. 63-18, six miles west of the foregoing observations.

A re-examination was also made of the relations between the mica schist, the gneiss and the granite in secs. 13 and 14, T. 63-18, where some interesting observations were reported in the 15th annual report (pp. 295 and 296), made in 1886. Those descriptions record a conformable transition from mica schist through gneiss to granite. But in the late review, while on one side was found a granite which becomes gneissic, and on the other a mica schist which changes slowly to a gneiss, there was also found a line of separation between these two general divisions, which could be traced plainly along the bluff, diverging slowly from the lake shore toward the west. The general situation is illustrated by the following sketch, fig. 1.


FIGURE 1. RELATION OF GRANITE AND GRANITE-GNEISS ON GNEISS AND MICA SCHIST.

(1) is a confused gneiss, with considerable greenish, schistose rock, apparently hornblendic, with a general elongation coincident with the structure of the country. As gneiss it is reddish, with marked micaceous inter-laminations, and is strongly feldspathic. It is evidently a part of the gneiss-mica-schist formation of the region. The contact line is seen to cut off obliquely the gneissic structure at a point near the western extension, but not so generally as the sketch shows.

(2) is a reddish and gray granite, less interrupted by mica schist, and less evidently a rock formed from the schists *in situ*.

(3). The area represented by (3) iscompound of a schistose-gneiss, very firm, running in the same direction as (1) and (2), and its relation to (2) is not ascertainable, but as it differs but little from (2), at least some parts of (2), it is reasonable to infer that it is a condition of (2). It also has more massive granitic rock in non-conformable contact along the southern side. The lake shore is high and precipitous at (1) and eastward and westward from there, rising abruptly from 40 to 50 feet. At (3) the rock rises abruptly to about 100 feet above the water.

No. (2), and also probably No. (3), have been nearly or quite molten, although they have a great resemblance, in mineralogic composition, to No. (1); and exhibit an "igneous" contact, i. e. a non-formable plane of union with No. (1). No. (1) on the other hand, seems to have taken on a crystalline structure *in situ*. It is highly probable that Nos. (1), (2) and (3) are essentially the same rock, and an analysis would not show a marked difference of composition, the igneous contact plane being the result of deep-seated movements when the whole was more or less plastic, No. (1) having maintained its original position more nearly than No. (2). The greater the displacement of the molten parts from their original positions, the greater the probability of contrasting chemical compositions. There is a segregation of pegmatitic veins in No. (1) as well as No. (2), some of these deposits being in isolated masses.

Where the small later diabase dike runs down toward the lake the granite and gneiss seem to blend. Well within the granite mass are remaining some bands of micaceous rock, and an evident gneissic structure pervades quite an area. It is true that this gneissic rock is cut off along one side by non-gneissic, but upwardly it passes gradually, so far as can be determined, into a rock that cannot be distinguished from the truly igneous rock. Indeed, here can be seen, on close inspection, the same gneissic structure pervading the granite as already noted at secs. 23 and 22 in T. 63-17, and the phenomena on a smaller scale are substantially all repeated here.

2001. From the central part of the later diabase dike, above mentioned.

2002. The same near the contact; the contact side of the specimen is shown by a yellowish film.

2003. Granite, from the eruptive facies, as above, but somewhat schistose.

Two other recent diabase dikes were noted crossing this granitic rock at this place, one 15 feet wide and the other 10 feet. These also run in a N NE direction, and sometimes include masses of granite from the country rock. They are cross-columnar, and finer at the contact sides, facts which indicate that the granite was cold when they entered it. They may date from the Keweenawan.

2004. Diabase from a dike 15 feet wide. On passing westward from the above to the point marked (3) in fig. 1, there can be seen, as at (1) and (2), a massive granite underlying a gneiss and mica schist, with irregularities of contact, the granite rising to the summit of the hill. Along the crest of the hill the line of contact is abrupt and distinct.

Still farther west the granite runs inland toward the west and the schist is in contact with the lake. This granitic mass has all the features of an intrusive rock, and as such it would not be suspected of having any genetic relation with the schists.

So far as seen along section 14, 63–18, the intrusive contacts of the granite on the gneiss prevail, the gneissic structure being cut off by sudden transition to non-gneissic, the separation line being tolerably straight and running about east and west. There is, however, within the supposed eruptive rock, and not at the contact, a gneissic structure, and even bands of mica schist, probably remnants of the original schist. This resembles closely the remnants of the schistose structure, seen in the gneiss of sec. 22, T. 63–17. Still there is a long distance, especially west of the bay at (3), where the contact between massive rock and schists is distinct and the transition abrupt like an igneous contact. This is visible along the tops of the hills and descends at one point toward the lake.

2005. Gray gneiss, NE¼ sec. 13, 63–18, on the hill nearly opposite the two small islands, 75 feet above the water of the lake.

At this place there is a great amount of gray, micaceous gneiss, confused by many infiltrations of granite and by interlaminations of quartz and feldspathic veins. Some of the segregated parts are hornblendic. Occasionally large dark spots or strata are seen. These are porphyritic with hornblende. Some of these appear like inclusions of basic rock which originally was a part of the mica-schist formation, but some are more like segregations *in situ*, since it occasionally happens that a hornblendic periphery surrounds a segregated quartz nodule, the two evidently being due to the same force, viz., chemical regeneration. Hornblende seems also to be not uncommon elsewhere in this gneiss.

The whole rock shows many short crumplings and fractures. Sometimes a layer or vein of light-colored material is bent back and forth upon itself in the midst of the darker rock, and its serpentine outline is distinct on the weathered surface. It is sometimes difficult, even impossible, to decide to what cause, and to what epoch in the dynamical history of the rock such serpentine banding can be assigned, especially since the present schistose structure is in entire non-agreement with it.

2006. Dark hornblendic rock, as above, associated with 2005.

This gray gneiss apparently is a portion of the mica-schist formation, and although it is very like some parts of the Archean which have been pronounced of igneous origin, and was so considered by the writer in 1886 on the occasion of the first visit here, it is probable that the rock as a whole has not been molten so as to flow freely, but only plastic, and for that reason its original structures and its heterogeneity have not been destroyed entirely. It is not granite, and its gneissic structure cannot be considered a secondary structure produced in granite or in any other eruptive rock. It shows a repetition of the characters of the gneissic rock described already on sec. 22, T. 63-17.

2007. From a narrow dike of granite (2-4 inches) cutting this gray gneiss, NE¼, sec. 13, 63-18.

2008. Coarse hornblendic rock, apparently after pyroxene; from boulders, some of which are very large.

Passing along this coast westward one can see the transition mentioned in the 15th report. It is from mica schist to gneiss (a gray gneiss), but it is not carried distinctly to granite. But the granite as granite, seen here, always makes an igneous and abrupt contact on this gneiss. There are, however, places where great confusion prevails, and the granite approaches gneiss in character, and at the same time some dikes from the granite enter the schist, and schist, or gneiss, is included in the granite. About the same place large knobs of granite, apparently segregations, are developed in the schist.

2009 represents such granite.

When, near the same place, the true irruptive granite is permeated by pegmatitic granite, the transition is so general and so indistinct, that the writer described it as a passage from the mica schist to granite, through gneiss. The transition, however, so far as revealed here, is only to a gray gneiss. The next step is an unconformable contact on a massive granite, and such contact can be traced along for some distance, the two rocks only differing, so far as can be seen, in their structures. It is not possible, therefore, notwithstanding some confusion and local blending, to affirm here a graduation from mica schist to granite, however reasonable and even probable it may be from a theoretical standpoint. Indeed, such transition, from the nature of the case, must be very rare, since, once fused and rendered mobile, the softened portion of the mass would at once shift its place under the pressures of the crust, and would form abrupt contacts on the firmer portions.

There is hence lacking an observation on a continued transition from the mica schist to the granite, uniting the two gneisses, viz.:

(a). That gneiss which is native to the mica schists, and

(b). That which is in the granite.

If (b) be a result of contacting on the schists, or a development from shearing, it is a secondary structure, and no such transition can be expected to be found. If it be an original condition in the granite, due to a remnant of the sedimentary structure, and really preceded the massive condition, being lost in general by fusion and flowage, such transition ought to exist in some places and may be found. There is no difficulty in uniting, in places, the mica schist with gneiss in conformable gradation, nor is there any difficulty, in other places, in tracing a gneiss into a granite and back again. The difficulty consists in showing that these two gneissic rocks are the same in origin. All the surroundings, whether structural or mineralogical, point theoretically to such identity, and it is but following the guide of such indications to assume it actually exists. It is only because of the time-worn notion that an igneous rock is necessarily of deep seated source, that a conservative regard for tradition demands actual demonstrations before such notion can be effectively set aside.

*The Conglomerate of Stuntz Island.*

It was for the purpose of reviewing the theory lately advanced by Smyth and Finlay as to the nature of this rock and its origin* that a short re-examination was made of some of the phenomena on the south shore of Vermilion lake. It was found that there are serious and far-reaching errors in the observations no less than in the conclusions of these geologists, which wholly vitiate and negative the theory put forth by them as to the origin of this rock and as to the structure of the region.

Without here entering into a thorough examination of their paper, nor into an exhaustive presentation of the facts pertaining to this horizon, and especially to this part of this con-

*Trans. Am. Inst. Min. Eng., Oct. 1895.

glomerate, the following will mention a few facts wholly inconsistent with the brecciation idea of these authors. The examination began on the small island off the coast at the east side of sec. 20, 62-15.

(1). Two pebbles in immediate contact show the following difference:

2010. Very fine and siliceous quartz porphyry.

2011. Granular and coarse rock, either more crystalline or more coarsely fragmental. To fully distinguish these a microscopical examination would be of use.

(2). The conglomerate embraces jaspilyte pieces, and fragments of graywacke. One large graywacke piece is near the water on the southeastern side of the island.

2012. Quartz porphyry from the extremity of the point nearest the island. It is a very different rock from 2011 and 2010, and being not far separated from the place of origin of those, it is hard to suppose a rock originally massive and homogeneous, as supposed by Smyth and Finlay, could vary so much in so short a distance.

On the point, in sec. 20, the bulk of the rock is like 2012, but a little further west it is more pebbly, and shows the contrasts presented by

2013, coarse grained, and

2014, fine grained,

Which were taken from contacting pebbles, one about fifteen inches in longer diameter and the other about ten inches. There are many pebbles thus contrasted on this surface, many of them two inches and four inches in diameter, rounded and perfectly distinct. How could a quartz porphyry change its character thus?

(3). Further south, on this point, on a broad dome of the slates, can be seen a conglomeratic band about one foot wide, crossing the slates (the slates are more like graywackes here) the pebbles in which are like the quartz porphyry of the point's extremity. This band is not a dyke, but it has indistinct boundaries, and really fades out into the adjoining graywackes. It runs straight, the rocks here not showing any crumbling. It is evidently a clastic, and conformable with the slates.

2015. Chips from pebbles in this band.

2016. Pieces of the graywacke from the adjacent country, not in contact. These may be compared not only with the pebbles of the conglomerate band, but with pebbles 2013.

2017. Pebbles from the supposed sheared quartz porphyry —larger one—differing from the next.

2018. Pebbles from the same place as 2017, on the same point.

2018½. Large slab from the beach, showing a large variety of pebbles.

In the same place are many pebbles of jaspilyte, all nearly white. All the pebbles here are well rounded, and small, averaging about 1½ inch but rising also to 6 inches. This is near the lake on the east side of the point, not far from the head of the small bay. It is perhaps 30 ft. distant from the nearest known jaspilyte. Could such rounding of a multitude of jaspilyte pebbles be attributed to contact and shearing in an adjoining massive quartz porphyry? The jasper pebbles are more angular than the quartz porphyry pebbles, and occasionally one is quite angular, standing in the rock transverse to the prevalent structure.

2019. Near the lake on the east side; pebbles in contact, showing remarkable differences; one lot (a) are coarse and specked by white feldspar in a greenish matrix, and another (b) are very fine-grained.

(4). There is a sedimentary succession in the conglomerate, becoming finer at increasing distance from the rock on which it lies unconformably. The rocky strata dip south, away from the outcropping jaspilyte. This section is visible along the shore on the east side of the same little bay which indents the point on sec. 20, 62-15.

The actual contact of the basal conglomerate on the jaspilyte was invisible through an interval of about ten feet. Toward the contact with the jaspilyte the jaspilyte pebbles increase in amount until they make four-fifths, or even in some places nine-tenths of the conglomerate mass. They are distributed through a horizontal thickness of at least 100 feet (33 paces), in the conglomerate, and the "quartz porphyry" is as a matrix holding them. This gradation from very abundant to less abundant indicates strongly that the jaspilyte pebbles have their source from the jaspilyte bosses, either in the manner of a conglomeratic accumulation or by reason of igneous intrusion and abrasion. Messrs. Smyth and Finlay favor the igneous abrasion theory, but the chief difficulty, at this point, is the great superabundance of the jaspilyte over the other pebbles, and the great thickness of conglomerate through which this superabundance extends. How could one-tenth, or even one-fourth, tear off and surround and transport the nine-tenths, or the remaining three-fourths, so as to make a rock of such proportions composed of such fragments?

In regular succession, southward from this basal conglomerate, and overlying it, is the following ascending sedimentary series.

2020. Quartzyte, quite fine-grained. It is coarser toward the south, and its finer parts appear as sheets adhering on the southerly slope of the conglomerate.

2021. The same quartzyte at 10 feet from the conglomerate. Nos. 2020 and 2021 are together about 20 feet thick.

2022. Contains some pieces or pebbles from a quartz porphyry, or a rock resembling it, which weather white, in contrast with the rest of the rock, which is green. It is slightly fibrous, and were it not for its position and composition, it might be likened to an old greenstone dike, sheared, like those cutting Stuntz island. It is about 2 ft. thick. It shades into rock 2023 which is similar, but darker, and has pyrite crystals, and which is argillitic, 10 ft. thick. Above this is rock 2024, a harsh quartzyte with small pieces of what appears to be siliceous black slate, in general much like the quartzyte (2021) which lies on the conglomerate. After an exposed thickness of perhaps 40 feet this rock dips below the swamp toward the south and the section ceases.

This observed section, with conspicuous stratigraphic alternations, cannot be explained on the brecciation theory, and is referable to sedimentary action.

Beyond No. 2024, across a narrow swamp, rises the main (E-W) topographic axis of this point, and if there be no irregularity the great graywacke series at that place overlies No. 2024. This takes in argillytes and slates. Beyond that, still further south, are low jaspilyte ridges, and after one or two valleys the "north ridge" rises to view.

The map of Smyth and Finlay, of this point, might be corrected by extending the jaspilyte widely over the areas left white. It is apparent that the jaspilyte is in outcrop all about the western part of the conglomerate, running below the conglomerate.

Across the little bay, still on sec. 20, where Smyth and Finlay mention "granite porphyry," is an alternating series of graywackes and fine graywackes, or slates, dipping NE at an angle of about 30°. This alternation and dip are seen in the face of a vertical cliff looking west, about twelve rods from the extremity of the point. The NE dip is accompanied by small sinuosities and anticlinals whose axes run NE. Some of the beds are two feet or more in thickness, but the slaty beds are irregular in their alternation, and owing to intermittances in deposition, or to folding and squeezing, they are not entirely uniform in thickness. But that they illustrate the sedimentation of the rock series seems necessary to admit.

The curious supposition of Messrs. Smyth and Finlay that at this place laccoliths of "quartz-porphyry" cut off the bedding of the older formation seems not to apply. Whatever "quartz-porphyry" there may have been seen here is probably of the nature of a fragmental graywacke deposited non-conformably on large masses of the older fragmentals. After glaciation not only do the sedimentary alternations appear on the glaciated knob, but the non-conformable contacts are evident. There may have been also a large amount of fracturing and faulting, followed by compression, and that, even without a non-conformity of sedimentation, would account for the irregularity in the stratification. These graywackes are probably the same as those forming the main ridge on the point further southwest.

2025. Shows the manner of contact of the black slate and graywacke at this place, where there are numerous alternations, the width varying from two inches to one foot. The bands here run east and west. This is a little southwest from the cliff mentioned.

On Stuntz island, at the east end, the coarsest parts are toward the south, and if that indicates the direction of source of the materials they must have come from the direction of the mines. The same is true of the point next west of Stuntz island. The southwest end of the island, however, is of slate, etc.

2026. Fine-grained pebble from the conglomerate on Stuntz island.

2027. Coarse-grained pebble, lying in contact with the last. There are a great many instances of pebbles in contact in the rock, both of quartz and porphyry, but of contrasting lithology.

On Stuntz island there are large areas where the rock is coarse, like a coarse graywack, but only sparsely sprinkled with pebbles. Why should such a structure be formed if the rock resulted from shearing of a quartz porphyry? How could the rock *en masse* be sheared to a granular rock, according to the theory proposed, leaving rounded pebbles differing in grain and color from the mass, and also contrasting with each other? If the rock be, instead, of the nature of a graywacke accumulation such contrasts of kind, and variations of size, are to be expected.

2028. Fine-grained siliceous graywacke. At the boat landing at the south side of Stuntz island, the conglomerate is suddenly replaced by a very fine graywacke, appearing it is true, outwardly like a quartz porphyry, which, though sheared, is not composed of pebbles. The transition from a rock composed almost exclusively of pebbles from one inch to three inches in diameter to this fine graywacke, is perfectly abrupt, but like a sedimentary transition. There are almost no visible pebbles in this fine graywacke for a thickness of about 20 feet. Then, next further south it is finely granular with pebbles as large as peas, through a thickness of about two feet. Then for 15 ft. it is very fine again with occasionally a pebbly form. Then comes a six-inch bed of grit, with a few pebbles reaching three-fourths of an inch, but mainly as large as a pin's head, then fine graywacke becoming coarse graywacke, and finally conglomerate, 30 feet to the water. In this last coarse grit rock are some curious pebbles, unlike any seen before in this formation. They cannot be extracted, being very fine-grained and rather soft. They are grayish green and olive, weathering away so as to give depressions in the surface of the rock. They are in immediate juxtaposition to and contrast with some very hard pebbles of quartz porphyry which have perfectly rounded outlines and stand out above the weathering surface, owing to their greater endurance. Whence this contrast if the rock comes from the brecciation of a homogeneous quartz-porphyry? The rock containing these contrasting pebbles is a coarse gritty graywacke, with only scattering pebbles, none of which are like itself.

2029. Shows one of these soft pebbles weathered out on the surface and depressed below the siliceous grit in which it lies.

We visited two islands north of Stuntz island, and then Ely island, and went to the top of the last and walked along on the crest westward about half a mile. In it all we found only the conglomerate and its variations to coarse graywacke, except that at about north from the island in SE¼, NE¼, sec. 20, we noted a very fine-grained condition of the graywacke, approaching slate, respresented by

2030, a fine-grained graywacke or slate which stands in coarse sheets directly at the shore, the structure running E and W—same direction as that of the conglomerate. There is a suggestion of a bedded structure, coincident with the coarse slates.

From this review we* came unanimously to the conclusion that this rock cannot result from the shearing of a quartz porphyry eruptive. It was a conglomerate before the shearing took place, and in some places it is passing to a coarse sericitic schist, pebbles and all, by reason of that shearing.

Without attempting here to arrange the evidence it may be said that the main considerations are involved in the section presented on a former page. In the main there were but two kinds of rock supplied, quartz-porphyry and jaspilyte, and they must have come from the near vicinity. There were probably dikes of quartz porphyry that cut the older formation, and it is probable that Messrs. Smyth and Finlay have described such in some places, particularly in the region lying east of Stuntz island—the "burnt forties," a spot which we did not examine. Besides the sedimentary structure and the fragmental nature of all the formation, the immediate contact of phases of quartz-porphyry in the form of pebbles which are quite unlike, seems to be fatal to the hypothesis of Messrs. Smyth and Finlay.

A short re-examination was also made of the outcrop of rock on Hoodoo point, not far north of the boat house. This is near where the survey camp was located for nearly a month in 1886. This rock is noted by Smyth and Finlay as a conglomeratic condition of graywacke—as coarse sediments as they found, in which designation there was concordance by all our party. The occasional coarser pebbles, distributed through the rock, are, however, a feature not uncommon in the graywacke of the region, and it is difficult to understand why there should be a different origin assigned to this rock.

### *The Contact of the Saganaga Granite on the Ogishke Conglomerate.*

Our party then started, by the usual canoe route, to make an examination of the Saganaga granite and of its relation to the conglomerate with which it is in contact. This was at the instance of Dr. Grant who was not satisfied with the descriptions that had been made, whether by others or by himself.

The rock at the narrows of Knife lake, Sec. 14, T. 65-7, is

*With the writer were Messrs. Grant, Elftman and Bain.

the same that has been noted widely about Knife lake by the parties of the survey, and prevails westward from the narrows, especially along the west side of the lake. It is a flinty rock that weathers to a light color, and is represented by rock No. 1107 obtained in 1886 at the portage landing coming from Doughnut lake, and from Kekequabic lake. It is apparently like some flint that appears in the slates of the Animikie on Gunflint lake, although the formation here is supposed to be the Keewatin (Upper Keewatin). It is perhaps like some flint that Arch. Geikie describes in the Lower Cambrian at St. David's and ascribes to tuffaceous origin. It here has a close connection with the greenish schist seen on the portage trail north from Kekequabic lake and on the north shores of that lake which have been shown by Grant to be of tuffaceous character and origin. It seems to be in keeping with all that we know of this rock and its stratigraphic relations to call it tuffaceous in its origin, and to leave it in the Keewatin. It varies to a sort of slate, and has a sedimentary structure.

2030½. Green, coarse graywacke, constituting the ridge over which the trail passes from Otter Track lake to Oak lake, and preventing Hunter's "island" from being in fact an island. It is apparantly only a variation of the rock that forms the shores of Knife and Otter Track lakes, and yet it is not the same as much of the graywack seen about Tower. Its green color indicates the presence of much material of eruptive and diabasic character, but the rock also shows numerous subrounded grains of quartz as large as pinheads. The rock might be designated *greenwacke,* to distinguish it from the more siliceous of the graywackes. It is apparently a rock that would also fall into Wadsworth's group of porodyte.

2031. Coarser-grained portion.

2032. Finer-grained portion.

The above rocks are from Oak portage, NE ¼, sec. 24, 66-6. Ordinarily one would take the rock at this portage for granite, and it has been so classed by all geologists who have noted it.* It is light-colored and granular, but varies, in a coarse and not very evident alternation, from coarse to fine. It is greenish gray and gray, the green color prevailing in the fine parts. The strike of the structure which may be due to sedimentation is

*A. Winchell noted the fragmental character of the rock at Oak portage. He failed however, to make distinction between it and the massive granite of the region, and supposed the latter was a hardened condition of the former. Sixteenth annual report pp. 213, 214. The fragmental quartzes of the recomposed granite he confounded with the original quartzes of the massive granite.

about W NW, in harmony with the structure which is seen on the south shore of Oak lake. In some places a thin, even slaty structure is evinced in the fine-grained parts; and on making search farther north about two rods there is an appearance of fragments of the fine in the coarse.

2033 represents the rock thus included in the granite (?).

2034. At 15 rods east of Oak portage, on the Canadian side of Saganaga lake, a light-colored, feldspathic rock with quartzes, perhaps fragmental, but it can hardly be distinguished from a massive crystalline granite. It lacks, however, the dark elements of granite, and is not fresh and sharp. It shows pyrites and muscovite.

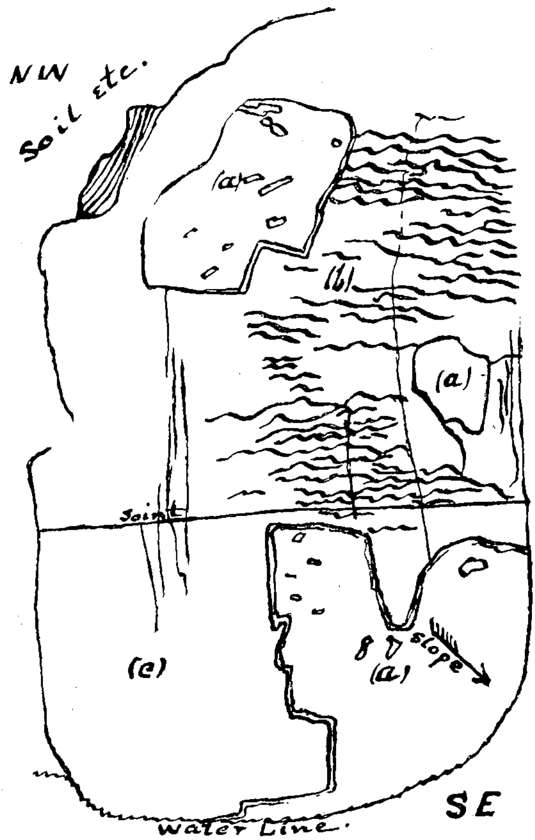


FIG. 2. WAVE MARKS IN RECOMPOSED GRANITE NEAR OAK PORTAGE, SAGANAGA LAKE.

At a point about 20 rods east of Oak portage, on the Canadian side of Saganaga lake, is a curiously marked surface of this supposed "granite," a structure which is quite unlike any ever seen in any granite in the state, and apparently inconsistent with the presumed massive nature of this rock. It is visible at the water. It is apparently ripple-marked; this curious surface, sloping under the water, is about 4 ft.x10 ft., and is represented by Fig. 2.

The ripple-marked surface (b) runs under a thin scale or sheet (a), about 2 inches thick composed of a breccia or breccia-conglomerate, the coarser pieces being angular and embraced in a finer debris.

2035 represents the finer debris of this layer, evidently a granitic debris.

2036 represents one of the hard pebbles (more rounded than usual) also embraced in layer (a), and some angular pieces.

The supposed ripple-marked layer itself is a mere scale, and separates from the rest of the rock. Indeed its ripple-marked character is not preserved over the surface (c), but a shaly thin-sheeted rock there takes its place. The rock immediately below these thin scales, and that also above the conglomerate layer (a) is undistinguishable from the rock of the country.

2037. Rock below the supposed ripple-marks.

That which is above the conglomerate only appears under water, but the superposition is evident, the water being clear and quiet.

The surface bearing this marking slopes ESE. The ripples are about two inches across.

2038. Coarse debris of granite, shore of Oak lake, Canadian side of the portage, at about 200 paces from the portage. This is in the midst of the rock called "granite" in this region.

It is apparent, from the foregoing facts, that there is a great thickness of "recomposed" granite in this region. The rounded quartz pebbles are sometimes three-quarters of an inch across, and their exterior is coated with a finer debris more or less stained by iron oxide.

2039. Same as the last, but farther east and coarser, and more quartz-ose: at one-fourth mile east of the portage.

2040. From contact layer underlying 2038.

2041. A finer condition found near the place of 2038.

It seems to be a proved fact that this rock here is fragmental, and has a remarkable thickness for rock of that origin. It remains to find its relation to the true eruptive granite, on one side, and to the Archean greenstone and agglomerate, and the slates associated, on the other. All the signs, that can be found, of bedding, make this rock dip 80° SSW, but that is not in accord with the slope of the ripple-marked surface which is on a mass certainly *in situ*, as the same rock mass extends under the lake some distance.

2042. Rounded pebbles picked from this rock at the same place as 2039 and 2040.

From the portage landing on Saganaga lake (as above), passing to the United States side of the little bay in sec. 24, we found a grayish rock, which, were it somewhat coarser and gray in color, would be a graywacke of not uncommon character. This is inter-bedded, or at least is overlain on the upper side, conformably by a gray, fine-grained rock which differs not, apparently, from the rock 2021 which overlies the Stuntz conglomerate at Vermilion lake. It is noticeable also that this rock weathers peculiarly. Besides being more ready to rot and to disintegrate than granite, its own color (light greenish-gray), within is first deeply changed to a light yellowish gray, and at the very surface it is often brown with iron rust to the depth of half an inch. This fine-grained rock, which is in contact conformably with this recomposed granite, is a hard siliceous rock which extends north and south for some distance. There is a similar rock in conspicuous outcrop on Oak lake, in the direction in which this extends.

2043. At a short distance further south, SE¼ sec. 24, 66-6, at a point a little north of the entrance of the stream from the south, is an interesting inter-stratification of this recomposed granite with a fine, hard, purple slate, the latter represented by 2043. The "granite," in beds varying from 15 feet downward, is interstratified in the slates in true sedimentary fashion. If it were to be metamorphosed it would present the characters of many outcrops of the mica schists and gneissic mica schists which are to be seen about the northern confines of Vermilion lake, in which it has been presumed by some geologists that intrusive granite has entered between the original bedding planes of the schist. This observation seems to settle one of the questions that remained to answer.

We now cross this peninsula eastward, or northeastward, perpendicular to the strike, with a view to ascertaining the extent of this recomposed granite or graywacke, by coming upon the underlying formation.

2044. NE¼, SW¼, sec. 19, 66-5. Here is a ridge of Saganaga granite, represented by the rock of this number, in two phases. This differs from the recomposed granite in the possession of some of the dark minerals, hornblende, etc., which seem to have been lost in the process of disintegration and reconsolidation, and do not appear in the recomposed rock. In this original granite they are much decayed and turned to chlorite, but still it is plain that this rock is in its original structural condition. The contact of this on the recomposed rock is hard to find, owing to the covering of bushes and debris. The large quartzes of the original granite have gone into the other as clastic grains.

In returning to the shore we succeeded in tracing these two rocks into near contact, the interval unseen being 10 feet. The distinction between them is the presence or absence of the green mineral.

2045. At another point, seen only by Mr. Elftman, the rock below the fragmental series is represented by this number, which seems to show the ferro-magnesian mineral altered uniformly to a straw-yellow, somewhat resembling clinochlore.

It seems, therefore, that the recomposed granite grades almost insensibly into the original. It must be, therefore, that the original rock suffered profound decay, and that much of the decayed rock was not removed from its place. The abrasion and the transportation must at first have been very gentle. This decayed part of the original granite was gently covered by other debris of the same granite, and on consolidation the line of separation between them is hard to find.

The other side of this bay is occupied by graywacke and slates beautifully planed off showing the strike and dip as already noted.

2046. Fluor granite, from Fluor island in Saganaga lake, near the center of sec. 14, T. 66-5, on the east side of the island, and south of the large quartz vein. Blue fluorite is disseminated more or less in most of the granite, which is red, some of the cubes being half an inch in dimension. The cubic form does not, however, generally appear.

Following the lead of Grant we come to NW¼ SE¼ sec. 7, T. 65-5, where he described the contact of the conglomerate and the Saganaga granite (or syenite), considering the granite intrusive in the conglomerate (20th report, p. 84). It was because of the microscopic characters of the specimen (No. 322) collected at Oak portage by the writer in 1878, (9th report, p. 85) that it appeared to him that some of the supposed "granite" is not granite at all, but a debris from the granite, making a sort of arkose. The conglomerate here is plainly the Ogishke conglomerate. It contains numerous large boulders of the granite, and these are more and more numerous, even touching each other, at the exact contact.

At the same time that this is the Ogishke, it is also plainly the same pebbly re-composed granite seen at Oak portage and southward and eastward from there, but rendered green by mixture of debris from adjoining greenstone hills. The Ogishke is therefore later than and non-conformable on both granite and greenstone. The granite is, however, later than the greenstone since dikes of granite cut the earlier greenstones (20th report, p. 83). The greenstone (or the Kawishiwin) is therefore the oldest rock in this part of the state.

NW¼, NE¼, sec. 17, T. 65-5. On a high greenstone shore of West Seagull lake, the greenstone is cut by two systems of granite dikes, one of which at least is referable to the Saganaga granite. The manner of intrusion is in zigzag, sometimes narrow but occasionally 20 feet wide dikes. The larger, irregular bosses, surrounded on all sides by greenstone, seem to closely resemble the same features of the granite which intrudes in the mica schist in the NW part of Vermilion lake. There are not, here, any late diabase dikes, but such exist, cutting the granite, about the shores of this lake. The greenstone is of the same irregular structure as that seen on the southeast side of Gobemichigamog lake, and on Twin mountains. It is sometimes rudely stratified over small spaces, and has lenticular bands or bunches of finer-grained greenstone. It is debris from this greenstone which colors the conglomerate of the region and which, at Ogishke Muncie lake, has furnished boulder masses to the conglomerate.

2048. Proceeding to Gunflint lake, through Red Rock and Saganaga lakes, samples were procured of the chalcedonic silica on which was based the paper of H. V. Winchell, "Geological age of the Saganaga syenite," published in the American Journal of Science.*

2049. Also of a vitreous or vein silica at the same place, distant about 20 feet from the chalcedonic silica, indicating different methods of origin of silica (and perhaps different dates), in the same rock.

2050. Granite in which these two forms of silica are embraced.

*Op. cit. Vol. XLI, May, 1891.

*The Gabbro and the Sills of the Animikie.*

Some re-examination was made in 1896 of the Animikie in the vicinity of Gunflint lake and southeastward for the purpose of ascertaining, if possible, the relation of the sills to the great gabbro mass which come very near together at Loon lake which lies next south of Gunflint lake. It is the published opinion of Dr. A. C. Lawson* that the sills are of comparatively late date, later than the Keweenawan and perhaps later than the Trenton. Prof. Irving considered the sills as surface flows contemporary with the Animikie, in accord with the Canadian Geological survey, and with the early reports of the Minnesota Survey. At the same time Dr. Lawson put the gabbro in the Archean and Irving put it at the bottom of the Keweenawan, later than the Animikie and hence later than the sills of the Animikie which he considered cotemporary surface eruptives. The writer put the gabbro at one time at or near the base of the Animike, owing to the discovery of gabbro sills in the supposed basal quartzyte of the Animikie, such sills then being considered, without exception, so far as their views had been published, by all geologists, as of the same character as the trap flows of the Keweenawan, which are surface rocks cotemporary with the fragmentals with which they are found. There was discovered, however, not long afterwards, sufficient reason to abandon that view and to fix the gabbro at a date later than the Animikie but earlier than the bottom of the Keweenawan, the bottom of the Keweenawan being a sandstone or quartzyte, or often a great conglomerate.† According to that view the gabbro disturbance could be taken as the closing event of the Animikie, and with this the metamorphic and broken condition of the Animikie, and the formation of the "red-rock," as at Wauswaugoning bay and at Duluth, from the fusion of the Animikie strata, is in perfect harmony, in all their phenomena, so far as known. There is no known instance in Minnesota of "red-rock" later than the gabbro disturbance, except in the form of pebbles or debris from the Animikie. It would not be impossible, however, and perhaps not improbable that the later igneous disturbances of the Keweenawan operated on the clastics in a similar manner and generated the same kind of acid eruptive. The only *a priori* objection to such a hypothesis consists in the

*Bulletin VIII., of the Minnesota Survey.

†Crucial points in the geology of the Lake Superior Region. *American Geologist*, Vol. XVI, p. 150. A rational view of the Keweenawan.

proportionately feebler action of the Keweenawan, and the more free escape which the molten basic magmas had to the surface. Such free escape precluded the formation of laceoliths and sills, or the deep seated accumulation of larger reservoirs from which sufficient heat could have been generated to effect the fusion of the surrounding clastics. Hence, while it is not impossible that some of the "red-rock" of the state may be of Keweenawan eruptive age, there is no known instance of it, but all the red-rock, so far as examined into sufficiently, can be certainly, or at least presumptively, assigned to the date of the gabbro and the accompanying surface flows. Such surface flows, dating from the gabbro revolution, are hence stratigraphically older than the quartzyte and conglomerate that constitute the base of the Keweenawan.*

From the narrows at the outlet of Gunflint lake we passed westward to the high hill and to the breccia in SE¼, sec. 24, 65-4, the latter being exposed near the railroad, on the south side, and the hill being on the north side. The strata dip toward the south, as shown in the figure below. The high hill

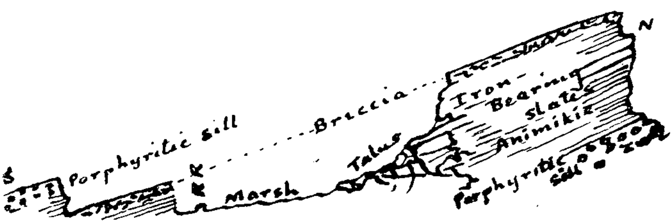


FIG. 3. PORTION OF THE ANIMIKIE, CONTAINING IRON AND INTERLEAVED WITH DIABASE SILLS.

is composed essentially of the iron-bearing member of the Animikie, with a sill of curiously porphyritic diabase (with the so-called huronite) beneath it. Toward the top, and forming a portion of the summit (Elftman), is a breccia of the iron-bearing beds. The breccia is seen near the railroad track (No. 1897) at a lower level, and there it is also underlain by unbrecciated slates, etc. It is from five to six feet thick, and is composed of Animikie slate and quartzyte, some of the pieces being over two feet long. It can be followed superficially southward fifteen rods where it runs under a diabase sill but separated from the sill by ten feet of non-brecciated slates. It appears, therefore, that it is caused by a horizontal slip in the slates

*In the final report, vols. IV and V, the gabbro and red-rock eruptives are specially designated *Cabotian*, as they preceded the basal conglomerate of the Keweenawan, here referred to. The later basic eruptives are designated *Manitou*, and the term Keweenawan is made to include both, as originally defined.

themselves. The cement of this breccia is a greenish, fibrous matter apparently actinolite largely. According to Mr. Elftman, this breccia occurs near the wagon road about a mile and a half west of this point.

This section can be traced easily on the surface to the base of the Cross river bluff which is on the south side of the river. In the top of this bluff is the commencement of the "black slate" of the Animikie of Grant, supposed to be immediately above the iron-bearing member. Near this river but on the north side, south from the exposure of the breccia at the R. R., the rock assumes over a wide area, an appearance like the graphitic rock of Pigeon point. It is in the midst of the slates. The effect of the trap seems to be to gather carbon in spots. No signs of fault, other than the above horizontal slide, can be seen in this region.

2051. The porphyritic structure of these sills is quite sporadic and the crystals are singularly grouped. The samples do not show it. Some isolated crystals are four inches long, and resemble in size, but not in purity, those found in the diabase at Beaver bay* (No. 128). Sometimes finer crystals, about one inch or half an inch in average size, are massed together, and outside of this mass is a surrounding periphery of still finer crystals. Sometimes the finer crystals are gathered in great numbers in spots by themselves, making small areas of white weathering feldspathic rock which resembles some forms of the gabbro. If these bunches of crystals were free from decay such areas would be exactly like the feldspar rock (or anorthosyte) of the gabbro as seen along the shore of lake Superior or at Beaver bay. Altogether these features make a curiously spreckled diabase, some of the spots of grouped crystals being ten and twelve inches in diameter. Twenty-five samples collected.

This observation as to the character and sporadic distribution of these crystals suggests a possible origin of the anorthosyte of the region, viz: that the peculiar masses have come from a generation of large labradorite crystals, making a coarse phase of the diabase, such crystals becoming agglomerated in spots in large quantities. Such agglomerations would float in the general diabase mass, and would be erupted with the diabase. Thus the gabbro might be a great development of such coarse crystallization where at great depths the physi-

*Sur un cristal de labrador du gabbro de Minnesota. Bull. Soc. Franc. de mineralogie, t. 19, pp. 90-92. 1896.

cal conditions were favorable for a longer continuation of such a generation. Once formed in a tranquil mass of diabase they would remain *in situ* unless the diabase were extruded, and in case of movement they would go with the diabase, even if it were forced to the surface. These lumps would also appear in dikes and in sills. When solidified and lodged the diabase might still flow past them, and they might perhaps even act then as foreign pieces and be able to chill the diabase which at last came to rest alongside of them, producing a finer grain and even a basaltic columnar structure perpendicular to their exterior. One such occurs in the shore a little west of Split-rock point. It is impossible, however, to apply this theory to all the included anorthosyte masses, for they are not all of a light color, and some inclusions are of red rock, and there can hardly be a question of the foreign origin and transportation of such masses.*

2052. There is much ferruginous dolomyte in the Animikie, in the hill on sec. 24, 65-4. It is gray within and weathers rusty.

2053 represents a structure that is developed in the Animikie in connection with the above breccia, consisting of spherical concretions from 1/16 in. to 1/2 in. in diameter. Compare 1374.

2054. Of the same rock mass as 2051, but not porphyritic feldspar. It has large dark crystals, which are mostly in the form of plates. On closer examination they are found to be of magnetite which is striated by polysynthetic twinning.

2055. West end of Loon lake; from an obliquely ascending ridge, near the shore at the southwest head of the bay, at two-thirds the distance toward the top. The ridge is of a fine-grained dark rock, a siliceous portion of the Animikie, but is affected profoundly by the gabbro which is adjacent in the hill higher up. This may have been originally some of the siliceous slates of the Animikie but under the microscope now a thin section shows that every original element is recrystalized. The quartz is not in clastic form, but interlocks. Mica is generated and embraces poikilitically both magnetite and quartz, and a small amount of calcite is sheltered amongst the other grains. The rock is almost entirely of quartz, but there is enough of the colored minerals to give it an opaque, dark gray color.

2056. Similar rock, belonging to the Animikie still higher

*Mr. A. E. Barlow has recently gathered together and published all the data known concerning such dike rocks, adding many new facts,—"On some dikes containing huronite," read before the Geological Society of America, Baltimore, Dec. 28, 1894, published in the Ottawa Naturalist, Vol. IX, p. 25.

up—more siliceous. In this section this has much more silica, and occasionally a few fibres of grünerite. There are also grains which are crowded with microlites, appearing like the residuum of a molten magma, which take the shape which the the other grains leave room for in their interstices. These are white, but cloudy, and perhaps are fundamentally of orthoclase. Their regular extinction shows that they have a crystalline basis, but owing to their clouded and crowded condition no other characters can be determined.

2057. Same as the last, but with evident feldspar developed, some of which is striated and some is the result of the clearing up of the grains which in rock No. 2056 are cloudy and indeterminate. This was collected quite near the gabbro, indeed was collected *as of the gabbro* near the contact with the Animikie, but proves to be of the Animikie. This is fine-grained and gray, appearing considerably like No. 2056, 150 feet, more or less above Loon lake.

2058. Characteristic gabbro, 150 feet from the foregoing, south. In thin section this gabbro is seen to contain olivine older than the diallage and than the feldspar, with a little magnetite surrounded by biotite. This is the commencement of a belt of gabbro ten or twelve miles in width and its effect on the Animikie was very prolonged and powerful. It is finer here than usual, by reason of contact with the Animikie slates, which stand at an angle of 60°—70°, dipping southerly. They are also crumpled and twisted, also hardened and rendered massive, so much so that on first approach the ascending ridge, especially near the top, was supposed to consist of gabbro.

2059. Still another phase of the fragmental rock, essentially a quartzyte, but containing incipient orthoclase, mica, etc. The quartz is wholly altered from its original clastic form, not even the outlines of the original grains remaining, and is recrystallized into grains of irregular shapes which interlock and accommodate themselves to their surroundings. This quartz is closely comparable to much that is seen near the bottom of the Animikie(?) as at Chub (or Akeley) lake, where the Pewabic quartzyte has been wholly changed in the same way. The accompanying substances being somewhat different originally, and more abundant here than in the Pewabic quartzyte, the accompanying minerals after metamorphism are both more numerous and somewhat different than in the case of the metamorphism of the Pewabic quartzyte at Chub lake. But the cases are perfectly parallel and analogous, and the resultant rock can, in neither case, be referred to a supposed "silicification of the gabbro," as urged by Bayley and Van Hise. (19th annual report, pp. 209, 210).*

2060. A curious granitoid or gneissic condition of the same quartzyte, from the same place, (west end of Loon lake). Fine-grained, gray and quite siliceous. Under the lens of the microscope this rock is different from others already mentioned only in having a more differentiated condition of all the minerals. There are distinct feldspars of triclinic and of orthoclastic kinds, but although they are easily identifiable as such they are still partially or wholly crowded with numerous impurities, looking as if they were in a state of decay, as such phenomena are usually interpreted, instead of in a state of growth. It is apparent that quartz was the first of the secondary minerals to take the new shapes, next came the biotite which sometimes surrounds the quartzes, and which is scant, but which is associated with a blue-polarizing mineral resembling glaucophane, and lastly the feldspars. Consequently the residual impurities, and the microlites that formed last from them, are nearly all embraced in the feldspars. It appears sometimes that a purification took place in this impure mass, and a clearly transparent portion of a feldspar crystal grew up in the center, the microlites of mica and of iron(?) being driven to the surrounding zone. Still, more than two-thirds of this rock consists of secondary quartz. V. Nos. 1647-49. The gabbro comes absolutely to the shore of Loon lake.

2061. "Black rock" phase of the Animikie, west end of Loon lake, same place as the last. This rock is very siliceous but scattered through it are sufficient colored grains of biotite and of magnetite to make it all appear to be nearly black. It is very fine-grained. Under the microscope it appears as completely secondary in its present condition as the foregoing. The quartzes interlock, and occasionally a large quartz extinguishes over an area embracing many biotites and magnetites, which therefore, in this case, must have preceded the quartz as to generation.

According to the stratigraphical scheme which has been worked out by Dr. Grant for the Animikie of this region, all these siliceous beds are near the top of the Animikie, which must be correct unless there be faulting such as to lift the bot-

*The Loon lake rock is without doubt a part of the Animikie, but that at Chub ake is believed to be a modified condition of the jaspilyte of the Keewatin.

tom of the Animikie to the surface at this place. There is no direct evidence of such faulting here.

As to the relation of the gabbro to the diabase sills (for the gabbro is incontestably later than the Animike), the first impulse is to make them of the same date. This is owing not only to the essential identity, lithologically, of the gabbro and the sills, but also to the nearness with which they here approach each other, as well as the sameness in the manner with which they are both known to form sills in the Animikie. It is to be remembered that according to Lawson (Bulletin VIII) the sills are later than the gabbro, and even later than the whole Keweenawan. Also, according to Grant, where the gabbro proper forms sills, as at Chub (Akeley) lake, it is not finer grained at the contact on the quartzyte, although, at the same place, and in the same quartzyte, a diabase sill is finer at the contacts. This difference indicates different conditions of intrusion, and two dates of sill formation, one being, as he supposes, at the date of the gabbro and the other that of the diabase sills in general. Several of the sills are porphyritic with scattered plagioclases. In that respect they are like those seen at the railroad cuts west from Gunflint lake which are near the bottom of the Animikie.

2062. Slaty quartzyte, from the Animikie underlying the diabase sill at Mt. Reunion, south side of Rove lake.

2063. The lowest stratum seen at Mt. Reunion. A coarser quartzyte.

2064. From the sill of "diabase" that forms the summit of Mt. Reunion—an even, medium-grained, gray and fresh rock, from one of the fallen masses. This section shows olivine and augite both older than the feldspar, a character of gabbro, and also augite younger than the feldspar, a character of diabase. The earlier augite is sometimes twinned, with a narrow band between two broader ones, but the cleavage (100), in this case running from one side to the other unbroken through the narrow band, indicates a diallagic variety of the augite; and since extinction in one part is parallel to this band, the plane of association is perpendicular to the brachypinacoid, and therefore is 001. At the same time the crystal is so cut that the other of the broad bands shows an acute bisectrix, and also the prismatic cleavages between which its extinction bisects the included angle. This rock, therefore, is not distinguishable from the ordinary gabbro, and is probably continuous with the main gabbro mass, but here appears as a very thick sill in the Animikie.

Of this hill three-fourths of the total height are composed of rock like Nos. 2062 and 2063, the latter at the bottom of the perpendicular cliff. The talus by aneroid measures 210 feet above the lake, from which the entire hill is estimated to reach somewhat over 400 feet. About one-half of the vertical cliff is of slaty quartzyte, which is also presumed to extend downward under the talus to the level of the lake. No rock is seen at the lake opposite Mt. Reunion, but about a mile and a half further east appears

2065. On the south side of Rove lake near the water, in the manner of a sill, apparently somewhat decayed. A thin section shows the olivine largely replaced by opaque and by chloritic substances, and the augite uralitized, and a notable amount of secondary quartz present.

The hills rise almost continuously on the south side of Rove and of Mountain lakes, as on the south side of Mud and other lakes, from 300 to 400 feet, but rarely less than 250 feet. Mt. Reunion is the most bold and precipitous, at the same time the highest near the lake, of all the hills along here.

In approaching the north end of the portage from S. Fowl lake southward, and noting the forms of the hills visible to the south, which are bold and conspicuous, I observed that the hill just west of the portage, containing the later dike cutting the sill as described in 1893 (Nos. 1898-1901) slopes gradually throughout its whole E-W. extent toward the east, as if the formation thus dipped. There are minor irregularities in the form of the sill, but on the whole the dip, as viewed from the north, is eastward. The hill on the east side of the stream has about 150 feet of sill on about 150 feet of slates. It also has irregularities in its basaltic direction. These irregularities, in dip, in the disappearance of the slates, in the succession of hills (running E and W), separated by jogs, and the obliquity of the hills to the general strike of the E-W range, seem to indicate a broken, and perhaps a deeply faulted condition of the Animikie.

On approaching the region of North and South Fowl lakes one is struck with the bold and precipitous aspect of the adjoining hills, their form and hight. There is an enormous exhibition of the northward facing cliffs, comparable to the range of which Mt. Reunion is a part. These northward facing cliffs slope southward, or south-eastwardly, along the east side of

North Fowl lake, and these are of the type of those usual about Mountain and Arrow lakes, great Logan sills (Lawson) having slates below them though rarely showing any above the great trap layer. There seems to have been faulting, or at least uplifting since the injection of these sills, for the basaltic columns which must have been perpendicular to the slates are also tilted toward the south conformably with the present position of the slates. In some places slates can be seen underneath these sills as in the hill on the Canadian side of the outlet of South Fowl lake. Besides this tilting there is a zigzag or saw tooth outline of the tops of these hills which may be partly due to faulting, their upper surfaces running southward so as to apparently run under the next one to the south. These hills are short, sharp on the north, irregularly overlapping, east and west, although often having a general range-like succession for many miles, bringing out a peculiar characteristic topography which prevails over a large area in northeastern Minnesota, southward and eastward from Gunflint lake. This type seems to run off into Canada at the southern end of South Fowl lake.

So far as can be judged now the hills seen in the town next south of South Fowl lake and on the Indian Reservation, thence eastwardly to Pigeon point, even including the hills directly west from the South Fowl cliff, are mainly of the dike type, as contrasted with the sill type. The trap here does not lie on the slates, but rises through them, and forms basaltic escarpments of trap which rise sometimes to the hight of 100 or 200 feet above the adjoining talus. For instance, the cliff on the Canadian side at the outlet of South Fowl lake has trap lying on fissile slates about 125 feet above the lake, the upper surface of the basaltic trap dips conformably with the slates southward. The cliff immediately at the river on the west side has a different structure, for in it no slates are visible, so far as examined, but a trap rock descends from top to bottom on the face of the cliff. It is the eastward termination of a long and large range which apparently has the dike shape, showing knobs that rise suddenly, one after another, extended in a series for several miles, abrupt on both sides. The southern slope of this range is not so abrupt as the northern, due probably to the lodgement of glacial debris on the southern side, but southward from this range this type of hill is the prevailing one, and it is especially exemplified in the dikes of the Grand Portage Indian reservation.

It is noteworthy that this dike-structure occurs to the southward of the region that exhibits the sill-structure. It has been observed also that the slaty rock that is cut by the dikes is of a different character from that which contains the sills. Its stratigraphic position, taken in connection with the general dip of the Animikie, must be above the slates which exhibit the sill structure. This rock, which seems to constitute the top of the Animikie, has received the name of Grand Portage slate, from the route along which it is well exposed. It is a fragile rock whencompared with the tough siliceous slates below it, and easily breaks in any direction. It is to be presumed, therefore, that this difference in the lithology is the prime cause of the difference in the manner of intrusion of the igneous rock. The slates split easily along their bedding and admitted the molten rock horizontally, forming the well known sills, but on reaching the Puckwunge slate the igneous rock rose in great volume through vertical fissures which on consolidation have formed the great dikes of the region. According to this the rock protruded into the Animikie, whether as dikes or sills, may have had, and probably did have, so far as the Cabotian invasion is concerned, about the same date: and it is further probable that that event was the same as that which gave origin to the great gabbro mass of northeast Minnesota.

### THE BASE OF THE UPPER SERIES OF THE KEEWENAWAN.

It has been the uniform practice of geologists for many years to exclude the Animikie from the Keweenawan. There has been found latterly a distinctly conglomeratic horizon, later than the Animikie, which has been accepted as the base of the Keweenawan. This conglomerate contains debris from the Animikie and also from the "red rock" which is the product of the alteration of the Animikie, viz: quartz porphyries and aporhyolyte, and quartzyte which, though granular and clastic originally, is cemented by secondary quartz and sometimes wholly altered to a vitreous quartzyte. As this alteration was produced by the gabbro-diabase intrusions such as those above described, as is easily observed at Grand Portage and on Pigeon point, it becomes necessary to separate the great eruptives of the region, included by Irving under the single term Keweenawan, into two epochs, one preceding this conglomerate and one following it. The lower series of eruptives, the great gabbro and the attendant sills, dikes, basalts, surface flows and the "red rocks," have been distinguished as Norian, and the term Keweenawan, originally covering the whole, could appropriately be restricted to the later eruptives. This would be, however, a violation of one of the rules lately adopted for the use of stratigraphical terms by the International Congress of Geologists, which requires that a term once defined and introduced must never be applied in any other sense or limitation, either by enlargement or restriction. This upper series, therefore, is without a proper stratigraphical designation, for the same rule would require that the term Keweenawan shall include both series. This upper series [since named Manitou] is that which becomes locally interstratified with red sandstones, whether tilted or horizontal, and gradually fades out, but which still covers a very extensive region in the lake Superior basin and in the Mississippi valley. Since this upper series is easily distinguished from the lower in the vicinity of Grand Portage bay and southwestwardly from there, some name like Manitou, derived from the Grand Portage region, would be appropriate.*

The facts given below bear upon the nature and distribution of the great conglomerate and quartzyte at the base of the upper series.

*In the Puckwunge Valley.* This place was first visited by the writer in 1893, and the specimens collected then are enumerated in the report for that year (Nos. 1902-1906, p. 13, 22nd annual report.) The outcrop of this conglomerate is about in the centre of the NW¼ sec. 25, T. 64-3 E. It is by compass 10° east of south (magnetic) from the great cliff of the south end of South Fowl lake. It is reached by ascending the small stream Puckwunge or Big-root, that joins the Pigeon river sec. 18, T. 64-4E. which is canoeable without obstruction to near the centre of sec. 24, 64-3 E, where it is obstructed by trees. It is thence necessary to make a traverse southwardly over a thinly timbered but often thickly shrubby, level tract of glacial till and gravel, frequently covered by lacustrine red clay, to the hill range that is visible about a mile away. This tract is one of good soil, in the main, and is arable, but it has occasional knolls and short ridges which are kame-like, rising six to fifteen feet above the rest of the country; and it is crossed by a second stream flowing in the same direction (east) near the foot

*Compare the writer's discussion of this division of the original Keweenawan into two series, in the American Geologist, Vol. XVI, pp. 150-162, 1895.

of the hill-range. The hill-range, which rises about 350 feet, has a small notch caused by the erosion of an insignificant stream which flows down the slope toward the north crossing the strike of the conglomerate and quartzyte, which is dry in the lower reaches except in freshet time. This creek has caused a small gorge and the conglomerate is exposed in this gorge and above the creek in the hill-slopes.

There are distinctly two parts to the conglomerate, viz., in descending order:

1. Fine conglomerate or grit stone, 18 ft., (1902.)
2. Coarse conglomerate grading upward into fine conglomerate or grit, 18 ft, (1903.)

The dip is toward the SW by S, 12 degrees, and is distinct. This rock is essentially a white quartz-pebble conglomerate, the coarsest stones being about 6 in. in diameter, rounded-lenticular and hard, altogether water-worn. There is very rarely a distinct banded red-jasper pebble, and some that are not banded, and more common a gray siliceous pebble like basanyte. Some of the pebbles are reddish brown. The great majority of them are of vein quartz, but some appear to be of chalcedonic fineness of grain. The general appearance and character of this are like those of the quartz-pebble conglomerate seen in the St. Louis valley a short distance above Fondulac.

The rock is not exposed throughout its whole thickness, but on ascending the slope in the hill westward from the little gorge a rock was found (1904) forming a perpendicular low cliff which is similar to the fine conglomerate (1902) and indicates that the rock which composes the slope above the gorge is a part of the same stratum. That gives the fine conglomerate a thickness of 126 feet, the covered slope being estimated at 100 feet, and a total thickness of the grit and the conglomerate of 144 feet. Below the visible portion the conglomerate may continue much farther.

Above this rock the hill still ascends about 150 feet, and so far as can be seen it consists of a dark trap rock which recalls Irving's "black traps" of the Lake Superior shore eastward from the Brule river. Mingled with it is much amygdaloid, and surface rocks of eruptive origin, and some that, weathering much lighter (2067), may be of the nature of a volcanic tuff. These are represented by the following samples:

2066. Basic dark trap with chalcedonic geodes, resembling that at the mouth of Gooseberry river. This forms the summit of the hill range at the notch where the little creek comes through. (Compare 1905.)

2067. Gray or bluish, fine-grained, globuliferous rock; weathers nearly white; at a somewhat lower level than the last, forming a little cliff about 25 feet high.

2068. At points still farther south, and perhaps 50 ft. higher than 2066, the exposed rock is rather coarsely porphyritic, in the manner of that forming sills in the Animikie west from Gunflint lake. The same rock, however, is also fine-grained in other places. The country is covered with forest and moss, and from the scattered outcrops south from the outcrop of the conglomerate it is impossible to make out any detail of the structure.

A thin section of rock 1905 shows a finely porphyritic, fine-grained basaltic glass, which is probably of the species zirkelyte named by Wadsworth, in Bulletin No. 2, p. 31. The granular structure is due to devitrification. It holds silica in considerable areas, which have a broken and shadowy extinction somewhat like fibrous chalcedony. These areas are of irregular shape, and frequently also enclose calcite.

2069. Varieties of pebbles from the coarser part of the conglomerate. In collecting these pebbles a special effort was made to obtain some that were characteristic of some formation, and among these the rock taconyte was sought for. Thin sections were afterward made of some of those that promised to show the peculiar glauconitic taconitic structure. They were found to be of clastic structure, the constituent parts not made up evidently of crystalline secondary silica, but consisting of a red or brown substance forming a grit, which still is wholly secondary. The rounded forms of the more colored parts are perfectly characteristic of a fragmental source. With high powers these rounded grains are seen to have multitudes of crystalline microlites mingled with a more or less felted polarization, the whole composed of quartz, fine hematite forming the coloring agent. Magnetite crystals are disseminated, and in all cases their idiomorphic forms jut into these brown grains. This shows that both the grains and the magnetite have been formed (as to their present composition) by an alteration from some pre-existing material, and that the brown grains have received their magnetite and probably also their hematite since they took the rounded shape. They were hence not devitrified or aporhyolite prior to the rounding. The generation of this iron, accompanied by the deposition of abundant quartz, both in the grains and as a cement between them, is a characteristic of the taconyte rock of the Mesabi range where the original rounded shapes were acquired when the material was formed as a glauconitic sand. These characteristics fix this conglomerate as later than the Animikie; they are not those of pebbles of aporhyolyte for which these grains might be mistaken and which also is found abundantly in this conglomerate at Grand Portage island. Both sorts of pebbles point to the Animikie as their source. The original taconitic character of the base of the Animikie extended therefore as far east as the Puckwunge valley. Both here and at Grand Portage island this conglomerate and quartzyte are followed, in ascending order, by an important series of dark traps and amygdaloids, which constitute, along the shore westward from Grand Portage bay the "black traps" of Irving, which he was rather inclined to exclude from the Keweenawan.

[*Note.* In 1897 Mr. Elftman visited the outcrop of this conglomerate seen on the shore of Grand Portage bay about a mile west of the village of Grand Portage. This is visible as a light-colored bluff when seen from Grand Portage island. He found the conglomerate grading into a light-colored quartzyte or hard sandstone, containing pieces of the Animikie and of felsyte, reaching a thickness of something more than 100 feet and overlain by beds of trap and amygdaloid, the whole constituting a stratum which he could trace by the topography further than the hill examined, but he saw no other outcrop.

2070. Traveling eastward from the creek and little gorge where the principal exposure of this conglomerate occurs, there is seen to be a shoulder or terrace formed of this conglomerate, and of some of the higher beds of grit (1906). Under it (whether immediately in contact or not was difficult to determine) is a diabase sill (2072), and at a quarter of a mile further east the rock 2070 appears about in the interval between the sill and the conglomerate, having at that point an exposure of at least 50 feet. This indeed is well toward the top of the hill, as if the strike of the conglomerate had receded toward the south. It is a part of the Grand Portage graywacke. The thickness of the sill is also at least 50 feet. The sill at the same time, or at least a rock adjoining that cannot be distinguished from that of the sill, is seen to be in contact and underlying a portion of the conglomerate, even cutting it, and from it a large apophysis runs southward 35 feet wide, becoming narrower and narrower. The appearances point toward the conclusion that the sill is younger than the conglomerate, the line of contact being somewhat tortuous. There is a sudden northward jog in the line of the hill range, an isolated hill standing out from the main line, and this hill is composed apparently of a swelling out and northward projection of this sill, although the direct connection could not be traced in the time at command. In it is noticeable an occasional spotting of crystalline red rock like that at Mt. Josephine and on the ridges in the Indian reservation, and that indicates that it is older than the diabase that cuts the conglomerate.

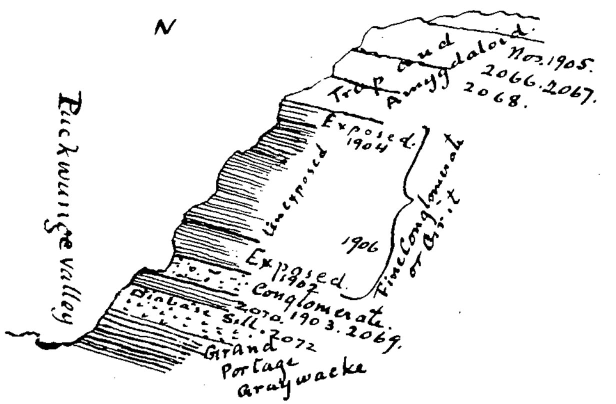


FIG. 4. SECTION OF THE HILL-RANGE, SOUTH SIDE OF PUCKWUNGE VALLEY.

2071. Returning toward Puckwunge creek there was encountered a surface outcrop of the Grand Portage graywacke. It has on casual examination the appearance, as well as the geographic position of a lower bed of rotted trap, and for that it was taken in 1893 when seen in the same place. This indicates that the rock 2070 (Grand Portage graywacke) may have a thickness of at least 200 feet.

2072. Fine-grained condition of the sill mentioned as underlying and cutting the conglomerate and a portion of the Grand Portage graywacke. It is to be remembered that there is a series of dikes of diabase which is later than the great dikes. This is shown by the dike cutting the sill which constitutes the bluff at the south side of South Fowl lake. Many other instances could be mentioned. It is quite possible that the later intrusion formed sills as well as the earlier, and the porphyritic condition is not a character which could be depended on to distinguish one from the other.

*About Grand Portage.* The route of the Grand Portage trail runs almost wholly over drift deposits which are underlain, as indicated by occasional exposures, by the rock which above is called Grand Portage graywacke.

2073. Grand Portage graywacke from the trail at one mile from the landing at Pigeon river.

2074. On Grand Portage island; quartzyte at the lower plane, where in contact with the trapsheet. A dark fragmental rock.

2075. Trap, from about two feet lower, in the intruding sheet.

2076. The lower contact of an overlying trap on a quartzyte layer, very fine-grained, same place.

2077. Upper quartzyte layer at the contact, baked and hardened.

The quartzyte seems to have accumulated very readily and rapidly between the eruptions, judging from the quickness with which it resumed its prevalent character.

2078. Coarse porphyritic granite, from St. Cloud, used for the new water-power dam at Minneapolis; also for monuments, of which a large one was exhibited at the Chicago Exposition, 1893. Subsequently passed through the Colosseum fire. Compare the Ortonville granite, No. 1980.

## Rock Samples Collected in 1897 to Illustrate the Field Notes of N. H. Winchell, with Annotations.

*In Carlton county.* A review was made, in May, 1897, of some of the rock ridges in Carlton county with a view to distinguish, if possible, the slates at Carlton from the rocks found in the central part of the county, and the possible boundary line separating them. Following is the list of specimens and their localities. The conclusions are presented in the final report on Carlton county.

2079. Massive green rock NW cor. NE ¼ SE¼ sec. 5, 47-18, west of the little creek, occurring in coarse jointage blocks greenish, and specked more or less with large pyrite cubes. The sample has a fine, fibro and lamellar, indistinct structure.

2080. North from the last, at SE ¼ SW ¼ sec. 29, 48-18, the country rises considerably higher than the foregoing, with knolls and ridges of drift. In this more elevated area this rock outcrops. It is light weathering, fine-grained graywacke, jointed like rock 2079, but much more siliceous. It forms a large (comparatively) area of nearly homogeneous rock, and it has the appearance, except for its composition, of an igneous rock. Its chief variation consists in the black, calcareous "snow-shoe track" of the slates at Carlton. On close inspection an indistinct bedding structure is discernible in a few places, varying from nearly level to 45° toward the north.

2081. Thinly bedded portion of the same rock as 2080, folded and twisted, but dipping N about 45 degrees. Calcareous "snow-shoe tracks" are here common.

*2082*. East from 2079, about SE ¼, NE ¼ sec. 5, 47-18. From a large area of indefinite and confused greenstone of the Keewatin, one of the coarser parts, occurring in belts or layers, or as irregular parts or masses, imperfectly agglomeratic.

2083. Another phase of the same rock, finely laminated.

2084. Same place; another phase, with pyrite.

2085. Same place; another phase, apparently sedimentary, at least bedded, greenish, sub-crystalline.

2086. SW¼ sec. 4, 47-18. Fissile, dark colored schist, somewhat micaceous, with folia of quartz, with pyrite. Structure dips ESE about 45°. Of the same formation as Nos. 2082-2085.

2087. At Atkinson, centre of sec. 25, 48-18. Black-weathering masses in slate. Sample shows both the calcareous (or sideritic) material and the rock in which these are embraced.

2088. Pebbly forms in the slate, SE ¼ sec. 9, 48-17, west of Carlton. These are hard, gray, and fine-grained, resembling the slate. It is difficult to decide whether they are indigenous or foreign pebbles.

2089. Short Line Park. Amygdaloidal condition of the "gabbro." This structure is more common here than had been supposed. It is specially abundant near the cut of the St. Paul & Duluth R. R.

2090. Fair sample of the gabbro at Short Line Park, coarse and fresh. A dike 60 feet wide runs through this rock in the direction N 45° E (true).

2091. North side of sec. 32, 49-15, at the crossing of the creek by the highway. An amygdaloidal phase of the "gabbro" of the region of Short Line Park contains large blebs of red rock in scattered patches, but not so red and conspicuous as in the large boulder seen at Cloquet.

### ELY AND LONG LAKE.

2092. Ely: a rude breccia-like portion of the greenstone, in the interstices between the agglomeratic forms. The fragments average perhaps ¼ to ½ inch. Knobs west of the Catholic church.

2093. From the periphery of some of the agglomeratic masses at Ely. This periphery is not always distinctly amygdaloidal, but is finely specked with a white-weathering mineral in round spots as large as a pin-head. This belt in general is outside of the coarsely cavernous belt which is frequently interrupted, or wanting, but which is apparently the representative of the pipe-like amygdaloidal structure.

2094. Near Long lake, at Ely, eastward from the boathouse. A pebbly or brecciated confused phase of the greenstone. Not only the pebbles, but some of the rock have a fineness like that of felsyte, but no quartz phenocrysts are visible.

2095. The acid porphyritic rock which appears in the agglomeratic greenstone westward from (and near) Ely. It is traceable for 50 rods, more or less, or a quarter of a mile, appearing like a dike about 20 feet wide (sometimes wider) running about N 30° E (true). This rock and the adjacent greenstone mutually enclose fragments from each other. It is, perhaps, due to a folding on a grand scale, rather than to intrusion, that this belt of acid rock here appears in the midst of the greenstone.

2096. Samples of this acid rock at the "contact" on the greenstone. It is finer grained at the contact. This belt of acid rock varies from 15 to 50 feet in width.

2097. Purplish, argillitic "slates," fine-grained.

2098. The same, coarser-grained, schistose. These are from SE¼ sec. 29, 63-12. The slates strike about N 45° E. It is uncertain whether these, which alternate with each other, are both sedimentary, as their structure indicates, or are greatly sheared portions of an acid rock. It seems possible that rock 2098 is the product of wastage from a rock like the white dike 2095.

2099. Sample of the matrix of a conglomerate seen on an island in Long lake SW¼ sec. 29, 63-12, supposed to be the equivalent of the Stuntz conglomerate. The conglomerate holds pebbles of different kinds, viz.:

1. Mostly of rock like 2095 sometimes containing a few quartz grains, making a quartz porphyry; 2. A non-quartziferous felsyte; 3. Quartz, only a few pebbles seen; 4. Greenstone; 5. Hornblende porphyry. This conglomerate passes rather suddenly into argillyte toward the south.

2100. Quartz from this conglomerate, in form of nearly white pebbles of chalcedonic (or jaspilitic) quartz.

2101. From the bluff on the mainland SW (in the direction of strike) from the island foregoing; firm and siliceous, apparently a conglomeratic phase of the rock of the island. Some of the pieces of foreign rock are 8 or 10 inches in longer diameter, but outwardly the mass of the rock is rather fine, and uniform, the appearance suggesting a breccia rather than a conglomerate.

2102. Rising in the midst of this breccia is a small area of what appears to be an acid rock like No. 2095, but more quartzose. It can be seen only about a rod and is lost under soil and bushes. It may be a coarse compacted detrital rock, derived from a rock similar to 2095. Some pyrite is disseminated in it.

2103. In NE¼ SE¼ sec. 30, 63-12 is a high greenstone range with some appearance of belonging below the non-conformity.

2104. Dioryte, so called by A. Winchell, near the point NW ¼, SW¼, sec. 29, 63-12, small island in Long lake; apparently a condition of the prevalent greenstone.

2105. Green fibrous schist. On the main land across from the last mentioned island.

2106. Siliceous or flinty condition of sericitic schist, NW¼, NW¼, sec. 29, 63-12, west end of Long lake. It is sparsely interstratified with a coarser acid rock, similar to 2098. The flinty structure stands about vertical.

2107. Acid rock, in the greenstone near the center of sec. 32, 63-12, perhaps in the extension of the quartz porphyry 2095.

2108. Near the center of sec. 31. Sericitic schist, excavated by the sinking of a shallow pit; probably in line of extension of that mentioned in sec. 29.

2109. Schistose greenstone, SW cor. sec. 36, 63-13, forming the rock at a long cut at the RR. This is apparently in the line of extension of the range seen in sec. 30, 63-12.

2110. An apparent amydaloid of saponite, in the dump pile of the Zenith mine, east of Ely.

2111. Ore from the long-litigated "sec. 30," 63-11.

2112. Variations of jaspilyte, from the pile at the pit on sec. 30, 63-11.

2113. From the ridge south from Ely, visible from the town. The ridge where visited is much affected by spots and nodules and pseudo-veins of epidotic rock.

*Rocks from a section made in traversing from the NW corner of Long lake to Burntside lake.*

2114. Shore of Long lake at the point of starting; greenish, sub-crystalline, showing epidotic surfaces.

2115. Forty or fifty feet above the lake and about 30 rods from it, more coarsely crystalline, with hornblende.

2116. Eight rods further north. Finely porphyritic with feldspar in spots. In some spots weathers red.

2117. Eight rods further north. A compact dark green rock, not plainly crystalline.

2118. At nine rods farther north. Much like the last, but coarser and somewhat crystalline.

2119. At nine rods farther north, just on the southern brow of the main hill. A very tough, light-weathering rock showing a phase of the regional metamorphism. A crystalline rock, light green in color.

2120. From the very top of the hill; somewhat coarser, but otherwise like the last; 200 feet above the lake.

2121. At one mile north from the lake; a dike of reddish granite two inches wide, disclosed in pulling off the moss, running with the structure about E and W.

2122. Hornblende schist, coarse, about twenty rods north of the last.

2123. Mica and hornblendic schist irregularly alternating. At the top of the hill south from Burntside lake, and at 100 ft. ± above the lake, and perhaps fifteen rods from it. But there is considerable granite to the south from this.

2124. Granite, at the shore of Burntside lake, north from the west end of Long lake.

2125. At the quartz vein of McIntosh, Wells, Prindle and Dutton. NE¼, SE¼, sec. 36, 63-13. In reaching this place from the railroad several forms of the greenstone appear in low ridges. One is represented by the rock of this number. Its outer weathered surface is blotched by the original bouldery forms, the difference in color being due apparently to variation in the frequency of the hornblendes which are large and conspicuous, both in the "boulders" and in the matrix, but more frequent in the matrix.

2126. At the extreme NE corner of sec. 36, 63-13, on a well known jaspilyte belt, traceable, according to Mr. McIntosh for about a mile, is this rock. This belt seems to blend with the country rock (greenstone, schist, etc.) producing an intermediate phase, a siliceous greenstone. This is only another illustration of the intimate connection of the jaspilyte, in origin and in date, with the green rock in which it lies, as first pointed out in bulletin No. VI. At this place the whole formation has that irregularity which has been called bouldery, i. e. it is blotched in a similar way, and the grayish and greenish jaspilitic silica surrounds these forms. This is similar to a structure later observed at Moose lake.

2127. Ore from the quartz vein in SW¼, SW¼, sec. 30, 63-12. This vein runs about ⅛ mile a little N of E. It is a large showing of white quartz, and some assays have given a promising amount of gold.

2128. A part of the vein is rusty on weathering, apparently by oxidation of siderite.

*Taylor's Falls and Mesabi Range.* A review was made in May, 1897, in company with Messrs. Grant and Berkey, of some of the features of the Keweenawan at Taylor's Falls.

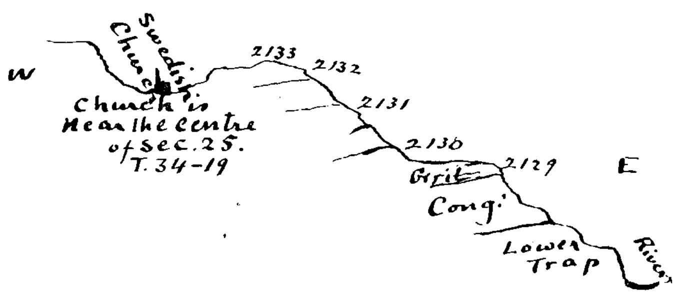


FIG. 5. APPROXIMATE PROFILE OF THE WEST BANK OF THE ST. CROIX RIVER AT TAYLOR'S FALLS.

2129. Samples of grit, or volcanic debris and quartz, with epidote, about 200 feet above the river.

2129A. A very fine, flinty condition of 2129.

This grit forms an irregular layer, lying on the conglomerate or breccia of much coarser character, the general structure or dip being WSW about 10° or 15°, according to Berkey who has made a careful survey of the park. This is appproximately at the contour line of 910 to 920.

2130. Coarsely porphyritic trap, overlying 2129, the interval of unexposed rock being perhaps 30 feet. In this interval can be seen, however, occasionally irregular crags or knobs of trap.

2131. A coarsely amygdaloidal layer is irregularly mingled with and overlain by this fine-grained epidotic rock which in some places appears to be fragmental, but probably is not. Its observed thickness is irregular but not over two feet.

2132. Still higher, contour of 1030 or 1040, is compact diabase again, more or less porphyritic but seamed by a compact greenish rock that resembles 2931. This is probably the product of segregation in fissures in the diabase. The widest fissure is about three-fourths of an inch, and the samples are from it.

2133. Porphyritic diabase, highest point, topographically and stratigraphically, of the trap.

The rock 2129, as a grit has a thickness not to exceed 10 feet at the point examined (Corner of Government and West streets), but it lies on a curious conglomeratic rock made up of large and small masses of trap, sometimes amygdaloidal and sometimes not, which has a thickness between 30 and 40 feet. This might easily be mistaken for a rough condition of the trap of the region, brecciated, etc., but there is more or less of the rock 2129 disseminated through it.

Following southwestwardly, approximately along the strike of 2129, though the rock is much hid by drift, was found at one block west of the public school building, a knob of rock much like 2129, more or less brecciated, the pieces being mostly less than three inches.

2134. From a breccia of 2129 at one block west of the public school building.

We followed the general strike of this conglomerate southwardly about parallel with the river, and thus descended to the railroad track where the highway is crossed by the railroad, and where is a well known old exposure of conglomerate. Before reaching that place, however, we made a sharp detour toward the east, and struck another road nearer the river, where the St. Croix conglomerate is somewhat exposed on the westward side of the road near where it descends to the lower level. This conglomerate is distinct and characteristic, the rounded hard stones easily being dislodged from the matrix. Some of these stones are from the older conglomerate, one such being about 18 inches across and showing its original conglomeratic character with the greatest perfection—indeed, much better than any of the older conglomerate seen *in situ*. The two conglomerates are superposed, the only thing separating them being a time interval with no rock to represent it, but in which interval elsewhere must have been formed most of the upper Keweenawan rocks, as represented, apparently, by the highest eruptive flows at Taylor's Falls.

In following down the road toward the old quarry by the railroad but little can be seen of the rock, owing to the drift, but it is apparent that the two rocks continue in the bluff, the upper one not being exposed any more. At the old quarry, both in the bluff and in the general flat area below the bluff especially near the railroad, the older conglomerate is exposed. There is some uncertainty here as to the nature of the upper part of this old bluff; i. e. whether it belongs to the earlier or the later conglomerate, for the bottom parts are undoubtedly of the earlier, having the cement characteristic of it (i. e. rocks 2129 and 2129A), and being made up of large masses of the underlying traps. The upper part of the bluff, while apparently composed of the same sort of trap boulders and continuous, in that respect, from the lower part, and thus outwardly being of the same conglomeratic mass as the bottom, yet has a different cement and contains fossils. Mr. Berkey, who has examined the bluff critically, came to the conclusion that there is but one conglomerate in the cliff, and that the fossils indicate its age, i. e. Upper Cambrian. In that case the cement varied from volcanic debris to a more or less calcareous sandstone which contains fossils, and the fossils ought to be of the Middle Cambrian age, earlier than the Dicellocephalus horizon.

In case the upper conglomerate here superposes directly the lower, the fossils ought to be of about the Dicellocephalus age, and that would easily account for the change in the nature of the cement. The fossils have since been carefully examined by Mr. Berkey and the stratigraphic horizon has been found by him to be in the Upper Cambrian (*Am. Geol.*, XXI, 279-294, 1898), and essentially the basal portion of the unconformable Upper Cambrian of the region, and but little older than the original Dicellocephalus horizon.

Unfortunately the drift is so abundant at Taylor's Falls that it is impossible at present to determine the amount of this supposed older conglomerate, or to know whether there is much more than is actually exposed. It seems that its strike is diagonally across the town of Taylor's Falls, and cross the river about NW and SE, bringing it nearer the level of the railroad and of the river itself at points further south. If it occurs in Wisconsin it would be only at some place considerably south of St. Croix Falls, for all the trap at St. Croix Falls (in Wisconsin) if judged by the horizon of this conglomerate would be older, and hence of the Norian (or Cabotian series as defined in the final report of the survey), the approximate parallel of the trap at Short Line Park, near Duluth, and of the Rice Point "gabbro."

If this view of this lower conglomerate be correct, it will be found to develop, elsewhere, into the conglomerate that contains pebbles of taconyte jasper, seen at New Ulm, and in the Puckwunge valley in the northeastern part of the state; it would be found to be the stratigraphic homologue of the great conglomerate seen in northwestern Wisconsin, underlying the Barron county quartzyte, and would mark the point of stratigraphic separation of the Keweenawan (of Irving), into two great eruptive epochs, the lower one the Cabotian, and the upper one the Manitou, of the Minnesota geological report.

However, it is not by any means established that this fragmental horizon is of such important significance. The roundish trap masses that compose a large part of it, at least at the corner of Government and West streets, and amongst which the finer debris is disseminated, may be of the nature of volcanic flow breccia, and may be repeated at other horizons in the trap series, thus indicating as believed by Berkey, (Am. Geol. XX, pp. 345-383, 1897) so many surface lava flows during that portion of the Keweenawan represented at Taylor's Falls.* The water which distributed and stratified the fine debris may have been the result of copious rains, forming local lakes, as suggested by Dr. Berkey. Until more light can be thrown on the extent and nature of this fragmental stratum, its interpretation must be held as unsettled. In case this fragmental horizon be not the representative of the Puckwunge conglomerate, there is no known criterion by which the age of the trap at Taylor's Falls can be determined, i. e. whether it is of the Cabotian or the Manitou.

2135. Siliceous pisolitic ore, from the Republic mine, sec 4, 58-18, next west of the Mountain Iron mine (H. V. W.).

2136. Pisolitic ore, not siliceous. Republic mine or Mountain Iron mine.

2137. Taconyte, with a siliceous (calcedonic) cement, embracing iron ore both massive and in rounded pellets, (=*a*, on p. 160 of 21st annual report.)

2138. Chalcedonic silica from the same place, showing inclusions of a white, powdery stuff resembling kaolin, but per-

*The significance of this conglomerate has been discussed in the *American Geologist*, by the writer, viz. Vol. XXII, pp. 72-78, 1898.

haps entirely of fine silica (=*b* on p. 160 of 21st annual report).

2139. Greenish, fine Pokegama quartzyte, clearly stratified Mt. Iron mine (=*c* on p. 160, 21st annual report).*

2140. Same as 2139 but coarser (= *d* of p. 160, 21st annual report).

2141. "Quartzyte," apparently a feldspathic sandstone, rusted in blotches. Same place (= *e* of p. 160, 21st annual report).

2142. Fossil wood, lignite, Cretaceous. Standing on end, 88 feet below the surface. Two feet in Cretaceous shale. Sec. 18, 58-18.

2143. Taconyte, Cincinnati mine, showing a fault plane along which ferriferous waters passed and up to which the hematitic alteration operated but beyond which the rock is not stained (H. V. W.).

2144. Taconyte, sec. 6, 58-17.

*Trip to Snowbank lake, 1897.* A review of some unsettled points in the geology of the region of Snowbank lake was made in August, 1897, in company with Messrs. Grant and Elftman. The main results of this trip are incorporated in the chapter devoted to Lake county in the final report, but many details, and the listing and location of the rock samples with their structural and petrographic significance, are not there given, although many of the specimens are quoted, with references to the 24th annual report.

The following is intended to be little more than a catalogue of the rock samples collected on this trip, accompanied by enough explanatory notes to indicate their intended bearing on the subject under investigation.

The chief purpose of this trip was to examine the relation of the Animikie to the great conglomerate which has been called Ogishke at one end and Stuntz at the other, the two being apparently the same formation chronologically. This would have a bearing on the suggestion of Irving, later approved by

*In the final discussion of the geology of the Mesabi iron-bearing rocks, it was found when the data came to be all considered, that the name Pewabic was applied originally, not to a member of the Animikie, but to a metamorphic jaspilyte of the Keewatin, and hence that the ores which in the eastern end of the Mesabi range as defined, had been classified as Mesabi ores, were mostly, if not wholly, of much older date. That quartzyte and those ores were allowed to retain the name Pewabic, as a convenient term for that part of the iron-bearing region, and it became evident at once that another term was needed for the quartzyte which forms the base of the Animikie along the Mesabi range westward from the Dunka river and Iron lake. Such term was taken from the Pokegama falls, where this quartzyte strikes across the Mississippi river and is well exposed.

Van Hise, that the base of the Animikie is extended northward to Vermilion lake and there is represented by the Stuntz conglomerate, being at the same time subjected in that region to a more complex and profound folding.

It is sufficient to state, here, that no evidence whatever was found to warrant the parallelizing of the base of the Animikie with the Ogishke, nor with the Stuntz conglomerate, but presumptive evidence was discovered that indicates their total separateness; and this presumption is converted to demonstration by facts discovered later respecting the positive limitation of the Animikie to the south slopes of the Giant's range and its non-conformable superposition on the Ogishke conglomerate, or at least on the series of rocks with which the Ogishke is associated.

2145. Saturday lake (east of Fall lake), SW¼ NE¼ sec. 36, 64–11. Pebbly green schist, common about the southwest shores of Saturday lake, south of the east end of the portage from Fall lake.

2145A. Pebbles from 2145. These are frequently greenish, especially on fresh fracture, and they blend with the rock so as to be almost indistinguishable. But the fine-grained pebbles are hard and weather nearly white. The schistose structure runs N 45° E (true mer.), and the pebbles are elongated in the same direction. Occasionally they present a slatiness or at least a lamination which does not agree with the main slatiness. These pebbles could all be referred to parts of the Lower Keewatin, and this locality may be said to exhibit the Upper Keewatin, a a probable parallel with the sharply folded conglomerate seen at the SW shores of Long lake, which it also somewhat resembles.

2146. Lighter-weathering, fine-grained rock, appears irregularly in 2145, and transgresses the general structure in the manner of an intrusive, but is schistose in the same direction. On the first knob south of the portage landing.

2147, two rods south from 2146, and apparently a part of it, runs parallel with the general schistosity, is about 14 in. wide and stands vertical, and in that respect is like the pebbly schist.

2148. A little further southeast but still on SW¼ NE¼ sec. 36, 64–11, another low bluff rises, consisting of a more uniform greenstone, showing no sedimentary banding but embracing white siliceous masses curiously shaped, and calcite spots distributed somewhat as in amygdaloid, this becoming more evident as the calcite weathers out.

2148A, shows the nature of the siliceous parts of this rock. These vary from two inches to two or three feet in the greater dimension. Such masses, if in the Lower Keewatin here, may have been contributed to the conglomerate represented by 2145. At four or five rods from the lake, southward, the country rock is a peculiar, fissile sericitic schist, a graduation from the rock 2148, one of the intervening outcrops being

2149, which has nodules of calcite and apparently of white chalcedonic silica, and also some fine laminae of chalcedonic silica separated by thin laminae of greenish schist.

2150. At ¼ mile, more or less, further SE this rock appears. It is like 2149 but firmer and this schistose greenstone seems to constitute the southern shore of Saturday lake. It is probable that in this immediate vicinity is the transition from the Lower Keewatin such as that seen along the south shore of Fall lake, and the base of the Upper Keewatin, the latter being represented at first by a finely fragmental rock derived from the Lower Keewatin, but difficult to distinguish from the Lower Keewatin, and later by a coarse conglomerate like 2145 and like the conglomerate seen on the northwest shore of this lake (Saturday L.) where it runs for half a mile forming a hill range in NE¼NE¼ sec. 36, 64-11. In this range the rock is very schistose and has, as at 2145, veins of vitreous silica. Frequently a whitened, weathered surface presents much the aspect of the Stuntz conglomerate, but in general the matrix of the pebbles here is much more green.

There is much drift on both sides of Saturday lake, and particularly along the north side, where it forms the shore and rises in a level plateau to about 25 feet. At the portage to the next lake east (Urn lake, sometimes called Ella Hall lake) the lake shore is made up of great granite boulders, and the country about is buried under drift, while the immediate beach is sand. The portage to Urn lake is over abundant drift, apparently of the nature of a terminal moraine, though the trail runs mainly on a plateau about 40 feet above the lake.

2151. At the east end of the trail, a little south of the landing. This rock is a rigid, greenish-gray, slaty schist, similar to 2150 and 2152. It stands vertical and strikes N 68° E (true mer.), probably a part of the Lower Keewatin.

2152. On the north side of Urn lake, center of sec. 30, 64-10, is a rigid dark schist, an incipient mica schist, about vertical, striking E. and W.

2153. Mica schist, SE¼ NE¼ sec. 30, 64-10, north side of Urn lake. In this schist, which strikes 38° E. of N. is incipient granitic rock. It is twisted. The granitic belts cross it somewhat irregularly and are lenticular. They are also parallel with the schist. They are not distinctly granite, but fine-grained or flinty. The sample shows one of the micaceous forms of this schist.

2154. Shows one of the coarser aspects of the granitic rock at the same place. It plays the role of a pegmatyte, but is rather fine-grained.

2155. A portion having a flinty or felsitic aspect. It is really a part of the rigid schist, parallel in structure with the mica schist.

2156. About four rods northeast of this, at the lake shore, is a basic dike, cutting this schist. Its size cannot be seen, but it is at least forty feet, running under the soil on all sides. Its direction even cannot be determined. It has no schistose structure. It contains enclosures of the granite, and is closely jointed, at least on the burnt surface, and sparingly sprinkled with calcite nodules like an amygdaloid, which on weathering out leave the surface porous and pitted.

Granite blocks supervene at the shore a few rods further east, in great numbers, and that rock is certainly *in situ* in the immediate vicinity although it could not be seen. At a distance of about three rods from the lake is a small outcrop of granitized schist which strikes SE and NW, with a dip of 75° NE, apparently away from the supposed granite *in situ*. The lake shore further east is of drift.

2157. Northward from this locality about ⅛ mile is a hill rising about 150 feet. This hill is of a schistose greenstone (2157) cut by at least two dikes of granite. This greenstone extends conspicuously, in a low range, northeastwardly not far distant from the lake, rising above the drift of the lowland, with occasional exposures of intrusive granite.

2158. It is apparently the same range of greenstone which abuts on Basimenan lake at the southwest corner of sec. 16, 64-10, and which furnishes the stone which has formerly been used by the Indians for making pipes, represented by this rock. This is near the shore of Basimenan lake, a short distance up the little creek which joins the lake south of the greenstone range. The rock here has no schistose structure, and is rather hard for use for pipes, but, according to Vincent Dufault, who accompanied this party as guide and general canoeman, the Indians found places where it is much softer.

2159. The dull point just west of the mouth of the river coming into Basimenan lake at this place is made of greenstone with hornblendic element prominent, even more prominent than in 2157, although of the same range. It has a sharply hornblendic crystalline schistose structure with dashes of granite in irregular patches, and in some places the dark green rock has a distinct element of light-weathering feldspar.

2160. SW½NW¼, sec. 22, 64-10, on the south side of Oak Point lake. Here is a range of micaceous gneiss, very siliceous and fine-grained, almost exactly like that seen on the NW side of Urn lake (2153). It is pyritiferous. The hill rises about fifty feet. A little further south and east, and extending about half way to Little Sucker lake, is a red-weathering granite. This becomes gray and extends to the portage landing on Oak Point lake, but not to that on Little Sucker lake. About midway between the two lakes appears

2161, which is a siliceous gneiss, very fine-grained and pyritiferous and like rock 2060.

2162. Along the shore of Little Sucker lake in the NW¼ sec. 27, 64-10, is a massive greenstone, but with irregularities and quartz veins, schistose but not laminated, similar to that seen on the south side of Saturday lake. This seems to vary, a little further east, to the flinty rock represented by this number, although no observation was made on the manner of transition between the two rocks. This fine-grained rock weathers nearly as light as a white granitic, and appears to consist very largely of fine jaspilitic silica. It is grayish-green within, fibroschistose, but not visibly laminated, rising in bold glaciated bosses. On the weathered surface it is pitted by the decay and removal of some mineral (pyrite?). The same siliceous, finegrained rock (hardly a greenstone) is in several islands that cross the lake in a line toward the west. This rock forms an important belt in the Archean, and as a rock mass it is somewhat different from any rock elsewhere seen. It is apparently a dependency of the greenstone, and comes nearest to being a jaspilyte liberally mingled with the greenstone elements in finely disseminated and comminuted condition.

The same rock appears on the south shore of Little Sucker lake near the portage landing going south to Pine lake, but toward the east. It rises steeply from the water, as it does in other places, in a glaciated moutonée.

2163. SW¼ NE¼ sec. 27, 64-10. Shore of Pine lake. The greenstone here is schistose, but not laminated nor foliated, appearing conglomeratic. The pebbly forms, however, may be due to brecciation of a formerly sedimentary stratified rock, the coarser beds being broken so as to show as isolated roundish masses in the midst of the finer, the whole having suffered severe pressure and shearing.

2163A. Roundish, pebble-like masses from 2163. These masses, while greenish, are considerably more siliceous with jaspilitic silica, and are occasionally porous with elongated cavities as if amygdaloidal and comparable to the bombs of the agglomeratic greenstone seen at Ely and elsewhere widely. They are usually not over four inches in diameter.

2164. NW cor. SW¼, sec. 26, 64-10, Pine lake. A specked or pepper-and-salt, greenstone, so styled by Elftman. The dark specks are due to small hornblende crystals; occupies much of the eastern part of this lake.

2165. About on the ½ section line of sec. 26 where it crosses the south shore; rising in a conspicuous high shore, rock similar to 2164.

2166. At the point where the line between secs. 27 and 34 crosses the lake shore; a slaty schist.

At the centre of sec. 34, 64-10, Pine lake, is a conglomerate, containing jaspilyte and siliceous greenstone pebbles. It rises as a glaciated dome directly from the water. The structure, dip, strike, etc., cannot be made out with certainty, owing to the smallness of the exposure, but a general elongation of the pebbles and frequency of short seams, indicate a strike about east and west (true mer.)

The little long island, however, just northeast of the center of the section, is of a grayish, amorphous and agglomeratic greenstone at the west end, showing no pebbles. It rises about thirty feet. The eastern end is of a distinct conglomerate like that seen at the center of the section, already mentioned, and contains pebbles of fine and siliceous greenstone, and jaspilyte. The greenstone end of the island rises higher than that composed of conglomerate. The gray, siliceous greenstone pebbles are identical with some rock seen on Little Sucker lake (2162). In attempting to find the contact of this conglomerate on the greenstone, the two rocks could be traced toward each other so that they were separated from four to five feet, but owing to the prevalence of bushes, moss and trees, the exact contact was not visible, but there appeared to be gradual loss of the dominant characters of each, indicating a gradual transition from one to the other, or a basal portion of the conglomerate, composed of fine greenstone debris, which, on becoming solidified, closely resembles the rock from which it was derived.

2167. SW¼ sec. 34, 64-10. Warren's exploration near Pine lake. This is a region of hilly greenstone knobs, the rock being that which carries fine jaspilitic silica. The diamond-drill cores are of greenstone mainly, but also contain some of the usual jaspilyte. The fracture and structure of the rock are like the same in the rock at Kawasachong falls. The rock contains pyrite, calcite, and apparently siderite, and is slickensided by mountain pressure and movement.

2168. Near the section line, north side of sec. 34, 64-10, shore of Pine lake. A rigid, coarse, green schist, slaty and standing about vertical, appears at the point, and also in the bay further south. On the north side of the point this varies to a very fine flint, or flinty, gray-green slate, which may have been the source of flinty pebbles seen in the conglomerate mentioned, and which is also very much like the flinty greenstone of Little Sucker lake. This flinty slate is represented by this number. This flinty rock here and at Little Sucker lake is apparently only a vast jaspilyte bed, or lens, belonging in the Lower Keewatin, modified by the cotemporary introduction of much fine debris, which, in other places, went to constitute fragmental greenstones nearly or quite free from jaspilitic silica. The occurrence of small tourmalines in this rock, (2162) shows the presence of more or less of those gases which are attributable to volcanic source, and agrees with the hypothesis that the silica itself was due to chemical precipitation in the Archean ocean by reason of volcanic action.

2169. NW¼NE¼ sec. 32, 64-9, south shore of Moose lake. At about a quarter of a mile from the lake. Graywacke here strikes a little S of W, with a high dip toward the S. This is about 75 feet above Moose lake, but farther east rises to over 100 feet above the lake, with still southerly high dip, and a schistosity which runs about parallel with the lake. In the graywacke are hits of slate like the slate in which the graywacke is imbedded and also pebbles of graywacke like itself and there are also various sharp flexures and evident fractures in the bedding. It is probable that by brecciation and subsequent compression and shearing a clastic rock which originally consisted of alternating argillyte and graywacke has been caused to contain isolated pieces of one rock in the body of the other, and thus to take on the aspect of a conglomerate. Compare rock 2273.

2170. A little further east, after crossing the little creek coming from Flask lake, is another prominent ridge composed of this rock. This is apparently a porphyry and homogeneous, the crystals being of feldspar. Its contact is parallel with some slates of the formation, but it is also mingled in fragments with the slates mutually over a thickness of ten or fourteen inches, all elongated in lenticular pieces. The porphyry is not observably finer at this contact. This is NE¼ NE¼ sec. 32, 64-9, or perhaps a little further east. The field appearance is that of brecciation along the line of contact of a coarse-grained stratum on a fine-grained one, followed by shearing movement and pressure.

2171. This rock is similar to 2170 in being porphyritic. It comes from the next little ridge. It also contains "porphyritic" hornblende. It is in general a green rock, and a pebbly conglomerate, forming a ridge about 75 feet wide. It can only be interpreted as a constituent member of a vast fragmental formation, and may be compared with the conglomerate seen at Kekequabic lake and eastward to Zeta lake.

2172. Just before descending to Flask creek the country rock changes to a coarse conglomerate, dipping at 85° in the same direction. The pebbles are of a fine amorphous, gray or greenish-gray, siliceous rock, jaspilyte, greenstone, and are from six inches in diameter downward. Some of the pebbles are also of flint, and of "peppery" greenstone. This stratum is 200 feet thick. It also contains apparently pebbles of an older conglomerate, in which the pebbles are not distinguishable from those of the main formation. This again may be due to brecciation. Just before reaching this conglomerate appears

2173. A fine grained, apparently finely crystalline rock, gray and firm. This can be followed somewhat in the manner of a dike, about parallel with the general strike, for a distance of twenty rods or more, but its width varies considerably. It may be compared with Nos. 2263 and 2264; also with the porphyritic acid dike near Ely.

2174. Contact edge of 2173 showing a finer grain as if contacting on a colder surface.

2175. A curious, massive-looking green rock, apparently a bed of the conglomerate, but appearing outwardly like a greenstone. Twenty to twenty-five feet thick. This is about NW¼ NW¼ sec. 33, 64-9.

2176. Fine, brown, granitic rock, which runs like a dike, cutting the conglomerate near its contact with the greenstone, on the south side of Flask creek, but running nearly parallel with the strike.

2177. The distinctly conglomeratic portion of the rock in this immediate vicinity dips, with the rest, toward the south, at 85° under the rock represented by this number, which is an apparent greenstone, but still plainly a fragmental rock. It indicates that, older than the coarse conglomerate, is a considerable thickness of fine greenstone debris, which, when hardened and "recomposed," appears like the greenstone from which it was derived. In this are a few, imperfectly rounded fragments that were not far transported from their sources, but no banded variations due to sedimentation. On the weathered surface is a siliceous mesh-work which stands above the rest of the rock, a character which sometimes serves well to distinguish a clastic greenstone from an igneous one.

2178. SW¼SW¼ sec. 32, 64-9, south of Moose lake. A great range of greenstone runs through the country about east and west, rising about 200 feet above Moose lake. It is sometimes agglomeratic, but has forms of greenstone as pebbles, two or three inches in diameter, of differing grain and texture, but these are scarce. The whole is irregular and frequently much-jointed, and it contains occasional narrow belts of red conglomerate. Taken as a whole there seems to be a mingling of igneous rock with detrital, perhaps partly due to folding and shearing, but in large part probably due to cotemporary action of eruptive and marine forces.

The rock of this number is a curious micaceous greenstone that cuts the other greenstone in bosses and dikes. According to Elftman there is much of this in the region, and it cuts the jaspilyte. This here cuts agglomeratic greenstone.

2179. The finer parts of the general conglomerate.

2180. Red-weathering pebble, from the conglomeratic banded jaspilyte, near the sec. line between secs. 20 and 21, 64-9, but nearer Moose lake. This jaspilyte is here native to the formation in which it exists, and is at the same time crowded with pebbles, and even boulders, of detrital origin. The details of this locality are given in the final report, Vol. IV., in the chapter devoted to Lake county. It is sufficient here to state that the phenomena of this jaspilyte seem to be demonstrative, not only of the great age of jaspilyte but of the theory which ascribes it to chemical oceanic precipitation in the Archean age at a time and place when oceanic forces had full sway. The facts of this occurrence also seem to show that jaspilyte was formed in the Upper Keewatin as well as the Lower.

2181. Fragmental greenstone in which this jaspilyte lies, taken on the northwest side of the main jaspilyte band (compare 2273).

2182. Jaspilyte, showing close interbanding of other sedimentary materials, taken along the east side of the main jaspilyte mass (compare 2274). Still further east this graduates into a green slaty rock, viz.

2183. A firm, sub-crystalline schist, standing nearly vertical, the schistosity coinciding with the sedimentary structure; a sort of roughly schistose chloritic argillyte.

2184. On the trail between Moose lake and Flask lake. There is a large exposure of conglomerate and graywacke between these two lakes. It is sometimes charged with crystals of feldspar like the conglomerate at Zeta lake, and sometimes appears more like the Stuntz conglomerate, the former represented by this specimen.

2185. Hardened conglomerate, crystalline, approaching mica schist. On the face of the rock are boulder forms and irregular areas of granite, or granitic rock, which weather red. SE¼ SW¼ sec. 26, 64-9. This hardened conglomerate is a condition of the conglomerate of the region, and it is evident that the hardening is an incident of nearness to the granitic area of Snowbank lake.

2185A. Conditions of 2185, showing the remnants of stratification, and some pebbles.

2186. Conglomerate, from centre of sec. 26, 64-9, Snowbank lake.

2187. Porphyritic condition of the conglomerate at ten rods further west, at the lake shore of Snowbank lake; resembles 2184.

2188. Mica schist, lake shore, Snowbank lake, SW¼ NE¼ sec. 26, 64-9.

2189. Quartz porphyry, so-called, cutting 2188, and cut by the granite of the region. Same place as 2188.

At this point the mica schist, a metamorphic condition of the conglomeratic and graywackentic formation extending from Moose lake, is cut by large dikes of granite, as well as by this porphyry. According to Mr. Elftman, who has been over much of the country, this earlier porphyry is a part of a large formation found toward the south and southwest; the equivalent of the porphyry which cuts the greenstones on the Kawishiwi, described by Grant, and probably of that seen near Ely. It would thus be the source of pebbles seen in the great conglomerate about Moose lake. Be that as it may, and there is much reason to doubt it, the gradual change that certainly takes place in the rocks of the country in approaching Snowbank lake seems to bring them into such a crystalline condition that it is reasonable to consider this porphyry as a culmination of that alteration, producing a plastic mass which on any favorable occasion was ready to enter fissures in the surrounding strata, and on solidification to appear as dykes, or even as igneous masses of great size. In this rock are preserved, then, not only the feldspars of the original clastic rock, such as already noted in the conglomerate about Moose lake, but also some of the pebbly forms, for the latter are also visible on a weathered surface. That this porphyry is distinct from those on the Kawishiwi river and at Ely is shown by the fact that this cuts the conglomerate to which those are supposed to have contributed pebbles.

As to the granite, which cuts both the mica schist and the porphyry, some of it is distinct pegmatyte, and hence is not to be considered a normal intrusive, and some of it is uniform granite, there being no observable areal distinction between them, except that the former is always in small patches or dike-like bodies, and the latter forms great bosses. How much later this granitic formation was than the intrusion by the porphyry, it is difficult, even impossible to state, on the basis of any facts at hand. That is to say, it is not possible to affirm, with certainty, whether the granitic intrusion was essentially of the same age as that of the porphyry, only differing from the porphyry by being at the culmination of the epoch of which porphyry was the commencement, or was the product of a later grand epoch, such as that of the gabbro epoch, separated from the porphyry by a long period of quiet. In any case, the source of the materials of the granite, from facts already stated, and to be stated, was the same as that of the materials of the porphyry, viz.: in the schist and conglomeratic schist of the country, by a powerful metamorphosing force which rendered plastic and then recrystallized the detrital elements of the older rocks.

2190. SW¼ NE¼ sec. 24, 69-9. Snowbank lake. Near the head of the little bay, but on the north side of it, is an outcrop of a phase of the formation which is not granite nor mica schist. It is massive and indistinctly porphyritic, with small dim feldspars, or pieces of feldspars. It is finely granular on a weathered surface, and shows a grayish red color, the redness coming from the feldspars, which have a tendency to that color, and the mass of the rock being gray or greenish. It is not well developed as granite. It probably was not in a zone of differential shearing but was heated and pressed uniformly.

2191. Sample from the same place, from the same rock a short distance from the shore (say 150 feet). This shows the conglomeratic and the finely porphyritic structure, seen in 2190, in the same mass; but as it contains a granite pebble, which according to the provisional interpretation offered by Mr. Elftman, can come only from the granitic dikes and masses of the mica schist, this conglomerate must be separate and later than the Snowbank lake conglomerate, and of the age of the conglomerate of Moose lake.

*The conglomerate of Snowbank lake:* The question having arisen, in the field-work, of the existence, as above, of two conglomerates, one a micaceous and schistose, and the other the Moose lake conglomerate, and the distance between them being reduced here, according to Mr. Elftman, to 150 feet, it was deemed best to make a thorough examination of that interval. His idea would require no granite to cut the upper one, but only the lower; and no granitic pebbles in the lower, but many of them, from dikes in the lower, to exist in the upper.

On landing at the same place again, the first thing to be noticed was granitic boulder-like masses in the supposed lower, micaceous conglomerate, immediately at the landing. As it was suggested that they might be intrusive masses, like the dikes, although entirely isolated, further search was made in the same vicinity. These isolated granitic masses do not appear like intrusive, or indigenous granite, mere splashes of granite half-formed, off-shoots from the rock 2190 penetrating the surrounding mass, as seen at Disappointment lake (see under 2206), but they appear rounded and foreign masses, same as that seen in 2191.

Next it was noted that in passing over the interval to the location of rock 2191, a great rock ridge immediately sets in, rising from the lake shore, the rock No. 2190 continuing, though much moss-covered, with identical characters across the whole interval to the place of 2191, though perhaps becoming more and more crystalline. It is somewhat porphyritic, generally dark colored, sometimes a little schistose and micaceous. But finding that sample 2191, containing a conspicuous pebble of fine-grained granite, came from a lot of loose angular blocks, evidently but not certainly the talus of the hill, on a slope descending toward the south, it was essential to further examine the country rock underlying. The hill mentioned here rises still about 175 feet. On ascending the hill it was found that the same rock mass continues, though a subordinate crest was found to be composed of reddish granite. This granite mus therefore cut the supposed upper conglomerate. Both of the criteria of distinction therefore were negatived, viz., granitic pebbles are in the supposed lower conglomerate, and granitic dikes cut the supposed upper conglomerate.

In order to ascertain whether the piece from which was obtained the sample 2191 was *in situ* in the immediate vicinity, that locality was re-examined, when it was found that most of the moss-covered blocks are, truly, from a different kind of rock, viz.:

2192. Black, or dark-gray, and like a basic dike, its relations not seen. But on skirmishing about a little, and pulling off the moss, there was found a large conglomeratic area, within twenty feet, containing boulders of granite, and identical, in all essentials, with the rock 2191.

2193. Granite pebble, from the "lower" conglomerate.

The main hill, which here rises 200 feet, more or less, is made of the same kind of conglomerate, with varying degrees of coarseness. It is evidently cut by granitic and perhaps by other dikes. It follows, so far as this search indicates, that the metamorphic conglomerate, seen so abundantly about Snowbank lake, is the same as that seen between Snowbank and Moose lakes, and belongs to the base, or near the base, of the Upper Keewatin.

2194. Augite-syenite, from the small island, NE¼ SW¼ sec. 19, 64-8, Snow bank lake (same as 271E, already described by Mr. Elftman, who first identified the rock).

Another examination was made, under the guidance of Mr. Elftman, in the north side of sec. 19, 64-8, between Snowbank lake and Black lake, of the supposed superposition of one conglomerate (the more northern) over another supposed to be older. There is one continuous conglomeratic mass extending from one lake to the other, all standing nearly vertical. In the northern part, the strike being nearly east and west, is found a noticeable amount of jaspilyte, and little or none of this is seen in the southern part. The southern part is also more crystalline than the northern, but it is not a mica schist. These differences, however, are hardly sufficient to establish a distinction which would warrant the assignment of the northern part to the base of the Upper Keewatin and the southern part to the base of the Lower Keewatin, (1) because the absence of jaspilyte from a portion of a conglomerate may have been caused by the exhaustion of the supply in the later part of the period of its formation, or by its being covered by sedimentation and protected from further degradation—considerations which would go to show the greater age of the northern instead of the southern part of this conglomerate. If the northern strata, at this place, be considered the younger, as believed by Mr. Elftman on the basis of the jaspilyte contained in them, such variation from no jaspilyte in the older strata to frequent fragments of it in the younger, in the same conglomeratic mass, is not a variation that requires such a profound non-conformity. Many causes can be invoked for the appearance of jaspilyte in such a mass at one horizon and not in another. Anything that would bring the line of erosion and distribution from one rock to another, would be sufficient to cause the appearance or the disappearance of jaspilyte fragments in the process of accumulation of a conglomerate. Subsidence, elevation, sudden or gradual, volcanic action, long-continued base-leveling, etc., would materially modify the nature of any coarse fragmental in process of accumulation. Such variations, in respect to other sorts of pebbles, are not uncommon in all conglomerates. (2) The difference in metamorphism is not marked. The southern part is not a pronounced mica schist, while the northern part is not free from metamorphism. Indeed, so far as could be observed, the metamorphism was progressive from north to south, i. e., in the direction toward the granitic area of the central part of the lake.

It should be added that, taken together, these parts seem to constitute a great conglomeratic mass, the same as occurs between Snowbank and Moose lakes, and quite similar in many respects to the great mass frequently named Ogishke, lying further northeast.

2195. Supposed augite-granite (Nos. 271E and 591E, described by Elftman in the report for 1893); just east of the section line between secs. 19 and 20, 64-8, Snowbank lake.

2196. Red, fine, porphyritic granite, at the section line between secs. 19 and 20, 64-8.

*Disappointment lake.* An examination was made of the iron ore location at Cheadle's cabin, so-called from an exploration made several years ago on the south shore of this lake, by Mr. Cheadle, for the trying of the iron ore there seen. In all former reports this iron ore has been assigned to the Animikie and the facts here observed, taken in connection with what had been discovered respecting the rock called muscovadyte, and its relations to the gabbro and to the Kawishiwin greenstones, conspired to cause a considerable alteration in the survey's classification of the iron ores, and in theoretical views as to the gabbro. The place was visited again in 1898 for renewed inspection, and these views were confirmed.

2197, SW¼NE¼, sec. 4, 63-8, Cheadle's cabin. In reaching this place the party passed several small points along the southwest shores of Disappointment lake, which, without close examination, appeared to be of mica schist, such as seen in many places on Snowbank lake. Also on the portage from Snowbank lake the same mica schist is seen, cut occasionally by small red dikes of granite. This rock is obtained immediately on landing at Cheadle's where is a conspicuous display of fine-grained, non-micaceous rock, mainly massive, but conglomeratic in bands, gray, firm and resembling muscovadyte. This dips S or SSE, at an angle of 45° to 80°.

2198. Conglomeratic condition of 2197.

2199. Siliceous iron ore, showing the rock rather than the ore, mainly a dark, ferromagnesian rock.

2200. The same, with more quartz, the last being recrystallized by the action of the gabbro.

2201. Low-grade ore. Cheadle's.

2202. Gabbro, cutting this conglomerate, at a point 30 ft. ± further south. The gabbro embraces pieces of conglomerate. The conglomerate certainly contains the ore, and they both pass under the gabbro, or into it, the average northern limit of the gabbro being some further south.

2203. A piece of the conglomerate (now a fine-grained rock, like muscovadyte) at the gabbro contact.

The large point in the southern part of sec. 33, 64-8, consists of hard, subcrystalline, massive conglomerate, in which are a few hornblendes, but scarcely visible mica-schist characters. It cannot be separated from the conglomerate, which is distinctly a mica schist. It is cut by a basic dike running about east and west, and about four feet wide. Westward along the shore of this point the country is nearly bare of vegetation, and the rock is frequently seen in large surface exposures. It consists of the same conglomerate as on the south side, cut by several basic dikes, with irregularities of strike, although it is nearly ENE. One small granitic dike (8 in. wide) also cuts the basic dikes. Toward the west there is an increasing tendency to siliceous veining, characteristic of mica schist—such small veins as cross each other but hardly make anything more than a coarse mesh work in the rock itself, appearing on the weathered surfaces. It also shows reddened areas, both of boulders of foreign granite, and splashes, as it were, of incipient granite, of irregular shapes from six inches to two feet across, roughly embracing sometimes areas that are not red. Many of the pebbles have a zonal structure, green in the centre, then pink, then granitic, then hornblendic.

2204. From a narrow (8 in.) granitic dike, as above.

2205. Micaceous and hornblendic condition of this conglomerate, as above.

2206. Micaceous and hornblendic condition of the same from a little further west but still containing numerous pebbles.

Further west, and south, this conglomerate becomes more characteristically a mica schist, as seen widely about the western shores of Snowbank lake. Along the west shore of Disappointment lake it is decidedly micaceous and decidedly conglomeratic, on the hills back from the shore, in the SE part of sec. 32, 64-8. Here the rock varies from a firm wackenitic formation with many red granitic boulders to a more distinct mica schist. The granitic boulders are large and abundant. The rock is sometimes distinctly bedded, dipping about 75° to the SW, and on weathered surfaces it is red and sub-granitic.

In the hills mentioned is considerable red granite, conspicuous from a distance, viewed from the east. This, however, is in the form of dikes cutting the conglomerate, the latter rock having been broken away from the granite in large blocks, leaving the granite exposed. The conglomerate here is not only conspicuously cut by red granite dikes, but also contains pebbles of red granite, as well as reddened splashes or areas where the whole conglomerate itself is red. The red-weathering patches in the conglomerate seem to be places semi-granitized. This is not far from the centre of sec. 32, 64-8, a little SE from the centre. The red granite dikes cut several basic dikes. This massive, firm conglomerate, can here hardly be called schist, although it has been uniformly denominated mica schist. It is a very siliceous rock, probably made up of the debris of granite, quartzose rocks and perhaps quartz porphyry, and was originally, where fine-grained, a graywacke.

2207. Red granite, from the dikes above. These vary in width from a few inches to four or five feet.

The southwesterly part of the shore of Disappointment lake was again examined.

2208. There is a scarcity of rock exposure; but at SW¼ NE¼ sec. 5, 63-8, the exposed rock shows an approach toward mica schist, and also toward the muscovadyte seen at Cheadle's. It is rather fine-grained, distinctly bedded, gray, siliceous and apparently hornblendic.

2209. Nearly the same as the last, but from the extremity of the point, a little further north; somewhat coarser and more siliceous, quite similar to the rock at Cheadle's. There can be no doubt as to the transition, along the strike, from mica schist to the muscovadyte at Cheadle's, a fact reported by H. V. Winchell in the 17th annual report, pp. 116-117, 1888.

2210. Northeast end of Disappointment lake. Somewhat more greenish and less quartzose, but still a part of the same conglomerate.

*The results of observations* about Snowbank and Disappointment lakes in 1897, may be summed up, as they appeared at that time, about as follows:

1. The conglomeratic formation about Moose lake, extending to Snowbank lake, is reasonably considered as one.

2. At Snowbank lake it becomes micaceous and hornblendic, and constitutes, in that form, many prominent topographic features about the western and northern shores.

3. It is cut by granitic dikes in many places, especially whenever it has the micaceous and hornblendic composition.

4. The red granitic dikes cut a coarse augite granite on the north shore of Snowbank lake, and this augitic rock may be older than the conglomerate. We have no evidence on that.

5. Much of the eastern and northwestern shore is also composed of this conglomerate, but the southeastern is occupied by a coarse gray granite.

6. At the portage to Disappointment lake the rock is conglomerate mica schist, cut by granite, but near Disappointment the schistose character is less pronounced, and the conglomerate is a massive hard rock, the boulder forms often being perfect and frequently of granite.

7. Throughout Disappointment lake the shores are apparently of this conglomerate.

8. It becomes micaceous in the vicinity of granitic dikes and the mica schist, at least toward the south, becomes the muscovadyte, so called, in the Minnesota reports, in the vicinity of the gabbro, and has not in this form been distinguished from the muscovadyte of the Lower Keewatin.

9. The effect of the granitic revolution, on the older rocks, appears sometimes more profound than that of the gabbro, and extends a greater distance from the present outcrops of the intrusive rocks. In the latter case also the earlier structures (bedding, boulders, etc.) are more obscured, the rock becoming nearly homogeneous and massive. The effect of the granitic revolution was profound and widespread, the gabbro revolution was intense and more local.

10. The gabbro cuts through the conglomerate, appearing in tongues and sills for some distance (say 300 feet) north from the general limit of the gabbro. The conglomerate was followed southward about 150 feet from the point at which the iron ore appears.

11. The gabbro varies considerably, often taking the form of an igneous muscovadyte, and having its coarse homogeneous structure only at some distance south from the point at which its gabbroid characters are recognizable.

12. The iron ore is in this great conglomerate, and not in the Animikie, and was undoubtedly originally jaspilyte, like that seen westward from Moose lake, on the portage to Wood lake, the alteration being due to the general revolution which produced the gabbro.

13. There is but one conglomerate, so far as can be seen; it was converted to a micaceous, and sometimes a hornblendic, rock at the time of the granitic disturbance; and this mica schist now passes to muscovadyte toward proximity to the gabbro. At the same time this tendency toward muscovadyte is within a belt of country which seems to be occupied by clastic greenstone containing occasional lodes of jaspilyte. This belt of clastic greenstone, now altered to muscovadyte with its olivinitic magnetite, runs southwestward toward the southern confines of Birch lake, and is the same belt which has uniformly been considered, hitherto, to have been composed of the strike of the basal portions of the Animikie.

14. The normal gabbro has an intimate association with this muscovadyte.

15. This conglomerate has to be parallelized with the Upper Keewatin. It is earlier than the granite which cuts it about Snowbank lake, but later than the granite on which it lies at Saganaga lake.

16. There is no evidence here to connect the Animikie with this conglomerate. The Animikie exists nowhere in the region.

17. It is apparent that in some places the granitic disturbance came upon the Lower Keewatin, and in others upon the Upper. In the former case hornblendic schists, and more rigid and uniform mica schists result, (and it is possible that this preceded the granitic revolution which gave dikes in the conglomerate), and in the latter the conglomeratic character is more persistent, with development of scattered small hornblendes.

[NOTE.—It is important that the granitic area of Snowbank lake be further examined for the purpose of delimiting the granites, which seem to occur there, of two different dates. It may be also that there is a Lower Keewatin conglomerate, viz. that which is seen at Cheadle's, passing to muscovadyte through mica schist, and an Upper Keewatin conglomerate, viz. that cut by the red granitic dikes and other granite.]

On returning to Tower, by way of Prairie portage, an examination was made of the river flowing from Sucker to Basimenan lake. It is a large stream and has a water-fall and rapid descent immediately at the outlet of Sucker lake, the barrier being granite or granitized schist, the whole fall being about 30 feet.

2211. Light colored granite, at the outlet of Sucker lake. The general aspect of the structure is that of intrusion in the schists, which are crumpled and subcrystalline.

2212. Squeezed schist, same place.

Lower down, on the Canadian side of the stream, is an exposure in the bank which is of a rock in some places granitized and in others subgranitized schist, viz.

2213. Granite, at the river, Prairie portage.

2214. Granitized schist, Prairie portage.

The schists of the region are sericitic and fragile, when weathered, and occasionally become argillyte and graywacke.

## ROCK SAMPLES COLLECTED BY N. H. WINCHELL IN 1898 WITH FIELD ANNOTATIONS.

### *Third Visit to Snowbank Lake.*

*The Kawishiwi River.* At the west end of the short portage going from the Kawishiwi river (Centre of SW¼ sec. 30, 63-10) is a knob of granite causing rapids. This granite has been examined and mapped by Grant (20th report). The Kawishiwi river proper was left at the next bay (east) where another portage leads to Clearwater lake, to NE¼ NE¼ sec. 31, 63-10. Occasionally on this portage the mica schist is seen to be conglomeratic, like that at Snowbank lake. The granite permeates the schist in a multitude of small dikes and veinings, often in all directions, and the schist itself is granitized where acid. Where not acid, or where basic dikes cut it earlier than the granite, the resultant rock is a dark hornblendic one.

2215. NE¼ NW¼ sec. 5, 62-10. On the south side of the large triangular island surrounded by the Kawishiwi river. This rock comes from the point at which in 1886 was noted firm, tough "greenstone" in the report for that year (16th Report, p. 342), but it is not normal greenstone, as that term is now understood. It is a fresher rock than the greenstones, is distinctly crystalline, rather coarse-grained, and dates from the epoch of the intrusive granite, approaching dioryte. It is a dark granitoid rock, a variant from the granites of the immediate vicinity. This occurs on both sides of the little bay, and particularly on the south side.

2216. Another, but similar phase of the dark rock 2215. North side of the little bay.

2217. Still another phase, from the south side of the same bay. The structural relation of this rock to the red granite is not visible, but apparently there are intermediate stages of acidity, due to the acquirement of quartz and orthoclase, through which the dark rock gradually passes into the regular granite.

2218 illustrates a stage in this transition, and

2219 is another, a red granite with much hornblende. These last two are from the same shore farther west.

2200. A short distance further west; darker than 2218 and 2219, but lighter than 2215-17.

It is an important observation that, as above, this fresh eruptive dark rock, which might be called greenstone, with a qualification, shading through dioryte passes into hornblendic granite. All stages of this transition could be represented by samples. In one direction the rock, for the most part, is dark and green and in the other it is a distinct red granite, but in some places knobs and areas appear that show intermediate stages. This local difference in the acidity of the crystalline rock is believed to be due to local variations in the acidity of the original clastic rock from which the igneous rock was locally produced by intense metamorphism, which here reached the point of fusion. The original structures are entirely lost, and the present conditions are only those of a massive crystalline rock.

2221. At the narrows of the Kawishiwi river, NE¼ SE¼ sec. 5, 62-10, a little west of the so-called "Palisades" of the Kawishiwi. This rock forms a small knob on the north shore. It is a fine-grained "greenstone," or hornblende schist and is cut by many veins of red granite, and seems to be finally wholly replaced by the palisade rock. It is sometimes very fine-grained, as if it had chilled by contact on a colder rock, but that could not be on the red granite. The sample shows some disseminated red feldspar, which is not the usual thing.

2222. Fine-grained sample of this rock; composed apparently largely of fine horneblendes, with some feldspar equally fine; sharply crystalline, hardly a schist, though having a schistose rift.

2223. Centre W½ SW¼ sec. 3, 62-10; south Kawishiwi river. Back from the shore a few rods is a ridge of gabbro. In this gabbro, in spots, are angular pieces of muscovadyte, from two or three inches to eight inches in diameter, the gabbro passing round them.

2224. (Specimen missing.) NE¼ NW¼ sec. 3, 92-10; at the granite contact on the gabbro, at the river shore. A gray but red weathering rock, fine-grained, apparently intermediate between gabbro and granite, forms a low point having an unfavorable exposure. There is no evidence that the gabbro had any connection with this in age or genesis.

Again at two points were noted the easy transition from the red granite of the region to the coarse gray dioryte, even on the same rock surface, within six feet. Fine, red aplitic dikes cut both. The hornblendic element in the dioryte is the chief point in which this differs from gabbro, and at a distance such gray dioryte, when fine-grained, is easily mistaken for gabbro.

2225. NE¼ SW¼ sec. 24, 63-10, on the portage from Kawishiwi to Triangle lake, near the Kawishiwi. The granite continues but a short distance north of the river, but passes through a schistose lamination, the laminations being of fine, or red felsitic, rock, separated by thin sheets of green substance which is fine and apparently allied to the greenstone which supervenes next north.

2226. From a large inclusion of greenstone in the granite, near the same place as 2225.

2227. At the corner of secs. 8, 9, 16 and 17, 63-9, is a prominent greenstone ridge which extends NE and SW. It appears fresh, fine-grained and diabasic, but much of it is agglomeratic. The sample represents the non-agglomeratic.

2228. Diabase dike cutting 2229; these are narrow, reaching 4 ft. They show sometimes clustered crystals of plagioclase, like the sills at Gunflint lake, and are equally fresh.

*Porphyry of the Lower Keewatin.*

2229. Two hundred paces south of the ¼-post, east side of sec. 8, 63-9, southwest of Snowbank lake. A large area extending westward from this place is occupied by a peculiar light-weathering porphyroidal rock whose structure and relation to the greenstone, and whose origin, are very interesting and important in the solution of the geological questions of the Archean, but whose peculiar phenomena cannot be fully set forth here.* In general this rock is massive.

No. 2229 furnishes much debris to the conglomerate 2230. It is apparent, from all the facts observed, that the rock 2229 is a member of the Lower Keewatin.

2230. In the main a greenstone. It contains pieces, near the contact with 2229, both rounded and angular, of 2229, and constitutes a conglomerate of later date than 2229.

2231. Fragmental (?) greenstone, a part of 2230. This rock has firm, fresh, uniform, massive aspect.

2232. At a quarter of a mile north of the east ¼ post of sec. 8, 63-8, the rock is gray, siliceous, hardly porphyritic, a near approach to graywacke. This is apparently a variation in the rock 2229, the great porphyry of the region. This continues further north, without much variation, for quite a belt, when suddenly a green phase comes on, resembling 2231. This rapidly fades out into a bluish-green, coarse, schistose slate, then to lighter, coarse slate or graywacke. This continues northward to the swamp, where the section corner-post stands.

2233. North from the same swamp; a bluish-gray rock, hardly a slate, striking north, 52°W, standing nearly vertical.

2234. In another swamp, at 52 paces south from the section corner of sec. 9, are low moss-covered knobs of slate like 2233, and in close proximity to them is found this greenstone, probably a dike running with the formation northwestwardly. Outwardly, however, this is hard to distinguish from 2231.

2235. A greenstone which carries masses and pebbles of porphyry (2229) from ⅛in. to ¾in. in diameter, strung out

*Compare the chapter on Lake county, final report.

NW and SE in a pseudo-sedimentary manner. The two rocks, porphyry and greenstone, are irregularly mixed, each, occurring in isolated knobs, but in general the porphyry is in smaller masses in the greenstone. This is on the north line of sec. 8, 63-9, about a quarter of a mile west of the northeast corner of the section.

2236. From a dike 650 paces west of the corner post, about 2 feet wide, running N and S, across the quartz porphyry, or porphyrel, may be compared with 2235. This dike runs "under Copeland's cabin," i. e. through the ruins of that cabin, now burnt.

2237. At 670 rods west from the same corner post (i. e. NE cor. sec. 8, 63-9) four rods west of the above cabin. At this place the porphyry, so-called, presents fragmental characters. It is roughly schistose in a direction E25°±N, and ridged with interrupted finer belts resembling siliceous argillyte. It holds pieces of greenstone, and of slaty greenstone varying in size from 10 inches downward, (rounded) to half an inch, also pieces of jaspilyte, and rounded quartz. The slaty greenstone is like argillyte and runs usually with the structure, standing on edge. The rock contains much quartz in grains less than a pea in size, but also as large as an inch in diameter, the last being very rare, while other quartzes, as if phenocrysts in quartz porphyry, are abundantly disseminated. Indeed the bulk of the whole rock consists of more or less rounded fragments of orthoclase and quartz lying in a pellucid matrix which appears to be quartz, essentially, sufficiently abundant to keep the quartz and orthoclase grains from interlocking, but apparently allowing them to come loosely into contact.

2238. In other places nearby are other variations in this porphyry. It may hold distinct crystals of orthoclase in abundance, or none at all. It also varies to a fine-grained gray rock with no apparent quartz nor feldspar as crystals, but yet on close examination it is seen that fine quartz grains are still present. In other cases it holds vitreous quartz grains surrounded by a mesh of quartz which is like that of the jaspilyte, i. e. very finely granular and interlocking. The specimen having this number represents such "chalcedonic" quartz, as matrix for vitreous quartz grains, from about a quarter of a mile north of Copeland's cabin. If this be real "chalcedonic" silica, same as that of the jaspilyte lodes, it raises the hypothesis that the whole mass of this quartz-porphyry with its variations may be due to oceanic precipitation followed by the formation of phenocrysts, sometimes of quartz and sometimes of orthoclase, and sometimes of both, from the hot solutions of the Archean ocean, the whole having been at first a siliceous and alkaline mud. It seems, from the field observations, that this rock which is usually accepted as an igneous one (i. e. the quartz-porphyry), presents occasionally characters that are usually accredited only to those rocks that are of oceanic origin. These fragmental signs are indistinctly seen in much of this rock, but outwardly, and megascopically, it appears like a massive quartz porphyry. Its age is very near that of the oldest greenstone. In no place is it seen to be intrusive on any rock, so far as examined, at least not on that older greenstone. Quartz porphyry of later date is known to be intrusive on the Upper Keewatin, as at Snowbank lake, but that may be attributed to subsequent plasticity of this mass in some of its deeper-seated portions, under the influence of pressure and folding. The occasional signs of fragmental accumulation seen in this rock would, in that case, be the result of erosion and transportation and sedimentation, identical with the same in normal sedimentary rocks.

2239. In a swamp next further west from the last, but distant from it not more than twenty rods, appear small isolated outcrops of a sub-granitic rock, somewhat resembling the granites of Kekequabic lake, probably of the same date and origin.

Passing westward through this swamp and onto the spur of dry land coming from the north (NE¼ NW¼ sec. 8, 63-9) the porphyry, or porphyrel, appears in isolated patches and belts, sometimes having the appearance of intrusive relations to the greenstone, i. e., to a greenstone, although such areas and belts might have been formed, so far as can be seen here, by the folding and twisting which the rocks have suffered. The porphyry occurs suddenly in knobs and small areas, sometimes coincident with the schistosity of the greenstone and sometimes across it. This greenstone is the later greenstone, contains small deposits of jaspilyte, is non-agglomeratic, yet massive. It differs from the agglomeratic, or fundamental, greenstone; (1) it is not agglomeratic; (2) with a hand-glass it can be seen that the green, hornblendic element is roundish, and is embraced in a mesh-work of the white element which is apparently silica, which on weathered surfaces stands out above the hornblendes, giving a sharp roughness. This siliceous element is so abundant in some ridges that it gives the rock a white appearance of weathered porphyry. In an igneous greenstone the white element, which is feldspathic, weathers away faster than do the hornblendes, and the latter mineral forms the prominent roughness. (3) It holds detached masses of the porphyry, and is, apparently, in some cases intruded by the porphyry, and brought into abrupt contact with it by folding.

2240. Sample of the conglomeratic (?) transition from the porphyry to the later greenstone. Same place as 2235; same horrizon as 2230. This rock is wholly composed of debris, mostly of pieces of porphyry, but partly of greenstone. The pieces of porphyry are not, now, markedly of rounded outlines, and seem not to have been worn long by wave action, but they are of all sizes from several inches in diameter to mere grains, and some of them are of white jaspilitic quartz. This is illustrated by plate Z, Vol. IV, final report, from photographs.

This porphyry is a great formation. It was at first estimated at 1000 feet in its extent north and south, but later observations indicated that 2000 feet would be nearer the truth. There is much reason to believe that it is wholly an oceanic formation, and that the "contacts" which it makes suddenly upon the greenstone are due to folding and displacement. Not enough detailed examination was made to establish that idea for all the area of its extent, but what was seen in the region examined would not negative that hypothesis. Such isolated contacts would be therefore like the displacements of limestone and gneiss in the Adirondacks which mutually penetrate each other along the plane of superposition. But the fragmental transition, such as illustrated by rocks 2240 and 2230 can hardly be taken for anything but a detrital phase, incident to oceanic accumulation, in passing from one rock to another. This not only makes two greenstones, separated by this porphyry, but implies a great and sudden variation in the nature of the materials undergoing oceanic accumulation. Throughout most of the northern part of the state where this greenstone formation has been studied, no such body of porphyry has been found. That at Kekequabic lake is the most important seen up to this time, and at that place there is no such good opportunity to examine its structural relations. It has to be allowed a place in the Archean separating at this place what has been called the Kawishiwin into two great members.

The remarkable thing about this porphyry is its acid character, as it lies between two basic rocks. While it seems to be a rock accumulated by oceanic forces it does not show plainly any sedimentary structure. It is mainly massive and looks like an igneous rock, as much so as the fragmental and massive greenstone. There is no known earlier granitic rock whose disintegration could have furnished this as a detrital product. It contains no pebbles of granite—only pebbles that can be referred to the earlier greenstone and some of its accidental variations, including jaspilyte. Hence it is a problem to assign a source to this great acid mass.

If we allow the chemical precipitation of the silica of the jaspilyte in the midst of the greenstone Archean, or closely following the congealation of the earliest greenstone crust of the earth, thus producing the jaspilyte masses which everywhere occur in the greenstone, it is reasonable to presume that those conditions may have been prolonged in time and intensified in degree as well as extended in area, and that under favorable circumstances an enormous amount of siliceous mud, varying occasionally to pure silica, may have been produced. There have been noted repeated instances of the gradual passage, by inter-stratification, from jaspilyte to argillyte, and to a chloritic schist, as well as to iron ore. In one remarkable instance such banded jaspilyte has been seen to be at the same time a coarse conglomerate, showing that violent agitation, as well as chemical precipitation, was an attendant of the Archean ocean, both taking place, in some cases at least, at the same point and simultaneously.

Under conditions producing chemical precipitation of silica, if the Archean ocean was deep, and if the precipitation was rapid and abundant and the mass cooled slowly (for the Archean ocean at this time must be considered to have been heated) it might be that crystals of quartz of considerable size would be formed throughout the mass, and that all the quartzes of this porphyry may have originated, in some such manner as selenite, pyrite and other crystals form in a mud that holds the elements of those minerals in saturated solution. The general absence of a banded stratification, under this hypothesis, is the greatest obstacle; but if the precipitate accumulated rapidly it must have been subject to the same forces, whatever they were, which excluded the banded structure from great thicknesses of fragmental greenstone, and from greater thicknesses of the Ogishke conglomerate, and from the Stuntz conglomerate. It is perhaps due to copious and quick accumulation that the sedimentary structure is not seen in some large and important fragmental terranes. A subsequent crystallization of the mass would also result in the obscuration, or the obliteration of the sedimentary structure, a fact seen in many great limestone strata of the Silurian.

If, however, as seems to be proved by the presence of orthoclase crystals in this porphyry, the precipitate was not wholly of silica, but included a considerable amount of potassa, the crystalization of such a deposit of alkaline mud would not only re-arrange the molecular structure of the deposit throughout its whole thickness but would still more effectually destroy whatever sedimentary structure the ocean may have stamped upon it. Elsewhere it has been shown by the writer that potassium was probably retained as an element of the atmosphere, after the solidification of the first crust, for a period long enough for the cooling of the crust and the ocean to bring potassium within the bounds of possible condensation and precipitation.* This is an inference from the observed later introduction of acid-alkaline rocks in the Archean than the ferromagnesian. It is a striking coincidence with that argument that, here, the oldest known acid rock not only shows signs of oceanic agency but also embraces, along with phenocrysts of quartz, those of orthoclase, and that the fine matrix of these phenocrysts is both siliceous and alkaline, in a state of fine crystallization.

The heated waters of the Archean ocean had, at the date of this precipitation, only been able to accumulate by the ordinary methods of detrital sedimentation, a coarse "mud-conglomerate," a stratum seen at this place to have a thickness of about 105 feet, made up wholly of roundish and more or less squeezed greenish pebbles. This band sometimes has been designated a "greenstone conglomerate" from the nature of its pebbles, but in other cases it has been styled "mud conglomerate," from the fineness of their grain and the smoothness of their outlines, which also indicates an original plasticity. Under such conditions not only would the alkaline ocean hold in solution much silica, but such silica would, with alumina (also present as a product of decay and dissolution of the greenstone crust), necessarily unite to form such minerals as orthoclase. Hence would result, possibly, a rock as an oceanic product which is usually considered a normal igneous rock. Even with this origin for the earliest acid rock, which is here a quartz-porphyry, this rock is not far removed from the same operations and the same agencies as those which are called ig-

*The origin of the Archean igneous rocks. *American Geologist*, XXII, 299, 1898.

neous, for heat and moisture and plasticity are the essential conditions for the production of all acid igneous rocks unless they be derived from some premordial magma. This explanation differs only in requiring a lower degree of heat (less than the boiling point of water), a longer period for crystallization and an enormous scale of operation, as contrasted with the restricted limits of normal volcanic action. It also implies the formation of the rock over broad expanses of the ocean's bed rather than in the reservoir's of the earth's crust; and as a corollary it points to the porphyritic rather than the granitic as the structure assumed by the earliest acid rocks.

2241. At 430 paces west and about 80 paces south of the NE cor. of sec. 8, 63–9, is a conglomeratic place in the porphyry. Toward the NE from the porphyry can be seen a gradual change, the rock beginning to appear pebbly mainly with quartz-porphyry pebbles, with quite a number of greenstone, hard flinty slate and jaspilyte quartz and gray quartzyte. The change is within a foot and there is no apparent base for the conglomerate. The distinct conglomerate has a thickness of about 20 feet and grades off to graywacke which is distinctly bedded. The pebbles of the conglomerate are small and the rock so gradually grades into the non-conglomeratic kind that it is impossible to point out the contact with the porphyry proper. The transition is as indistinct as that from the Saganaga granite to the overlying base of the Ogishke conglomerate, at the northwestern corner of Saganaga lake. It seems quite likely that here the true base of the Upper Keewatin is seen lying on this Lower Keewatin porphyry. This specimen represents the porphyry at the exact contact on the greenstone, where the change is sudden, like an igneous contact.

2242. Porphyry at 10 feet from the same contact. These show no difference in fineness of grain, even the porphyritic crystals of quartz and feldspar continuing of uniform size up to the exact contact plane in No. 2241.

Going north on the section line between secs. 4 and 5, 63-9, only graywacke and slate are encountered, with a strike N 50° W at first, but veering to N 20° or 30° W. This has the appearance of being a part of the Upper Keewatin in the syncline of a fold the south arm of which would lie against the porphyry and greenstone above mentioned. In some places it is intersected by greenstone dikes which are frequently pinched out by the folding pressure.

2243. Sub-granitic narrow dike running with the structure in the foregoing slate and graywacke. It is plain by the structures that before the general twisting and kneading this slate and graywacke contained both greenstone dikes, sub-granitic dikes and large amounts of vein quartz, for these all shared in the close folding. The rock was in some cases closely broken and thrust zigzag and back upon itself, for it is in some belts shattered finely, so that no general nor special strike nor structure remains. In general the dip is nearly vertical.

2244. Near the quarter section post, before crossing the creek, at Nelson's cabins, the graywacke is normal, but at a little further west is a ridge of this rock. It is quite similar to 2243, but as it is in large amount its variations can be studied to advantage. It is rather homogeneous, massive like an igneous rock and spreads irregularly over several knobs, plainly intrusive in its action.

2245. On looking about over these knobs it appears that this rock is generally finely porphyritic with feldspar, and had originally pebbles of porphyry and fragments of a dark rock, constituting a conglomerate, showing in spots traces of a sedimentary structure, and really is but a condition of some parts of the fragmental formation. Yet it appears like rock 2243, and is massive as a granite, having angular cross-jointage. The appearance and action of this intrusion is quite similar to some of the granite of Kekequabic lake. Nos. 2243, 44 and 45 constitute a series showing what outwardly indicates intrusive and igneous action of a rock that originally was fragmental, and which still retains (in No. 2245) unquestionable pebbly forms of different kinds of rock. This, however, all appears to belong to the Upper Kewatin, and may be said to repeat the phenomena of Kekequabic lake, on a small scale.

2246. At the same place, but a little to the east of the N-S section line is a dike of porphyritic granitic rock which may be an apophysis from 2245. This is 700 paces north and 50 paces east of the south section corner. The rock that this dike cuts is a gray sub-crystalline condition of the formation; and if 2246 is derived from the same mass as 2245 its connection would be at such depth as to allow for a considerable degree of difference from that mass, i. e., a more complete fluidity and a more thorough recrystallization, on the one hand or on the other, for its production forms a different phase of the clastics.

At a little further north the dip varies from vertical to 70° and finally to 45° southeast. On the north side of the next creek, about half a mile north of the section corners of 4, 5, 8 and 9, 63-9, is a fine greenstone pebbly conglomerate, exposed for at least 25 feet.

At 200 paces north of the east ¼ post of sec. 5, is a ridge of greenstone, evidently the source of the conglomerate mentioned, constituting the north side of the syncline. In this the schistosity runs E 20° N which makes a large angle with that of slates and graywackes next further south.

2247. On the town line, north side of sec. 5, 63-9, not far from the lake; a gabbroid rock in which apparently pyroxene and magnetite (?) exist, the latter being reddish, and perhaps rutile, or some other titanium mineral. This, at one place at least, has a sharp contact on a schistose and conglomeratic greenstone containing jaspilyte in considerable masses. It differs from the greenstone containing the jaspilyte in that the hornblendes (or pyroxenes) produce the prominent roughness, the feldspathic ingredient occupying the depressions on the weathered surfaces, while in the normal greenstone of this place the roughness is produced by a white siliceous net work which permeates the rock and stands out on weathered surfaces. There is no doubt that this point is in the Snowbank lake zone of metamorphism, and it may be that the old greenstone, whether igneous or fragmental, has been metamorphosed or even fused so that on cooling it would give a gabbroid rock, if not a real gabbro.

2248. Still further west, not far from the west end of the lake (which is near the section line running north in the next town) is a sub-porphyritic granite. This acts at first like an intrusive, but rapidly widens out in the schistose greenstone. This specimen comes from 10 feet from either side.

2249. Is from the same rock further along where it rises into a prominent knob, isolated and about 25 feet high.

2250. Same rock at its north contact on the greenstone.

This rock has much pyrite in scattered cubes, is gray within, fine-grained and scatteringly "porphyritic" with a feldspar. Its southern line of contact on the greenstone is curious, for it is mixed with the greenstone very confusedly. There are many angular pieces of the porphyry in the schistose greenstone through an interval of six or eight feet, and in many places these two rocks both appear to share in that confusion, there being many pieces of the greenstone mingled with the debris of the porphyry. It is difficult or impossible to decide whether the porphyry, as an intrusive, has spread itself amongst the greenstone, involving and surrounding many pieces, and itself losing many, or whether the greenstone as a fragmental has formed a basal sedimentary contact on the porphyry—or whether, again, this confusion is due to friction and brecciation along a plane of contact between the two rocks. Whatever the cause, it is apparently at the same horizon as seen near the section line between sec. 5 and 8, three-fourths of a mile further south. This is probably the rock that forms fine-grained, red weathering dikes in the upper greenstone which holds the jaspilyte along the south side of this lake, and in the graywackes near Nelson's cabins, as described. These are all later than the great quartz porphyry and belong, apparently, above the agglomeratic greenstone. They are hence liable to be intruded by that porphyry, in some of its apothyses, if on metamorphism that mass should become plastic.

2251. From a narrow red dyke, or vein (perhaps from 22-48) three inches wide cutting the greenstone 2252 in a winding zigzag course along the side of a vertical cliff which looks NE. This is nearly as fine and siliceous as flint or felsyte, and the only mineral besides the fine-grained quartz, or mesh of quartz, which can be identified, is pyrite which is sprinkled sparsely through the rock.

2252. Dioryte, having a gabbroid look. Occurs irregularly over considerable areas in the midst of the general greenstone, which is also cut by 2251.

2253. In the rock 2252 are also several siliceous, sprawling, dike-like areas of a granitic rock, nearly white.

At the west end of this lake, which is SW¼ SW¼ sec. 33, 64-9, is a large boulder of well characterized gabbro, and at a short distance further north, on the section line, are numerous such pieces.

2254. Finally, at the west end of another small lake a fresh-looking greenstone or dioryte appears rather suddenly, cutting a coarse conglomerate which is probably near the bottom of the Upper Keewatin. This is not gabbro, but has conspicuous plagioclases. At the contact with the conglomerate it is very fine grained.

The conglomerate is a coarse and conspicuous rock, containing pebbles of greenstone, jaspilyte, agglomeratic and amygdaloid, slaty and flinty pieces from slates and graywackes that lie further south, and of a fine-grained, porphyritic granitic rock similar to 2246. It must be considered the base of the Upper Keewatin, and the equivalent of the Ogishke conglomerate.

It appears, therefore, that in the Lower Keewatin is a nonconformity, or basal conglomerate, viz., that above the agglomeratic greenstone, that being the oldest known conglomerate, and apparently the base of the clastic series of this part of the state, and lying much lower than the base of the Upper Kewatin. Its pebbles consist almost wholly of greenstone, or greenstone mud. (See under No. 2240.)

On ascending the bluff on the north side of the lake at which occurs the foregoing Ogishke conglomerate the route passes at once over an area of 2254, which forms a great display. It is a kind of gabbroid rock, but probably dioritic. This indeed forms the next hill range, and apparently cuts older greenstone.

2255. The same rock as 2254, but showing an imperfect amygdaloidal structure in certain narrow belts, the fillings being pinkish white, hard and indistinctly radiated, as large as peas; and some of them also green and one-half an inch in diameter.

2256. Same rock, showing the white fillings.

2257. Showing the green bunches, which seem to be fine-grained parts of the rock itself, having its fine hornblendes arranged in a stellate manner.

2258. Thirty paces north of the quarter post, west side of sec. 33, 64-9. Same rock, very coarse, forming a rough country, the ridges running a little north of east. The hornblendes are conspicuous and stand above the weathered surface.

the next ridge is sharp and consists of agglomeratic greenstone, rising as high as 2258. The summit of the ridge is 250 paces north of the quarter post, rising precipitously above the adjoining valleys.

The next ridge consists of greenstone conglomerate, with some pebbles of jaspilyte, and some of a rock indistinguishable from 2255 or 2258. The great bulk of this conglomerate consists of a fine-grained siliceous greenstone which may have come from the agglomerate masses of the oldest greenstone. It is largely cemented by quartz. Toward the north this graduates into finer conglomerate and to graywacke, interbedded with coarser conglomerate. Although much folded it dips sometimes south or southeast, or stands vertical.

2259. The finer part of this conglomerate, a gray grit or graywacke.

2260. Toward the north this same ridge is porphyritic. The rock remains grayish-green, the crystals are wholly of white feldspar, and are more numerous in some places than in others. The rock seems to be fragmental owing to a rude banding like that of sedimentation. Throughout this rock are foreign pieces of jaspilyte and of greenstone, the former sometimes being six inches in diameter. Sometimes this rock is free from feldspar crystals.

2261. Occurs rather suddenly, in small amount, in 2260. It is a singular mica-porphyry, running like a dike, rather schistose, a rare rock species, only seen in this vicinity.

2262. Represents the slightly porphyritic phase of 2260; a green schist.

The conglomerate last mentioned, although approximating the characters of the lowest (Lower Keewatin) is too varied and too nearly associated with distinctive graywackes to be positively assigned to that horrizon, although located near an agglomeratic ridge of greenstone. It is in many respects allied to the Upper Keewatin, and especially in that toward the north more distinctive characters of the Upper Keewatin supervene.

2263. Appears as a dike, about parallel with the structure and the porphyry. It is about ten feet wide. This is near Moose lake, on the section line, and cuts slates and graywacke. It is fine, gray and non-porphyritic.

The quartz porphyry of this vicinity seems to be in contact with the slate and graywacke, cutting them as an igneous rock, but also has a kind of an alternation as if a sedimentary member of the same formation. These two relations, so associated, are hard to understand. But in view of the zigzag fracture and intense squeezing, it may be these alternations are due to dynamic fracture followed by pressure as well as to inclusion of slate in the porphyry in the act of intrusion. The numerous bits of slate and of jaspilyte in the porphyry constitute a difficulty in considering the porphyry as primarily an igneous rock.

2264. Similar rock, having a similar dike-like action and appearance, about 5 feet wide, cutting a greenstone conglomerate next north of an agglomerate ridge. It is fine, gray, and has scattered pyrite cubes; can hardly be distinguished from 2263, but occurring further south.

On the portage from Moose lake to Flask lake the supposed Stuntz conglomerate is found to be cut by the same granitic porphyry as noted above, in dike-like yet sometimes lenticular masses from a foot to 25 feet wide. It also becomes decidedly a greenstone-looking rock, except for being specked by porphyritic crystals of feldspar. In one place it was a quartz porphyry; also it weathers red and is apparently sub-granitic.

2265 is the red and granitic phase.

2266. A coarser, red and more distinctly porphyritic granitic phase. These all carry many pieces of greenstone, except that they are rare in the last, which, also, exists in larger mass.

2267 is a green hornblendic rock which also has the jointage and aspect of an igneous rock. It is firm, fine-grained, weathers coarsely very schistose and is full of pebbles, rounded and angular, mostly greenstone. These seem to be of the nature of inclusions in a basic intrusive, owing to the nature of this rock.

2268 is a fair sample of the porphyry. It is usually (here) not a quartz-porphyry. It does not contain pieces of slate and graywacke which it cuts except where such can be attributed to zigzag shearing and lateral overlap and inclusion, but it almost always holds pieces of greenstone, frequently angular, but sometimes rounded.

2269. In the coarse (Stuntz) conglomerate, on the same portage, are very fine-grained, light green beds that appear like igneous intrusions in their manner and sharp jointage, but which may be attributed, perhaps more reasonably, to the hardening of siliceous mud beds.

The rock 2266 occurs again further north in an irregular boss-like area, almost granitic, and perhaps an apophysis of the Snowbank lake granite. It cuts rock 2267 which contains pebbly patches, the pebbles being of lighter-weathering, fine-grained greenstone, such as mentioned as referable to bombs from the agglomerate, but sparsely disseminated. Amongst these pebbles are some that are dark-green and hornblendic, and a few are of granite, one of the last being 3 in. in diameter. One mass of apparently amygdaloid greenstone was observed about a foot in diameter, somewhat elongated, resembling the amygdaloidal parts of the bombs.

2270. Bright green schist, at the summit of the island in Moose lake, crossed by the section line between secs. 28 and 29, 64-9. This schist is cut by a rather fresh diabase dike, 4 feet wide, and by a narrow vein-like quartzose dike of fine red granite. This rock is charged with carbonate of iron, which oxidizes but does not stay so as to stain the weathered surface. This green color, however, fades out in other places, and the surface is more or less rusty, the interior being gray, viz.:

2271. A compact, pyritiferous, fine-grained rock which becomes rusty and schistose.

2272. This schist is stained a malachite green at little depth in scattered points, indicating that the pyrite is cupriferous.

2273. On the trail from Moose lake to Wood lake, westward from the exposure of conglomeratic jaspilyte. The last and highest ridge before reaching Wood lake is composed of a reibungs breccia of fine graywacke and argillyte, the two rocks being closely folded and broken uniformly into a series of alternating short parts. On the upper weathered surface where glaciation has evenly planed the rock off the two parts recur in an irregular regularity, causing the rock to present an aspect of a squeezed conglomerate, but on the face of a vertical surface the different pieces can be seen to extend downward for a foot or more in the general mass. The rock must have been at first a banded argillyte.

2274. Jaspilyte bedded with the slates on the southerly slope of the hill containing the conglomeratic jaspilyte near Moose lake, on the trail to Wood lake.

*The Source of the Stuntz Conglomerate.*

Returning from the third trip to Snowbank lake we took a day to visit the "burnt forties," near Soudan, so-called by Smyth and Finley, in order to examine the jaspilyte and greenstone in that vicinity, and especially to ascertain the extent and number of the quartz-porphyry dikes cutting the jaspilyte, reported by Smyth and Finley.

Thoroughly convinced that the Stuntz conglomerate is a conglomerate and not a breccia, the problem has been to find a source for the pebbles and other similar materials of which it is composed. It was therefore with a confident expectation of finding some verification of the repeated assertion that dikes of quartz-porphyry here cut the jaspilyte, and thus a sufficient source for the pebbles of the overlying conglomerate, that this visit was made.* We were at first disappointed and nonplussed to find nothing of the sort. It appeared to be all conglomerate, and finer conditions of the same; even that most conspicuous interruption of the main jaspilyte mass by what Smyth and Finley called porphyry proved to be a faulted break of the structure by which the visible continuity of both is destroyed, and one comes immediately into contact with the other, the fracture plane being across the general strike, the direction of the strike, however, being but little deranged.

*At the time this region was examined first by the survey parties it was covered by a forest. At present the rock is bare over almost the entire region, and the relations of the various rocks are beautifully revealed.

It was evident at once that, not only in a faulting whose planes run north and south, but in a more extended folding whose axes run east and west, had the formation been dynamically affected. It was observed that the quartz-porphyry conglomerate came directly into contact, along east and west planes, with the jaspilyte, but contained almost no fragments of the jaspilyte, while in other belts, more remote from the jaspilyte mass, could be seen abundant debris of jaspilyte mingled with the quartz-porphyry pebbles. Hence it was evident that the Upper Keewatin conglomerate had been folded along with the Lower Keewatin greenstone and jaspilyte, so as to bring together strata which had no chronologic relations of immediate sequence.

Northward, however, from this great break were found several greenstone dikes cutting the conglomerate, similar to those on Stuntz island, and one considerable east-west band of greenstone.

Still further north, on another ridge, near the lake shore, on which is located the corners of secs. 13, 14, 23 and 24, 62-15, we found what we sought, viz.: an old Lower Keewatin quartz-porphyry forming a conspicuous hill-range, rocks 2275 and 2276.

Subsequently we found, in returning to Tower, that this rock (2275 and 2276) extends along the lake shore interruptedly, but it is encroached on and covered by the lake. It is seen in the high rocky island next east of the east entrance to Stuntz bay, where it resembles No. 2276 in some respects, but is finer and has less quartz.

In traveling again the length of Stuntz island it became evident that the eastern and northern portions of that island also consist of this rock, and must have shared in the supply of material to form the conglomerate that constitutes the southern side of the island, the transition from the former to the latter being very blind, and resembling that which has been noted before, viz., at Saganaga lake, where the recomposed granite can hardly be distinguished from the true granite, and at Ogishke Muncie lake, where the recomposed greenstone can hardly be distinguished from the true greenstone of the Twin peaks. This elusive habit of the plane of superposition of the Upper Keewatin on the Lower Keewatin, is probably responsible for numerous failures to detect the structural differences between the two formations, as well as the petrographic distinctions. The figure on page 313 of the fifteenth annual report, illustrates the nature of this transition, the coarsest pebbles not appearing at the very base of the formation, but after the accumulation of a considerable thickness of very fine detritus.

2275. "Burnt forties," near Soudan, at the corner of secs. 13, 14, 23 and 24, 62-15. Gray quartz porphyry, with some feldspar, the probable source of the pebbles of the Stuntz conglomerate. Compare Vol. IV., Chapter 29.

2276. The same rock, weathering pinkish, probably from abundance of orthoclastic material, approximating a granite structure. "Burnt forties."

2277. In the vug-like angular spaces of 2276, as exposed on the weathered surfaces, is a very fine-grained green aggregate, probably consisting of a single green mineral. "Burnt forties."

It is likely that other places could be found composed of this rock, perhaps some of Ely island. It seems to have a general course from the "burnt forties" westward and a little north, so as to run under Vermilion lake.

The source of the pebbles of the Stuntz conglomerate was never before detected. It is an important addition to the geology of the state to have solved this long-standing problem.

2278. Metallic copper, from the Montana shaft at Tower. This copper is in a shear vein which runs diagonally across the iron ore deposit. It often occurs as thin films in the greenstone in the vicinity of this vein, and is accompanied by different copper minerals. These minerals have been studied by Dr. C. P. Berkey. (Proc. Lake Superior Mining Institute, IV, 73, 1896.)

2279. Fiery red jasper, from the Lee dump, Tower. Several masses a couple of feet in thickness were thrown out. According to Mr. McCloud (teacher) much more had been thrown out, but owing to its beauty had been carried away. This is a curious rock, and in general fracture and color it resembles that found at the bottom of the palisades on the shore of Lake Superior (No. 140). Its relation to the ore (hematite) of the mine, and to the greenstone, are unknown.

2280. Mass of pyrite, silica and jasper, like 2279, the pyrite having been largely oxidized and removed, leaving a spongy, rough siliceous mass. The origin of this red jasper and its association with pyrite in the Lee mine make a new and problematic feature in the geology of the iron ores. This red jasper is similar to that seen in the form of pebbles in the conglomeratic jasper north of Moose lake. as mentioned.

# II

# RECORD OF GEOLOGICAL FIELD WORK IN NORTHEASTERN MINNESOTA 1892 to 1898

BY U. S. GRANT.

## INTRODUCTION.

The following paper was prepared for publication in accordance with instructions from the state geologist, who desires to have the facts of the field work, together with notes on the rock specimens collected, printed in the reports of the survey. Thus this paper is largely a transcript of the field notes, usually abridged, but sometimes increased slightly by later information or by laboratory work. No effort is here made to write a general report on the districts examined nor to always present the conclusions to be drawn from the investigations in the field. Such conclusions are generally to be found in volume IV of the final report, where also will be found some, but by no means all, of the detailed field descriptions.

The record of the writer's previous field work, of which the present record is a continuation, has been published in the 17th annual report, pp. 147-215, and in the 20th annual report, pp. 35-110. Some special details and conclusions have been published as follows:

The geology of the Kekequabic lake in Northeastern Minnesota, with special reference to an augite soda granite. 21st Ann. Rept., pp. 5-58, 1893.

Preliminary report of field work during 1893 in Northeastern Minnesota. 22nd Ann. Rept., pp. 67-78, 1894.

Preliminary report on the Rainy lake gold region. 23rd Ann. Rept, pp. 36-105, 1895.

The stratigraphic position of the Ogishke conglomerate. Am. Geol., vol. 10, pp. 4-10, 1892.

Note on an augite soda granite from Minnesota. Am. Geol., vol. 11, pp. 383-388, 1893.

Volcanic rocks in the Keewatin of Minnesota. Science, vol. 23, p. 17, 1894.

Note on the Keweenawan rocks of Grand Portage island, north coast of lake Superior. Am. Geol., vol. 13, pp. 437-439, 1894.

The international boundary between lake Superior and lake of the Woods. Minn. Hist. Soc. Collections, vol. 8, pt. 1, pp. 1-10, 1895.

Notes on some water divides in Northeastern Minnesota. (Abstract.) Bull. Minn. Acad. Ntl. Sci., vol. 4, no. 1, pt. 1, pp. 39-40, 1896.

Lakes with two outlets, in Northeastern Minnesota. Am. Geol., vol. 19, pp. 407–411, 1897.

Sketch of the geology of the eastern end of the Mesabi iron range in Minnesota. Engineers' Year Book, University of Minn., pp. 48–62, 1898.

During the prosecution of the field work 1,099 rock samples have been collected. The numbers on these specimens are green and the specimens can thus be distinguished from any other rock series of the survey or of the museum. Where these rock specimens are referred to in vol. IV of the final report or elsewhere, except in articles by the writer, in the annual reports, the numbers are followed by the letter G. Lists of these rock specimens have been published as follows, in each case the rock names and localities being given:

Nos. 1–298, collected in 1888, 17th Ann. Rept., pp. 201–215.
Nos. 299–734, collected in 1891, 20th Ann. Rept., pp. 96–110.
Nos. 735–893, collected in 1892, 21st Ann. Rept., pp. 59–67.
Nos. 894–1016, collected in 1893, 22nd Ann. Rept., pp. 78–86.
Nos. 1017–1067, collected in 1894, 23rd Ann. Rept., pp. 220–223.
Nos. 1068–1099, collected in 1898, 24th Ann. Rept.

In giving the directions of strike, etc., the directions are referred to magnetic north.

## Field Work of 1892.

The work during this year was done in July, August, September and October. There were usually four in the party, the writer being assisted by Messrs. L. A. Ogaard and A. H. Elftman, and a Chippewa Indian, Wanwiegwan. For a short time in August the writer accompanied the state geologist in the vicinity of Kekequabic and Gabimichigama lakes and to the eastward of the latter lake.

### *Vicinity of Thomas and Frazer Lakes.**

The main body of Thomas lake lies in secs. 28 and 33, T. 64–7 W., and the main body of Fraser lake in secs. 22 and 23, T. 64–7 W. The notes immediately following relate to these lakes and to the district northeast and east of Fraser lake, in Ts. 64–6 W. and 64–7 W. The main points presented are those relating to the gabbro, ferruginous quartzyte, granite of Kekequabic lake and glacial phenomena.

At *Thomas lake*, on the north shore, in SE¼ of SW¼ sec. 32, T. 64–7 W., is a low exposure of coarse-grained magnetite. This has the appearance of the usual titaniferous magnetite facies of the gabbro, and the ordinary gabbro is found along

*Other notes on the geology about these two lakes can be found in the 15th Ann. Rept., pp. 145–148, 360–361; 17th Ann. Rept., pp. 187–190.

the shore both to the east and to the west. On the little island which is just southeast of this locality, but in the same one-sixteenth section, coarse gabbro occurs. On the south end of this island is an outcrop of a dark, fine-grained, granular rock which in thin section is seen to be an olivine gabbro (No. 735). In places it has many rusty spots. This rock was seen within a foot of coarse gabbro and no intermediate facies or contacts were observed. The two rocks differ much in general appearance and very markedly in the size of the constituent mineral grains.

*On Fraser lake* the shores of two eastern arms were examined and no rock but the ordinary gabbro was seen. These two arms of Fraser lake are not shown on the township plat, and the smaller lakes in this vicinity—sec. 24, T. 64–7 W.—are not correctly represented.

There is a small lake (not shown on the township plat) just south of the southern of the two eastern arms of Fraser lake, and another small lake in the NE¼ of sec. 24, T. 64–7 W. The shores of these two lakes and the portages between them were examined but no rock except the usual coarse gabbro, which occurs in many outcrops, was seen. It sometimes contains biotite. The shores of the lake, which lies in the northern part of sec. 19 and the southern part of sec. 18, T. 64–6 W., are mostly marshy, but several outcrops of the usual gabbro, often containing biotite, occur. No. 736, which is a coarse biotite olivine gabbro, was taken from near the center of the northern side of this lake (SW¼ SE¼ sec. 18, T. 64–6 W.) and well represents the rock on the shores of these three lakes.

From the last mentioned lake north to *Marble lake* (situated in N. ½ sec. 18 and S. ½ sec. 7, T. 64–6 W.) the usual gabbro was seen in several places, and this same rock makes the shores of this lake, which were carefully examined. Marble lake lies in a basin surrounded by gabbro hills, and this same rock was found for half a mile westward in the NE¼ of NE¼ sec. 13, T. 64–7 W.

On going northwest from Marble lake to *the lake which lies largely in the N½ of NE¼ sec. 12, T. 64–7 W.*, the usual gabbro was seen. A small stream enters the east end of this lake, and just north of this stream and near the northeast corner of the NW¼ of NW¼ sec. 7, T. 64–6 W., is an outcrop of fine grained gray rock (No. 737) having streaks of biotite running in various directions. About 300 yards north of this, in the SW¼ of SW¼ sec. 6, T. 64–6 W. is an outcrop of tough greenish rock (No. 738) blotched with reddish areas. No outcrops were found between the two here mentioned. This (No. 738) is evidently from the conglomeratic formation previously described from the vicinity of this lake (see Nos. 637 and 638, 20th Ann. Rept., pp. 80-81).* These specimens (Nos. 637, 638, 737 and 738) are regarded as belonging to the Keewatin, which has here been somewhat metamorphosed by the gabbro. On going along the north shore of this lake a few rods back from the water a few outcrops of the conglomeratic formation were seen, but no bedding was observed. Around the north end of the bay in the SW¼ of SE¼ sec. 1, T. 64-7 W., are several outcrops of the same rock showing a rather distinct lamination (sedimentary) on weathered surfaces. The strike, as measured on the outcrops, is N. 65° E. and the dip is 90 degrees. No. 739 was obtained near the north end of the bay; it is a hard, fine-grained, greenish siliceous rock. On the west side of this bay is an outcrop of the same rock, striking N. 45° E.; dip 90°. The same rock is seen in several places just west of the lake and one outcrop occurs at the extreme southwest corner of the lake; here (NW¼ of NE¼ sec. 12, T. 64-7 W.) the rock is of coarser grain than usual and appears to be entirely recrystallized (No. 740), but still shows a few pebble forms. All the other outcrops on the south shore of the lake—there are several of them—are of gabbro, finer grained than is usual and well represented by No. 741 (from the NE¼ of NE¼ sec. 7, T. 64-7 W.), which appears to be an olivine gabbro. On the east shore of the lake is an exposure of the conglomeratic formation not so fine-grained as usual; this rock is represented by No. 742 (NW¼ NW¼ sec. 7, T. 64-6 W.) which is a fine-grained crystalline rock composed of biotite and apparently quartz and feldspar; it is similar to No. 740. Fine-grained gabbro, similar to No. 741, occurs within 100 yards of No. 742, but no contact of the two formations was found.

On going north from this lake (the lake which lies largely in the N½ of NE¼ sec. 12, T. 64-7 W.) for about one-third of a mile near the east side of sec. 1. T. 64-7 W., the conglomeratic formation (Keewatin) is seen in a few places. Near the lake the strike is N. 90° E. and the dip 85° towards the south. On going north from the lake the rock becomes less crystalline and acquires a rough slaty cleavage. No. 743, taken about one-

*The lake here described in the 20th Ann. Rept. as in the S. ½ of Sec. 7 and the N½ of sec. 18, T. 64-6 W., is not located correctly, but is the lake mentioned above as lying largely in the N. ½ of NE¼ sec. 12, T. 64-7 W.

fourth of a mile north of the lake and probably near the center of the east side of the SE¼ sec.1, T. 64-7, W., shows a less crystalline condition of the country rock; this specimen is a hard, dark gray argillyte. Its strike is N. 75° E. and the dip 85° towards the north of this; the slaty cleavage coincides with the bedding. The strike of all the exposures here seen varies from N. 75° E. to N. 90° E., and the dip is nearly vertical.

On going north from the bay in the SW¼ of SE¼ sec. 1, T. 64–7 W., several exposures of the conglomeratic formation are seen; the rock is hard and tough, as elsewhere, and the pebbles are not very numerous and are sometimes lacking entirely. The first of these exposures which shows dip and strike is about one-eighth mile from the lake; here the strike is N. 60° E., and the dip is vertical. The rock gradually becomes less crystalline and more slaty on going north for one-fourth mile from the lake; at about this distance, probably in NW¼ of SE¼ sec. 1, T. 64–7 W., is an outcrop whose strike is N. 30° E., and whose dip is vertical. A rough slaty cleavage coincides in direction with the bedding. Here is a belt, two feet wide and running with the strike, of a fine-grained diabasic rock (No. 744), the feldspar of which is in part reddened. This seems to represent an old diabase dike or sill. No. 745 represents the country rock from this same exposure; it is fine grained, tough and greenish.

About 200 feet north of the last outcrop is another where the country (Keewatin) rock is in contact with a granite, evidently the pyroxene soda granite of Kekequabic lake.* The relations of the two rocks are shown in figure 2 on p. 38 of the 21st annual report, which represents the whole of the outcrop. The Keewatin rock strikes N. 20° E., and dips 85° towards the east of this direction. The granite at the contact does not appear finer grained than in other parts of the outcrop. No. 746 shows the granite and No. 747 the other rock. The former is a pinkish, rather fine grained granitic rock. Under the microscope it is seen to be made up of larger feldspars, not markedly idiomorphic, in a finely micrograniticgroundmass composed mainly of feldspar, green augite and quartz. The latter rock is a tough, laminated, greenish gray rock. In thin section this is seen to be a more or less confused aggregate, of fine but varying grain, the principal minerals being feldspar, green augite and quartz. The large feldspars of the granite are absent, and

*For a description of this granite see 21st Ann. Rept., pp. 33-54; and for a geological map of this district see pl. 2 of the 21st Ann. Rept. and pl. 80 (Fraser-Lake plate) of vol. 4 of the Final Report.

while the two rocks have a rather similar mineralogical composition they are markedly different under the microscope, and especially when examined macroscopically.

North from this last exposure for about one-fourth of a mile many outcrops of the granite were seen. It is coarser grained than that at the contact above mentioned. A specimen from one of these outcrops is No. 748 (NW¼ of SE¼ sec. 1, 64–7 W.) which is a medium-grained reddish granite apparently granitoid in texture and not having a microgranitic groundmass as has No. 746 from the contact. Now on going east more granite is seen and in less than one-fourth of a mile the Keewatin rocks again appear. Just before reaching the slates the granite is finer grained, as is shown by No. 749, probably from the NE ¼ of SE¼ sec. 1, T. 64–7 W. The next outcrop east of No. 749 is composed of the hardened Keewatin rock showing no bedding. In this rock are two irregular vein-like forms which weather gray and on the weathered surface are rather sharply marked off from the country rock. No. 750 shows this vein-like rock,—probably a part of the granite; and No. 751 shows the Keewatin rock. Both of these specimens are probably from the same one-sixteenth section as No. 749. Fifty feet east of Nos. 750 and 751 the Keewatin is again seen, striking N. 20° E. and standing vertical. And to the east for a short distance are more exposures with the same dip and strike. On returning to the bay in the SW¼ of the SE¼ sec. 1, T. 64–7 W., another contact between the granite and the slaty Keewatin rock was seen. The line between the two was distinct and ran usually with the strike (strike N. 30° E., dip vertical), but cut across it for a short distance.

From the southwest corner of the lake which lies largely in the N½ of NE¼ sec. 12, T. 64–7 W., a portage leads southwest to *Shooply lake* (mainly included in the SE¼ of sec. 11, T. 64–7 W.)* Near the northeast end of this portage are two outcrops of the metamorphosed Keewatin (compare Nos. 740 and 742), and about two-thirds of the distance across the portage is an outcrop just south of the trail. This is made of a fine-grained, granular, gray or yellowish gray, biotitic rock represented by No. 752 (SE¼ of NW¼ sec. 12, T. 64–7 W.). It is difficult to tell from the hand specimen whether this is a fine-grained facies of the gabbro or a part of the Keewatin metamorphosed by the gabbro, but it is thought to probably belong in the latter category.

*For notes on Shooply lake see 15th Ann. Rept., pp. 147–148; 17th Ann. Rept., pp. 186–187.

From the field notes given above it is possible to draw some *conclusions, regarding the gabbro, the granite and the Keewatin,* which apply to the locality above described and which also have, at least in part, a wider application. The gabbro is in general a rock of coarse and rather uniform grain, but at its contact with the Keewatin it becomes finer grained, although apparently still retaining its gabbro texture and composition. The gabbro has markedly metamorphosed the Keewatin rocks, near the contact entirely recrystallizing them. Biotite is a product of this metamorphism by the gabbro. The granite is intrusive into the Keewatin rocks as evinced (1) by its manner of contact, (2) by its finer grain at the contact, and (3) by its action on the Keewatin rocks. This metamorphosing action is not as marked as in the case of the gabbro and, instead of biotite, green augite,—a mineral characteristic of this granite mass (the Kekequabic granite),—has been produced. Specimen No. 637, which represents the conglomeratic part of the Keewatin, contains a pebble which closely resembles the porphyritic facies of the Kekequabic granite. This occurrence may be explained, in the light of the facts and conclusions above given, in two ways. First, there may have been such a porphyritic granite of earlier date than these Keewatin rocks and the Kekequabic granite; second, the Keewatin rocks may be here divisible into two parts, one earlier than, and the other later than, the Kekequabic granite.

From Fraser lake a trip was made through the *southwestern part of T. 64-6 W.* to the Kawishiwi river. From the lake at the north side of sec. 19, T. 64-6 W., a portage leads southeastward to a pond on the east line of this section. Gabbro of the usual kind is seen near this portage and on the south shore of this pond. From this pond a portage leads to the lake which lies mainly in the S½ of sec. 20, T. 64-6 W. On this portage and a few yards from this pond is an outcrop of gabbro and a ferruginous, banded quartzyte. The relations of the two rocks are shown in a figure in the chapter on the Fraser lake plate in vol. 4 of the final report. The strike of the quartzyte is apparently east and west, and the dip is 50° towards the south. The gabbro is of some finer grain than the ordinary facies of this rock, but is not noticeably finer just at the contact than it is several feet distant. The two rocks are sharply separated from each other and the gabbro holds a few pieces of the other. The exposure of the quartzyte is less than 20 feet wide and extends along the strike for some 30 feet. Just to the east of this and in the strike of the quartzyte is a low ridge where this rock is exposed for over 100 feet along the strike and for about thirty feet across the strike. No. 753 represents the quartzyte and No. 754 the gabbro from the outcrop shown in the figure referred to. The first is a coarse-grained rock composed mainly of quartz and magnetite with varying amounts of other minerals which appear to be olivine and pyroxene. The rock closely resembles the coarse quartzose, magnetitic and olivinitic rocks found elsewhere along the northern border of the gabbro, as at Akeley and Gabimichigama lakes. To the south of the above described locality are many outcrops of the ordinary gabbro.

On the portage above mentioned are many exposures of coarse gabbro much decayed; in places the gabbro has furnished considerable soil, and very few smooth, fresh gabbro surfaces were seen. No large foreign boulders were seen, but there were a very few small slate and granite boulders.

The lake which lies mostly in the S½ of sec. 20, T. 64-6W., is surrounded by gabbro hills, all decaying and forming soil. The shores of the western half of this lake were examined and many exposures of the ordinary gabbro were seen.* On going south from this lake to the lake which lies mainly in sec. 32, T. 64-6 W., and along the west and south shores of the latter lake many outcrops of the usual gabbro, decaying to form soil, were seen. From this latter lake south to the Kawishiwi river in the NE¼ SE¼ sec. 5, T. 63-6 W., gabbro, often very much decayed, occurs in many places, and almost no foreign boulders are to be seen.

### *Kawishiwi river, mostly in Ts. 63-6 and 62-6 W.*

The notes given under this heading refer principally to the gabbro, to the Keweenawan granites and to a possibly driftless area.

The south and west shores of the Kawishiwi river in secs. 4 and 9, T. 63-6 W., show many gabbro outcrops, the rock being much decayed and forming boulders of disintegration. This gabbro is very coarse grained. In secs. 8 and 7, T. 63-6 W., the gabbro is much decayed and in most places crumbling into soil. Only a very few, small, foreign boulders were seen. There are, however, a few places where the gabbro is not decayed, and one peculiar phenomenon is the presence, within a few yards of a mass of decaying gabbro, of a gabbro boss, smooth

*For further notes on this lake and vicinity see under the district west of Little Saganaga lake.

and round,—as smooth and rounded as any in the country, but showing no glacial striæ.

Along the Kawishiwi river in secs. 17 and 21, T. 63–6 W., and on the shores of *Boulder lake*,* which lies largely in the S. ½ of sec. 16, T. 63–6 W., gabbro occurs in many places, but the shores were not carefully examined.

The shores of *lake Polly* (the irregular lake lying largely in secs. 28 and 33, T. 63–6 W.) were not all examined, but the eastern arm was, as was also the east side of the central arm. All the outcrops seen were of gabbro of the usual coarse grain. A few red granite or syenite veins or dikes were seen cutting the gabbro. The gabbro about this lake, while showing some signs of decay, is not nearly as decayed as that a few miles to the north.

From lake Polly a trip was made up the river, the headwaters of the Kawishiwi, which empties into this lake in the NW¼ of sec. 34, T. 63–6 W. Gabbro was seen in several places along the river in this quarter section. It is quite coarse grained and is cut by many branching vein-like dikes of red granite; these are from half an inch to ten feet across and run in every direction. The rock of these dikes varies considerably in grain, but the sides of the dikes are not noticeably of finer grain than the centers. No. 755 (from the west end of the second portage from lake Polly, probably in the SW¼ of NE¼ sec. 34, T. 63–6 W.) fairly represents the rock of these granite dikes. It is a fine grained, pinkish, biotite granite, the biotite being in comparatively small amount. A short distance east of the portage just mentioned the granite dikes become very numerous and make up one-third of the various outcrops of gabbro. Further east and south along the river, in secs. 34 and 35, T. 63–6 W., the granite dikes are not so numerous, but are occasionally seen in the gabbro.

The shores of a small lake, which apparently lies in the N½ of sec. 2, T. 62-6, W.,† show outcrops of coarse grained gabbro, sometimes cut by small granite dikes.

At the southeast corner of this lake a stream enters and a portage of a half mile leads southeast along the stream; following up the stream in a south or southeasternly direction for about a mile beyond this portage a large lake (Syenite

*The Chippewa name for this lake signifies "the lake where big rocks are in the rapids." There is an immense boulder in the middle of the rapids at the north end of the lake.

†T. 62-6 W. had not been surveyed when this visit was made, and so locations can not be given accurately here and about Syenite lake.

lake) is found. Gabbro was seen in a few places along this portage, and along the river, a quarter to a third of a mile north of Syenite lake, gabbro and a fine grained dioryte occur in considerable amounts. There are two exposures which show the gabbro, the dioryte and the granite, which is still seen in the form of dikes. The gabbro is very coarse grained and is composed largely of feldspar; the dioryte is of much finer grain and is sharply separated from the gabbro by a distinct contact line. Dikes of the dioryte were not seen in the gabbro, but angular fragments, of various sizes and shapes, of the gabbro occur in the dioryte. There are numerous dikes, of all sizes up to twenty feet in width, of the red granite cutting both the gabbro and the dioryte. The dike walls are sharply marked. No. 756 represents the dioryte from this locality; it is a fine grained, dark gray, quartz dioryte. A hurried examination of the thin section shows a granitic aggregate of plagioclase, hornblende, quartz, magnetite and pyroxene. The last is in small, scattered grains which usually have rounded outlines.

*Syenite lake* is a good sized body of water, lying approximately in secs. 12, 13, 14, 23 and 24 of T.62-6 W. The shores of this lake were visited in many places, but a careful examination of the whole lake was not made. Gabbro occurs in several places on the bay and long narrow arm at the north end of the lake, and this rock is usually cut by dikes of granite. At the south entrance to this arm granite occurs, and in the little bay just to the east gabbro is again seen. It is here, as for several miles to the north, very coarse in grain and composed largely of feldspar. No. 757, from the east shore of this little bay, shows this gabbro which is even coarser grained than is usual. At the entrance to this bay granite occurs and this rock continues along the east shore of the lake. Nos. 758 to 763 well represent the different facies of this granite; they all came from the east shore of Syenite lake, taken in order from north to south. These specimens show a hornblende granite of fine but rather uniform grain and varying in color from almost white to brick red. On the south and southwest shores of the lake gabbro occurs, often associated with and cut by the granite. The gabbro is of coarse grain and similar to No. 757. Southeast of the lake, and about a mile distant, is a range of hills striking northeast and southwest. They rise 300 to 400 feet above Syenite lake and are apparently composed of the same red granite or "red rock" of the Keweenawan.

The district from lake Polly to Syenite lake offers excellent outcrops for the study of the *relations of the gabbro and the Keweenawan granites* to the south. In this general locality, as well as in others which the writer has visited, the following facts are quite apparent. On approaching, from the north, one of these granite areas, its proximity is indicated by the presence of a few small dikes of granite in the gabbro. These dikes are met with at distances of from one to five, or even more, miles from the main granite mass as exposed at the surface. The dikes increase in number and size on going south, i. e. on approaching the main granite area, and at the edge of this area apophyses can be traced directly from the granite into the gabbro. The evidence for the later date of the granite is conclusive. The granite dikes are not particularly finer grained, either as a whole or at their contacts with the gabbro, than the rock of the main mass of the granite, thus indicating the heated condition, as well as the deep-seated position, of the gabbro at the time of the intrusion of the dikes. Still the sharp edges of the dikes and the rare mingling of the elements of the two rocks in the locality here described would indicate that the granite, while perhaps not much younger than the gabbro, was of later date than the solidification of that rock. In other areas there are facts which seem to indicate that the two rocks were molten about the same time.

Along the south shore of the Kawishiwi river in sec. 12, the south and west shores of the lake in sec. 11, T. 63–7 W., and the portage (in secs. 10 and 11) from this lake to *lake Alice* (the large lake in the center of T. 63–7 W.) many outcrops of gabbro were seen. The gabbro often is decaying, and very few foreign boulders occur. North of lake Alice and in the NE¼ of sec. 4, T. 63–7 W., is a small lake on whose shores gabbro occurs. From this small lake a portage leads to Thomas lake, striking the latter in the NW¼ of SE¼ of sec. 33, T. 64–7 W. On this portage, gabbro, not much decayed, occurs, and many foreign boulders were seen.

### *Kekequabic Lake and Vicinity.**

This lake lies in the NE¼ of T. 64-7 W., the SE¼ of T. 65-7 W., and the SW¼ of T. 65-6 W. The notes below refer principally to the granite of Kekequabic lake and its relation to the surrounding rocks, but some notes on the general geology are included.

*Other notes on Kekequabic lake and vicinity may be found as follows: 15th Ann. Rept., pp. 148-160, 361-369; 16th Ann. Rept., pp. 99-108; 321-327; 20th Ann. Rept., pp. 69-82; 21st Ann. Rept., pp. 5-58.

The small island (NE¼ SE¼ sec. 34, T. 65-7 W.) near the *north shore of Kekequabic lake*, and just opposite the portage to Pickle lake, is composed of a massive, hard, ringing, greenish rock. It contains crystals or fragments of crystals of feldspar, hornblende, and fragments of various kinds, not apparently rounded by water action. No. 764 represents the rock of this island which is probably a tuffaceous deposit.

The point on the east side of the bay (north shore of Kekequabic lake) in E½ SW¼ sec. 34, T. 65-7 W., is made up of hard, black to gray, slaty argillyte (No. 765). Strike N. 50° E., and dip 75° towards the south of this. Slaty cleavage corresponds with bedding. The argillyte is cut by a small, irregular dike of the porphyritic augite granite. The contact of the two rocks is sharp, and the dike sends stringers into the argillyte and also includes pieces of it. The dike rock is markedly porphyritic with white feldspars, and it holds much pyrite. No. 766 shows the two rocks in contact.

Along the north shore, east of this point, the same argillyte continues for a short distance, and then rock similar to No. 764 occurs; this contains many rounded and angular fragments and appears to grade into distinctly bedded gray slates and also into the soft green hornblende schist of the lake. This schist is here often conglomeratic with rounded pebbles of all sizes up to a foot in diameter. These rocks, varying somewhat, extend eastward along the north shore for a mile. The strike is from N. 50° E. to N. 60° E., and the dip is from vertical to 75° toward the south.

A small island (NE¼ SW¼ sec. 35, T. 65–7 W.) near the north shore is composed of the green hornblende schist. On the weathered surfaces the bedding is apparent and the schistosity in general agrees with this; strike N. 65° E. to N. 75° E., and dip vertical. In places the rock is full of pebble-like forms which are very apparent on the weathered surfaces, but, as most of the pebbles are similar to the enclosing rock, they are hardly discernible on a freshly fractured surface. A few of these pebbles are of a gray slaty rock and of quartz. No. 767, from this island, is a good example of the green schist on this lake.* This same rock occurs along the shore, to the eastward, in sec. 35, T. 65–7 W. Near the east side of the section the strike is N. 75° E., and the dip is from vertical to 80° towards the S.

The shores of the small *lake in the W½ SW¼ sec. 34, T. 65-7 W.*, have a few outcrops of slaty argillyte which varies in color

*For a description of these green schists see 21st Ann. Rept., pp. 23-26.

from black to gray to greenish. The greenish variety is sometimes more like graywacke. The dip and strike were taken in six places, the strike being N. 40° to 50° E., and the dip from vertical to 80° toward the south of the strike. In general, the bedding and slaty cleavage, the latter usually not being well developed, coincide in direction. On one little rocky island at the east end of the lake the strike is nearly E. and W. and the dip 70° toward the S.

The rock of *Plum lake* (lying mainly in the center of the E½ sec. 33, T. 65–7 W.) is similar to that of the lake just described except that the graywacke is more abundant. When the latter is not interbedded with the argillyte, it appears massive. The strike, as shown in several places along the north shore, is N. 50° to 60° E., and the dip from vertical to 75° toward the S. No. 768 well represents the graywacke from the north side of the lake; it was taken from the west side of the bay in the SW ¼ of NE¼ sec. 33. At the west end of the lake, at the portage, is an outcrop of a fine-grained, gray, brown weathering schist (No. 769). Strike N. 60° E., and dip vertical; bedding and schistosity parallel.

The shores of the *lake in SE¼ sec. 32, T. 65-7 W.*, and N½ sec. 5, T. 64–7 W., show outcrops of black to gray to greenish, slaty argillyte and some little greenish graywacke. The strike, as taken in five places, varies no more than 3° from N. 50° E., and the dip is from vertical to 80° towards the S. The small lake in the SW¼ SE¼ sec. 33, T. 65–7 W., has outcrops of argillyte similar to that on the other lake. Strike, measured in one place, is N. 50° E., and dip vertical.

Mr. Elftman visited the high hill in the NE¼ sec. 35, T. 65–7 W., north shore of *Kekequabic lake*. The rock is similar to No. 764, probably a tuff. No. 770 represents this rock from the top of this hill. He also went to the top of the hill in the SW¼ sec. 36, T. 65–7 W.; the rock is a fine-grained condition of the augite granite. He also visited the island in the NW¼ of SW ¼ of the same section, but found no rock except the porphyritic facies of the augite granite.

On the east side of the northern point in the NW¼ NW¼ sec. 3, T. 64–7 W., are black and gray slaty argillytes; strikes and dip not well shown, but the strike appears to be N. 25° E. and the dip 65° to 70° towards the east of this. On the south side of this point at the entrance to the little bay the same slates are seen; here the strike is N. 10° W. and the dip 55 degrees towards the east. The same slates occur in this bay and also on the shore just south of the entrance to the bay; the strike is the same, but the dip in some places becomes steeper,—70°.

On the west side of the little point in the SE¼ SW¼ sec. 2, T. 64–7 W., is an outcrop of the granite which is broken into parallel layers.* In some cases there are minute quartz veins along the division planes between the different layers. Nos. 771A to 771F were collected here. The rock is very poor in quartz.

On *Pickle lake* (NE¼ sec. 34 and NW¼ sec. 35, T. 64–7 W.), at the portage to Kekequabic lake are gray to white slates striking N. 75° E., with a vertical dip. The slaty cleavage makes an angle with the strike, running more to the north. At the point just east of this portage the same rock occurs. At the south shore of Pickle lake, near the center of NW¼ sec. 35, is a hard green slate whose cleavage strikes N. 30° E., and the dip is vertical (the needle is disturbed here and the strike given may not be correct). The strike of the bedding is not clear. South from the shore a few yards the same rock occurs minutely interbanded with dark red jaspilyte. The bands of jaspilyte vary from one-sixteenth inch to one inch in thickness. The rock is much crumpled. It is represented by No. 772. This same rock extends along the south shore of this little bay (the southern one near the east end of Pickle lake). On the point on the north side of this bay is a hill composed of hard, gray to greenish, slaty rock considerably crumpled. The cleavage strikes N. 60° E., and is vertical. At the east entrance to the bay on the north side, near the east end of Pickle lake, the gray and green slates are again seen, here holding a few small bands of jaspilyte. Strike N. 60° E., dip vertical; cleavage coincides with bedding. These slates extend westward along the whole north shore of the lake. The strike and dip, as measured in two places, are the same as just given.

*Spoon lake* (the long narrow lake in secs. 26, 27 and 34, T. 65-7 W.). The point on the south side of the lake, in SE¼ SE ¼ sec. 27, is made of hard gray slate. Slate, gray and green, breaking into cuneiform fragments, is seen along the south shore in sec. 26. On this shore, in NW¼ SE¼ sec. 26, medium grained, dark gray diabase (No. 773) occurs, and is also seen a short distance further east. The hills in the NE¼ of SE¼ sec. 26, back from the lake, are composed of the same hard, gray and green slates; strike not always distinct, but where seen it is N. 65° E., and the dip is vertical. Slaty cleavage not well

*See 20th Ann. Rept., rock No. 549 on p. 70, and fig. 5 on p. 71; 21st Ann. Rept., pp. 34 and 35.

developed and having the same direction as the bedding. On the hills between this lake and Currant lake (small lake in W½ SW¼ sec. 25, T. 65-7 W.) the hard gray and greenish slates are again seen; strike N. 70° E., dip vertical. Around the bay at the east end of Spoon lake the same slates occur, commonly crumpled, but with a general northeasterly strike. A diabase dike, standing vertical and striking N. 40° E., crosses the point on the north of the entrance to this bay. This dike is about 30 feet wide; the diabase mentioned above (No. 773) evidently is a continuation of this dike. On the north shore in SW¼ NE¼ sec. 26, the slates become coarser and graywacke-like; strike N. 50° to 60° E., dip vertical. Here a dike, three feet wide, of fine-grained diabase cuts the slates; the dike runs N. 45° W. and is about vertical. Along the north shore in sec. 26 are many outcrops of the slate and graywacke, the latter predominating and commonly showing no bedding nor cleavage. It is green to gray in color and varies in grain from that which resembles an argillyte to a graywacke where the quartz grains are quite noticeable; the latter is the usual facies. This rock is broken into angular, often wedge-shaped, pieces and joints. In the main western body of the lake there are almost no outcrops except on the islands in the S½ of sec. 27; three of these islands were visited and the rock was found to be graywacke.

*Eastern part of Kekequabic lake.* There are three small islands near the center of the N½ of sec. 36, T. 65–7 W. The largest of these is composed of green hornblende schist (No. 1409 of N. H. Winchell's rock series). The dip is 15° to 70° towards the northwest. The island east of this is made of the same kind of rock; strike N. 38° E., dip 70° to the south of this. This rock is conglomeratic, or rather contains pebble-like forms, at the water's edge, and probably this feature exists throughout much of the rock, the action of the waves making it more distinct.

Mallmann's peak (high hill on the north shore of Kekequabic lake in SE¼ sec. 30, T. 65–6 W.) is composed of hard graywacke varying to argillyte. The bedding is not always distinct, but when seen varies much in dip and strike. The following strikes were noted in different places: N. 10° E., N. 20° W., N. 30° W., N. 70° E., N. 55° W., N. 60° W.

From the head of the little bay in the NW¼ SW¼ sec. 31, T. 65–6 W., a trip was made south to the summit of the hill; this summit is probably near the S.W. corner of this section. Within 100 yards of the lake shore the pyroxene granite was seen;

it is fine-grained. The same rock is seen in a few outcrops all the way to the summit of the hill. No. 774 shows the granite from the top of the hill; it is a fine-grained reddish granite.

Just north of the east side of the base of the promontory at the southwest corner of sec. 29, T. 65–6 W., is a bold bluff composed of gray argillyte varying to graywacke. Strike N. 85° W., and dip 70° towards the south of this. The rock is hard and brittle and shows little slaty cleavage. On the east side of the bay, which is just east of the above mentioned promontory, the rock is gray to greenish slate, often showing a marked slaty cleavage parallel to the bedding. The strike, as taken in several places, here and on the adjoining hill, does not vary more than 5° from N. 90° E., and the dip is 70° to the south. In places there is a pretty well developed cleavage which stands vertical and strikes N. 30° E. At the top of this hill is a knob of coarse diabase (No. 775). On one side the diabase was seen in contact with the slates; the contact line was rather irregular but had a general northwesterly direction. The same slate occurs on the west side of the point in the SE¼ SW¼ sec. 29, T. 65–6 W., and on the east side of the point the rock is coarse graywacke. At the portage to Alpha lake (this portage is near the center of S½ sec. 29) the slates strike N. 50° E. and dip 75° to the south of this. Up on the hill, to the west of the portage, are good exposures of interbedded slate and graywacke striking N. 45° E. and dip 80° towards the southeast. The graywacke is often very coarse and holds numerous pebbles of slate up to half an inch in diameter. The point, on Kekequabic lake, south of this portage is composed of slate and graywacke, as is also the east shore of the bay in E½ SW¼ SE ¼ sec. 29, T. 65–6 W.; here the strike is N. 30° E., and the dip is vertical. The southeast and south shores of this bay are also of slate and graywacke. On the south shore, just west of the entrance to this bay, is more diabase similar to No. 755. These two exposures of diabase are probably parts of a dike which runs approximately north and south. A short distance west of this outcrop of diabase the slates occur, striking N. 40° E., and standing vertical. The rest of the south shore in sec. 32 and in the SE¼ NE¼ sec. 31, T. 65–6 W., has many outcrops of the slate, which as a rule is darker colored and has fewer graywacke beds than on the north shore. The strike is, in general, N. 30° E., and the dip is about vertical. Along this shore near the west line of sec. 32 some of the green, hornblendic schist, similar to that found further west on this lake, is interbedded with the slate.

On going south from the east side of the little point in NW¼ SW¼ sec. 31, T. 65-6 W., south side of Kekequabic lake, no rock is seen in place until about 150 yards from the lake. Here is a low ridge, trending east and west, whose eastern end is composed of augite granite porphyry with large white feldspar phenocrysts. This rock, in addition to the usual phenocrysts of feldspar and augite, also contains those of hornblende and biotite. The west end of this ridge is composed of another facies of the augite granite. This (No. 777) is porphyritic with small, flesh colored feldspars and in general appearance is markedly different from No. 776. The two rocks come in contact (No. 778), but the relative ages of the two are not clearly shown, although No. 776 seems to be the younger. No. 776A represents No. 777 within three inches of the contact, and No. 777A represents No. 776 within six inches of the contact. South of this place about 150 yards is an outcrop of the usual augite granite, and beyond this is an outcrop of the augite granite porphyry. Farther south several outcrops of the granite were seen; it resembles Nos. 777 and 774, most of it being like the latter. After going south from the lake for about half a mile and turning east, several outcrops of granite were seen on the slope which descends eastward to the little stream in the E½ SW¼ sec. 31, T. 65-6 W. In one of these there is a small amount of the augite granite porphyry; this exists in small, branching, vein-like forms, which are sharply marked off from the enclosing granite. Farther east is more granite and finally a large exposure of this rock is seen enclosing a mass of the country rock. This has been altered by the granite and is represented by Nos. 778A and 778B. The former is more altered and closely resembles No. 747 (see p. 89) from another granite contact. Nos. 779 and 779A represent the granite surrounding the other rock; this granite is quite fine grained and is porphyritic with small feldspars. One hundred feet east of this is an outcrop of the country rock which is a dark slaty argillyte in which mica has been developed. A few yards farther east is another outcrop of the same with some gray bands. Strike N. 15° E., and dip 73° towards the west of this. Other outcrops, with the same dip and strike, are seen near at hand. This is near, but just west of the small stream mentioned above. In the stream bed are outcrops of slate, but the lower part of the stream shows no rock in place. Just east of the mouth of the stream and about 100 yards from the lake shore the granite is seen again.

On the west side of the little point, south shore of Kekequabic lake, in NW¼ SW¼ sec. 31, T. 65-6 W., is a dike of diabase, trending north and south and apparently about twenty feet in width.

Along and near the south shore of Kekequabic lake, in sec. 31, T. 65-6 W. (especially just east of the center of this section), considerable examination was made of the belt of crystalline rock which has been termed both a porphyritic conglomerate* and also a hornblendic facies of the granite.† Nothing was found in this rock which indicates bedding, the only parallel structure is a rough jointing which strikes N. 15° E. and dips 78° to the east of this. No. 781 shows some of the freshest hornblendes in this rock. Just south of this belt of rock is an exposure of what appears to be granite; this varies somewhat and a specimen (No. 782) shows a facies of the rock of this exposure which approaches in general appearance the so-called conglomerate, and No. 783 shows a facies of the latter resembling somewhat the granite. The foreign pieces in the rock in question are not commonly well rounded, but are generally subangular and sometimes sharply angular. They are not arranged in any discernible manner, and they are of only a few kinds—dark green rocks of various grades of fineness of grain, and apparently composed of chlorite and hornblende. No. 783A shows these foreign pieces. No gradation from this rock into the ordinary granite was found, although Nos. 782 and 783 may represent intermediate facies. No contacts were seen between this rock and the slaty rocks just to the south. The former is a completely crystallized rock, while the latter show their fragmental nature very plainly. The two rocks were seen within 100 feet of each other, and here the slate is much harder than usual. While the evidence concerning the nature of this rock is not complete, from what is known of the field relations, and while no careful laboratory study has been made of it, still, as far as the writer can see, it is better to regard it as a hornblendic and syenitic facies of the granite rather than as a metamorphosed part of the adjoining sediments.

On going southeast from the southern corner of the bay, of Kekequabic lake, in the NW¼ NE¼ sec. 32, T. 65–6 W., about one-eighth of a mile from the lake is a ridge of slate and fine

*20th Ann. Rept., p. 76 (Nos. 593, 594, 594A, and 595), and p. 79 (No. 630).
†21st Ann. Rept., p. 37.

grained graywacke; strike N. 27° E., and dip 90°. Beyond (southeast) this are other outcrops of slate and graywacke becoming coarser and darker colored, similar to the grits found in the SE¼ of sec. 31, T. 65–6 W.* At about half a mile from the lake is a small beaver pond, and at the west edge of this pond is a diabase dike (No. 1752, N. H. W.; 21st Ann. Rept., p. 158) running approximately north and south and about 50 feet in width. The country rock about this pond is a hard gritty rock which, when struck with the hammer, rings like cast iron. In this rock are some hard, dark, fine grained bands. The strike is N. 20° to 30° E., and the dip 65° to 70° towards the east of this. The rock is similar to 632, mentioned above; it varies considerably in grain. Nos. 784A and 784B show this rock. A section shows angular and sub-angular, but not rounded grains of quartz, feldspar, hornblende, and several kinds of rock; this rock is perhaps a water deposited tuff. About 100 yards east of this pond is a small lake whose northern shore is made of grits similar to Nos. 784A and 784B. On the north shore is a cliff where the grit contains small blood-red fragments, perhaps of jaspilyte (No. 785). Here also is a dike-like mass about ten feet wide, of a porphyritic rock (No. 786) which closely resembles the porphyritic augite granite of Kekequabic lake. The east and south shores of this little lake show outcrops of dark slaty rock and grit; the strike varies somewhat, but has a general northeasterly direction. East of this little lake is another (probably the one in W½ SW¼ sec. 33, T. 65–6 W.) and from this a trip was made, in company with Prof. N. H. Winchell, to the top of West Twin peak.†

In company with the state geologist several points of interest were visited at Kekequabic lake and to the eastward as far as to the eastern side of T. 65–5 W. During this time the writer did not take complete field notes, that being done by Prof. Winchell,‡ but a few points of particular interest were noted.

No. 787 (1766 of N. H. Winchell's rock series), from the west side of the bay on the south side of Kekequabic lake, in SW¼ NW¼ sec. 31, T. 65–6 W., represents the matrix of a marked conglomerate.

Considerable examination was made of the porphyritic granite on the promontory in Kekequabic lake at the southwest corner of sec. 29, T. 65–6 W., but no evidence—at least none

*20th Ann. Rept., p. 79 (No. 632).

†See his notes; Nos. 1752 to 1764, 21st Ann. Rept., p. 158.

‡See Nos. 1765 to 1785; 21st Ann. Rept., pp. 158-160.

which appealed to the writer's mind—to show that this porphyritic granite was a metamorphosed conglomerate, was seen. Near the base of this promontory, on the east side, is a bluff where the porphyry seems to have been much shattered and crushed. In places it appears somewhat like a graywacke and in others the fractured nature of the rock causes it to be very rough on weathered surfaces. Specimens Nos. 788A, 788B, 788C and 788D, are from this place—so also is No. 1768 of N. H. Winchell's rock series. An examination of the rocks in thin section shows that they are more or less fractured portions of the granite porphyry, and neither the field evidence, nor that revealed by the microscope, seem to indicate a "metamorphic" origin for the porphyry.

A visit was made to the north side of *Epsilon lake*, and evidence of the unconformity, described from this place,* was looked for, but no conclusive evidence was found.

No. 789 shows the peculiar porphyritic rock from the narrows of *Zeta lake*, SW¼ NE¼ sec. 28, T. 65-6 W. This is the same as No. 1769 of N. H. Winchell's rock series.†

### *T. 65-5 W.*‡

At Gabimichigama lake some examination was made of the north and east shores of the lake with special reference to the rock which has here been called "muscovado." There seems to be conclusive evidence that the rock to which this name has been applied—especially along the eastern shore of this lake in secs. 29 and 32, T. 65-5 W.—is part of the Keewatin sediments modified by the gabbro. This statement of course does not apply to all the rocks which have been included under the term "muscovado" in other localities.

In the NE¼ NE¼ sec. 34, T. 65-5 W., on the south side of the stream is a ridge of ferruginous quartzyte. Just to the south is the gabbro, and the two rocks were seen within twenty feet of each other. The quartzyte dips about 55° towards the SSW, and it holds considerable biotite. The gabbro is rather fine grained, and a sample of the finest part of the gabbro is shown by No. 790. Just across the stream from this locality are many outcrops of greenstone (No. 791) which contains a few granitic fragments. No signs of stratification were seen. No. 791 is the same as No. 1780 of N. H. Winchell's rock series.

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*16th Ann. Rept., p. 323.

†For notes on Zeta lake see 15th Ann. Rept., pp. 157-159; 16th Ann. Rept., p. 321.

‡Other notes on this township are given later in this report.

## *Epsilon lake.**

This lake lies in the SW¼ sec. 21, SE¼ sec. 20, and N½ sec. 29, T. 56-6 W. The notes below relate mostly to an area of hornblende porphyryte around the southern part of Epsilon lake.

Where the north line of sec. 29 crosses the southeast shore of the lake is a grayish purple, hornblende porphyryte (No. 792).† This porphyryte extends along the shores of the little bay just south of this locality and several rounded bluffs of the same rock occur just back from the water. Nos. 793 and 793A represent this porphyryte from one of these bluffs, NW¼ NE¼ sec. 29. The same rock continues south and west to the southwest corner of the lake, where slaty argillyte and graywacke, much crumbled, are seen. On the shore just north of this is hard, siliceous argillyte, which strikes N. 80° W., and dips 55° towards the south of this. A short distance further north, but south of the north line of sec. 29, green and gray slate and graywacke, much crumbled, are found. These rocks extend in a ridge along the northwest side of the lake, and on going northeast the strike becomes more constant and has a general northeast direction with a vertical dip. At one place near this section line is a diabase dike, 15 feet wide, striking northwest. There is also a small amount of dark red jaspilyte in the green slaty rocks; this jaspilyte is similar to that described from Pickle lake.‡ The slate becomes very schistose in places resembling the sericitic schists common elsewhere. Just north of this section line a band, two and a half feet wide, of a gray, rusty weathering rock (No. 793B) occurs in the slates. This is parallel with the bedding. The slaty and schistose rocks extend northeastwardly to the portage to Knife lake.

The south shore of Epsilon lake in SW¼ SW¼ sec. 21 and SE¼ SE¼ sec. 20, is composed of hard, siliceous, gray to black, argillitic, slaty rocks. They have been folded in places, but as a rule they dip 45° toward the SSW. On the west side of the little bay in the SW¼ SE¼ sec. 20, the hornblende porphyryte again occurs, and on the east side of this outcrop is the slate. It is very fissile and decayed near the contact, as is the porphyryte. The two rocks were traced within three inches of each

*For other notes on this lake see 15th Ann. Rept., p. 157; 16th Ann. Rept., pp. 321-326.

†A petrographical description of the hornblende porphyryte of Epsilon lake is given in the 21st Ann. Rept., pp. 55-58.

‡No. 772, p. 98.

other, but the exact contact line was not determined. The porphyry here is green and decayed; it is represented by No. 794; this grades, in the space of three to five feet, into the usual form of the porphyry, through No. 794A. The contact runs north and south and appears to be vertical. The slate seems to have a dip parallel with the contact, although the bedding is indistinct. No. 794B shows the slate at the contact.

There are several rounded knobs of the porphyryte, south of the south end of Epsilon lake and near the center of sec. 29, which were explored. These knobs as a rule are steep and bare of vegetation and soil. A diabase dike was here seen cutting the porphyryte, and this may be a continuation of the dike mentioned above as near the northwest shore of Epsilon lake. On these hills, about one-eighth mile north of the southwest corner of Beta lake, the slate and porphyryte are again seen in contact. The slate is green to grayish in color and is very fissile and decayed, as is also the porphyryte near the contact. The two rocks are green and somewhat difficult to distinguish near the contact, but their different texture and the presence of remains of porphyritic crystals in the porphyryte made the distinction possible, especially on wet surfaces. At this place in the porphyryte are irregular but sharply defined areas of apparently graywacke. These areas are usually ten to twelve feet across, and four of them were seen. The rock of this inclusion is represented by No. 795. The porphyryte near the contact with the slate has a green groundmass, and this feature extends northwards, often for several rods from the slate. In fact this green groundmass seems to be the usual color of this rock near the edge of the porphyry; it is shown by No. 796. It is the same as the usual facies of the porphyryte (which has a purple groundmass), except for its green color, its fissured and more or less decayed condition, and its finer grain.

No. 797, from the south shore of Epsilon lake, in the NE¼ SE¼ NW¼ sec. 29, is a fresh, typical sample of the hornblende porphyryte of Epsilon lake.

The hills in the NW¼ sec. 29 were examined. The largest hill here (NW¼ NW¼ sec. 29) is composed of the usual, purple hornblende porphyryte, but at its northern side, about 200 feet north of the summit, the slates occur, dipping about 75° towards the south. The contact of the two rocks was seen in but one place; here it runs along a smooth, glaciated surface and no samples could be obtained. The contact is exposed for eight feet; it is a sharp, easily noticed line, running about parallel with the bedding of the slate, but curving somewhat. At one place in this one-sixteenth section and one in the SW¼ SW ¼ sec. 20 a large dike of coarse diabase was seen. At each place the dike was seen for a width of at least 150 yards; it has a north and south direction. At the contact with the slates the diabase is quite fine-grained and it sends irregular branching stringers into the slates. No. 798 shows the main facies of the diabase, and No. 798A is from one of the small stringers.

The examination of the hornblende porphyryte at Epsilon lake failed to reveal any other origin than that of a truly igneous rock for this porphyryte. It is of later date than at least some of the surrounding sediments, as is shown by its contacts, its finer grain at the contacts, and its inclusions, which can be referred to the country rocks. No study of the slates from near the contact has been made, but it would seem that the metamorphosing action of the porphyryte on the slates was small.

*Amœba Lake.*

This lake is an irregular body of water lying mostly in sec. 7, T. 65-6 W. The rocks of this lake are a series of Keewatin slates, graywackes and grits, at times cut by diabase dikes. The distribution of these rocks, their dips and strikes, etc., are given below. The description will begin at the northwest corner of the lake, at the portage to Knife lake (SE¼ NW¼ sec. 7) and extend eastward along the north shore, etc.

Near the northwest end of the above mentioned portage is rock varying from fine-grained graywacke to hard siliceous argillyte; strike N. 60° E., and dip vertical. At the southeast end of the portage is a coarse diabase similar to No. 798 (above). It is represented by No. 799, which is a coarse olivine diabase. This rock extends along the shore of Amœba lake northward for nearly 200 yards, where a fine-grained graywacke occurs. The two rocks were traced within 20 feet of each other, but no contact was seen. The diabase, however, is noticeably finer grained near the other rock. Continuing along the north shore in sec. 7, black and gray slates are seen in several outcrops. No. 800, from the NW¼ SE¼ NE¼ sec. 7, is a fine-grained, dark, laminated, flinty rock. The term slate is applied to these rocks as a general designation, but they frequently show no slaty cleavage, and at times have a conchoidal fracture. Along this shore only three outcrops were seen which show the bedding plainly; the strike is N. 30° W., and the dip vertical. Just before coming to the little bay whose eastern end is crossed by the west line of sec. 7, the slates are seen in connection with a gritty rock; the strike and dip are the same as given above. The grit, which is very feldspathic, contains numerous fragments, of all shapes and sizes up to those an inch across, of black slate similar to that found along the shores of this lake. The fragments are rarely more than an inch in greatest diameter. Nos. 801 and 801A (SE¼ NE¼ sec. 7) show this rock and the included fragments, one of which is perhaps a piece of a black quartz porphyry. On the north side of this little bay, at its eastern end, the same gritty rock occurs, but here the black slate fragments are lacking. On going east, from the extremity of this little bay, for about one-eighth mile, slate and graywacke with some grit were seen in a ridge; dip 80° towards N. 65° E.

The east shore in SE¼ NE¼, sec. 7, is composed of graywacke and slate; strike usually not distinct, but in one place it is N. 30° E., and the dip is vertical. On the north side of the island in the same one-sixteenth section the strike is N. 50° E., and the dip is vertical. This island is made of grit and graywacke. The island just south of this island is composed of graywacke with a few narrow bands of black slate. The strike, taken in two places, is N. 30° E., and the dip vertical. The finer portions of the graywacke are sometimes laminated, but this is not very common, and when the lamination is lacking and there are no bands of slate present the bedding is obscure. No. 802 from this last island (NE¼ SE¼ sec. 7) shows the fine-grained graywacke and its lamination. The shore just east of these islands and southward to the end of the point in the NE ¼ SE¼ sec. 7 is made of graywacke and grit, the latter often holding fragments of black slate. Just east of the south end of the southern of these two islands the strike is N. 50° W., and the dip vertical, and on the end of the point the strike is east and west and the dip 80° towards the north. From this point eastward to the portage in NE¼ SW¼ sec. 8 the rock is grit and graywacke; the strike is N. 75° E., dip 90°. On a little island near this portage the dip is 75° towards the south. A few rods west of the portage, on the south shore, the strike is N. 80° E., and the dip vertical. The point in the SW¼ SW¼ sec. 8, is mostly made of hard, gray, siliceous, conchoidally breaking slate; there is a little black slate and fine grained graywacke. The strike varies a few degrees either side of E. and W., and dips 65° to 80° towards the N. The point in the N½ NE¼ NW¼ sec. 17, has essentially the same rock as the last; dip 75° towards the N., 15° W. This gray slate in places becomes almost flint. The shores of the small bay in NE¼ NW¼ sec. 17, are of grit, usually coarse and associated with some coarse graywacke. The shores of the larger bay in NW¼ sec. 17 are also of the same rock, containing no slate or fine graywacke bands, and so not showing the bedding. Gray, flinty slates again appear on the point at the west of this last bay. The head of the bay in the NE¼ of sec. 18, has grit along its southeast side; on the western side of the head of this bay are no exposures. Back from the shore and southeast from the head of this bay is a ridge of grit; at its top are many branching dikes of diabase which vary from two inches to twenty feet in width. No general direction for these dikes was noticed, but they seem to extend along the top of this ridge, which trends northeast. The diabase is commonly fine grained and similar to No. 798A, but in a few places it is coarser and resembles Nos. 798 and 799. The northern half of the east shore of this bay (in NE¼ sec. 18) is composed of gray, flinty slate; strike N. 60° E., dip vertical. Almost across the bay and in the same one-sixteenth section (NE¼ NE¼ sec. 18) the dip is 75° towards N. 15° W. At this last place No. 803 is taken to show the flinty slate which has a conchoidal fracture. At the end of the point on the west side of this bay the rock is gray and black flinty slate, dipping 70° towards N. 30° W. The south shore of Amœba lake, in the SE¼ of sec. 7, is composed of graywacke and slate, most of the latter being black; dip 90° to 75° towards N. 20° W. At the east base of the point, in the NW¼ SW¼ SE¼ sec. 7, there are branching dikes of fine grained diabase, similar to 798A. The end of this point is made up almost entirely of diabase; it rises in a bold bluff and is quite similar to No. 799. The broad bay that extends into the NW¼ of sec. 18 has its shores mostly of graywacke and slate, but on the southern part of the bay the rock is almost exclusively slate. On this bay the dip is from 90° to 75° towards N. 20° W. The narrow bay which lies in the SW¼ SW¼ sec. 7, has graywacke in several outcrops. On the north side of the bay the strike is N. 20° E., and the dip 90°. The shores of the blunt point (on the west shore of the lake) in the SE¼ SE¼ sec. 7, are made of graywacke and grit, and the bay on the north side of this point has its shores mostly of grit, in which are frequently seen pieces of black slate. The point on the north side of this bay is made of graywacke, slate and grit; strike N. 55° E., and dip 90°. On the south side of this point, near its base, is coarse diabase, which extends along the shore for nearly 100 yards. It is again seen on the north side of this point, and continues northward to the portage to Knife lake.

*Lake in E. ½ sec. 8, T. 65–6 W.*

The description begins at the portage, (NE¼ SW¼ sec. 8) to Amœba lake and extends eastward along the south shore, etc. The rocks of this lake, except for the lack of diabase, are like those of Amœba lake. On the south shore just east of the portage graywacke and slate occur; dip 70° towards N. 35° W. but not very evident. A little east of this, in NW¼ SE¼ sec. 8, is an outcrop of graywacke and grit the latter holding some pieces of slate; strike east and west, dip 80° towards the N. The bay and island in NE¼ SE¼ sec. 8 show outcrops of graywacke and slate, the latter predominating. The bay in the center of W½ W½ sec. 9 has its shores mostly of grit holding slate fragments. The point at the north entrance to this bay is composed of slate and graywacke; dip 80° towards N. 10° W. The small bay at the northeast corner of the lake has its shores of the same rocks and these continue westward to the point in SW¼ NE¼ sec. 8 which is made entirely of gray and black slates; dip 75° towards N. 5° W. Just east of this point the dip is 95° towards N. 15° W. On the east shore of the bay in NW¼ NE¼ sec. 8 are slates with some little graywacke and grit; the strike is N. and S. and dip 65° towards E. The rocks lithologically are similar to those seen just to the south, where the strike is about at right angles to this. On going back from the shore this N. and S. strike was found to change gradually to nearly E. and W. At the lake shore are a few bands of very black, perhaps carbonaceous slate (No. 804). North of the end of this bay is a round hill composed of black and gray slate with some grit on the north side of the hill; strike N. 30° E., dip 90°. The point on the west side of this bay shows slate, graywacke and grit; dip 75° to 80° towards N. 75° W. A little farther south slate and graywacke occur, dipping 75° towards N. 80° E. At the southwest side of the bay in SE¼ NW¼ sec. 8 is a bold cliff rising some 150 feet above the lake. At its base are gray and black slates dipping 75° towards N. 65° E. The north side of the point at the south entrance to this bay has graywacke and some slate, dipping 90° to 70° towards the S. The island in the mouth of this bay is made almost entirely of slate, dipping 75° towards N. 10° E. to N. 25° E. The island in SE¼ NE¼ sec. 8 is made of slate, grit and graywacke; the strike, as taken in several places, is quite constant, being N. 80° E., and the dip is from 90° to 75° towards S. 10° E.

*Lake in N½ Sec. 9, T. 65-6 W.*

The main part of this lake lies in N½ sec. 9, and it extends into SE¼ sec. 4 and SW¼ sec. 3, T. 65-6 W. The rocks are quite similar to those of Amœba lake except for the lack of diabase and for the presence of tuffaceous deposits. The description begins at the west end of the lake and follows along the north shore to the narrows and return, and then the lake east of the narrows is described.

On the north side of the bay at the west end of the lake is a ridge of slate and graywacke, the former usually black and in much larger amount than the latter; strike N. 75° E., and dip varies 10° on either side of vertical. On the north shore farther east, just north of the west end of the western island, the rock is the same; strike N. 80° E. and dip vertical. The same rock, with about the same dip and strike, continues eastward along the north shore almost to the narrows of the lake, at which place on the north shore is quite an amount of grit with slate; the rocks have been crumpled somewhat, but seem to have a general east northeasterly strike. On the south shore just west of the narrows there is slate and a green rock (No. 805) holding hornblende crystals. This is regarded as a basic tuff. This rock and the slate seem to be mixed together and broken and crumpled. This same rock (No. 805), with considerable gray flinty slate, is seen in several places along the south shore in W½ NE¼ sec. 10. There is also some graywacke which grades into the slate on one hand and into the tuff on the other. No. 806 shows a facies intermediate between the graywacke and the tuff (No. 805). The western part of the south shore is made of grit holding black slate fragments; bedding not distinct, but the strike is apparently N. 70° E., and the dip about 90°.

The two islands in the western half of this lake are made mostly of grit, with some slate; strike N. 70° E. and dip about vertical. On the eastern of these islands is a bold cliff rising 100 feet above the water; here the grit in places becomes conglomeratic, holding pebbles of different kinds and sizes up to those six inches in diameter. This conglomerate resembles that on Camper's island in Ogishke Muncie lake, except that the boulders are not so large nor so numerous as at the latter locality.

On the south shore east of the narrows are several outcrops of grit with little slate, considerably twisted but having a general northeasterly strike and a dip of 80° to 65° towards the southeast. Farther east on the south shore are graywackes, slates and rocks like No. 806, much twisted. Just beyond are high cliffs of the same rock finely interbanded; the general strike is east and west and the dip from 80° to 55° towards the north, and there are several small, sharp flexures. This rock, with increasing amounts of slate, extends to the northeast end of the lake. The north side of the eastern half of the lake is made of slates, grits and small amounts of graywacke and rock like No. 806; the strike varies from N. 80° E. to N. 60° E., and the dip is about vertical.

In some places about this lake, especially in a high cliff on the north shore just west of the narrows, there is a noticeable jointage which dips eastward at an angle of about 40°.

Between this lake and the *small lake in E. ½ sec. 4, T. 65-6 W.*, just to the north, are slates and greenish graywacke with some rock like No. 806; strike N. 55° E., and dip vertical. The southern part of this small lake shows black and gray slates, often twisted, but in general striking N. 60° to 40° E.; dip about 90°. At the north of the lake is a ridge of black and gray to greenish slates intimately interbanded with greenish graywacke and tuff similar to No. 806; strike north and south and dip vertical.

### *Lake in E. ½ sec. 3, T. 65-6 W.*

This lake also extends into the W½ of sec. 2 and the N½ of sec. 10, T. 65-6 W. The rocks are slates, graywackes and grits passing into water deposited tuffs. A hill on the southeast side of the lake shows a marked conglomerate.

Near the end of the little bay in the NE¼ SW¼ sec. 3 is a ridge of yellowish green rock (No. 807) regarded as a tuff; it is in general similar to Nos. 805 and 806. It appears massive, and is very tough and hard, but in places its finer grained facies show lamination, and on top of the hill this rock (No. 807) is seen intimately interbranded with gray slates. The rock here is much twisted and broken, but has a general NNE strike and a vertical dip. No. 808 shows a fine grained facies of the tuff interbanded with greenish gray slaty rock which seems to be only a very fine grained condition of the same. This rock also grades into fine grained graywackes. This ridge extends along the shore in this one-sixteenth section; strike N. 25° E., and dip 90°.

On a little island just northwest of the large island in this lake is black slate, dipping 65° towards the west. On the west shore of the lake, a little to the northwest of this small island are large amounts of black slates mixed with some gray slates and fine grained graywackes, dipping 80° towards N. 65° W. This black slate, with some graywacke, extends northward along the west shore to the north end of the lake. The strike is N. 25° to 40° E., and the dip about 90°. In places the rock shows no slaty cleavage, but usually this is quite distinct and parallel to the bedding. (Here, as elsewhere in this report, the very fine grained, compact rocks termed slate, do not always show a distinct slaty cleavage.) On the east side of the lake, near its northern end, is a ridge of hard flinty slate, usually gray in color, but sometimes quite dark colored. The strike where first seen is N. 80° E., and the dip 45° to the north of this; this strike and dip are not constant, varying some, and on tracing the ridge south for 200 yards the rock gradually assumes a vertical position and a strike of N. 35° E. This strike is maintained for some distance along the east side of the lake in the NW¼ NW¼ sec. 2. Here the rock is well represented by Nos. 809A and 809B, which are hard, flinty, gray slates, breaking conchoidally. A little farther south the rock becomes less laminated, and in places the bedding cannot be seen, and the rock has an indistinct schistose structure which runs with the bedding when this is seen. Strike N. 40° E., dip 90°. This condition extends to the south edge of the NW¼ sec. 2.

The large island (in the NE¼ SE¼ sec. 3) has at its southern end a cliff of slate and coarse graywacke (No. 810) which seems to be a facies of No. 807. Strike N. 30° W., dip 60° toward N. 60° W. This strike gradually changes to N. 10° W. and N. 10° E. On going northeast along the south shore of this island, the dip becomes nearer 90° and the rock becomes entirely black and gray slates. About the center of the north side of the island the rock is slate, striking N. 25° E., and standing vertical.

The east shore of this lake, in the SW¼ sec. 2, is made of slate, graywacke and grit. The first is the most abundant; it is sometimes hard and flinty and has a conchoidal fracture and again it is very fissile, the cleavage being parallel with the bedding, which strikes N. 20° to 40° E., dip about vertical. This continues to the end of the point in SE¼ SE¼ sec. 3. The rest of the east shore to the south end of the lake is of similar rock, except that the graywacke is the most abundant; strike varies little from N. 30° E., and dip is about 90°. 200 yards south of the south end of this lake, on the portage to Knife lake, the rock is in places brecciated and cemented by a black substance, as is shown by No. 811. This passes into the usual graywacke by loss of the brecciation and the black cementing material. In the SW¼ of sec. 10, on either side of the portage, is a steep hill rising some 200 feet above Knife lake. The western of these hills is made of a hard, fine grained, green rock (No. 816), which shows, as far as examined, no bedding. At the Knife lake end of the portage is a peculiar, massive appearing, nearly white, graywacke-like rock (No. 815).

The west shore of this lake (i. e. the one lying mainly in E½ sec. 3, T. 65-6 W.), north to the bay in the NE¼ SW¼ sec. 3, is made up of grits, tuffs, graywackes and slates. The first two are not abundant. They seem to represent water deposited volcanic material mixed with more or less of ordinary sediment. The dip is 70° towards N. 70° W. to N. 50° W. No. 812, from the SE¼ SW¼ sec. 3, shows a form of the tuffaceous deposits.

On ascending from the lake, the broad hill in the N½ NE¼ sec. 10, black and gray slate and fine grained graywacke are seen; they are quite fissile; strike N. 60° E., dip vertical. Further up the hill the rock has been much fissured and crumbled. It weathers white and on this account is quite noticeable from the lake. In this rock are strings and contorted pieces, of various shapes, of a fine grained siliceous rock—the whole appearing like a conglomerate that has been much squeezed and crumpled and its pebbles much distorted. On the south part of the hill is a noticeable black knob; here the rock is a decided conglomerate. The pebbles are well rounded and are very numerous, making up more than one-half of the rock. The matrix is dark green in color, fine grained and much like a large number of the pebbles, which are accordingly most evident on weathered surfaces. Most of the pebbles are from one-fourth to one inch in diameter; a few are three inches in diameter, but rarely are they more than one and one-half inches. The majority of the pebbles are of fine grain and dark gray to greenish in color. No granite or jaspilyte pebbles were noticed, although searched for. No bedding was seen in this conglomerate. No. 817 represents the conglomerate, and No. 817A is a collection of pebbles from it. Among these are several varieties of gray to dark gray to greenish, fine grained, slaty and flinty rocks, apparently quartz porphyry, and fine grained greenstones. No. 817B shows some variolyte-like pebbles. The fissured slate, described above, is seen directly under the conglomerate on the side of this hill; in fact the two rocks were seen grading into each other. At this place no bedding is seen, but the cleavage of the slate strikes N. 30° E., and dip vertical. The pebbles of the conglomerate are seen to suddenly grow less and the fissile cleavage of the slate disappears, all within a distance of two feet, and in this distance the two rocks appear to grade into each other. Whether here is an unconformity at the base of the conglomerate or a passage from conglomeratic to non-conglomeratic deposits is not clear.

*Lakes in Secs. 1 and 2, T. 65-6 W., and Sec. 36, T. 66-6 W.*

The western and southern of the lakes examined in these sections show outcrops of slates and graywacke, while the lake which lies mostly in the SW¼ sec. 36, T. 66-6W., has a coarse conglomerate.

The pond in the SE¼ NW¼ sec. 2 shows outcrops largely of black slate, often very fissile, with some graywacke; strike N. 20° to 40° E., and dip from vertical to 70° towards the west of this.

The north shore of the lake which lies along the center of the E½ sec. 2 is made of graywacke and black slate, the latter being very fissile and, in places, soft. It appears to grade at times into a rather soft, green, schistose rock (No. 812A). Strike N. 20° to 25° E., dip about 90°.

The shores of the lake which lies mostly in SW¼ sec. 1 are made largely of fine grained, greenish graywacke, varying to a grit; a little black slate is also present. No. 813 shows a facies of the rock of this lake intermediate between grit and graywacke. It contains minute pieces of red jaspilyte and at times also pieces of black slate. The bedding in the rocks of this lake is not very evident, but the strike seems to be about north and south and the dip vertical. At one outcrop on the north side, near the east end of the lake, bedding is distinct; strike N. 40° W., dip 90°. At the north end of the lake, at the portage, is considerable slate with grit; strike varies from N. 70° to 90° E. and dip 75° towards the south.

On the west side of the lake which lies largely in SW¼ sec. 36 near the south end, in NW¼ NW¼ sec. 1, is a fine exposure of coarse conglomerate which is very similar to the Ogishke conglomerate as seen at Ogishke Muncie lake. The boulders are numerous, at times making up half, or more than half, of the rock. They are of all sizes up to those two feet in diameter, and are well rounded, except some of the smaller ones. No jaspilyte pebbles were noticed. The principal rock of the boulders is a coarse horneblende granite similar to the Saganaga granite and evidently from that granitic mass. The matrix of the conglomerate varies much; it is usually a coarse or fine grit, not slaty, and it frequently has a decided greenish color. No. 814 shows the conglomerate, No. 814A the common granite of the boulders, and No. 814B fragments of various boulders. These include several varieties of greenstone, some of them porphyritic with feldspar, coarse grits quite similar to parts of the matrix of the conglomerate, gray flinty rock, and fine grained pinkish granite similar to the aplyte dikes in the Saganaga granite mass. On the west shore, a little north of this place, is another exposure of this conglomerate. Bedding was seen in only one place; strike N. 15° W., dip 90°.

At the west end of this lake, in E½ SE¼ sec. 35, there is a ridge of conglomerate whose matrix is similar to No. 813; the pebbles are not very numerous and granite pebbles are rare. There are, however, a number of pebbles of a green rock (No. 814C) which shows small hornblendes in a hard, indistinctly blotched, fine grained matrix; this rock is somewhat similar to some of the tuff seen on the north side of Kekequabic lake (see No. 1059 of N. H. Winchell's series of rocks). The rest of the shores of this lake have a number of outcrops of conglomerate. It varies much in matrix and size and number of the boulders, but the coarse granite boulders (No. 814A) are almost everywhere numerous. Evidences of bedding are not common; in one place on the north shore in NE¼ SW¼ sec. 36 the strike is N. 40° W., and the dip 90°.

### *Lake Avis.*

This lake lies mostly in sec. 35, T. 66-6 W., and extends into secs. 26 and 34. The description begins at the point on the west shore crossed by the west line of sec. 35, and extends west and south, etc. The rocks are slates, graywackes and grits, some, at least, of the latter being marked tuffs.

At the end of the point crossed by the west line of sec. 35 are black and gray slates; strike N. 80° E., dip 90°. The little island just off this point is also made of slates, striking N. 60° E. and standing vertical. On the shore a short distance west of this point there is slate and coarse grit (No. 818). The rocks have been flexed but show a general east and west strike. This rock (No. 818) is distinctly fragmental, the grains being usually from one-sixteenth to one-eighth inch in diameter; among these grains are quartz, white feldspars and various fine grained, almost flinty rock fragments which vary in color from light gray to black. In thin section this specimen is seen to be composed of a heterogeneous mass of fragments of various minerals and rocks; among these the following are prominent: quartz, feldspar, hornblende, quartz porphyry and trachyte. There are many fragments of a rock composed of long laths of feldspar in a fine grained, greenish, perhaps devitrified groundmass. This rock (No. 818) is regarded as a tuff, and much of the rock termed grit in this vicinity is also probably tuffs passing into sediments in which the volcanic fragments are less abundantly mixed with ordinary sediment.

The little island in the head of the bay in SE¼ NE¼ sec. 34 is made of grit and graywacke, twisted some, but having a general north and south strike. At the west side of the head of this bay is a ridge of slate, at times of a greenish color; the general strike is north and south, dip 90°. The west shore in sec. 34 is made of slates, grits and graywackes, hard, firm and non-slaty; strike varies from N. 60° to 90° E., and the dip from 90° to 65° towards the north. Here is considerable grit (tuff) like No. 818, but not so coarse grained. On the south shore in sec. 34 and SW¼ SW¼ sec. 35 the rock is hard, gray to black slate; dip, in two places, 75° towards S. 60° E. On the west shore of the bay in S½ SW¼ sec. 35 are several outcrops of this same slate, and two outcrops on the east shore; strike N. 25° to 55° E., dip about 90°. In the NE¼ SW ¼ sec. 35 is a ridge, 100 feet high, of the same slates; dip 90° to 70° towards N. 60° W. The point on the east shore near the center of the south side of NW¼ sec. 35 has hard slates, striking N. 30° E. and standing vertical. Along the shore just east of this point are several outcrops of the slates, standing vertical and striking N. 20° to 40° E. Most of the shore of the bay in NW¼ NE¼ sec. 35 is made of sand and gravel,—a rare occurrence in this part of the state,—and just back from the shore is a low drift ridge. A short distance east from the head of this bay is a ridge of slate and graywacke striking N. 35° E. The point on the east shore crossed by the north line of sec. 35 has fissile slate and graywacke; strike N. 25° E. A short distance north of this is a small island where the rock is split into parallel layers from one to eight inches thick, dipping 75°

towards N. 60° W. The rock here has been much twisted. Near here on the east shore are graywacke and grit; strike N. 50° E., dip 70°. This grit and graywacke extend along the east shore to the north end of the lake. In the bold bluff near the north end, on the east side of the lake, the dip is 75° towards N. 60° W. From the north end of the lake south, along the west shore, to the little point in S½ NW¼ NW¼ sec. 35 the rocks are slate, black and gray, graywacke, sometimes greenish in color, and grit; strike varies from N. 15° to 40° E., and the dip from 90° to 70° towards the west. Some grit like No. 818 is seen along this shore and increases in amount on going south. The little point just mentioned is almost entirely made of this rock; here the dip is 70° toward N. 40° W. In places this rock has fragments one-half inch in diameter. No. 819, which is similar to but coarser grained than No. 818, represents the rock of this point. The prominent hill at the base of this little point is made of hard graywacke and grit with a few slate bands; strike varies from N. 10° to 80° E., and dip almost vertical.

*Lake in N½ Sec. 34, T. 66-6 W.*

This lake has rocky shores and the rock is almost all slate, gray and black, sometimes hard and flinty, and sometimes very fissile. The strike averages N. 25° to 30° E. and the dip varies 10 degrees on either side of the vertical. Some little grit was seen, especially on the point on the north shore in NW¼ NE¼ sec. 34 and also on the west side of the lake. At this point the strike is N. 30° E. and the dip 90°. Some of the beds of grit (tuff) contain fragments of gray to greenish, fine grained rock; these are mostly angular and are flattened in the plane of the bedding. No. 820 shows the rock with these fragments; the weathered end of the specimen is a horizontal surface and the flat sides are perpendicular to the bedding.

*Lake at NW Corner Sec. 25, T. 66–6 W.*

This lake also extends into secs. 23, 24 and 26 of T. 66–6 W. The east shore has a few outcrops of slate, with some little graywacke and grit. A schistose structure, parallel with the bedding, sometimes appears. Strike N. 10° to 35° E., and dip about 90°. On the north shore are grits striking N. to N. 10° W.; dip 90°. In a few places there are small slate fragments in the grit. The west shore has grit along its northern half and grit and slate along its southern half.

*West Seagull lake.*

This lake lies largely in secs. 5 and 8, T. 65-5 W. The following brief notes relate to the granite and its contacts.*

Nos. 821 and 821A are specimens showing the contact of the Saganaga granite and the Ogishke Muncie conglomerate in NE¼ SE¼ sec. 7, T. 65-5 W.

Near the centre of the SE¼ sec. 7 there are several rounded hills of greenstone cut in all directions by branching dikes of granite; sometimes these dikes are 30 feet across. The greenstone at this place varies considerably in grain, but is perfectly massive. No 822 is a good representation of the usual greenstone of this place; it is a rather fine grained, hard, dark green rock composed essentially of hornblende and feldspar, the former in large amounts. A figure in the chapter on the Akeley lake plate in vol. IV. of the final report shows the relations of the greenstone and the granite. The granite is similar to the main mass of the Saganaga granite as exposed at West Seagull lake. But sometimes, near the locality here described, the granite in the dikes becomes some finer grained and poorer in quartz as the distance from the main granite area increases.

*South of Seagull lake in T. 65-5 W.*

The notes here given treat of the Saganaga granite and the greenstone to the south of it. They are a continuation of the notes given on page 78 of the 20th Annual Report.

On going east, along the *north line of sec. 22,* from the northwest corner of this section the greenstone† is seen in several outcrops just east of the section corner. This rock is here sometimes massive and sometimes schistose, the schistose cleavage striking about east and west and standing vertical. No. 823 represents the schistose phase of this rock. Less than one-eighth mile from this section corner are two outcrops of a gray porphyry (No. 824) which consist of rather small, white to pinkish, porphyritic feldspars in a fine grained groundmass apparently of hornblende and feldspar. In places the porphyritic feldspars are in part arranged with their long axes in one direction (east and west) and there is also an indistinct schistose structure which runs in the same direction and stands about vertical. In one small area this porphyry was seen in sharp contact with the greenstone. About one-eighth mile

*Other notes on the geology of this lake may be found in the 16th Ann. Rept., pp. 293-295; 20th Ann. Rept., pp. 83-86.

†In 20th Ann. Rept., p. 88, called mica schist,—more properly a greenstone schist or hornblende schist.

from this section corner the granite appears. At first it is a fine grained rock (No. 825). A few outcrops of rock similar to this are seen and then the ordinary granite occurs, extending to the ¼ post. This granite, while being in general similar to the main mass of the Saganaga granite to the north, is a little finer grained than usual and has less abundant quartz, which mineral is at times almost entirely lacking. Biotite in considerable amount is seen in places in this granite. No. 826 represents the granite from the place it was first seen to the ¼ post. In a few places this granite has vein-like forms of rock similar to No. 825. From the ¼ post east to the northeast corner of sec. 22 the granite occurs in several places. As a rule it has little quartz and considerable biotite and is a hornblende-biotite syenyte. In places there is an indistinct gneissic arrangement of the minerals which runs about east and west and stands vertical, and in other places the rock is perfectly massive.

From the northeast corner of sec. 22, eastward along the *north line of sec. 23*, to the quarter post, the granite occurs in many outcrops. It is the same hornblende-biotite syenyte, and the gneissic structure, while not very distinct, is still often seen. From the quarter post to the northeast corner of sec. 23 the syenyte becomes more gneissic and chloritic rather than hornblendic. This is shown by No. 827. The rock is in places much darker colored, as shown by Nos. 827A and 827B.

On the *east line of sec. 23*, the granite extends southward for nearly a quarter of a mile from the northeast corner of this section. It is well represented by the specimens mentioned above (Nos. 827 to 827B). Nearly one-fourth mile from this section corner the greenstone appears. A few rods east of the section line granite is seen running through the greenstone in the form of dikes. About a dozen of these dikes were seen, varying in width from one to twenty-five feet, and in general, though not always, having an east and west direction. The contact with the greenstone is sharp, but neither of the rocks appears particularly different at the contact than away from it. In places the granite holds fragments of the greenstone. In some places both the greenstone and the granite show an indistinct schistose structure running east and west and standing vertical. No. 828 shows the granite and a small part of a greenstone inclusion. No. 829 and 829A show the greenstone, the latter representing the large amount of the greenstone at this place. Just south of this place is a steep sided valley, running east and west, with a prominent hill on its south side. On ascending this hill the greenstone is seen in many places. and there is a small amount of a porphyry similar to No. 824. The greenstone varies in grain, but is a green, dioryte-like rock. Nos. 829B to 829D represent the greenstone from this hill, No. 829C representing the usual facies of the rock. No. 829B shows some quartz grains. Near the east quarter post of sec. 23 the greenstone is represented by No. 829E.

Going south, on the *west line of sec. 23*, from the northwest corner of this section the granite is seen in a few outcrops. The greenstone occurs at about one-eighth mile from this section corner. About one-fourth mile from the corner, porphyry, similar to No. 824, is seen. The greenstones occur quite frequently south of this. South of the west quarter post of sec. 23 the greenstone in places is composed of rather indistinctly outlined areas of a green and of a purplish color (No. 830). Between this quarter post and the southwest corner of the section a small amount of a hard, very fine grained gray rock (No. 832) was seen, also a small amount of fine grained, light gray rock (No. 831), porphyritic with small feldspars and hornblendes. About one-eighth mile north of the southwest corner of sec. 23 is a small ridge of porphyry similar to No. 824.

On the *west line of sec. 26*, a short distance south of the northwest corner of the section, is a ridge of porphyry (No. 833) similar to No. 824. Farther south are many outcrops of greenstone (No. 834) which show scattered hornblende crystals. In places on the weathered surface of the greenstone more or less rounded (but usually well rounded) fragments are seen included in the greenstone; these are usually under two inches in diameter, but sometimes, especially in E½ of NE¼ sec. 27, they are six inches in diameter. These fragments are not usually distinct on a fresh fracture, as they are quite similar to the matrix. One of the specimens numbered 834 shows some of these fragments. No parallel arrangement of these fragments or other indications of bedding are seen. In one exposure at the W¼ post of sec. 26 a few fine grained granitic and slaty fragments or pebbles were seen in this greenstone. A short distance north of the southwest corner of sec. 26 medium grained gabbro occurs,* and south of this to the stream a short distance south of this section corner the greenstone is seen. West of this section corner greenstone was seen, and also along the south line of sec. 26 eastward to the stream.

*This is the only place where an isolated mass of gabbro has been seen by the writer north of the gabbro boundary. At the time it was seen its true importance was not recognized, and in the later field work this outcrop was forgotten.

Along the *north line of sec. 27* are some outcrops of greenstone similar to No. 834, but not showing pebble forms or fragments. About one-eighth mile west of the northwest corner of this section and just south of a pond is an exposure of porphyry similar to Nos. 824 and 833.

Along the *west line of secs. 27 and 34* the greenstone extends south almost to the small lake which is one-fourth of a mile south of the northwest corner of sec. 34. The rock resembles No. 834 and in some places has the foreign fragments above mentioned. Just north of this lake is an east and west ridge on the north side of which is the greenstone. This has a yellow, granular appearance. On the top of the ridge is gabbro of medium grain, and the same rock is seen near the section line on the south shore of this lake. Eastward from the northwest corner of sec. 34 for half a mile no exposures occur.

On the east line of *sec. 21*, south of the ¼ post, the greenstone forms several steep ridges usually trending east and west. On the south line of this section, east of the ¼ post, are many outcrops of greenstone, coarser grained than usual and similar to Nos. 834 and 829A. Oftentimes pebbly areas are seen where the pebble-like forms are well rounded. No bedding was seen. West of this ¼ post the greenstone continues in numerous outcrops, varying considerably in grain and composition. In places it is purple like No. 833, and in other places it approaches an argillyte, and in some of the latter places are twisted laminæ much resembling those seen in sediments, although no other evidence of bedding was seen. No. 835 shows a quartziferous phase of the greenstone from the south side of SW¼ sec. 21; this is quite probably a sedimentary rock. Along the west side of sec. 21 greenstone outcrops are common. Along the north line of sec. 21, west of the ¼ post, is more greenstone at times becoming coarse grained; this is represented by No. 836 which seems to be a coarse diabase considerably altered. East of this ¼ post to the northeast corner of sec. 21 the greenstone is finer grained and resembles No. 823.

## *Seagull Lake.**

This is the large lake lying mainly in the northeast quarter of T. 65-5 W. The notes are confined to two diabase dikes which cut the Saganaga granite (the rock of this lake), and to a peculiar rock from Cucumber island (the largest island in this lake).

*For other notes on this lake see 10th Ann. Rept., p. 88; 16th Ann. Rept., pp. 295-299; 20th Ann. Rept., p. 88.

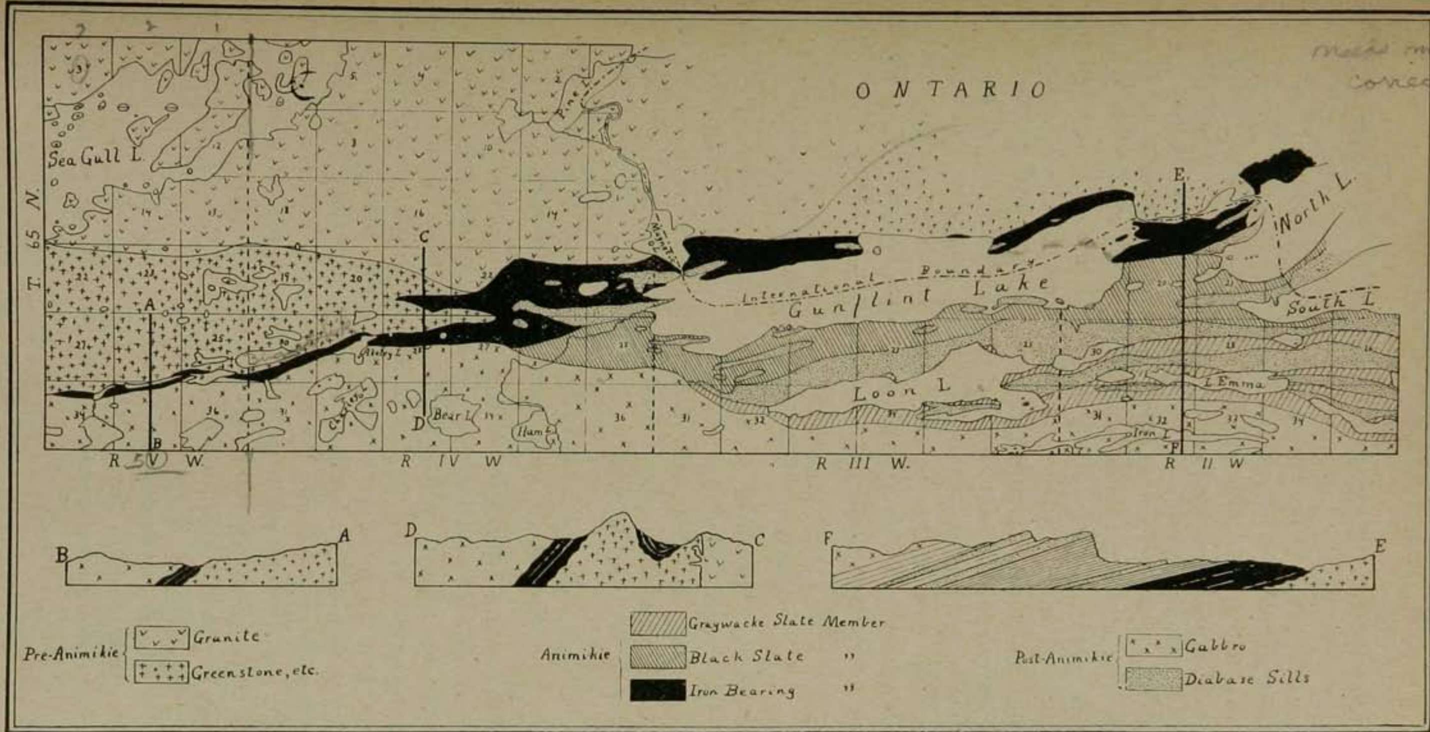


FIG. 1. Geological map of the Mesabi iron range in Cook county. The data for the geological boundaries on the Canadian side of the international boundary are very incomplete. The horizontal scale of the sections is twice that of the map, and the vertical scale is several times the horizontal. (From the Engineers' Year Book, University of Minnesota, 1898.)

A diabase dike, trending northeastwardly, occurs at the southeast side of the large island in sec. 15, T. 65–5 W.; and another diabase dike occurs on the northwest side of Cucumber island in NE¼ NW¼ sec. 12, T. 65-5 W.

On the northwest side of Cucumber island, in SW¼ NW¼ sec. 12, T. 65-5 W., is a peculiar greenish rock* which has a rough weathered surface. This rock (No. 837) is now much altered and has in it much calcite; its original nature has not been determined, but it was quite evidently a rather basic igneous rock, perhaps a camptonyte, which probably cut the surrounding granite. No contact between the two rocks was seen, but an angular granite fragment was found in No. 837. This rock contained two kinds of phenocrysts, one of which is completely altered to a greenish mass, and the other is of a darker color and in the center of some of these darker areas is a small amount of a comparatively fresh, red mineral. On the weathered surface is a thin, yellow-brown, oxidized film whose outer surface is black.

*Lake in NW¼ sec. 20, T. 65–5 W.*

The shores of this lake show a number of outcrops of greenstone well represented by No. 838. A few sub-angular fragments darker than the main mass of the rock were seen included in the greenstone; one of these is in the sample collected. No evidence of bedding was seen.

*The iron-bearing and associated rocks west of Gunflint lake, mostly in Ts. 65–5 W. and 65–4 W.*

The following notes give details concerning the geographical distribution and relations of the rocks westward from Gunflint lake for about twelve miles. The distribution of these rocks is shown on the Akeley lake and Gunflint lake plates of volume 4 of the final report of this survey, and also on the accompanying map, which is here introduced that the following notes may be more easily understood. The oldest rocks of this district are Archean granites and greenstones with some sediments (Keewatin) on the west. These are overlain unconformably by southward dipping Animikie strata, the lower member of the Animikie being the iron-bearing horizon. Over the Animikie is a later mass of coarse gabbro, and this igneous rock has metamorphosed the iron-bearing horizon of the Animikie, especially along its narrow western prolongation, into a coarse

*This is called "chlorito-graywackenitic conglomerate" in the 16th Ann. Rept., p. 298, rock number 597.

grained banded rock which is here termed a ferruginous quartzyte. This rock is composed of quartz, magnetite (this mineral often being in large enough amounts to constitute an iron ore), olivine and forms of pyroxene and amphibole.* The Animikie strata have been intruded by diabase sills.

*Gabimichigama lake.*† The west shore in sec. 36, T. 65-6 W., and N½ sec. 1, T. 64-6 W., has many outcrops of a fine grained, granular, gray rock (No. 840), which seems to be part of the Keewatin. It is in some places distinctly banded, as if by sedimentation, but the bands are much contorted and frequently disappear entirely. This rock often shows a pronounced jointage which separates the rock into nearly horizontal layers. On the west shore, near the center of the S½ of sec. 1, T. 64-6 W., the rock is in general similar to No. 840, but in places has small amounts of magnetite, as shown by No. 841A. On the north shore of the bay, in S½ SW¼ sec. 1, T. 64-6 W., is an outcrop of a medium grained yellowish rock (No. 841A) in which biotite flakes are abundant. In section this rock is seen to be largely composed of biotite, feldspar and quartz. The quartz incloses poikilitically the feldspar, which, in considerable part at least, is plagioclase. This rock is regarded as belonging to the Keewatin rocks metamorphosed by the gabbro. At the west end of this bay rather coarse grained, biotitic gabbro (No. 841) occurs. On going northwest from the northwest side of this bay, for half a mile rock similar to No. 840 is seen. It is uniformly fine grained and shows little evidence of sedimentary bandings. The south shores of this bay and the shores of the bay in the N½ N½ of sec. 12, T. 64-6W., are made of the usual coarse gabbro. The same rock is also seen on the portage, which starts from the southeast corner of the last mentioned bay, and on the northeast corner of the small lake, elongated in an east and west direction, in the S½ N½ of the same section.

At the end of the point on the north side of this bay is the us-

*It is only just to state that all the geologists who have published anything concerning the belt of rock here called ferruginous quartzyte do not agree with the above statement as to its age and origin. It is evident from the writings of Dr. W. S. Bayley that he considers it as a part of the gabbro. Prof. N. H. Winchell, who has until lately regarded it as Animikie, now considers that this rock represents a metamorphosed condition of Keewatin sediments. Messrs. H. V. Winchell and A. H. Elftman agree with the writer in regarding this rock as a metamorphosed condition of the iron-bearing member of the Animikie.

†This lake lies mainly near the S. W. corner of T. 65-5 W., and extends into the adjoining townships. Notes upon the geology of Gabimichigama lake may be found in the 10th Ann. Rept., p. 98; 15th Ann. Rept., pp. 167-172, 378-381; 16th Ann. Rept., pp. 89-95; 17th Ann. Rept., pp. 110-111; 21st Ann. Rept., p. 159; 24th Ann. Rept., p. 104.

ual gabbro, but on the north side of thic point, near its end, the gabbro is cut by a dike 16 feet wide. This dike dips 80° towards S. 50° W.; both sides are exposed. The rock from the center of the dike is a medium grained, somewhat altered diabase (No. 842), while the edges of the dike are very fine grained (No. 842A). The usual gabbro extends, along the south shore, from this dike eastward to the end of the bay in SE¼ SE¼ sec. 1, T. 64-6 W. On the north side of this bay is a rather fine grained, gray to yellowish, granular rock (No. 843), which is lithologically a gabbro. It contains a few, not prominent, porphyritic plagioclases. Just northwest of this the ferruginous quartzyte appears; it dips 40° towards NNE. Farther northwest along the shore is more of this rock and here it is in places represented by No. 844 (SW¼ SE¼ sec. 1), a peculiar, rather fine grained, dark yellowish gray rock, similar to No. 882, which see. At the extreme western end of the blunt point in SE¼ sec. 1 is an outcrop of coarse gabbro, and just to the north is more of the ferruginous quartzyte. The two rocks were seen within five feet of each other and here the gabbro is a little finer grained. On the north side of this point and in NE¼ SE¼ sec. 1, T. 64-6 W., is some white to yellowish, granular rock (Nos. 845 and 845A), which seems to be composed of feldspar and quartz, with some biotite. On weathering some indistinct boulder-like forms, up to those a foot in diameter, nearly like the rock itself, are seen. There are two sets of joint planes in this rock, dipping respectively about 75° towards the north and 30° towards the south. On searching along the shore just to the southwest a contact between this rock and the ferruginous quartzyte was found. The contact plane is about vertical and the quartzyte strikes nearly N. and S. Between the two rocks is a layer, an inch or two in thickness, of decayed rock, and the two rocks seem quite distinct from each other, the quartzyte being easily distinguished by its coarser grain, banding and presence of much magnetite. The exact meaning of this contact cannot be stated with certainty, but in the mapping Nos. 845 and 845A have been considered as Keewatin rocks, which are overlain unconformably by the ferruginous quartzyte (iron-bearing member of the Animikie), and both have been completely crystallized by the gabbro.

A short distance northeast of this the quartzyte is seen again, here forming a noticeable westward facing cliff. Here the dip is about 20° towards the E. No. 846 is a sample of the quartzyte from this locality. This quartzyte extends eastward to the west side of the bay near the center of the west side of sec. 6, T. 64-5 W. On the east side of this bay a fine grained diabase dike, 5 feet wide, cuts the gabbro. This dike stands vertical and strikes N. E., appearing again on the east side of the point which makes the east shore of this bay. On the end of this point is more fine grained diabase,—evidently part of a dike, but the dike walls were not seen. The gabbro continues eastward and northward, along the shore, in sec. 6, T. 64-5 W. Here on the south shore it is frequently much decayed and crumbling into rusty soil. On the north line of secs. 5 and 6, T. 64-5 W., between Gabimichigama and Clothespin (Peter) lake no rock but the usual coarse gabbro was seen, and the same is true along the north half of the west side of sec. 5.

The shores of the island in the NW¼ sec. 6, T. 64-5 W., are of coarse gabbro, except for the southern shore which is composed of fine grained, granular, Keewatin rock, not stratified as far as seen. In one place the gabbro was seen within ten feet of this rock, and the former still retained its coarse grain. At the southwest corner of the island is the locality figured several years ago.* The fragments included in the gabbro show no distinct stratification lines. The gabbro is still of coarse grain, even when in small stringers. The included fragments represented by No. 847 (which also well represents this rock all along the southern shore of this island), are of various shapes and sizes and many have rounded outlines.†

The island at the northeast corner of the NW¼ NE¼ sec. 6, T. 64–5 W., is made largely of the yellowish Keewatin rock which shows much twisted and broken sedimentary bands. In places boulder-like forms appear where the rock has weathered. The east end of this island has gabbro and this is cut by a few dikes of medium grained reddish granite (No. 849). These are sometimes two feet in width.

The promontory in the SW¼ SW¼ sec. 32, T. 65–5 W., has gabbro along its west side for a short distance north of the township line, but most of the west side and the north part of the east side is made of the fine grained, yellowish Keewatin rock. This often shows evidence of bedding, but it has been much crumbled. The little island just west of the end of this promontory is of this same rock, which is usually decayed and crumbling. Gabbro occurs on the east side, near the middle of this promontory, and extends eastward along the shore almost to the end of the point in the NE¼ SW¼ sec. 32. In the SE¼

*15th Ann. Rept., p. 172.

†In thin section the rock 847 is seen to exhibit an ophitic relation between the augite and the feldspar.—[N. H. W.]

SW¼ of this section, a short distance southwest of the portage to Clothespin (Peter) lake, the gabbro is cut by a small dike of fine grained diabase. Near here is a green coating on the gabbro already described.* There are also a few veins of gabbro pegmatyte at this place. No. 848 is part of a pyroxene crystal from one of these veins. At the end of the point in NE¼ SW¼ sec. 32, the rusty Keewatin rock appears again. It is here distinctly bedded, standing about vertical and striking N. 80° W. It is cut by a set of joint planes dipping about 15° toward the east. This rock extends along the west shore of this point almost to its base, where the gabbro is again seen.

The north shore in the NE¼ sec. 31, T. 65-5 W., shows slates and graywackes, striking about N. 45° W., and standing vertical.

*Crooked lake* is a narrow lake, trending northeast and southwest, in the SE¼ of sec. 6 and W½ of sec. 5, T. 64-5 W. The shores are of the usual coarse gabbro, often decaying. From the west end of this lake a trail leads southwest to Little Saganaga lake in NW¼ NE¼ sec. 7, and another trail leads north to Gabimichigama lake; the usual gabbro is the only rock seen along these trails.

*Clothespin* (*Peter*) *lake* extends east and west through the S½ of sec. 33, T. 65-5 W., and into secs. 32 and 34. The shores of this lake were examined, as was also the country in several places for short distances both north and south of the lake, and no rock other than the usual gabbro was seen.

*Little Saganaga lake* is the large lake lying mainly in secs. 7, 8, 9, 16, 17 and 18, of T. 64-5 W. Its shores are made of gabbro of the usual kind except for local variations in the relative abundance of the constituent minerals, and there are some areas of much finer grained gabbros.

The shores of the bay in the SW¼ of sec. 5, T. 64-5 W., were examined, as were also the lake shores west and south of this to the extreme southwest corner of the lake; the rock is the usual gabbro, and is of rather medium grain for this rock. In the SE¼ of sec. 12, T. 64-6 W., the gabbro is cut by two fine-grained diabase dikes, each about a foot wide; one of these is nearly horizontal and the other dips 60° towards the northwest. The prominent hill near the center of the S½ of sec. 12, T. 64-6 W., is made of the usual gabbro and a much finer grained, granular rock (No. 850) which seems to be in composition also a gabbro. This latter rock exists in large amount

*16th Ann. Rept., p. 92.

and, in fragments of various sizes, is included in the gabbro which also cuts it in many dike-like forms. These fragments of finer grained rock are commonly sharply marked off from the gabbro proper, but in some places the two rocks seem to blend.

The rest of the shore of little Saganaga lake was examined carefully. The gabbro outcrops nearly continuously along the shore. In sec. 16, T. 64-5 W., and along the whole of the south shore the gabbro is very rich in feldspar and becomes an anorthosyte. No. 851, from SE¼ NE¼ sec. 16, represents this facies of the gabbro which is composed practically entirely of plagioclase. In places branches of 3 to 12 radiating plagioclases (one to one and a half inches long) are seen in a matrix of plagioclase; these forms at times are quite marked on weathered surfaces.

The gabbro of this lake, especially on the south and east shores, is in many places decaying into soil. Sometimes this decay takes place throughout the rock and sometimes boulders are formed. These are of various sizes, from two inches to three feet in diameter, but it is noticeable that in any given decaying bluff the boulders of disintegration are all of nearly the same size. Notwithstanding this decayed condition of the gabbro there are many foreign drift boulders and many rounded, fresh bosses which show glacial striæ. The decay of the gabbro here is often as marked as in the apparently unglaciated region already mentioned,* but at little Saganaga lake the two facts mentioned in the last sentence show that this district is a glaciated one.

Along the east and south shores in secs. 16 and 17, T. 64-5 W., 20 to 30 small dikes of granite were noticed in the gabbro. These run in every direction and frequently branch. Most of them were seen in E½ sec. 16. They vary in width from two inches to four feet, and some of the larger ones were somewhat finer grained at their edges than in the centers. The rock of these dikes is represented by No. 852, a fine-grained, reddish, hornblende granite.

The prominent hill in SE¼ NW¼ sec. 9, T. 64-5 W., is made up of gabbro which is almost wholly composed of plagioclase. The shores of the lake in W½ SE¼, same section, are of this same rock—anorthosyte. On going north from little Saganaga lake, on the west line of this section to its northwest corner, gabbro was seen in several places. At a short distance south

*P. 95.

of this section corner is a hill of the usual gabbro and a fine-grained gabbro (No. 855).

*West of Little Saganaga lake in T. 64–6 W.* On the portage which runs southwest from the southwestern end of Little Saganaga lake (near NE corner of sec. 24, T. 64–6W.) the rock is coarse anorthosyte. Near the northeast end of the portage this rock is cut by a dike of diabase which stands vertical and strikes N. 28° W. The dike is 15 feet wide and was traced for over 200 feet. No. 853 is from the center of this dike; the edges are much finer grained. The shores of the lake in SW¼ sec. 13 and NW¼ sec. 24 were examined, except the south half of the east shore; the rock is anorthosyte. The shores of the lake in S½ sec. 23 and NW¼ sec. 26 were also examined; the rock is anorthosyte. West of the last lake is another, in S½ sec. 22; the shores of this lake are of the usual gabbro,—not anorthosyte, as are also the shores of a small lake probably in SW¼ sec. 21. These two lakes are not shown on the township plat. Gabbro is also seen from the last mentioned lake westward to the lake in S½ sec. 20.* On going northward from this last lake for about a mile, on west lines of secs. 21 and 16, the usual gabbro was seen in many places.

From a pond in SE¼ SW¼ sec. 12, T. 64–6W., a trail leads southwest for about half a mile to a small lake. On this trail the usual gabbro is seen in several places, but on this trail, a few yards from the pond just mentioned, is an exposure of gabbro which contains quartz in small grains evenly disseminated throughout the rock (No. 854). In places the rock becomes quite coarse, as is shown by No. 854A, which seems to be a quartz dioryte. In both Nos. 854 and 854A is some pinkish feldspar.

Magnetic iron ore,—the ferruginous quartzyte of the Animikie—is reported from just south of the north line of sec. 13, and also from the center of sec. 18, T. 64–6W.

*East and West lake*† is an irregular body of water lying in SW¼ sec. 14, SE¼ sec. 15 and NW¼ sec. 23, T. 64–5W. The shores of this lake were examined and found to be of rather coarse gabbro; it is usually composed largely of plagioclase with very little pyroxene, and frequently plagioclase and magnetite are the only minerals, the latter, however, not making more than one-fourth of the rock mass. Four granite dikes, not more than six inches in width, were seen cutting the gabbro.

*For notes on this lake see p. 92.
†See 10th An. Rept., p. 98, rock No. 771.

*Southern part of T. 64–5W.* A stream called Little Saganaga river enters the southwest corner of East and West lake. On following up this stream to the lake, which lies at the northeast corner of sec. 27, gabbro was seen in several places. Near a portage along this stream, probably in NW¼ SW¼ sec. 22, is considerable fine-grained gabbro represented by No. 856. The gabbro along this stream is of coarse grain and in many places is practically all plagioclase. The shores of the lake last mentioned are of gabbro; on the north side, included in the gabbro, is some fine-grained gabbro similar to No. 856. This fine-grained gabbro, which is usually most abundant near the north limit of the great gabbro mass, is here found about five miles south of the northern edge of this mass. Here are also a few small granite dikes. Southward from this lake for about a mile, along the stream, gabbro of very coarse grain is seen, cut in a few places by red granite dikes.

*Secs. 11, 12, 13 and 14, T. 64–5W.* Gabbro was seen in several places along the east shore of the narrow lake (not shown on the township plat) which extends north and south through the center of the northern three-fourths of sec. 14. The shores of Greenwood Island lake (the large lake in sec. 11) were examined; the rock is all gabbro of the usual kind and rather coarse in grain except along the bay in NE¼ SE¼ sec. 11, where the gabbro is of finer grain and shows a somewhat gneissic arrangement of the minerals. This structure, which is only local, dips 30° to 40° towards the south. On going, from the east end of this bay, east to a small lake near the center of sec. 12, and north to a small lake on the east like of sec. 11, gabbro is seen in several outcrops. The shores of the narrow lake on the west side of sec. 13 and those of a smaller lake just west of the center of this section show outcrop of the usual gabbro. On the west shore of this narrow lake some green copper carbonate stains were seen on the gabbro.

*Bashitanaqueb lake** lies mainly in sec. 2, T. 64–5W. Its shores are of the usual gabbro and fine-grained gabbro.

On the point, on the north shore of this lake, in SW¼ NW¼ sec. 2 is the usual gabbro. This extends north along the shore for only a short distance and is seen holding pieces of the fine-grained gabbro or granulitic gabbro, which soon occurs in large amount on the east shore of the bay in W½ NW¼ sec. 2, and also in prominent hills on the north shore of this bay. This rock is split into parallel layers, from an inch to a foot or more

*See also 16th Ann. Rept., p. 89; 21st Ann. Rept., p. 160.

in thickness, which dips 5° to 10° towards the south. The rock weathers rusty and crumbles into soil, the decay proceeding more rapidly along the cracks which separate the different layers, and thus the layers are made more prominent. The rock is of fine grain and where fresh is of yellowish gray or greenish gray color. Nos. 857 and 857A represent the fresh rock on the north side of this bay, and No. 857B shows the rock beginning to decay. Lithologically these rocks are granulitic olivine gabbros. No difference between the different layers was noticed. Going south along the west side of this bay the same granulitic gabbro is seen a few yards back from the shore, but before reaching the point in SW¼ NW¼ sec. 2 the ordinary gabbro again appears. The granulitic gabbro in places shows no sign of the layers mentioned above, but as a rule these are more or less noticeable; they have a constant southerly dip of from 5° to 10°. The usual gabbro continues south and west along the shore, to a small stream which enters Bashitanaqueb lake in NE¼ SE¼ sec. 3.*

The rest of the shores of this lake were examined and the rock was found to be the usual gabbro, except for small amounts of the granulitic gabbro included in the other. The rock of this lake is of a little finer grain than usual and at times the feldspars are in plate-like forms, frequently with their flat sides approximately parallel, thus giving a gneissic structure to the rock. Where this structure is seen it is commonly horizontal, but varies somewhat and rapidly disappears altogether. This gabbro of this lake is rich in olivine, that mineral usually being in excess of the pyroxene. No. 858 represents the rock of this lake; it also shows the plate-like forms of the plagioclases. This number is from the south shore in NE¼ NW¼ sec. 11, T. 64-5W., just east of the outlet. In this section the olivine is seen to be in part later than the feldspar. In the N½ SE¼ sec. 3, in places, small nodular bodies, from one-half to two inches in diameter, are seen in the gabbro. They seem to be aggregations of the basic minerals of the rock. These nodules are not sharply defined from the rest of the rock, and are hardly distinguishable except where the rock is weathered. They are somewhat irregular in shape, but have in general roughly spherical outlines. No. 859 represents the main rock at this place and No. 859A the nodules.

About this lake the gabbro in places presents a layered ap-

*This granulitic gabbro in layers is shown by figs. 5 and 6, plate MM, Vol. IV of the final report.

pearance, the different layers are uniform in composition and are separated from each other simply by a crack. These layers vary somewhat in position, but are more generally nearly horizontal than otherwise.

Along the north line of sec. 3, T. 64-5W., between Bashitanaqueb and Kakigo (Black Trout) lake considerable granulitic gabbro is seen, and also a little of the ordinary gabbro.

In going northeast from Bashitanaqueb lake, from the meander corner of the north line of sec. 2, for about half a mile much granulitic gabbro was seen; but on coming south towards the lake the usual gabbro was found. In one place, near north line of sec. 2, the granulitic gabbro shows the layered appearance and also, in a small area, a banded gneissic structure parallel to these layers. The banded gneissic structure is shown in No. 863, which is a granulitic olivine gabbro with some biotite and abundant magnetite. Sometimes the olivines are of considerable size and hold poikilitically rounded plagioclases.

*Muscovado lake* is situated in the SW¼ sec. 36, T. 65-5W. Its shores are mainly of granulitic gabbro, except its southwestern shore which is of the usual gabbro. The granulitic gabbro shows a more or less distinct layered nature, but the direction of the dip of these layers is not as constant as on Bashitanaqueb lake. On the south shore of Muscovado lake, just east of the portage to Bashitanaqueb lake the granulitic gabbro, as shown by No. 860, is not as fine-grained as usual.

At the southeast corner of Muscovado lake, a few yards back from the water and near the portage, is an exposure of the granulitic gabbro which shows a banded gneissic structure, dipping about 30° towards the south. The rock here is also well represented by No. 863, which is from another locality.*

On going north, from Muscovado lake, on the west line of sec. 36 a prominent ridge, 180 feet above the lake, composed of granulitic gabbro is crossed. A short distance north of the west ¼ post of sec 36 the usual gabbro occurs and continues north to the northwest corner of this section. In places considerable granulitic gabbro is included in the usual gabbro. A short distance north of this section corner, but just south of the stream, is a ridge, trending east and west, of the ferruginous quartzyte; dip 65° towards the south.

*Lake in center of sec. 3, T. 64-5W.* This lake is not shown on the township plat. The shores, except the northeast shore

*See above.

which is of granulitic gabbro, are of the usual gabbro. On the south shore, in NE¼ SW¼ sec. 3, is an outcrop of a medium-grained, dull reddish granite (No. 861). It was not seen in contact with the usual gabbro, but is in sharp contact with a small area of granulitic gabbro; the relative ages of the two rocks are not shown. The hill in the SE¼ NE¼ sec. 3 is made mostly of the usual gabbro, but its western side is of granulitic gabbro.

*Kakigo (Black Trout) lake and northward.* This lake lies in SW¼ sec. 34, T. 65-5W. The western and northern shores are of the usual gabbro, which here and in the vicinity (as at Bashitanaqueb lake) is usually well supplied with olivine. Granulitic gabbro makes the hill at the east end of the lake and extends in general along the south shore. On the north shore in NW¼ SW¼ sec. 35 the gabbro has a pronounced layered structure. The layers average about a foot in thickness and dip 15° towards the south.

On and to the east of the two portages along the stream, just north of Kakigo (Black Trout) lake, the usual gabbro occurs, and the same rock is seen a few rods northwest of the second portage. A little further northwest, on the south side of a little bay (near center of NE¼ sec. 34), the ferruginous quartzyte occurs dipping about 60° towards the south. This rock outcrops along the north side of a narrow ridge, and was traced westward, in a narrow belt about one-fourth mile south of the north line of sec. 34, to within one-eighth mile of the west side of this section. To the north of this ridge is a narrow valley and then a higher east and west ridge composed of greenstone.* In a few places pebble-like forms were seen in this rock. The ferruginous quartzyte rock has gabbro on the south of it. This quartzyte in places along this ridge is very finely banded as is shown by No. 862. This ferruginous quartzyte extends in a narrow belt eastward along the south side of the stream in N½ NW¼ sec. 35. Just to the south of this is the usual gabbro.

*Secs. 21 and 27 to 30, T. 65-4W.* Greenstone is the only rock seen on the west line of sec. 28, north of the stream entering the east end of Akeley lake. The same rock extends northward along the west line of sec. 21 until within about one-fourth mile of the north line of this section where granite occurs and extends north to the section corner. The granite here is of medium grain and has at times a gneissic structure standing

*Compare Nos. 1778, 1780, and 1781 of the rock series of N H. Winchell.

vertical and running east and west. The minerals of this rock here are mostly feldspar and hornblende, or more usually biotite. Along the north line of sec. 28 greenstone occurs. About 100 yards north of this line (in SE¼ SE¼ sec. 21) is an outcrop of distinctly banded rock dipping 75° towards the north. The rock is composed of bands and fine laminæ of magnetite and a fine-grained greenish siliceous rock. The bands and laminæ vary from minuteness to those three inches wide. No. 864 represents the rock as a whole, No. 864A is from one of the greenish bands and No. 864B shows one of the magnetite bands. The rock as a whole is probably one-third magnetite, but none seen is suitable for good ore. This rock is regarded as part of the Animikie strata. More outcrops are described in the following notes. See section CD on the map, figure 4, page 123, also see page 140 for further notes on this magnetic slate.

About fifty yards north of the wagon road and a few rods east of the west line of sec. 27 a pit has been sunk. The rock is greenstone with a thin capping, two or three feet thick, of iron ore (Animikie).

On the north line of sec. 29 west from the northeast corner of the section to a small lake, and also along the north shore of this lake fine-grained greenstone is seen showing a few twisted laminations on the weathered surface. On this section line west of this lake the greenstone is coarser grained. Greenstone also occurs along the north line of sec. 30, and along the east line of this section as far south as the quarter post, a short distance south of which a small amount of the ferruginous quartzyte appears.

*Lakes in sec. 19, T. 65-4 W., and sec. 24, T. 65-5 W.* The shores of the lake in sec. 24 are of massive greenstone, well represented by No. 865 from the south shore of the lake in NE ¼ SE¼ sec. 24,—a fine grained greenstone. In places the rock is crossed by numerous veinlets of chloritic material, and this gives the rock the appearance of a breccia cemented by the chloritic material. In places the rock is coarser grained, as shown by 865A. In the extreme northeast corner of NE¼ SW ¼ sec. 24 a fine grained syenyte porphyry is seen at the base of a hill. Farther up on the hill is greenstone and the two rocks were seen in contact, the porphyry (No. 866) being apparently finer grained here (No. 866A), and the greenstone coarser grained (No. 865A). A small amount of this same porphyry was seen at the northwest corner of this lake. On the east line of sec. 24, north of this lake, greenstone occurs to and beyond the northeast corner of this section, but less than an eighth of a mile north of this corner granite is seen. It is of medium grain, is composed of feldspar, quartz and chlorite, and is not usually gneissic.

The lake in S½ NW¼ sec. 19 has its shores of greenstone, usually of coarser grain than shown by No. 865. Just north of the west end of this lake a small amount of the porphyry similar to No. 866 was seen.

Greenstone occurs on the lake in S½ sec. 19 and along a portage leading north from this lake to a pond on the north line of this section. At the southeast end of this pond granite occurs. It is rather fine grained and composed of feldspar, quartz, chlorite and biotite. In places it is gneissic, but not decidedly so; this structure runs east-southeast, and when this structure is present the dark mineral is usually biotite. A few lenticular pieces of greenstone were seen in the granite, their long axes running with the gneissic structure.

*Paulson lake** lies largely in S½ S½ sec. 25, T. 65-5 W. Along the north shore the rock is greenstone, except for the most westerly outcrop (SE¼ SW¼ sec. 25) which is of the ferruginous quartzyte; just to the north of this outcrop is greenstone. Several sections were made from this lake to the lake just to the north (i. e. in N½ S½ sec. 25); the only rock seen was greenstone, which also occurs about the shores of this last lake.

Along the south shore of Paulson lake gabbro occurs and this same rock appears at the end of the point between the two western bays of the lake. At the southeast end of the lake is the ferruginous quartzyte,† just to the south of which is gabbro.

On the portage going northeast to Bingoshick lake is green-

*In 1887 names were given to some small lakes in the western part of T. 65-4 W., whose locations were not accurately known. It has been necessary to make corrections in these names and locations, but the names first used (1887, 16th Ann. Rept.) are retained for the lakes to which they were applied, and the locations are corrected. The corrected names and locations are as follows:

*Akeley (or Chub) lake;* center of sec. 29, T. 65-4W.

*Charley lake;* an irregular lake lying in the northern and central parts of sec. 32, T. 65-4W.

*Gaiter lake;* northwestern part of sec. 32, T. 65-4W.

*Flying Cloud lake;* a small lake lying mostly in NE¼ NW¼ sec. 31, T. 65-4W; sometimes called Gaiter lake.

*Bingoshick lake;* this lake lies mostly in N½ S½ sec. 30, T. 65-4W., and extends westward into sec. 25, T. 65-5W.; sometimes called Paulson lake.

*Paulson lake;* S½ S½ sec. 25, T. 65-5W.; in the 17th Ann. Rept. and in the 21st Ann. Rept., (p. 159) called Flying Cloud lake.

For brief descriptions of the rocks of this lake see also 17th Ann. Rept., p. 185, and 21st Ann. Rept., p. 159.

†17th Ann. Rept., p. 185.

stone (No. 867) which varies considerable in grain and sometimes carries biotite.

*Sec. 30, T. 65-4 W.* The two lakes in this section—Bingoshick lake (N½ S½) and the lake in S½ N½—have there shores of greenstone which varies considerably. No. 868, from the north shore of the former lake, in NW¼ SW¼ sec. 30, is a medium grained rock representing the prevalent phase of the greenstone. No. 869 from the south shore of the latter lake, at the portage, is coarse-grained and contains more feldspathic material than is common. No. 870 is from the south shore, near the east end, of the same lake; it is coarse-grained and splits into sheets that dip about 35° towards the south.

Along the stream which enters the east end of Bingoshick lake the ferruginous quartzyte occurs, dipping a little east of south at an angle of about 45°. On the south side of this stream and about 100 feet west of the west end of the portage (in NE¼ SE¼ sec. 30) is a bluff of the quartzyte rising some fifty feet above the stream. In this rock is a sill of gabbro-like rock about thirty feet in thickness, dipping with the quartzyte. The rock of the sill is decidedly finer grained at the lower contact and also towards the upper contact. The lower contact was seen in several places. The quartzyte does not seem to be changed at the contact. No. 871 represents the usual rock of the sill.* No. 871A is the same, finer grained, eighteen inches from the lower contact and No. 871B is still finer grained and was taken within two inches of this contact. If this sill is part of the great gabbro mass, and it appears very similar to the gabbro, then the evidence points to the fact that the ferruginous quartzyte is not, as has been claimed by some, a part of the gabbro.

On the east shore of Flying Cloud lake, at the south line of sec. 30, is an exposure of a gray biotitic rock (No. 872). It weathers brownish and splits into distinct layers which dip 30° towards the southeast. In this rock are a number of oval pieces, a foot or so long, of fine grained laminated rock which resembles the fine grained granulitic gabbros of the vicinity. In the hill above this outcrop is gabbro, but the relations of the two rocks were not seen.

Between Flying Cloud and Bingoshik lake a belt of the ferruginous quartzyte is crossed and in this is a sill of gabbro-like rock (similar to No. 871), about twenty-five feet in thickness.

*No. 871G is a coarse granulitic biotite gabbro with diallage, hypersthene and olivine, the last two embracing the other minerals. No. 871bG is a granulitic gabbro. [N. H. W.]

This may be the same sill as that described above (Nos. 871 to 871B). Compare Nos. 1343 and 1344.

*Akeley (Chub) lake* is in sec. 29, T. 65-4 W.

Just west of Akeley lake the gabbro, as it approaches the ferruginous quartzyte, becomes noticeably finer grained, as is shown by No. 873, which was taken within 100 feet of the quartzyte in W½ NW¼ SW¼ sec. 29. No. 884, from within eight inches of the contact between the main gabbro mass and the quartzyte (just east of Akeley lake in SE¼ NE¼ sec. 29) also shows the fine-grained character assumed by the gabbro in places at its northern edge. But this markedly finer grain is not always seen, although the rock at and within a few feet of the contact is commonly not so coarse as at the distance of a few rods.

Rather fine-grained gabbro occurs on the three islands in the northern part of Akeley lake, also coarser gabbro on the island in the southern bay of this lake.

On the north slope of the ridge adjacent to the north shore of the lake a sill of gabbro-like rock is seen in the ferruginous quartzyte, which here dips southward as usual. The sill is twelve feet in thickness. Both the top and the bottom contacts were seen, and at each the rock is noticeably finer grained than in the center of the sill. The rock of the sill is porphyritic with plagioclases, but the porphyritic character is confined largely to the upper one-third of the sill. The phenocrysts appear nearly black, are commonly half an inch in length but sometimes an inch and a half, and are somewhat tabular, the large faces being usually parallel with the sides of the sill. No. 874 shows this sill rock, or rather the porphyritic phase of it; No. 874A is from the top of the sill and No. 874B is from within an inch of the bottom of the sill. No. 874C is the ferruginous quartzyte just below the sill. The former rock does not seem to have been changed at the contact.*

No. 875 is the greenstone from just north of the pit (on north shore of Akeley lake) which goes through the quartzyte into the drift.†

*Sec. 28, T. 65-4 W.* At the headquarters of the Gunflint Lake Iron company near the west side of the small lake in sec. 28, T. 65-4 W., in sinking a well gabbro was struck and also a graphitic rock (No. 876) in contact with the gabbro. The former is peculiar in containing scales of biotite and graphite in a

*This sill is the same as that described in the 16th Ann. Rept., p. 85. Rock No. 1341.

†Ibid., p. 84.

fine-grained feldspathic matrix. At the contact the two rocks are somewhat decayed and the graphitic rock is quite soft (No. 876A) and easily cut with a knife. The origin of this graphitic rock at this place is not absolutely certain, but it is very probably a part of the black slate member of the Animikie, which is often quite carbonaceous, included in and recrystallized by the gabbro.

The sill of gabbro, in the quartzyte, which appears at the east side of Akeley lake, runs eastward and a short distance east of the west line of sec. 28 exposures show that this sill is not more than sixty feet nor less than thirty-five feet in thickness. At the east end of the little lake in SW¼ NE¼ of sec. 28, and to the eastward this gabbro sill is much thicker than towards the west; it is here at least 150 feet, and probably more, in thickness. In one place it is porphyritic similar to the sill north of Akeley lake (No. 874, page 138. This large gabbro sill in its coarser grained parts cannot be distinguished in hand samples from the main gabbro mass just to the south. The sides of this sill are noticeably finer grained than its center. No. 883, from the east line of sec. 28, represents the coarser parts of the sill.

A smaller sill, ten feet in thickness, occurs in the quartzyte near the east side of SE¼ NW¼ sec. 28. It is of gabbro-like rock similar to that just mentioned (No. 874), but it is not porphyritic. These two exposures (i. e. here and north of Akeley lake) quite probably represent one sill. Another similar exposure, in the same strike, is seen in SE¼ NE¼ sec. 28, near the south shore of the pond, and another at the east line of the section where the sill is only four feet in thickness.

The north line of the quartzyte in this section usually runs along the foot of the greenstone ridge, but in some cases rises up a short distance on the south slope of this ridge. This is the case near the center of N½ sec. 28 where some stripping has been done. Here the quartzyte lies on the greenstone and dips south at an angle of 50°. A thickness of about four feet of good ore was taken out here and then a diamond drill was run in at right angles to the dip. The drill is reported to have passes through fifteen feet of mixed ore, and then into the underlying greenstone. No. 880 represents the general character of the rock at this stripping.

At the bottom of a test pit near the east side of SW¼ NE¼ sec. 28 the quartzyte is represented by No. 882, a rock which contains much biotite and which in thin section shows beautifully pleochroic hypersthene.

The general dip of the quartzyte in sec. 28 is about 50° towards the south, varying somewhat, and in one place—at a test pit in NW¼ SE¼ NE¼ sec. 28,—there is some local crumpling of the beds. The dip becomes less towards the east end of the section.

The south shore of the lake in SW¼ NE¼ sec. 28 is of course olivine gabbro (No. 885), and here in one place the rock is a forellenstein (No. 884A).

*Secs. 21, 22 and 27, T. 65-4 W.* In the south half of sec. 21 there is a belt of magnetic slates running east and west. (See No. 864, p. 135). These slates exist in a ridge which rises nearly as high as the greenstone ridges which lie both to the north and to the south. The ridge of slate becomes lower towards the east, and toward the west no trace of it was seen beyond the pond which is near the center of SW¼ sec. 21. In crossing this section from south to north, a little west of the center of the section, one passes from a greenstone ridge to a valley and then onto another ridge composed of magnetic slates; beyond this is another valley, then a ridge of greenstone and finally granite. On the south side of the ridge of magnetic slate just mentioned (see fig. in the chapter on the Akeley Lake plate in volume 4 of the final report) the dip is toward the north 60° to 70°, on the north side near the top the beds are nearly flat, and on the north side near the foot of the ridge the dip is 15° to 20° towards the south. Here can be seen the actual junction between the slates and the underlying greenstone. The contact line, while being rather distinct, is not straight, the slates fitting down into small depressions in the greenstone surface, and the lower bed of the slate sometimes extending in vein-like forms for five or six inches into the underlying rock. No fragments of greenstone were seen in the slate. The lower layer of the slate, which is from two to six inches in thickness and gradually passes into the layer above, is of fine grain and dark gray when fresh but when weathered it is whitish and resembles some of the white bands in the jaspilyte which is so common on the Vermilion iron range; it is thus quite distinct from the greenstone (No. 878) underlying. No. 877 represents the lowest bed of the slates. No. 879 shows the magnetic slate. The author's interpretation of the geological structure at this place and to the southward is shown in section CD in figure 1, page 123. The rocks of the synclinal ridge just described are regarded as the equivalents of the ferruginous quartzytes in sec. 28, the former having suffered some but not extreme metamorphism while the latter have been profoundly metamorphosed by the gabbro.

On going north from the south quarter post of sec. 22 the greenstone is seen for about 100 yards, then the magnetic slates occur striking about 15° south of east and dipping from 70° to 90° to the north of this. Here a few bands, less than one inch wide, in the slates are rich in small red garnets (No. 888). A little farther north the slates again occur, somewhat crumpled, but dipping toward the north in general. At the next exposure the slates dip about 10° towards the south, and beyond this (to the north) are several other exposures of the slates with the same southerly dip. These continue for about one-fourth mile from the above quarter post. Beyond this is a swamp with no exposures and just south of the center of the section the granite is seen. This rock continues northward to and beyond the north line of the section. The granite where first seen is of medium fine grain and is gneissic in many places; this passes into the massive granite near the section line.

About 100 yards south of the northeast corner of sec. 22 a diabase dike cuts the granite. The dike (No. 899 strikes about northwest and is markedly finer grained (No. 889A) near the contact. A little more than one-eighth of a mile south of this section corner the magnetic slates of the Animikie occur. Here they are quite rich in magnetite forming iron ore, the ore lying above some greenish quartzyte No. 890). In this vicinity and to the southward are a number of small pits and strippings. One of these pits (a few yards east of the east quarter post of sec. 22) passes through the ore into what is called greenstone by the explorers, but which is one of the greenish quartzyte beds of the Animikie similar to No. 890. The general dip of the slates in this vicinity is 10° to 15° towards the south. About a quarter of a mile south of the above quarter post is a northward facing cliff of the slates crossed by a sill of porphyritic diabase (No. 891). There is some crumpling of the slates near the top of the cliff. No. 892 represents a gray taconyte from the slate at this place.

In the vicinity of the southeast corner of sec. 22 and just to the east there are some sharp crumplings in the slates, in one place the dip being toward the north 50° to 60°. And on the wagon road in SE¼ SE¼ sec. 22 are several small folds in the slates, the axes of the folds running northeast and southwest.

The top of the hill here is made of a diabase sill (No. 886), and about ten feet below this main sill is a smaller one six feet in thickness. The main sill is in places porphyritic with plagioclases. The small sill is finer grained both at the top and the bottom, and the larger sill is at the bottom, the top not being seen.

On Cross river near the south line of sec. 27 gabbro occurs. About 100 yards south of this line the gabbro is cut by a diabase dike (No. 893) which is thirty feet wide and runs about north and south. On this line east of the river gabbro is seen in a few places and also in a ridge about a quarter of a mile north of the southeast corner of this section. Less than an eighth of a mile north of the east quarter post of sec. 27, the magnetic slates occur and continue northward; the dip is 10° to 20° towards the south.

The ferruginous quartzyte which runs through secs. 29 and 28, T. 65-4 W. extends into sec. 27 and is seen in several places in the NW¼ of this section. It can be traced eastward into the N½ SW¼ NE¼ sec. 27 beyond which is a swamp. In this vicinity the dip of the ferruginous quartzyte is much lower than to the west (secs. 28 and 29) and averages from 10° to 20° towards the south. Many of the bands in the quartzyte here resemble the bands in the Animikie slates (iron-bearing member) which occur within half a mile to the east, northeast and north.

## Field Work of 1893.

During July the writer accompanied the state geologist on a trip along the north shore of lake Superior from Grand Marais eastward to the end of Pigeon point, and also on a trip northward from Grand Marais through Devil Track, Little Trout, North Brule, Winchell, Brule, Ida Bell and Kiskadima lakes to the workings of the Gunflint Lake Iron company in T. 65-4 W. The notes for these trips were taken by the state geologist. During part of August the writer attended the excursion of the Geological Society of America through the iron regions on the south of lake Superior, During the latter part of August, September and the first part of October he examined the region about Gunflint lake, especially in T. 65-2, 65-3, 65-4, 64-3 and 64-4 W. And in October a few days were spent at Tower, in company with Messrs. N. H. and H. V. Winchell.

In July and August a party under the charge of Dr. C. P. Berkey, working in co-operation with the writer, did a large amount of topographic work in Cook county. This work was based on a series of levels run from Grand Marais northward to the international boundary, the leveling being done by Messrs. L. A. Ogaard and A. N. Winchell.* After the disbanding of this topographical party Mr. L. A. Ogaard assisted the writer.

*T. 65-4 W.*

At the Y of the Port Arthur, Duluth and Western R. R. in SE ¼ sec. 26 the usual coarse-grained gabbro occurs, but just to the north and northwest of this are several cuts in a finer grained gabbro (No. 896) which, however, does not seem to be separable from the usual coarse rock. Cutting both these facies of gabbro in dike-like forms, from one-half inch to one foot in thickness, is a coarse white pegamatyte (No. 897),† composed essentially of white to greenish feldspar, quartz and biotite. The feldspar and quartz are intergrown to form graphic granite.

Along the railroad to the northwest of the above locality, near center of sec. 27, are several cuts in the gabbro and at one of these this rock is seen in contact with some mass, whose extent is not known, of slates. The gabbro is in general some finer grained near the slates, as is shown by No. 898 taken within two inches of the contact. No. 899 is the usual gabbro with large plagioclases two feet from the contact. The slates, which are lithologically like the black slate member of the Animikie, have been recrystallized and consist essentially of a fine-grained aggregate of quartz, graphite and biotite,—Nos. 900 and 901.

On the south side of the railroad track, west of the above locality but still in sec. 27, a dike of black diabase cuts the gabbro. This dike is eight to ten inches in width and is quite fine grained, the edges being almost or quite glassy. No. 902 shows one edge and about half the width of the dike.

At the west end of the railroad track (in NW¼ sec. 28) are several small dikes of similar diabase in the greenstone. These dikes are from one-fourth inch to two inches in thickness. They stand about vertical and strike nearly east and west, i. e. have the same general direction as the dike mentioned in the last paragraph. These small dikes (No. 903) have a marked basaltic jointage at right angles to their walls.

At a number of places in secs. 28 and 29 the ferruginous

*See report of C. P. BERKEY, 22nd Ann. Rept., pp. 134-140.

*Same as No. 1891, to be described in Vol. V of Fin. Rept.

quartzyte contains seams of hisingerite. Some of these from the shaft on the north side of Akeley lake are shown by No. 904. In some places also some graphite bearing layers occur in this quartzyte, as shown by No. 905 from the main shaft of Gunflint Lake Iron Co., SE¼ NE¼ sec. 28.

On the south line of sec. 23, from 300 to 500 steps east of the southwest corner of this section, the upper contact of the trap sill is exposed. It is distinctly finer grained at the contact and holds fragments of the overlying Animikie slates.

A short distance south of this the slates are bent into an anticline where the strata dip 10° towards the south and 10° towards the north. As exposed this anticline is about 150 feet across.

NOTE.

Time does not permit of the completion of these descriptions. It may be stated, however, that most of the writer's field work in 1893 dealt with the geographical extent of the different formations in the Akeley lake and Gunflint lake plates, and the information obtained is to a large degree presented on these plates and their accompanying chapters, (plates 81 and 82 of volume IV of the final report). For a few days in October the writer was with N. H. and H. V. Winchell in the vicinity of Tower. The notes for this trip were taken by the state geologist.

In 1894 a trip was made to the Rainy lake gold district. The notes made on this trip are largely used in the chapter on the north part of St. Louis county and in the appendix to the chapter on Itasca county in volume IV of the final report.

In 1896, 1897 and 1898 brief excursions were made in company with the state geologist to several points of interest in northeastern Minnesota, and notes on these trips are published by Prof. Winchell in this volume of the annual reports or in the chapters of volume IV of the final report. For a few weeks in the fall of 1898 the Mesabi iron range was visited. Some of the observations made are incorporated in the chapters and maps of the Mesabi range (in St. Louis county) in volume IV of the final report.

## *LIST OF ROCK SAMPLES COLLECTED IN NORTHEASTERN MINNESOTA IN 1898, BY U. S. GRANT.*

The present list is a continuation of lists found in: (1) the 17th Ann. Rept., pp. 201–215; (2) the 20th Ann. Rept., pp. 96–110; (3) the 21st Ann. Rept., pp. 59–67; (4) the 22nd Ann. Rept., pp. 78–86; (5) the 23rd Ann. Rept., pp. 220–223. Most of these rock samples have not been carefully studied in the laboratory, and so the names are to be regarded as sometimes only approximately correct. The specimens in this series are numbered in green and can thus be distinguished from those of any other series of the survey or museum. The specimens listed below, except the first two, were collected on the Mesabi iron range in the fall of 1898 while the writer was engaged in work jointly for the survey and the Duluth, Mesabi and Northern railway.

1068. Quartz porphyry. 10 steps W. and about 736 steps N. of the SE corner of sec. 8, T. 63–9 W. Within four feet of a greenstone conglomerate which lies just to the south of an east and west belt of quartz porphyry.

1069. Quartz porphyry. About 20 steps north of No. 1068. From near the center of the same belt of quartz porphyry.

1070. Green quartzyte (Animikie) from the dump of a test pit 760 steps N. and 685 steps W. of E¼ post sec. 13, T. 58–17 W. Near the Elba mine.

1071. Quartzose conglomerate, presumably from near the base of the Animikie. From the dump of a test pit 425 steps N. and 275 steps E. of W. ¼ post sec. 8, T. 58–16 W. Northeast of McKinley.

1072. Greenish graywacke from the same place as No. 1071. This is supposed to be part of the Keewatin here underlying the Animikie, but it may possibly be a part of the quartzyte horizon of the Animikie.

1073. Graywacke or fine-grained, gray quartzyte. From the dump of a test pit 200 steps N. and 940 steps E. of W. ¼ post sec. 34, T. 59–18, north of Mountain Iron.

1074. Similar to 1073, but with streaks of lighter color. Same place.

1075. Fissile gray shale with silvery micaceous flakes. Same place.

1076. Similar to 1075, but darker colored. Same place.

1077. Fine-grained, green quartzyte. Same place.

1078. Rather coarse-grained quartzyte. From the dump of a test pit 35 steps S. and 10 steps W. of the N. E. corner sec. 4, T. 58–18 W. Just N. W. of Mountain Iron mine.

1079. Graywacke or fine-grained, gray quartzyte. From the dump of a test pit 5 steps N. and 10 steps W. of S. E. corner sec. 35, T. 59–18 W. Near same place as No. 1078.

1080. Pinkish quartzyte with some soft white material between the quartz grains. From the dump of a test pit 10 steps S. and 10 steps E. of the N. W. corner sec. 10, T. 58–17 W. Northeast of Virginia.

1081. Red ferruginous quartzyte. Same place.

1082. Fine-grained gray quartzyte or graywacke. From the dump of a test pit 500 steps N. and 240 steps E. of S. W. corner sec. 3, T. 58–17 W. Northeast of Virginia.

1083. Similar to the last, but laminated. Same place.

1084. Pinkish to gray, siliceous schist. Same place.

1085. Similar to the last but darker in color. Same place.

1086. Quartzyte cemented by an abundance of hematite. From the dump of a test pit 505 steps N. and 390 steps E. of S. W. corner sec. 3, T. 58–17 W.

1087. Green, flinty taconyte. From the dump of a test pit just S. of Virginia and a few yards W. of the D. M. and N. R. R. Perhaps in SE¼ of SE¼ sec. 8, T. 58–17 W.

1088. Black, apparently carbonaceous slate. Same place.

1089. Interbanded black slate and a micaceous rock which contains many small carbonate crystals—probably both calcium and iron carbonate. Same place.

1090. More of this carbonate rock. Same place.

1091. Greenstone matrix of conglomerate. From a cut on the D. and I. R. R. R. east of Virginia and about one mile east of Mariska station,—the most easterly rock cut in this locality.

1092. Part of the same conglomerate, showing small pebbles. Same place.

1093. Quartz porphyry, considerably altered. Just S. of the R. R. track and about 150 paces W. of the cut mentioned under No. 1091.

1094. Dark gray clay slate. From the central cut on the D. & I. R. R. R. east of Mariska station.

1095. Graywacke with fragments of slate. Same place.

1096. Porphyry from first cut east of Mariska station.

1097. Graywacke (?). Same place.

1098. Contact of quartzyte and taconyte. From a boulder, evidently not far from its parent ledge; 1200 steps E. and 240 steps S. of N. W. corner sec. 2, T. 58–16 W. East of Biwabik.

1099. Quartzyte. From the dump of a pit 165 steps N. and 600 steps E. of S. W. corner sec. 4, T. 58–16 W. West of Biwabik.

# III

## *PRELIMINARY REPORT OF FIELD WORK DURING THE SUMMER OF 1895.**

By Arthur H. Elftman.

During the summer of 1895 the writer spent part of August and September in field work in the northeastern part of Minnesota. The party left Ely and followed the canoe route along the International boundary to Rose lake; thence southward to Grand Marais, and westward up the north shore of lake Superior to Two Harbors. The object of the trip was to study chiefly the anorthosytes and their associated rocks. Accordingly the principal outcrops of these rocks were visited.

### The Anorthosytes.

At Carlton peak nothing was found which will interfere with the writer's opinion previously expressed concerning these rocks, *i. e.*, "the anorthosyte occurs *only as included masses in the diabase*."† The upper part of the peak is made up of massive anorthosyte. Below this is found the dark, fine grained and compact diabase which occurs extensively in the region north of Beaver Bay, and which is usually associated with the anorthosyte. Between the main ridge of Carlton peak and lake Superior are a number of low ridges of volcanic flows, dipping toward the lake. The conclusion drawn from observations made at Carlton peak is that the base of the peak consists of the diabase occurring extensively in the region west and north of this locality; the anorthosyte forms only a cap upon the diabase, and its present position dates back to the time of the formation of the diabase.

North of Beaver Bay several extensive outcrops of anorthosyte have been exposed by fire. Numerous contacts with the black diabase occur here. In some places the diabase varies from a medium grained rock, at some distance from the anorthosyte, to a very fine grained rock at the contact. A microscopical examination shows the gradation of the different tex-

*The field work of Mr. Elftman was only in part for the survey, directly, but preliminary to the thesis required for the degree of Ph. D., and has not yet been published nor reported in full.—[N. H. W.]

†Geol. and Nat Hist. Survey of Minn., 22d Ann. Rept., p. 178, 1894.

tures of the rock, from a medium to a very fine holocrystalline mass.

At both of the above localities specimens of anorthosyte were found which show a metasomatic change from the plagioclase to a radial and compact zeolite. The characters of the zeolite show that it is probably thomsonite. The investigation of this mineral is at the present time not sufficiently advanced to admit of further discussion.

THE DRIFT.

In the valley extending several miles west of Gunflint lake were found a number of morainic hills. Dr. U. S. Grant informs the writer that these extend a short distance to the southwest. Considerable drift occurs along the north shore of Gunflint lake and eastward along North lake. This drift is probably the eastern extension of the Vermilion (12th) moraine in Minnesota.*

For several miles south of Hungry Jack lake the county road to Grand Marais passes through a belt of morainic drift. The knolls vary in hight from quite low to one hundred feet high. This belt is probably a part of the Mesabi moraine, which appears again west of Pigeon point.

*Warren Upham. Geol. and Nat. Hist. Surv. of Minn., 22d Ann. Rept., p. 51, 1894

## *LIST OF ROCK SAMPLES COLLECTED IN NORTHEASTERN MINNESOTA IN 1895, 1896 AND 1897.**

*BY A. H. ELFTMAN.*

The present list is a continuation of that found in the 22nd Ann. Rept., pp. 181-189. Many of these rock samples have not been carefully studied in the laboratory, and so the names are to be regarded as sometimes only approximately correct. The specimens in this series are numbered in white and after each number is the letter E; these specimens can thus be distinguished from those of any other series of the survey or museum.

The results of the investigations begun in 1893, and continued with interruptions until 1898, deal more or less directly with the rock samples in this and in the preceding list mentioned above. These results have been published in part as follows:

Preliminary report of field work during 1893 in northeastern Minnesota. 22nd Ann. Rept., pp. 141-180, pls. 5-6, 1894.

Notes upon the bedded and banded structures of the gabbro and upon an area of troctolyte. 23rd Ann. Rept., pp. 224-230, 1895.

The geology of the Keweenawan area in northeastern Minnesota. Amer. Geol., vol. xxi, pp. 90-109, pl. 11, Feb., 1898; vol. xxi, pp. 175-188, Mch., 1898; vol. xxii, pp. 131-149, Sept., 1898.

The rock samples here listed were collected in Lake and Cook counties and the vast majority of them represent rocks of Keweenawan age. As the samples were collected at several isolated and disconnected localities, the following contents is given to facilitate easy reference to samples from any given locality.



*This list was prepared from Dr. Elftman's notes and specimens by Dr. U. S. Grant.

*Saganaga lake.*

289. Recomposed granite. Portage between Oak and Saganaga lakes, NE¼ sec. 24, T. 66–6 W.

290. White vein quartz in No. 289. This quartz occurs in lens-like segregations and in fissure veins up to several feet in width. It contains considerable pyrite. An assay showed no gold nor silver.

*Basswood lake.*

291. Gneissoid hornblende granite. Island in Merriam bay, Canadian shore of Basswood lake.

*Grand Marais and Rove lake road.*

292. Hornblende pinkish gabbro. On the road north of North Brule river; perhaps in sec. 29 or sec. 30, T. 64–1 E. The gabbro in places has a marked banded structure and is highly olivinitic.

293. Hornblende pinkish gabbro. South of No. 292. The rock seems to contain a considerable proportion of granitic material which weathers red. The fresh rock has the appearance of the ordinary gabbro.

294. Augite syenyte. Perhaps in sec. 33, T. 63–1 E. This rock occurs frequently on the road from Brule river south to the valley which lies south of Pine mountains and composes the entire plateau between these two places.

295. Diabase. From the south side of the base of Pine mountain; probably SW¼ sec. 34, T. 63–1 E., or NW¼ sec. 3, T. 62–1 E. This rock is in abrupt contact with No. 294.

296. Quartz porphyry. Four and a half miles north of Grand Marais in a recent cut on the road. The rock is considerably fractured and many pieces are covered with secondary deposits of silica. No. 296 shows the compact fine-grained part of the rock.

297. Quartz porphyry, a porous facies of the above.

298. Quartz porphyry, a facies of the above with secondary silica.

299. Quartz porphyry, an altered phase of the above.

*Grand Marais and vicinity.*

300. Diabase. Back of Mayhew's dock on the outside of the "harbor rock," i. e. the rock forming the narrow, east and west running reef at the southeast of Grand Marais bay. This specimen shows the weathered and unweathered facies of the rock.

301. Diabase. Near the west end of the point on which is the light house.

302. Diabase. From near the center of the harbor rock. This is probably as fresh a specimen as can be obtained. One side of the specimen shows the wall of a fissure in which are radiating mineral clusters.

303. Diabase, weathered and reddened. East of Grand Marais, near center of sec. 21, T. 61-1 E.

304. Diabase, black. Same place.

305. Diabase, black. Same place.

306. Diabase, reddish. Same place.

307. Diabase, with amygdaloidal cavities filled by a radiating white zeolite. Same place.

308. Decayed diabase, with zeolite and secondary quartz. Same place.

309. Diabase, with small amygdules of a white, radiating zeolite.

310. Diabase, altered. Same place. At the east end of this exposure (Nos. 302–310) the black rock (diabase) is in contact with quartz porphyry which it cuts. The black diabase becomes finer grained and is considerably broken up and has incorporated some of the acid material. Nos. 311-314 represent these contact rocks.

311. Fine grained red rock. A short distance east of Nos. 302-310.

312. Similar to No. 311, but of a dark brown color. Same place.

313. Fine grained gray rock, blotched with red. Same place.

314. Diabase, in part reddened. Same place.

315. Diabase, yellowish. Nos. 315-320 were collected at or near the lake shore in NE¼ sec. 21, T. 61-1 E.

316 to 318. Apotrachyte.

319. Breccia of fine grained reddish to greenish rock, cemented largely by laumontite. Nos. 319 and 320 are contact

rocks of diabase and red rock, the diabase being similar to Nos. 302 to 310.

320. Fine grained brownish red rock.

321. Quartz porphyry. Near the county road west of Grand Marais, about in SW¼ NW¼ sec. 20, T. 61-1 E. This rock is below the diabase flows represented by No. 303. No. 321 extends northward and forms the main ridge of hills.

*West of Grand Marais.*

322. Diabase. Top of Terrace point, at the north side. N W¼ sec. 33, T. 61-1 W.

323. Breccia of fine grained reddish rock. From a copper exploration about a mile above the mouth of Cascade river; near NW corner sec. 1, T. 60-2 W.

324. Diabase, reddish. SE¼ sec. 9, T. 60-2 W. On the road from Lutsen to Cascade river rock outcrops are found in the creek beds. These outcrops are of diabase flows. No. 324 is from a coarse massive part of a flow. These flows, so far as observed, vary from a few feet to fifty feet in thickness.

325. "Mud conglomerate." West of mouth of Poplar river, sec. 33, T. 60-3 W.

326. Diabase amygdaloid. Nos. 326 and 327 lie above No. 325.

327. Diabase, reddened.

328. Red sandstone. East side of Poplar river, sec. 33, T. 60-3 W.

329. Diabase porphyryte. South slope of Sawteeth Mts., SE¼ sec. 29, T. 60–3 W.

*Carlton peak.*

This prominent peak lies in sec. 20, T. 59–4 W.

330. Diabase with a soft white mineral (saponite?). Along the shore in sec. 21, T. 59–4, diabase and amygdaloids make up the greater part of the shore. A quarter of a mile northwest of the shore is an outcrop of diabase which contains a soft white mineral—No. 330 (SE¼ sec. 21). In approaching Carlton peak on the trail leaving Engleson's shanty, there is no rock outcrop beyond No. 330 for about a mile, but glacial lake beaches and other deposits are abundant.

331. Coarse black diabase. This forms the first low ridge south of the peak proper.

332. Diabase. Crossing the valley between the ridges and ascending the east peak, the black diabase (Nos. 332 and 333)

continues to within several hundred feet of the top, and apparently is beneath the anorthosyte.

333. Diabase. From the outcrop nearest to the anorthosyte.

334. Anorthosyte, yellowish. The east knob of Carlton peak is composed of anorthosyte of varied lithological character, as represented by Nos. 334 to 337.

335. Anorthosyte, coarse and reddish.

336. Anorthosyte, coarse and reddish, containing masses of a radiating zeolite.

337. Anorthosyte, yellowish.

338. Anorthosyte or gabbro. The top of the main mass of the peak is made up of anorthosyte. West of this is a small knob of the same rock, No. 338. In places this rock becomes almost black, from the presence of the black minerals.

339. Anorthosyte. South of the east knob is another one composed of a rock (No. 339) which is largely decayed and forms soil in places.

340 to 342. Diabase. The ridge west of Carlton peak is composed of this diabase.

343. Fine grained reddish brown rock. On the south flank of the last ridge are found layers of the lake shore flows, represented by No. 343. These flows continue to the lake.

344. Amygdaloidal diabase. NE¼ sec. 28, T. 59–4 W. These flows vary in thickness from a few inches to twenty feet, they consist of layers of compact and amygdaloidal diabase.

345. Compact diabase highly altered.

346. Thomsonite. From a "nest" in the amygdaloid.

347. Vein material. Calcite, quartz and probably heulandite.

348. Thin veinlets. A part of the vein from which No. 347 came.

349. Amygdaloidal diabase. Some of the layers of the volcanic flows in this vicinity have their original corrugated or rope-like surfaces. The superimposed layers fit into the irregularities of the lower layers, as shown by No. 349.

350. Amygdaloidal diabase. Shows corrugated surface of flow. NE¼ sec. 28, T. 59–4 W.

*Beaver Bay and vicinity.*

351. Coarse black diabase. Near line between secs. 13 and 14, T. 55–8 W.

352. Porphyryte. No. 351 continues to form the shore towards

the east and is cut by a dike (No. 352) about an eighth of a mile east of the section line mentioned above.

353 and 354. Coarse black diabase. On the shore east of the last.

355. Fine grained diabase. East end of a grand beach, near center of south side of sec. 12, T. 55–8 W.

356. Still finer diabase. This cuts No. 355.

357. Fine grained gray granite. Cuts No. 355 in a dike four feet wide.

358. Fine grained gray granite. Cuts No. 355.

359. Small dike similar to No. 358, cutting No. 355.

360. Apotrachyte. This occurs at the mouth of Beaver river and forms the narrow neck connecting the promontory with the main shore.

361. Black diabase. East of the gravel beach below Mr. Wagner's house. This rock continues eastward along the shore.

362. Black diabase, quite fresh. A little farther east.

363. Coarse altered diabase; near last.

364. Anorthosyte. From the round point south of Shingle cove.

365. Fine grained reddish granite. From the top of the bluff, forming the point at Beaver Bay, west side.

366. Dioryte. This rock is a peculiar phase of the black diabase between Nos. 361 and 362. It appears only in streaks.

367. Fine grained black diabase. Between the lower sawmill and the wagon bridge.

368. Diabase. In the river gorge. A fine grained phase of the usual coarse black diabase.

369 and 370. A very fine grained black diabase appears in the outcrops mixed with an acid rock which appears to be cut by the former.

371 and 372. Black diabase cut by fine grained diabase. Near the wagon bridge.

373. Gray diabase. Above the bridge, on the east side of the river, the coarse diabase is somewhat coarser and lighter colored in places.

374. Fine grained part of the coarse black diabase, showing a few porphyritic plagioclases. East of and below the bridge.

375. Near No. 374 the rock is cut by and mixed up with a fine black rock showing flowage lines or lamination on the weathered surface.

376. Coarse gray diabase. This appears in one place as a

dike, four feet wide, cutting No. 374. The dike-like character disappears and the rock blends with the rock of which No. 374 is a fine grained part. The whole is apparently an example of a rock which, after partial cooling, is intruded by the non-solidified magma.

377. Anorthosyte. This is enclosed by the black diabase, and in places it contains a zeolite similar to that at Carlton peak (No. 336). From the rocky knob at the base of Beaver river spit.

378. Fine grained black rock. On the shore east of the anorthosyte. This black rock occupies a considerable area between the acid red rock and the coarse black diabase.

379. A slightly coarser phase of No. 378.

380. A laminated phase of No. 378.

381. Quartz porphyry. Nos. 381 to 385 represent the various phases of the acid eruptives associated with the "black rock" (No. 378). It cuts the black rock but does not seem to cut all of it, if a separation can be made, and in that case two fine grained black rocks exist here.

382. Quartz porphyry.

383 to 385. Fine grained reddish granites. See under No. 381.

386. Coarse diabase. This is cut by the red acid rocks.

387. Fine grained "black rock," apparently a gray fine grained diabase.

388. Coarse gray diabase.

389. Finer grained portion of the coarse diabase.

390. Diabase porphyryte. Contact between coarse diabase and fine black rock (No. 391).

391 and 392. Fine grained black rock.

393. The coarse diabase which incloses the anorthosyte masses. Found near the shore of the bay.

394 Fine grained part of No. 393.

395. Black diabase. On the country road near the W¼ post sec. 2, T. 55-8 W. This rock becomes amygdaloidal in places.

396. Light gray anorthosyte. At the bend of the county road on the south side of the hill; NE¼NE¼ sec. 27, T. 56-8 W.

397. Dark gray anorthosyte. Same place.

398 to 400. Diabase. Same place. A dike of diabase cuts the anorthosyte. The black diabase appears to form the base of the hill and the dike is an offshoot from the main diabase mass In general the diabase at the contact is fine grained (No. 398.)

No. 397 is coarser, several feet from the contact. No. 400 is the normal, coarse, black diabase. (Compare Nos. 188 and 189.)

401. Fine grained, reddish diabase. This specimen represents the rocks in the river bed. Center of SE¼ sec. 22, T. 56-8 W. (Compare No. 193.)

402. Decayed gray diabase. Same place.

403. Compact amygdaloidal diabase. Same place.

404 and 405. Fine grained compact black diabase.

406 and 407. Finer grained part of the coarse diabase intermingled with Nos. 404 and 405. Same place. While no definite relationship can be established here, still the fine grained black diabase seems to be an intrusive at this locality, cutting the coarse black diabase.

408. Diabase porphyryte from a boulder near Beaver Bay.

409. Anorthosyte with zeolite (thomsonite.) Beaver Bay. Same place as No. 377 which does not show the zeolite.

410. Quartz porphyry from a flow, at Beaver Bay, east of the anorthosyte mass.

411. Quartz porphyry from angular masses in No. 413.

412. Anorthosyte from angular masses in No. 413.

413. Black fine grained diabase which is below the quartz porphyry (No. 410) and cuts it and includes angular masses of it and of anorthosyte.

414. Fine grained diabase having a laminated appearance.

415. Radiating masses of reddish feldspar developed in the fine grained diabase.

416. Fine grained part of the coarse black diabase.

417. The same where it incloses anorthosyte masses. The successive ages of the rocks here are as follows: (1) Nos. 416 and 417 inclosing anorthosyte. (2) No. 410, quartz porphyry flows which lie upon and cut the preceding. (3) No. 413, which cuts all the preceding. It is intruded in the form of sill sometimes 200 feet in width.

*Splitrock river.*

418. Red apotrachyte. First falls of Splitrock river.

41 7. Same, showing fissility.

420. Brown, fine grained diabase, mixed with the preceding.

421. Amygdaloidal diabase. 200 feet below the first falls and overlying Nos. 418 and 419.

422. Diabase. This represents the flows immediately east of the mouth of Splitrock river; NW¼ sec. 7, T. 54-8 W.

*Stewart river.*

423. Diabase showing reddish and gray alternations. One mile east of Stewart river, north of the county road, sec. 21, T. 53-10 W.

424. Decayed diabase from the dump of the Stewart river copper mine.

*Pork bay.*

425. Decayed reddish diabase from the middle flow that forms the extreme point at the west side of Pork bay. Probably in sec. 36, T. 58-6 W.

*Carlton peak and Temperance river.*

426. Anorthosyte showing a red streak. At the contact with the Beaver bay diabase; lower southeast corner of the east knob.

427. Anorthosyte from the top of the main peak.

428. Black diabase cutting the anorthosyte south of the main peak. This diabase contains angular pieces of the anorthosyte.

429. Black diabase from the high sawtooth ridge west of Temperance river.

430. Reddish decayed diabase. Near the top of the ridge, but below No. 429.

431. Amygdaloidal diabase with thalite. From the first flow above the black diabase on Temperance river.

432. Reddish vein or dike, two to four inches wide, cutting No. 431.

433. Finer grained felsitic vein or dike in No. 431.

434. Altered diabase from the second flow from the bottom, Temperance river.

435. Altered diabase from the third flow.

436. Altered diabase at the Temperance river bridge.

437. Sandstone(?), two to six inches thick, between two layers of diabase and filling fissures in the lower layer.

*Poplar river (Lutsen).*

438. Amygdaloidal diabase from flows half a mile west of the mouth of the Poplar river. Sec. 33, T. 60-3 W.

439. Amygdaloidal diabase from near the top of the massive part of a flow.

440. Amygdaloidal diabase, showing the usual decayed condition common to the basic flows.

441. So-called vein in No. 438. This "vein" is due to alteration of the rock along a fracture line.

442. The same showing slickensided surface.

443. Red sandstone. Between several of the flows are thin seams of red sandstone and conglomerate. These flows continue eastward to the middle of the clearing at Lutsen where they lie upon a sandstone. This sandstone was found in Mr. C. A. Nelson's cellar and appears again along the east side of the river.

444. Red sandstone. Point on the east side of the mouth of the Poplar river. The sandstone lies between diabase flows; it dips about 10° towards the southeast and is exposed for about 350 feet along the river.

445. Altered diabase. In going up Poplar river the first four flows below the sandstone are quite similar in lithological character and average about twenty-five feet in thickness. No. 445 is from the fourth layer, counting from the sandstone downward. The river is crossed by two small faults, one having a displacement of about ten feet and the other only two or three feet.

446. Fine grained brown diabase from the fifth layer.

447. Coarser altered diabase from the sixth layer.

448. Luster-mottled diabase from the seventh layer.

449. Same showing a few zeolite amygdaloids.

450. Reddish fine grained rock from the bottom of the eighth layer.

451. Same from the middle of the eighth layer.

452. Same from the ninth layer.

453. Laminated rock of the ninth layer, lying above No. 452.

454. Coarse decayed diabase forming the upper falls of Poplar river. Probably in NE¼ sec. 20, T. 60–3 W.

455. Coarse black diabase from the hill, west of the "hay-marsh," known as the "rock pile." Probably in NE¼ sec. 20, T. 60–3 W.

456. Diabase porphyryte from the south slope of the first Sawtooth hill north of Lutsen.

457. Fine grained diabase from the same hill. This is a phase of the usual coarse diabase.

458. Fine grained brownish rock, near the middle of the south slope of this hill; evidently part of the later flows.

459. Vein material, largely quartz, from between the layers of No. 458.

460. Vein of heulandite and calcite from the cliffs west of the mouth of Poplar river.

460. Vein of heulandite and calcite from the cliffs west of the mouth of Poplar river.

*Cascade river.*

These specimens (Nos. 461 to 472), except No. 472, are from the W½ of sec. 1, T. 60-2 W.

461. Fine grained reddish and greenish diabase, representing the flows from the lake shore to the first falls of Cascade river.

462 to 464. Diabase, more or less altered, representing the rock adove the first falls.

465. Rather coarse, pinkish granite involved in the black diabase, apparently as a rounded boulder-like mass ten to fifteen feet in diameter.

466. Fine grained dark diabase. About an eighth of a mile above No. 463.

467. A porphyritic phase of No. 466.

468. Radiated zeolite masses from the amygdaloidal part of the diabase.

469. Red sandstone from a bed about 300 feet thick.

470. Gray nodule from the uppermost part of this sandstone.

471. Vein material; calcite and copper stains. About a quarter of a mile above the sandstone and above a bridge.

472. Altered diabase penetrated by quartz. Bay in SE¼ sec. 32, T. 61-1 W.

*Grand Marais and Devil Track river.*

473. Greenish diabase from the first dike east of Grand Marais. NE¼ sec. 21, T. 61-1 E.

474. Large plagioclases from the preceding. Some of these feldspars show alteration to a zeolite.

475. Quartz porphyry, east of No. 473.

476. Fine grained decayed diabase from a dike, three inches wide, cutting No. 475. This appears to be a stringer from the large dike, No. 473.

477. Greenish diabase. Fine grained phase of this dike near its contact with the quartz porphyry. The second large dike east of Grand Marais.

478. Minerals, apparently formed from the alteration of the feldspar of the preceding.

479 to 481. Forms of the acid eruptives east of this second dike (No. 477). Some of these eruptives may be fragmental volcanics.

482. Fine grained greenish diabase from the third large dike east of Grand Marais.

483. Plagioclase nodules included in this diabase.

484. Diabase. Going eastward to the mouth of Devil Track river (SW¼ NW¼ sec. 13, T. 61-1 E.) several more diabase dikes are seen cutting the quartz porphyry. In one of these dikes Mr. Hovey has sunk a test pipe; the rock from the pit is shown by No. 484.

485. Quartz porphyry, south of the mouth of Devil Track river.

*Kimball's creek and Cowtongue point.*

486. Brown andesyte or apotrachyte. Bed of Kimball's creek, centre of sec. 33, T. 62-2 E.

487 and 488. Phases of the same, 100 paces down the creek.

489. An amygdaloidal phase of the same from a higher layer, farther down the creek.

490. Mottled reddish andesyte or apotrachyte from another layer, farther down the creek.

491. Somewhat similar rock from a layer seventy-five feet thick; farther down the creek, NW corner of sec. 3, T. 61-2 E.

492. Fine grained greenish diabase cutting No. 491.

493. Quartz geode from the layer represented by No. 491.

494. Andesyte or apotrachyte forms the river banks for the next half mile.

495. A phase of the same, from the highest layer near the lake shore; probably in NE¼ NW¼ sec. 10, T. 61-3 E.

496. Fine grained brown diabase. Cowtongue point. SW¼ sec. 10, T. 61-2 E.

497. Conglomerate between layers of No. 496.

498. Probably a mixture of sedimentary and fragmental igneous material; same place.

*Gunflint lake and vicinity.*

499. Quartzyte with hisingerite. Shaft of Gunflint Lake Iron Co., SE¼ NE¼ sec. 28, T. 65-4 W.

500. Quartz vein rock. North of the "old nickel" pit. NE¼ sec. 28, T. 65-4 W. An assay for gold showed about $1.00 per ton.

501. Gabbro. On Pt. A. D. and W. R. R., W½ sec. 27, T. 65-4 W.

502. Decayed gabbro from fracture in the fresh gabbro. Same place.

503. Decayed gabbro at contact with graphite vein. Near same place.

504. Fresh gabbro from the east end of the first bridge east of the lake at the Gunflint Lake Iron Co.'s location. Near W. line of sec. 27, T. 65–4 W.

505. Graphitic rock.

506. Decayed gabbro. First cut east of the above lake.

507. Slate inclusion in gabbro.

508. Quartzyte inclusion in gabbro.

509 and 510. Fine grained siliceous rock at contact of slate and gabbro.

511 to 519. Various phases of graphitic rock.

520. Gray graphitic slate from the center of a mass, four feet long and one foot wide, inclosed in the gabbro.

521. Same at the contact with the gabbro.

522. Contact zone of the above showing graphite.

523 to 526. Various phases of the graphitic rock.

527 to 531. Magnetite sometimes showing copper carbonate stains. In 1897 the Johnson Nickel Co. did considerable test fitting in SE¼ sec. 34, T. 65–3 W. Nos. 527 to 541 are from this locality. The magnetite appears to be a phase of the gabbro.

532 to 540. Various phases of the gabbro sometimes altered, containing more or less magnetite and sometimes showing carbonate stains.

541. Gabbro with native copper.

542 to 552. Various phases of gabbro, usually rich in magnetite, containing apparently pyrite, pyrrhotite and chalcopyrite, and sometimes showing a banded structure. Portage from Tucker to Mayhew lake; NE¼ sec. 2, T. 64–3 W.

553. "Soft iron ore." Near south side of SE¼ sec. 22, T. 65–4 W.

554 and 555. Animikie quartzyte metamorphosed by the gabbro. SW. corner of Loon lake; sec. 32, T. 65-3 W.

556. Diabase containing aggregates of plagioclase crystals. From the sill north of the west end of Animikie bay of Gunflint lake. Sec. 24, T. 65-4 W.

557. Diabase with scattered porphyritic plagioclases. Same place.

558. Diabase with large crystals, apparently of augite. Same place.

*Grand Portage.*

559 to 561. Phases of the conglomerate and sandstone at the northeast side of Grand Portage island, sec. 10, T. 63-6 E.

562. Contact of sandstone and basic eruptive, from the bottom of the first flow above the main mass of the conglomerate. Same place.

563. Gray quartzyte. High bluff a mile southwest of Grand Portage village and north of the county road; probably in sec. 8, T. 63-6 E.

564. A red vein in this quartzyte.

565. Same quartzyte showing an undulating cleavage.

566 and 567. Wrinkled surface of this quartzyte at the contact with overlying diabase.

568 and 569. Diabase at the contact with the quartzyte; includes pieces of the quartzyte. This diabase overlies the quartzyte and is twenty feet thick; it is fine grained and compact in its lower and middle portions and amygdaloidal in its upper portion.

570. Red quartzyte from a layer, varying from a few inches to two feet in thickness, above this diabase. Above this are successive layers of diabase with more or less detrital matter between them.

571. Fine grained fresh diabase from a dike cutting the above diabase flows and quartzyte.

*Snowbank lake and vicinity.*

572. Dark slate. Near center of sec. 35, T. 65-8 W.

573. A coarser band in this slate.

574. Greenstone dike cutting slate. NW¼ sec. 2, T. 63-8 W.

575. Greenish sericitic schist. North shore of Ensign lake, SE¼ SE¼ sec. 9, T. 64-8 W.

576. More massive phase of this schist, NW¼ NW¼ sec. 14, T. 64-8 W. About half way across the portage from Ensign lake to the small lake in secs. 14 and 15, T. 64-8 W.

577. Greenish feldspar porphyry. East shore of Boot lake, NE¼ NE¼ sec. 21, T. 64-8 W.

578. Quartz porphyry and jaspilyte pebbles from conglomerate at the top of the cape in Boot lake; near center of sec. 21, T. 64-8 W. There are two conglomerates here, one of which is cut by the granite.

579. Matrix of this conglomerate.

580. The lower conglomerate.

581. Gray quartzyte.

582. Conglomerate.

583. Boulder of the upper conglomerate.

584. Fine grained diabase from a dikecutting all the forma tions here.

585. Lower conglomerate metamorphosed by the granite contact.

586 and 587. Phases of the granite from the point in SW¼ SE¼ NW¼ sec. 29, T. 64-8 W., east shore of Snowbank lake. No. 586 is gray and No. 587 reddish; they grade into each other.

588. Darker granite on the point east of No. 586.

589. Porphyritic phase of No. 588.

590. Fine grained granite, which cuts the crystalline schist on the point in NE¼ SW¼ sec. 20, T. 64-8 W., north shore of Snowbank lake.

591 to 597. Phases of the augite granite. West side of narrow bay in W½ sec. 20, T. 64-8 W., north shore of Snowbank lake.

598. Contact of the augite granite and schist, southern edge of granite.

599. Same, northern edge of granite.

600. Crystalline gneissic schist from the point (i. e. at W. side of sec. 20, T. 64-8 W.) on which is the augite granite.

601. Gray angite granite. NE¼ SE¼ sec. 19, T. 64-8 W.; western side of point, noth shore of Snowbank lake.

602. Granite porphyry. Near same place but in sec. 20.

603. Fine grained reddish granite. SE¼ SE¼ NE¼ sec. 19, T. 64-8 W.

604 to 606. Phases of the metamorphosed conglomerate, NE¼ NW¼ sec. 19, T. 64-8 W., north of Snowbank lake.

607 to 609. Pebbles from the upper conglomerate. Portage between Snowbank and Black lakes, NW¼ NE¼ sec. 19, T. 64-8 W. On this portage are two conglomerates separated by an unconformity.

610 and 611. Phases of conglomerate. SE¼ NW¼ sec. 4, T. 63-8 W., south shore of Disappointment lake.

612 to 613. Pebbles from this conglomerate.

614. Dark fine grained rock from a dike, four feet wide, cutting the conglomerate in SW¼ SE¼ sec. 33, T. 64-8 W., Disappointment lake.

615. Massive greenstone. Near the top, on the west side, of Disappointment hill, NW¼ NE¼ sec. 34, T. 64-8 W.

616. Greenstone. Above the preceding.

617. Dark siliceous schist, forming the top of this hill.

618. Greenstone. On the east side below the top of the hill; NW¼ NW¼ sec. 35, T. 64-8 W.

619. Pebbles from conglomerate. SW¼ SW¼ sec. 28, T. 64-8 W.

620. Fine grained syenitic rock from a dike in conglomerate. NW¼ NE¼ NE¼ sec. 34, T. 64-9 W.

621. Coarse massive greenstone. Near center of NE¼ sec. 32, T. 64-9 W., southeast of Moose lake.

622. Quartz vein material from this greenstone.

623. Porphyritic conglomerate (?), N½ of NW¼ NE¼ sec. 32, T.64-9 W., north of No. 621.

624. Another phase of the porphyritic conglomerate. Same place.

625. Fine grained schistose syenitic rock from a dike cutting Nos. 623 and 624.

626. Conglomerate. Ridge on north side of the small lake in the center of NE¼ NE¼ sec. 32, T. 64-9 W.

627. Pebbles from this conglomerate.

628. Porphyritic conglomerate. North of No. 626.

629. Coarse greenstone from top of ridge near center of NW¼ sec. 33, T. 64-9 W.

630 and 631. Conglomerate. South of the small lakes in SW¼ NW¼ sec. 33, T. 64-9 W.

632. Fine grained granitic rock from a dike cutting this conglomerate and the adjacent greenstone.

633. Granitic pebble from conglomerate. Portage from Moose to Wood lake; near center of west side of sec. 21, T. 64-9 W.

634. Jaspilyte. Same place.

635. Green schist. SW¼NW¼ sec. 19, T. 64-9 W, Wood lake.

636. Green schist from the base of the long point in the west end of Wood lake. Probably in SE¼ sec. 13, T. 64-10 W.

637. Greenstone, cut by granite. SE¼ NW¼ sec. 18, T. 64-9 W.

*Ts. 62-4 W. and 63-4 W.*

638. Fine grained diabasic rock from west shore of Pine lake, NE¼ SE¼ sec. 25, T. 62-4 W.

639. Breccia of quartz porphyry cemented by diabase. West shore of Pine lake, NW¼ NE¼ sec. 25, T. 62-4 W.

640. Reddish gabbro. Temperance river at S. line of sec 35, T. 63-4 W.

641. Gabbro. Temperance river, NE¼ SW¼ sec. 35, T. 63-4 W.

642. Magnetite. SW corner sec. 22, T. 63-4 W.

643. Gabbro rich in magnetite and olivine. About in S. part of sec. 20, T. 63-4 W.

644. Gabbro. Pit No. 1. In the vicinity of the W¼ post of sec. 22, T. 63-4 W., test pits have been sunk. Pit No. 1 is in NW¼ SW¼ sec. 22, while pits Nos. 2 to 4 are in NE¼ SE¼ sec. 21.

644 to 648. Gabbro and magnetite. Pit No. 2.

649. Fine grained granulitic gabbro. Pit No. 1.

650. Same. Pit No. 2.

651 to 656. Phases of gabbro and magnetite. Pit No. 2.

657. Granulitic gabbro. Pit No. 3.

658 to 662. Phases of the magnetite. Pit No. 3.

663 to 667. Gabbro with chalcopyrite and rich in magnetite. Pit No. 4.

668. Fine grained granulitic gabbro, north of these pits. SE¼ NE¼ sec. 21, T. 63-4 W.

669. Gabbro cut by dike of fine grained gray granite. SW¼ NE¼ sec. 21, T. 63-4 W.

670. Gabbro and red granite dike. North of No. 669.

671. Fine grained gray granite from dike cutting gabbro. NE¼ SW¼ sec. 26, T. 63-4 W. This granite is cut by augite syenyte and all are cut by diabase dikes.

672. Granite cut by augite and syenyte. Same place.

673. Gabbro. NE¼ SE¼ sec. 13, T. 63-4 W., Georgia lake.

*Brule lake and southward.*

674. Fine grained diabase. North side of the portage between Georgia and Brule lakes. NE¼ SW¼ sec. 18, T. 63-3 W.

675. Amygdaloidal phase of the preceding.

676. Porphyritic phase of the same.

677. Augite syenyte. High bluff northeast of Brule lake. Probably in sec. 9, T. 63-2 W.

678 and 679. Very fine grained black diabase. NE¼ sec. 18, T. 63–3 W.

680. Coarser diabase intermingled with Nos. 678 and 679.

681. Gabbro. About in SE¼ sec. 17, T. 63–2 W.

682. Fine grained gabbro. SE¼ sec. 24, T. 63–3 W.

683. Coarse gabbro which cuts No. 682.

684. Contact of Nos. 682 and 683.

685. Gabbro. Southwest corner sec. 24, T. 63–3 W. First

outcrop on portage southeast from Brule lake.

686. Gabbro. Center of NW¼ sec. 25, T. 63-3 W.

687. Fine grained granitic rock from a dike cutting gabbro. NE¼ SW¼ sec. 25, T. 63-3 W.

688. Apparently a mixture of the above granite and gabbro.

689. Coarse gabbro from the west point in the lake. SE¼ SW¼ sec. 25, T. 63-3 W.

690. Gabbro. NE¼ NW¼ sec. 36, T. 63-3 W. At the portage going southeast.

691. Augite syenyte from a dike, twenty feet wide, cutting gabbro. NE¼ sec. 36, T. 63-3 W.

692. Fine grained reddish granitic rock, from an exposure along the lake shore, NE¼ sec. 6, T. 62-2 W.

693. Quartz porphyry. NE¼ sec. 1, T. 62-3 W. On lake shore.

694. Fine grained diabase. SE¼ sec. 12, T. 62-3 W.

695. Luster-mottled diabase. S½ sec. 16, T. 62-2 W.

696. "Beaver Bay" diabase. NW¼ sec. 8, T. 60-3 W.

*Baptism river and vicinity.*

697. Fine grained brown diabase from a massive flow. South side of Bellmore bay, NE¼ sec. 11, T. 56-7 W.

698 and 699. Vesicular masses of lava, perhaps volcanic bombs, from between two flows, in the first bay south of Bellmore bay.

700. Brown diabase from a massive flow beneath Nos. 698 and 699.

701. Vein material (quartz, calcite, etc.) from No. 700.

702. Small geodes from No. 700.

703. Quartz porphyry, below diabase flows in SE¼ sec. 11, T. 58-7 W.

704. Laminated phase of No. 703.

705. Fine grained diabase from bottom of flow above No. 703.

706. Coarser diabase from the center of the same flow.

707. Quartz porphyry from Shovel point.

708. The same weathered.

709. Coarse black diabase from the sharp low point east of Baptism river.

710. Red sandstone, Bellmore bay.

711. Fine grained diabase. Northeast corner of sec. 11, T. 56-7 W.

712. Coarse phase of the same.

713. Fine grained reddish brown rock at the contact of black diabase and granite, northwest corner of sec. 12, T. 56-7 W.

714. Breccia of similar rock cemented by calcite. Near No. 713.

715. Gray granite from dike. NW corner of sec. 12, T. 56-7 W.

716. Finer grained and dark phase of the same near contact with the diabase.

717. Reddish phase of No. 715.

718. Laminated reddish felsyte. SW corner sec. 1, T. 56-7 W. Above black diabase and below Temperance river flows.

719. Fine grained red diabase. Temperance river flow. Same place.

720. A slight variation of No. 719.

721. Coarser diabase from one of the flows above No. 720. Same place.

722. Coarse diabase from the lake shore in the center of sec. 1, T. 56-7 W.

723. Beaver Bay diabase. NE¼ NW¼ sec. 1, T. 56-7 W.

724. A finer grained phase of No. 723.

725. Amygdaloidal diabase from a layer in Beaver Bay diabase, one-third of a mile north of No. 723.

726. A laminated brownish and yellowish rock associated with No. 725.

727. Felsyte, next to diabase, from granite dike cutting diabase. NE corner of sec. 1, T. 56-7 W.

728 and 729. Reddish granite from this dike.

730. Reddish granite from center of dike.

731. Fine grained granite at east contact of this dike.

732. Quartz porphyry from an apophysis of the large dike in sec. 36, T. 57-7 W.

733. Brown diabase, east of granite dike in southwest part of sec. 36, T. 57–7 W.

734. An amygdaloidal(?) phase of No. 733.

735. Brown diabase. Beaver Bay diabase. SW¼ NE¼ sec. 2, T. 56–7 W.

736. Quartz porphyry, above No. 735. Same place.

737. Red granite, a phase of No. 736.

738. Laminated quartz porphyry, a phase of No. 736.

739. Brown diabase, Beaver Bay diabase, NW¼ NE¼ sec. 2, T. 56–7 W.

740. Brown diabase, Beaver Bay diabase, from a flow in SE¼ NW¼ sec. 2, T. 56–7 W.

741. Fine grained dark brown diabase. First falls of Baptism river.

742. Amygdaloidal diabase with elongated amygdules of banded chalcedony and quartz.

743. Quartz porphyry at third or upper falls of Baptism river.

744. Fine grained brown diabase. Lake shore, west of the club house; sec. 15, T. 56–7 W.

745. Finely amygdaloidal diabase, ashbed diabase. West of and below No. 744.

746. Volcanic ash, a laminated phase of No. 745.

747. Scoriaceous balls associated with No. 745.

748. Another phase of No. 747.

749. Similar to No. 746.

750. Coarser diabase, Beaver Bay diabase, below the ashbed layers.

751. Apotrachyte. Baptism river below the bridge.

752. Diabase from below quartz porphyry, at the mouth of Baptism river.

753. Fine grained brown diabase from a flow at the first bend in the river; NE¼ sec. 15, T. 56–7 W.

754. Calcite from vein in quartz porphyry at the club house.

755. Amygdaloidal diabase, upper flow of Beaver Bay diabase. Below the quartz porphyry, above first falls on Baptism river.

756. Decayed diabase, matrix of the "anorthosyte conglomerate" at Baptism river bridge.

*Great Palisades and vicinity.*

757. Coarse black diabase, Beaver Bay diabase, from the massive flow below the Great palisades. Sec. 22, T. 56–7 W.

758. Laminated quartz porphyry at the east base of the Great palisades.

759. Quartz porphyry, from the top of the talus heap on the main face of the Great palisades.

760. Brownish siliceous vein in quartz porphyry, above the highest talus heap.

761. Decayed diabase, north of and below the east end of the Great palisades.

762. Reddish brown decayed diabase, from the first flow below the quartz porphyry of the palisades, at the west end.

763. Fine grained diabase from flow below No. 762.

764. Coarser diabase, Beaver Bay diabase, below No. 763.

765. Fine grained syenyte, from shore cliffs one-half to one mile west of the palisades.

766. Pinkish granite, about three and a half miles west of the palisades.

*Baptism river and vicinity.*

767. Reddish brown fine grained diabase from the flow above No. 706.

# IV.

# ADDITIONS TO THE LIBRARY SINCE THE REPORT FOR 1894

The present list consists of additions made from January 1, 1895, to July 10, 1899.

## A

*Albany.* State Museum: Ann. Rept., xlvii, xxx-xxxv, xlviii, xlix-2, l-1; Bull. iii, Nos. 11-13, 1893 and 1894; iv, Nos. 16 19; v, 20-23; Mineral Resources of New York, F. J. H., Merrill, 1895. Bull. Univ. of N. Y., vol. iii, Nos. 14-15, 1896.

*Altenburg.* Mitth. Naturf. Gesell. d. Ofterlandes, vol. vi, 1893.

*Amsterdam.* Vers'agen d. K. Akad. v. Wetenschappen, vol. iii, 1894; vol. iv, nos. 1-6, 1895., vol. iv, 7-9, 1895-96, v, 1-3, 1896, iv, 1896.

## B

*Baltimore.* Amer. Chem. Jour., xvii, Nos. 1-10, 1895; vol. xviii, Nos. 1-3, 4, 1896. Johns Hopkins Univ. Circulars, vol. xiv, Nos. 116-122, 1895; vol. xv, Nos. 123-124, 125, 126, 1896.

Baltimore Amer. Chem. Journal, xviii, 5-10, 1896; xix, 1-9, 1897; xx, 1-10, 1898; xxi, 1-6, 1899. Johns Hopkins Univ. Circulars, vol. xvi, 129-131, 132-136, 1898; vol. xviii, 137-140, 1899.

*Basel.* Verhandl. Naturf. Gesellsch., x, 3, 1895; xi, 1, 1895; xi, 2, 3, 1896-97; xii, 1, 1898.

*Belfast.* Rep. and Proc. Belfast Nat. Hist. and Philos. Soc., 1894-95. Rep. and Proc. for 1895-96. Ann. Rept. and Proc. Belfast Naturalist's Field Club, ser. ii, vol. iv, No. 1, 1893-94.

*Belgrade.* Ann. Geol. d. l. Peninsule Balkanique, T. iv, pts. 1-2; T. v, pt. 1, 1892-93-

*Bergen.* Bergens Mnseums Aarsberetning, 1891; Aarbog, 1892 and 1894; Aarbog for 1894-95-96-97-98. Development and structure of the whale, by F. Gulberg and F. Nansen, pt. 1, 1894; Crustacea of Norway, vol. ii, pts. 1 to 12.

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*Berlin.* Zeitsch. Gesellsch. f. Erdkunde, xxix, Nos. 5-6; xxx, Nos. 1-5, 6, 1894-95; vol. xxxi, Nos. 1-6; vol. xxxii, 1-6; vol. xxxiii, 1-5, 6, 1897-98;

Verhandl. xxi, Nos. 9-10; xxii, Nos. 1-10, 1894-95; vol. xxii, 1-10; vol. xxiv, 1-10; vol. xxv, 1-10; vol. xxvi, Nos. 1 to 4, 1899.

Mitth. d. K. Akad. d. Wissensch., 1894, ix-x; 1895, i-x; 1896, 1 to 10; 1897 1 to 10.

Zeitsch. d. Deutschen geol. Gesellsch., xlvi, Nos. 2-4, 1894; xlvii, Nos. 1-2, 1895; xlvii, 3-4, xlviii, 1-4, 1896; xlix, 1-4, 1897; l, 1-3, 1898-99.

*Bologna.* Memoire R. Acad. d. Sci. d'Instituto di Bologna, vol. v, pt. 3, 1893; vol. v, pts. 4-6, 1894-97; Rendiconto, vol. i, pts. 1-4, 1897.

*Bonn.* Verhandl Naturh. Vereins d. Rheinlande, etc., liii, 1-2, 1895; liv, 1-2, 1897; lv, 1-2, 1898.
Sitz. d. Niederrheinischen Gesellsch., fur Natur.—u.— Heilkunde, Hafte i, 2, 1895; 1896, 1-2; 1897, 1-2; 1898, 1-2.

*Boston.* Ann. Rep. of the Public Library, 1894; Ann. Rep., 1895, Technology Quarterly, vol. viii, Nos. 2-3, 1895; vols. iii to xi, 1890-98. Proc. Amer. Acad. Sci. and Arts, w. s. xxx, n. s. xxii, 1894-95; w. s. xxxii, n. s. x, 1-16; xxxiii, 1-27. Proc. Boston Soc. Nat. History, vol. xxvi, no. 4, 1893-94; vol. xxvii, 1896-97; vol. xxviii, 1-16, 1898; vol. xxix, 1-4, 1899.

*Brunn.* Naturf. Vereines Verhandl., vol. xxxii, 1893; vols. xxxiii, xxxiv, xxxv, 1896-97. Meteorol. Commission, vol. xii, 1892; vol, xiii, 1873; vols. xiv, xv, 1896-97.

*Bruxelles.* Bull. Soc. Belge d. Geol. Paleon. and Hydrol., T. vii, 1893. Bull. 1 and 2, 1887-88; No. 5, 1891; ix, 1895; xi, 1, 1897.

*Budapest.* Földtani Közlöny Ungarischen Geol. Gesellsch., vol. xxiv, Nos. 9-12, 1894; vol. xxv, Nos. 1-10, 1895; vols. xv, xvi, 1895; vols. xxvi to xxviii, 1896-97-98.

## C

*Cambridge.* Appalachia, vol. vii, No. 4, 1895; vol. viii, No. 1, 1896; viii, 2, 1896; 3, 1897; 4, 1898; xi, 1, 1899; Register, 1896; Register, 1897-98; Index to vol. i, 1876-78.
Mus. Comp. Zool., Ann. Rept. of the Curator, 1870, 1873, 1876, 1881, 1892-93, 1894-95; Bulletin, vol. vi, Nos. 1-4, 10-12; vol. vii, Nos. 1-11; vol. viii, Nos. 1-11; vol. ix, No. 1-8; vol. x, Nos. 1-6; vol. xi, Nos. 1, 4-10; vol. xii, Nos. 3, 5; vol. xvi (Geol. Ser. ii), No. 15; vol. xxv, No. 12, 1895; vol. xxvi, Nos. 1-2, 1895; vol. xxvii, Nos. 1-7, 1895; vol. xxviii (Geol. Ser. iii), No. 1, 1895.
Bull., vol. xxix, Nos. 1 to 6, 1896; vol. xxx, Nos. 1 to 6, 1896-97; vol. xxviii, Nos. 1-6, 1896-98; vol. xxxi, Nos. 1-7, 1897-98; vol. xxxii, Nos. 1-8, 1898; vol. xxxiii, Nos. 13-17, 1898. Memoirs, vol. i, No. 1, 1896.
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