THE GEOLOGICAL

AND

NATURAL HISTORY SURVEY

OF

MINNESOTA.

THE SEVENTEENTH ANNUAL REPORT.

FOR THE YEAR 1888.

N. H. WINCHELL,

STATE GEOLOGIST.

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ADDRESS.

THE UNIVERSITY OF MINNESOTA,
MINNEAPOLIS, March 31, 1889.

To the President of the University,

DEAR SIR: I have to communicate again an annual report on the progress of the geological and natural history survey of the state, being the seventeenth in consecutive order. Like the last two, this report pertains almost exclusively to the geology of the northeastern part of the state, and is accompanied by some text illustrations.

Respectfully, your obedient servant,

N. H. WINCHELL,

State geologist and curator of the general museum.

REPORT.

I.

SUMMARY STATEMENT FOR 1888.

The work done in the season of 1888 in consequence of the supplementary aid that was rendered the survey by the special appropriation and law of the Legislature of 1887, as mentioned in the last report, will be found reported elsewhere. The explorations for natural gas carried on within the state, whether by private enterprise or by the aid of the special fund, are detailed, with some considerations relative to the general subject of gas in Minnesota, in Bulletin No. 5. The special field-work which was directed, under the same law, to the discovery and definition of the iron-resources of the northeastern part of the state, will be included in this report. But the whole subject in general of the geology of the iron ores of Minnesota will find place in Bulletin No. 6.

There were two parties in the field during the season. One was occupied, in the first part of the season, in making collections of rock-samples from certain typical crystalline formations in typical localities. This was under the direction of Mr. Uly S. Grant. At the same time some new facts were observed. These, with notes made by him later in the season when occupied more specially with the examination of the iron-ore beds, are gathered together by him in a formal report which accompanies this.

The other party was during the whole season at work on the iron-ore beds. This was under the guidance of my son, Mr. Horace V. Winchell, whose report on his work will also be found accompanying this

The work of the season has added materially to our exact knowledge of the geology of the northeastern part of the state, and particularly to that of the nature and relations of the iron ores of the state. A general presentation of this knowledge, in a somewhat systematic manner, has been attempted in this report; but it must be admitted, notwithstanding the time spent on the study, and field-observations that have been recorded, there are still some important, and many less important, questions which the survey cannot answer. But with a consciousness that, however exhaustive the research might be made, there would be questions still unsolved, and that there is a general wish for a full and "final" presentation of the geology of that part of the state so far as present knowledge will yield it, and also feeling that the time has been long that the survey has been going on, and that the working span of one man's life cannot be depended on for indefinite extension, I am constrained to say that we shall enter now upon the preparation of the final report covering the northern part of the state. There will be some supplementary examination to be made, but this will be not very costly, and can be executed while the preparation of the report is in progress.

Volume II of the final report was issued in December, 1888. It is a quarto of about 700 pages, forty-two plates and thirty-two figures, of the same style as Vol. I.

A considerable portion of Vol. III is also ready, and the entire volume will be finished at once. It will contain, along with the paleontology of the strata discussed in Vols. I and II, an account of their systematic relations to the geology of the Northwest. There is also, in readiness for publication, a volume devoted to the birds and mammals of the state, prepared by Dr. P. L. Hatch and Prof. C. L. Herrick. These two volumes should be published at once, in style uniform with those already issued.

The monograph of Messrs. Woodward & Thomas on the microscopic fauna of the Cretaceous, which has been in process of preparation several years, has been completed by those gentlemen and has been transmitted for publication. It will form a chapter in Vol. III. Mr. Ulrich's work on the bryozoa of the Trenton was interrupted unfortunately, when it had proceeded so far as the engraving of the plates, eight having been completed and delivered. This was owing to the exhaustion of the fund for publication by the unexpected cost of Vol. II. Dr. Leo Lesquereux's report on the fossil flora of the Cretaceous in Minnesota, with the accompanying plates, is also intended for Vol. III. It is only an act of reasonable justice to a scientific author that his contributions be published as soon as possible. His rights are not all satisfied by the simple payment of the money involved in his contract to prepare the report. The value of scientific work, especially scientific authorship, is not measured by the manual labor involved in it. So its claims are not satisfied when the material money payment is made. The author expects, and he has a right to demand, that his work shall be published. His researches, so far as they are in new fields, may be covered by later investigators and be announced before his see the light. This reward for scientific authorship, while it cannot be expressed in dollars and cents, and cannot perhaps be included in definite terms in the contract with the author when he undertakes the work of any investigation, yet acts as a powerful stimulant and as a final element in the compensation he reasonably counts upon. He naturally is backward in asserting it; and it is a lamentable fact that credit for some valuable research and some discoveries has been lost to their authors because of the suppression, or at least the tardy publication, of their reports until after others had made the same discoveries and had announced them to the public. In the case of a state survey such delay not only injures the individual but also reflects on the value of the official reports. Wherever scientific facts are first published, there they are forever acknowledged and referred to by future authors. If the state has incurred the cost of an investigation, its chief value is lost if the credit of its discoveries cannot be secured by early publication, and if the same facts are published elsewhere.

The condition of the museum and of the unexamined specimens is about as has been stated in some of the late reports. Not only are the museum halls full to overflowing, but the so-called laboratories of the survey are also full. It has become necessary to deposit the boxes of rock samples in these rooms. All the packing, handling and labeling has been done heretofore in these rooms. Recently, owing to the storage of a large part of the surplus copies of Vols. I and II in these rooms, there has not been room left for doing this work, and it has been transferred to the office, on the second floor of the building.

A record of museum accessions is herewith again reported, the same having been crowded out of the last two reports. Its publication subserves the double purpose of acknowledging donations and of permanence of a record easy to consult in case of desire to find any specimen in the museum, or any information concerning any specimen when once the specimen is in hand. The method of labeling all specimens collected has been found very safe and permanent. It consists of mixing a solution of common shellac, such as can be got of a druggist, with some coloring material and carefully placing the numbers with a small brush or with a stick, on the specimens, by hand. The shellac, being dissolved in alcohol quickly hardens by the evaporation of the alcohol, and embracing the coloring material in the hardened mass, has the quality of permanence of color and insolubility in water. The upper right hand corner of the specimen is used. In case the natural surface is rough, or if the color of the letter to be attached would be so nearly the same as the rock as to render the designation indistinct, the surface is first colored over in a small rectangular spot with some other color of the same kind of material, and when hardened the number is applied over it. The specimens have been numbered as below.

The regular museum series, such as have been placed on exhibition, whether rock-samples, minerals or fossils, have their numbers in *red*, produced by mixing the shellac with "vermilion red."

The series of N. H. Winchell, mainly crystalline rocks, are marked *blue*, produced by mixing indigo with the dissolved shellac.

The series of A. Winchell, also crystalline, are marked *black*, produced by mixing the shellac with india ink.

The samples collected by H. V. Winchell are marked *pink*, a mixture of vermilion red and white lead with the dissolved shellac.

The samples collected and reported by Mr. U. S. Grant are marked *green*, made by mixing the shellac with paris-green.

The specimens in the archæological collection are marked in *white*, mixture of white lead with the dissolved shellac.

The list of museum accessions herewith reported includes only those marked in *red*. All others are listed in connection with the respective field reports.

II.

REPORT OF N. H. WINCHELL.

The crystalline rocks of Minnesota. General report of progress made in the study of their field relations. Statement of problems yet to be solved.

CONTENTS.

INTRODUCTION. In the course of any investigation that is extended over a number of years, like that of the work of the survey on the crystalline rocks of the state, it is necessary, for an intelligent application of effort, to review the progress made and ascertain as nearly as possible the amount and kind of work that remains. It is one of the characteristics of geological investigation, and particularly of research among the crystalline rocks, that as difficulties disappear, under the reflective scrutiny of the laborer, new problems are presented for solution. In the solution of these more advanced problems the geologist sometimes forgets, in the eagerness of his pursuit, that it is incumbent on him, in the interests of his own work, as well as for the information of others, to render an account of his progress and of his success in surmounting the difficulties that confronted him at the outset. There are but few investigators, in any branch of science, that have not made mistakes. They may have advanced under illusive guides along devious lines, they may have retreated where they ought to have advanced, or advanced where they should have retreated. They have entertained partial or wrong opinions; but it is evident that no one should be held to these errors that are incident to the process. The final statement only ought to stand for the result of the investigation. This may contravene, or it may modify or totally disprove some of the early views. There is hence a justifiable reluctance on the part of an investigator to publish his results till he is satisfied that he is right, and that the work is finished. In the case of the Minnesota survey, however, like all surveys, it ought to be "finished." That is, its work should be rounded out with a so-called completion; for it is evident that however far the work should be continued there would still remain unsettled questions. It is not within the power of one survey, nor of one generation, to exhaust the possible research that might be applied to the examination of the geology of the crystalline rocks.

For these reasons it is thought best to take an inventory of the survey's work and results in the examination of the crystalline rocks of the state. This will be preliminary only, and the apparent truth, as it may be expressed in this report, may appear different in the light of future discoveries, and the final report on this work may be somewhat different from that which is here foreshadowed.

1. WORK DONE BY THE MINNESOTA SURVEY ON THE CRYSTALLINE ROCKS.

The efforts of the survey have been directed, almost wholly, to the field relations of the terranes. It is evident that all laboratory determinations are subordinate, in their bearing on the general geology, to the labor expended in the field. That which is of first importance is a knowledge of the facts as to superposition, transition, and extent of the various kinds of rocks as they exist, in fact. No fine mineralogical disquisitions, or chemical determinations, or stratigraphical suppositions, or historical reviews of past speculations, can bear the weight of a feather in the balance against the facts of field observation. Dr. M. E. Wadsworth has truly said* that the field evidence must in all cases

* Notes on the geology of the iron and copper districts of Lake Superior, p. 74.

be the arbiter and guide to the conclusions of the microscopist in his laboratory work on crystalline rocks, as to their eruptive or sedimentary nature. This supposes that the facts as reported are the actual facts. It is true, however, that from different standpoints the same facts may be reported differently by different observers, or because of a lack of capacity or training in field observation on the part of one or the other.* So far as the work of the survey is concerned, while it would be obviously absurd to assert that no mistakes of field observation have been made, and no incorrect inferences have been arrived at by the field observers, it is no more than the facts of the case will justify to say that the Minnesota survey has devoted more time and accumulated more exact knowledge regarding the field-relations of the crystalline rocks than has any other state survey; and probably has given more time to field work in the crystalline rocks of the Northwest than the United States geological survey. In some instances extensive routes of observation have been gone over more than once for correction or verification. These field observations have been reported in whole or in part, from time to time chronologically in the reports of progress, but their fragmentary parts have not been grouped and presented systematically so as to show the results as they appear in the mind of the writer.

(a) *Early views. State of knowledge when this investigation was begun.*

When the Minnesota survey was begun, in the fall of 1872, there had been but little done on the crystalline rocks of the Northwest. In addition to the desultory and often fragmentary work of the Canadian survey, which should be classed rather as exploration and sketch-mapping, and which had been spread over the Canadian shores of lake Superior as far as to Pigeon river by Mr. Robert Bell, the only published information respecting the older terranes in Minnesota was in the reports of Keating, Allen and Schoolcraft, Shumard, Norwood, Whittlesey and Hall, with some brief notes by Bigsby, on the Lake of the Woods. Douglas Houghton had also visited Grand Portage and some points further west. Eames & Hanchett had also rendered short reports on some features of the northern part of the state.† There had been published also, in 1871, in the *Zeitschrift d. Deutschen*

* Compare Irving's and Wadsworth's different observations on the "Eastern Sandstone," *Copper-bearing rocks of lake Superior*, Monograph No. 5, U. S. Geol. Survey, p. 356, et seq.

†See Vol. I. final report, for some account of these early publications.

geologischen Gesellschaft, a paper by Dr. J. Kloos giving some notes on Minnesota, in which important new observations were recorded. It was two or three years later, however, that this last paper was first known to the writer.* Prof A. Winchell and Prof. R. D. Irving had also made some observations on the geology of the Northwest, particularly in Michigan and Wisconsin. The report of Foster and Whitney on the copper and iron districts of the lake Superior region makes no mention of the geology of Minnesota further than the reported occurrence of one or two minerals on the north shore of lake Superior.

So far as any of this work touches the geology of Minnesota, in the areas of the crystalline rocks, it may be divided into two classes.

1. That which is descriptive of the geographic extent of the crystalline rocks.

2. That which by careful mineralogical determinations discriminates the rock species from each other, or classifies the formations stratigraphically.

In the former may be placed the reports of Keating, Allen, Schoolcraft, Shumard, Eames, Hanchett and Houghton; in the latter are the reports of Norwood, Whittlesey, Hall and Kloos. Norwood's report partakes largely in the character of the first group. Whittlesey's was the result of observations made in company with Norwood, and embraces about the same facts and conclusions. Prof. James Hall's report of a trip from St. Paul to lake Shetek † in 1866, embraces the first reference of any of the crystalline rocks of the state to their supposed stratigraphic equivalents in the eastern states and Canada. He distinctly refers the gneisses at Redwood Falls to the *Laurentian*, and the quartzytes at New Ulm and Pipestone to the *Huronian*, names which had been adopted by the Canadian geologists, though with some ambiguity and overlapping of description, the former in 1854, § and the latter in 1857, § §

* See transalation of this in the tenth anual report.

† 1866, Trans. Am. Phil. Soc., Philadelphia, p. 329.

§ Geol. Report Can. Survey, 1857, p. 7. The name was used in "Sketch of the Geology of Canada," printed in French in Paris, 1855. This is embraced in "Canada at the Universal Exposition of 1855," by J. C. Tache, a report printed at Toronto, "by order of the Legislative Assembly," 1856. It was first announced in the report of the survey for 1852-53, which, however, was not published till 1854, at Quebec.

§ § In Mr. Murray's reports for 1853, 1854, 1855 and 1856 the terms "Huronian system" and "Laurentian system" are used incidentally, and as headings to chapters; but as these were not offered for publication by Mr. Logan till March, 1857, they cannot be considered as official announcements of those names till the date of their actual publication.

Just prior to the adoption of these terms, expressive of a distributive chronological classification of the terranes of the crystalline rocks, at least all those lying below the Potsdam sandstone, Messrs. Foster and Whitney* had employed the term *Azoic*, after Murchison and Verneuil,† and had divided them mineralogically rather than chronologically, into gneiss, mica and hornblende slate, chlorite, talcose and argillaceous slate, quartz and marble.‡ They considered them an indivisible complex series, whose foldings and metamorphic changes rendered a determination of their original stratigraphic order impossible. This term, with its significance as interpreted by Foster and Whitney, was adopted by Dana in the first and second editions of his Manual of Geology (1862 and 1864), and by the Vermont geologists in 1862 (Geol. of Vermont, Vol. I). It was not till 1874 when the third edition of this manual was issued (by some mistake also called "second" edition), that the terms used by the Canadian geologists were adopted in this work. They are continued in the fourth ("third") edition issued in 1879. Dr. Ebenezer Emmons evidently shared the views of Foster and Whitney. Aside from his opinion that the Huronian of Canada was only a synonym of his Taconic which he insisted was not "Primary," he divided the "primary" rocks into two groups,‖ based on the varying theoretical agency of heat in their production and present condition, viz., *pyro-crystalline* and *pyro-plastic.* In the former, in the main, he embraced granite, gneiss, mica slate, talcose slate, hornblendic and hypersthene rocks, that is to say, speaking broadly, the acid eruptive rocks and their accompanying schists, and in the latter he included the most of the basic eruptives.§

When the Minnesota survey began [1872] the Wisconsin survey, lately completed by Chamberlin, had not yet been instituted.§§ and the Michigan survey, revived in 1869, did not present its first final volume for publication till May 1, 1873. The writer, having been at work in 1870 on the Michigan survey, was, how-

* Proc. A. A. A. S. 1851, p. 4.

† The Geology of Russia in Europe, Vol. I, p. 10.

‡ Report on the Geology of the lake Superior land district; part II. p. 2. Am. Jour. Sci., (2) xxiii. 305.

‖ Manual of Geology, Second edition, 1860, p. 52.

§ Emmons also regarded some limestones as pyro-crystalline, and he embraces it in both series of that class of rocks. Op. cit. p. 60 et 66.

§§ The law ordering the Wisconsin survey was approved March 18, 1873.

ever, acquainted with the views of the director, Prof. A. Winchell, and of major T. B. Brooks, the geologist of the iron regions, touching the equivalency of the Marquette iron formation to the Huronian of Canada, as subsequently announced in Volume I of that report.

The first volume of the New Hampshire report by Prof. C. H. Hitchcock was issued in 1874, and that devoted to the stratigraphic geology of the Archæan in that state in 1877.

(b) *The problems, therefore, that were then unsolved*, touching the stratigraphy of the Azoic or Archæan, were as follows:

1. Could the Azoic be divided stratigraphically with any probable general applicability?
2. Could the terms Huronian and Laurentian, as employed by the Canadian geologists, find any equivalents in the crystalline rocks of Minnesota?
3. What relation did the Huronian bear to the Cambrian?
4. What relation did the Huronian bear to the Taconic?
5. What relation did the Cambrian bear to the Taconic?
6. What relation did the Animikie bear to the Taconic, the Cambrian and the Huronian?

Correlatively with these problems appeared others, although they did not present themselves so forcibly till some time later, viz.:

7. Could the rocks classed as Laurentian be distinctly shown to be of older date than the Huronian? All of them, or a part of them?
8. Could the Laurentian be subdivided?
9. Is the Laurentian derived from originally sedimentary rock? or from primarily eruptive rock?
10. If originally sedimentary, or if primarily eruptive, why is it mainly an "acid" rock?

(c) *Publications issued since the work began.*

In an appendix is a list of publications that have been issued since 1872, bearing on the geology of the crystalline rock, of the Northwest, so far as the writer has learned of them. It is probably not complete, but certainly embraces everything that has contributed to the subject any important information. To all of these the writer must acknowledge great indebtedness, and to none greater than to the geologists of Michigan and Wisconsin, Maj. T. B. Brooks, Dr. A. Winchell, Prof. R. Pumpelly, Dr. C.

Rominger, Prof. C. E. Wright, A. R. Marvine, Prof. R. D. Irving, Prof. (now President) T. C. Chamberlin, E. T. Sweet, and to Prof. M. E. Wadsworth, now state geologist of Michigan.

(d) *The various annual reports: progress from year to year.*

That there has been some advance in the science of the crystalline rocks in America at large as well as in those of the Northwest, and of Minnesota specifically, since 1872, is evident from a comparison of the problems unsolved in 1872 with those that are presented to the geologist in 1889; and while this advance is mainly due, of course, to the labor of the authors whose works are listed above, some of the steps of this progress may be accredited to the Minnesota survey. Some of these steps, due to a large extent, or wholly, to the Minnesota survey, it will be appropriate here to enumerate. There may be still a difference of opinion among the geologists of the United States and Canada as to what constitutes a step of progress, and as to who should be regarded as its author. But it is the design of the writer to mention only those steps which appear to his judgment to be actual advances, whether they appear so to others or not, and in that he holds no one responsible but himself. As to the responsibility and the credit for these steps, that is decided, as in all similar cases in science, by the dates of the published literature that announces them. The record, therefore, which will here be given, will be that of the progress, mainly, of the writer's own mind and apprehension of what he considers successive advances.

The first annual report, 1872.

The first annual report was made before any time had been allowed for examination of the crystalline rocks of the state by the present survey. Therefore the only design was to express concisely the state of knowledge that then was available, so far as it bore on any classification that might be accepted. The views of Foster and Whitney as expressed in 1851,* grouping the crystalline rocks in the same manner as Murchison and Verneuil, all in one system under the name Azoic,** were cited and their table of stratification was quoted. At the same time the subdivision into Laurentian and Huronian, introduced by Logan and Hunt

**Report on the Geology of the lake Superior land district.* Part II, p. 8. *Proc. A. A. A. S.* 1851, p. 4

** Geology of Russia, Vol. I, p. 10. *

of the Canadian survey, though contested by Prof. Whitney, was generally prevalent, and these terms were included in the brief description then published of their extension into Minnesota.

The most important question, however, which was considered in the first report, bearing on the classification of the Laurentian and Huronian, was that pertaining to the *Potsdam sandstone.* The bearing of this discussion, however, upon that classification was not fully apprehended, as its application and significance have been brought to light in some of the later years of the survey. Drs. Owen and Norwood, as well as A. Winchell * considered the red sandstones and quartzytes of Wisconsin and Minnesota as the conformable downward extension of the light-colored sandstones of the St. Croix and Mississippi valleys which they parallelized with the Potsdam of New York. It was just before the commencement of the Minnesota survey (Feb., 1872, Am. Jour. Sci., p. 93), that Prof. R. D. Irving demonstrated conclusively that at Baraboo, Wisconsin, there was a marked unconformity between the red and the light-colored sandstones, and that they could not belong to the same system. Prof. Irving coincided with Prof. James Hall,** who had previously regarded the light-colored upper sandstones as Potsdam and had been followed by nearly all geologists of America, in referring the lower quartzytes to the Huronian of Canada.

The first report of the Minnesota survey refers the lower quartzytes to the Potsdam horizon of New York and gives the name *St. Croix* to the overlying light-colored sandstones. In the light of all subsequent examinations, both east and west, there has appeared nothing that has disproved the correctness of this reference, but on the other hand every fact, whether of paleontology or of stratigraphy, which has been brought out since 1872, relating to this horizon, has been in accord with it. It must not, however, be considered as sufficiently demonstrated, so long as there are competent dissentients who still restrict the name Potsdam to the later sandstones. It will appear later in what way this bears on the classification of the rocks styled Azoic by Messrs. Foster and Whitney and later Archæan by Prof. J. D. Dana.

* Owen's report on Wis., Iowa and Minn., pp. 48, 187, and Table, p. 634. Am. Jour. Sci. (II) xxxxii. 226, 1864.

** Report of progress to the Governor of Wisconsin, 1860; also Notes upon the geology of some portions of Minnesota from St. Paul to the western part of the state, *Trans. Am. Phil. Soc.* Philadelphia, June, 1866.

The second annual report, 1873.

In the second report was an account of the geology of the Minnesota valley. While this entered into a somewhat detailed description of the field appearances of numerous outcrops of the crystalline rocks between New Ulm and Big Stone lake, there was no attempt made to classify them, or to refer them to any horizon of rocks exposed in the northern part of the state. They were regarded as a southern extension from the granites in the northern part of the state, and were presumed to have their parallelisms there if they could be referred to their proper places. The red quartzyte at (or near) New Ulm is again referred to the age of the Potsdam.

The sixth annual report, 1877.

The report contains the first recorded observations made by the Minnesota survey on the crystalline rocks of the northeastern part of the state. They were made at Northern Pacific Junction and about Little Falls, on the Mississippi river. An examination was also made of the granitic rock in the vicinity of Motley. These notes are simply descriptive, without any effort at classification.

In this report is a description of the geology of Rock and Pipestone counties, in which are large outcrops of the same red quartzyte as seen at New Ulm, and at Baraboo, Wisconsin. It is classed as Potsdam.

The seventh annual report, 1878.

In the seventh report is a sketch of a somewhat extended systematic examination of the mining geology of the northeastern part of the state. The coast of lake Superior was examined from Duluth to Pigeon point, a trip was made overland from Grand Portage along the international boundary to Basswood (or Basimenan) lake, thence to Vermilion lake, the St. Louis river, across to the Mississippi and down that river to Little Falls. Some examination was also made of the country between Pigeon point and the Brule river by ascending some of the valleys from the shore of lake Superior. Among the geological results of the season's field work, as stated in the report, on p. 10, are the following points which may be classed as advances in classification of the crystalline rocks of the state.

1. The syenites, granites and other rocks that had been named

Laurentian by the Canadian geologists graduate conformably into the schists and slates that had been named Huronian by the same—as designated and defined by Mr. Robert Bell. This is also stated by Mr. Bell in his report for the Canadian geological survey, 1873.* This definition, however, of the Huronian formation, as will appear later in this summary, was incorrect, and the correction was made by Mr. A. C. Lawson who named the schists *Keewatin series.*

2. The gray quartzyte formation, No. 4 of the seventh report, is the iron-ore formation of the Mesabi range and graduates conformably into siliceous iron-charged rock, "which in some places furnishes a valuable iron ore in large quantities."

3. The Cupriferous formations, later known as the Kewenian, or Keweenawan, lies unconformably over several formations, and is interstratified with the beds of the latest.

The evidences of these conclusions are not given in this report. The detailed observations have not yet been published, but a synopsis of them was published in connection with a preliminary description of rock samples collected, in the ninth annual report.

The eighth annual report, 1879.

So far as the eighth report records the work of 1879 on the crystalline rocks, it embraces the descriptive account of the outcrops in the Minnesota valley by Mr. Warren Upham, and some mineralogical notes on the eruptive ranges of the lake Superior region by Prof. C. W. Hall. The observations of the writer in the northwestern part of the state, in 1879, have never been published in full, but a synopsis of them was published in connection with a preliminary description of rock samples collected, in the tenth annual report.

In a preliminary chapter are some mineralogical notes on the "Cupriferous series at Duluth" (p. 22). In this a distinction is drawn between the labradorite rock, or "gabbro," and the red orthoclastic syenite which is mingled irregularly with it, the latter being regarded as the result of local fusion of some of the sedimentary strata, probably some of the strata of the Cupriferous series. The whole trap and Cupriferous series of lake Superior is here assigned to the age of the Potsdam sandstone.

*Report of progress, 1872-3, p. 106.

The Ninth annual report, 1880.

This report gives a preliminary description of 442 rock samples collected in the region of the crystalline rocks northwest from lake Superior, in 1878, with a running brief commentary on their field relations. It contains but little attempt at classification of the stratigraphy. A distinction of unconformity is made on p. 82 between the gray slates and quartzytes of the south side of Gunflint lake and the hydromicaceous rocks of the north side, the two being separated by a conglomerate-breccia, and the more northern rocks being regarded as the equivalent of what the Canadian geologists had styled Huronian. This conception of the Canadian Huronian was derived from Dr. Hunt's having described the Huronian as in the main a mass of greenstones, and Dr. Bell's report on the region westward from Thunder bay in 1872. Observations are recorded on p. 94 indicating a conformable passage from what was then regarded as Huronian to the lower syenites, or Laurentian.

The tenth annual report, 1881.

The preliminary description of rock-samples is continued in this report, embracing those collected in 1879, and extending the list to No. 836 inclusive. There is also a renewed discussion of the Potsdam sandstone and its western equivalents, and a short description of some typical thin sections of the rocks of the Cupriferous, or Kewenawan, in Minnesota.

This report embraces some attempt at partial classification, stratigraphically, of the crystalline rocks.* The strata that comprise the island at Grand Portage bay are described in detail, with references to the rock-samples illustrating them. This is followed by a "Generalized section of the alternating beds of the formation," and of the Animikie (Taconic) and lower terranes to the granites and syenites of the region north of Gunflint lake. It is as follows:

Generalized section at Grand Portage and northwestward to Gunflint lake.

1. The Palisade rock, or the "red rock."
2. Green shales, etc., in the bay east of Red point (Nos. 232, 235 and 239).
3. Layer of trap, like 540 (542) seen.. 14 feet.
4. Chalcedonic amygdaloid (543) seen.. 20 feet.

*See pp. 47, 49, 87, 94, 112, 123–136.

5. Fibrous green trap striking E. and W. through the island and forming its highest parts. In spots it is globuliferous with hard, dark, strong, shot-like pellets about ¼ inch in diameter, (Nos. 544 and 545)........ 35 feet.
6. Even-grained sandrock (546) seen........ 8 feet.
7. Trap bed, finely and irregularly jointed, with nodules of white saccharoidal calcite (547) seen........ 36 feet.
8. Quartzyte (548) seen........ 5 feet.
9. Conglomerate (549) seen........ 16 feet.
10. The rock No. 540, forming the great trap covering of the quartzyte hills at Grand Portage; seen 50 ft.; estimated........ 250 feet.
11. The slate and quartzyte terranes seen in the hills at Grand Portage, generally, and along the international boundary as far west as the west end of Gunflint lake, estimated........ 400 feet.
12. Jasper and iron-ore beds of the Mesabi, and southeast of Vermilion lake.
13. The micaceous and chloritic schists and slates of Vermilion lake and the dalles of the St. Louis river.
14. The mica schists, granites and syenites of the region north of Gunflint lake.

This takes no account of the great labradorite range, which in some places forms the Mesabi, nor of the iron-ore deposits of Mayhew lake, because these are apparently included in the rock Nos. 258 and 540, or in an immense outflow of molten matter at a date somewhat earlier (V. No. 695 and 816). Nor does it mention the conglomerate at Ogishke Muncie lake, because that is apparently an incident of the slaty and talcose beds included in sub-No. 13; nor the red granite of the region of Brulé Mt., because they are probably a modified condition of the Palisade rock.

Respecting the parallels of the quartzyte strata composing a part of Isle Royal, so far as found in Minnesota, the following statement is found on page 49.

Its dip, color and bedding recall the red quartzyte in S. W. Minnesota, but it is rather less siliceous than that. In the same manner, however, it overlies a coarse pebbly conglomerate, which in the same way indicates its relation to the red quartzyte of Grand Portage island and of Pigeon Point peninsula (No. 290), as well as to the sandrock and shales of Fond du Lac.

Not at that time having realized the fact of the existence of two hematite iron-ore horizons, in two separate and unconformable formations, there are some intimations of the confusion of stratigraphic interpretations which the writer discovered when the effort at general classification was undertaken. Thus, on page 94,—

The "Gunflint beds" (i.e., the jasperoid beds) south of Gunflint lake (see after No. 747) have been associated with the slates and quartzytes of the overlying formation (i. e., the Animike) rather than with the talcose, slaty beds underlying (see 426), but observations about Town Line and Ogishke Muncie lakes seem to indicate that they are here a part of a schistose, slaty formation, highly inclined, which belongs to the Huronian (i. e., as the Huronian had been described in the region) passing into the great conglomerate of Ogishke Muncie lake."

At the same time the conglomerate about Ogishke Muncie lake was regarded as a single formation, and, while in all descriptions and sections that had been given, it had, as a totality, been grouped as a part of a terrane separate from the Animike, yet there were stated to be some considerations that seem to require it to be considered a part of the Animike (p. 95); and that the horizontal slates (the Animike) as a whole may also pass into the tilted slates as a whole. It will only be necessary to state that this latter idea was one of the errors that are inseparable from the progress of any such investigation. It was recorded at the time as expressive of the stage of interpretation of the facts that had then been reached. Yet it was not wholly erroneous. The facts appealed to, conflicting as they appeared then, are facts still, and they go with numerous other observations to force the abandonment of the idea that the Animike is convertible into the "talcose" or sericitic slates and schists of the region further west, although they do become highly tilted. The former idea, however, when separated from the latter, and supplemented by further statement in harmony with a wider field of observation, has stood the test of all the study and observation that have been devoted to this point, and may be considered as a step of progress, *viz.*, The formation of horizontal slates of the vicinity of Gunflint lake and the international boundary is the same as the highly tilted slate and quartzyte formation that passes into the slaty conglomerate of the region of Ogishke Muncie lake.*

In regard to the epoch of the great outflow of the labradorite rock, the "gabbro," some general statements are given on pages 112 and 113, based on observations at Beaver Bay, which show that this rock preceded the advent of the bulk of the eruptive traps of the Cupriferous. The conclusions are in these words:

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* Prof. Irving and the Wisconsin and Michigan geologists, as well as all the Canadian geologists except Dr. A. C. Lawson, so far as known, regard these horizontal slates when broken and tilted and the tilted schists as both included in the Huronian; and Prof. Irving has referred to this hypothetical conversion of one to the other in support of that view. (Copper-bearing rocks of lake Superior, Mon. V., U. S. Geol. Sur., p. 443.)

(1) The Great Palisades are of a rock, the equivalent, geologically, of the slaty quartzyte (Nos. 127 and 528) at Beaver Bay, and below that point; and to the red syenite of the islands below Beaver Bay, and of the west bluff of Beaver bay; and to the red (often quartzless) rock associated with the gabbro at Duluth. These beds also constitute the red bluffs at Tischer's near Duluth, and New London, as well as the red rocks at Baptism river and the East Palisades.

* * * * * * * * * *

(2) The feldspar masses are of the same rock (geologically) as the Rice Point gabbro, and both are the result of copious, and perhaps one of the earliest, igneous outflows of the Cupriferous. * * * The late outflows derived fragments from the "clinker fields" and from the knobs of feldspar already formed, as they passed along; and when these had been covered by later sedimentation such sedimentary beds were also involved in the later upheavals and fusions.

The "slaty quartzyte" here mentioned as the probable equivalent of the Palisade rock, is a firm, purplish felsyte containing some angular quartz grains.

In the discussion of the question—what are the western equivalents of the Potsdam sandstone—the tenth annual report records some departures from the conclusions of the Wisconsin geologists, and reverts to the opinions expressed in the first annual report, to the effect that the Potsdam sandstone of New York is not found at all in the bluffs of the Mississippi river, but that it is more likely to be represented by the red sandstone and shales that constitute, with the associated eruptive rocks and conglomerates, the Cupriferous or Kewenawan formation of lake Superior. It maintains that the Taconic system was established correctly by Dr. Emmons, and that it is repeated in the Animike of Thunder bay, as well as in the Georgia group of Vermont. This last is an important step of progress, in the opinion of the writer, and one that no later discoveries have tended to invalidate. This conclusion was reached by a comparison of the described stratigraphy and the paleontology of the formations involved in the east, with those of the west. The Potsdam sandstone, or quartzyte, in both places lies probably unconformably over the Taconic.

The eleventh annual report, 1882,

While containing some matter relating to the mineralogy and lithology of the state, also embraces a table of the systematic geology of the crystalline rocks. This represents the "Huronian" as extending from the Potsdam formation through the

Taconic, also embracing the formation since named Keewatin by Dr. A. C. Lawson, and the mica schists since named (in the report for 1886) Vermilion group* by this survey. The black slates and the quartzytes of the Animike and the Ogishke Conglomerate are made the equivalent of some of the Taconic. This includes also the iron-bearing rocks of the Mesabi range and Vermilion lake, the "Gunflint" beds and the slates and quartzytes at Thomson. The magnesian sericitic schists of the region of Vermilion lake and north of Gunflint lake, while placed below the Taconic and above the mica schists (which are styled "Montalban?") are doubtfully supposed to represent the true Huronian.

Prof. A. H. Chester, in this report, parallelizes the iron districts of Minnesota, i. e., the Mesabi and the Vermilion ranges, both with the "Huronian," and specially dwells on the resemblance of the Mesabi iron-bearing rocks to those of the Penokee range in Wisconsin. He also calls special attention to the close geological similarity between the Vermilion iron deposits and those of Marquette.

The thirteenth annual report, 1883.

In this report is found the first statement that indicates the necessity of separating the Vermilion ore horizon from the Mesabi ore horizon. See pp. 24, 37. It is here assigned to the formation of "Huronian conglomerates and greenstones" (see Fig. 5, p. 22), the same that in the eleventh report was described (p. 170) as "magnesian, greenish, soft schists, becoming syenitic and porphyritic; seen on the north side of Gunflint lake, along the international boundary at Basswood lake, and at Vermilion lake," the formation of graywackes and sericitic schists which has since been designated Keewatin, the same that in the ninth report was said to be unconformably under the Animike at Gunflint lake.

This report also describes primordial fossils from the red quartzyte of southwestern Minnesota, the same that Prof. James Hall had classed as Huronian, and that had been also regarded Huronian by the Wisconsin geologists. These fossils are *Lingula calumet* and *Paradoxides barberi*, and the beds containing them are supposed to be represented in the lake Superior region by the red quartzyte at the head of Wauswaugoning bay and on

* About the same time the Vermilion group was named *Coutchiching* by Dr. Lawson. Am. Jour. Sci. (3) xxxiii., p. 473.

Pigeon point, which in the tenth report was supposed to be extended to Isle Royal.

The fifteenth annual report, 1886.

A large amount of field-work was done in 1886. It added much to the evidences of the correctness of the general parallelisms that had been gradually wrought out by the survey. It also introduced some new problems, and showed the necessity of instituting some subordinate divisions in the formations that had been spoken of in other reports. It also showed the necessity of abandoning some of the hypothetical parallelizations that had been entertained.

In respect to the gabbro formation, the Mesabi overflow, it was found to be indistinctly separable from another, and earlier, eruptive rock which constitutes a prime feature in the topography, and which occupies a wide belt of country running along north of the gabbro area, its line of direction being rudely parallel with the north limit of the gabbro. A general representation of the geographic areas of the various formations was attempted on a colored geological map of the northeastern part of the state. The gabbro was found to have extended so far north as to have covered from sight the line of strike of the Animike (p. 381) and to have come into contact with the older syenite (pp. 347–49). It was intimated that the Animike formation overlay one eruptive rock and underlay the other, and that it seemed to embrace the Ogishke Muncie conglomerate in its lower portion (p. 381). The entire eruptive rock was found to be in some places a remarkable agglomerate, and in various ways to become changed to greenish schists, chloritic and sericitic, and to embrace in its mass, generally in a manner of unconformity, the jaspilyte and iron-ore of the Vermilion lake region. At the same time this green rock exhibited at times very manifestly some signs of aqueous stratification; at other times no such structure could be found in it, and it merged into a dense, homogeneous, massive doleryte. The graywackes which are in this greenstone formation, fade out by merging into its evidently eruptive condition, but in many places are purely sedimentary, having much quartz as rounded grains and pebbles, arranged in sedimentary layers.

The mica-schist belt which was shown to be stratigraphically below the graywacke-greenstone horizon was named *Vermilion* group, or series. It was said to merge into the gneisses below sometimes conformably and at others to be united with them through a series of mutually intersecting dikes, the gneissic rock penetrating the schists, in their original condition probably of a basic eruptive, and the latter also cutting the contiguous gneissic masses. These rocks are both also cut by basic dikes of later origin (pp. 290–296).

The lowest rock seen was described as gneiss; but at the same time the gneissic structure was found to not always prevail. This lowest rock, which was accepted as Laurentian, is not only sometimes massive, but it is either granite or syenite, i. e. the dark mineral is sometimes mica and sometimes hornblende, or both at the same time.

The granites and syenites were not all put into the same stratigraphic horizon. The "fundamental gneiss," which manifestly lay below the mica-schist horizon, occupies a distinctly marked stratigraphic place. Such is that seen at the northwest end of Vermilion lake. Not to mention the red syenite which is intimately associated with the gabbro, and is certainly of the same date, in its present condition, as the gabbro, a further distinction was introduced by which the rock of the Giant's range, where the range consists of a narrow and abrupt ridge of granite rock, is separated from the age of the Laurentian, and is shown to be the result of local change in some bedded sediments probably later than the Laurentian — a change that, beginning with a partial crystallization of the beds *in situ* by which fine-grained, red-weathering syenite, not distinctly individualized as to its mineral constituents, was produced, and continued, under the action of the same dynamic forces, whatever they are, till a perfect fusion and subsequent extrusion and re-crystallization of the same matter were enacted. This was discussed and roughly illustrated on pp. 347 and 349. Some of the distinct observations are recorded on pp. 352 and 353. The cause of this fusion of the sedimentaries was supposed to be the great eruptive epoch of the gabbro; and this red syenite is made the parallel of the "red rock" of the earlier reports, the red quartz porphyry and the "palisade rock" of the lake Superior shore. The gabbro is not present, however, in all places where this fusion has resulted in extrusion of the acid molten rock, although it is nearly adjacent, or actually overlies the acid rock in many places. In the report this change in the ancient sediments is attributed to the contact of the molten gabbro on them, but there may be and probably are, many places where the extruded acid rock came from some greater depth, though yet within the super-crust, and its fusion and extrusion may not be attributed to immediate effect of contacting gabbro, but must be supposed to be only a part of a widespread and deep-seated metamorphic action that affected the region and culminated in extruded molten rock only along those lines where the dynamic action was most intense. Such a line of intense activity seems to be marked by the location of the narrow ridge known as the Giant's range, at least south and southwestward from Birch lake.

The sixteenth report, 1887.

The results of systematic stratigraphy contained in the sixteenth report, while varying somewhat from those of the fifteenth, in the main are concordant therewith. They were drawn from a special reconnoissance of the region of the typical Huronian, north of lake Huron, and a comparison of the results of that reconnoissance with a re-examination of the so-called Huronian of the Marquette and Gogebic iron regions of Michigan, united with previous knowledge of the region of northeastern Minnesota. In some of these results my brother and myself are not quite in concord, but these differences appertain solely to the possible parallelisms of some Michigan and Wisconsin formations with some in northern Minnesota, and on making further field examinations and research into the comparative lithology they may disappear entirely. In the following summary only those systematic results that are in harmony with the writer's convictions are stated, with some foot-notes that call attention to interpretations that are entertained by my brother.

The name Huronian, if used at all, should be applied only to the strata that were first included under the term when it was introduced and defined, and to their stratigraphic equivalents in other parts of the country. The English geologists do not recognize the formation in the British Isles, but include the strata that are presumably included under this term by the Canadian geologists, in the term Lower Cambrian, which embraces the Primordial fauna. The definition of the Huronian which has been accepted is that of Logan, based mainly on the observations of Murray in the region north of lake Huron, republished in the "Geology of Canada," 1863.* With this understanding the

*It is well known that the Canadian geologists have later extended the term widely beyond its typical region, and amplified its significance, so as to make it cover all the schists down to the gneisses of the Laurentian. Recently, however, Dr. A. C. Lawson has separated these schists from the proper Huronian, and has designated a part of them Keewatin. "Report on the geology of the lake of the Woods region." An. Rep. 1885, Can. Sur.

sixteenth report shows an effort to trace the original Huronian formation through Michigan and Wisconsin to Minnesota, and to ascertain the Minnesota equivalents of some of the minor divisions of the crystalline rocks older than the Huronian.

The Huronian, in its typical locality, embraces three principal members.

1. Red and white quartzyte, granular and sometimes conglomeritic.
2. Slate and gray quartzyte, sometimes conglomeritic, making a conglomeritic slate, or "slate conglomerate."
3. Very fine-grained gray or white quartzyte.

These are fragmental, and show every character that is known to indicate sedimentary origin. The formation embraces no mica-hornblendic schists, no sericitic schists, no typical graywackes, no gneiss or gneissic rock. The beds dip with uniformity toward the south, are cut by doleritic intrusions and are overlain by the products of such eruption. They lie unconformably on a "gneiss" which is admitted to belong to the Laurentian, from which the formation received many and conspicuous boulders. The thickness of the formation may be as great as ten thousand feet. There is considerable evidence to show that the upper quartzyte lies unconformably on the slates and slaty conglomerate, although there was no actual observation of such a relation. The formation also embraces red felsytes and some gray gabbro.

Broadly parallelized this is recognized at once as the Animike of Minnesota, embracing in that term the gabbro and "red rock" Mesabi, the Pewabic quartzyte,* the black slates and gray quartzytes and the Ogishke conglomerate. At the same time the upper quartzyte is provisionally parallelized with the true New York Potsdam sandstone quartzyte.** This quartzyte with its Potsdam characters, including a primordial fauna, is found to exhibit characteristic outcrops in Barron county, Wisconsin, southern Minnesota, southeastern Dakota as well as in New York, and in Vermont where it early received the designation "granular quartz."

Subsequently this unconformable quartzyte was traced through the Marquette iron region of Michigan, and its unconformity on the iron-bearing rocks was observed and figured at two points.

The iron-ore rocks of the region of Marquette are, in the 16th

* For a description of the Pewabic quartzyte see p. 86, 16th report.

** Compare "A great primordial quartzyte." American Geologist, March, 1888.

report, made the parallel of those of Vermilion lake in Minnesota, and hence a part of the Keewatin which underlies unconformably the Huronian. The dioritic group and the gold-bearing serpentine group of Dr. C. Rominger are, together, made the equivalent of the sericitic series (i.e., the Keewatin) of Minnesota, embracing in that the schists that hold the jaspilyte at Tower, the conglomerate of Stuntz island, the Kawasachong rock, the green conglomerates at Ely, the lower portion of the great conglomerate at Ogishke Muncie lake,* the dolomyte at Ogishke Muncie lake, and the "greenstone belt," in general, of the map accompanying the 15th report. This series of rocks is not found in the area of the original Huronian.

The iron-bearing rocks of the Penokee-Gogebic range of Michigan and Wisconsin, however, are not considered to be in the same formation as those at Vermilion lake. They are made to be the equivalent of the slates and iron-bearing rocks of the Animike of Minnesota, and hence of the true Huronian. The evidence of this need not be repeated at this place, although it is not expressed fully in the report here summarized. It will be given more fully in a later chapter in this report. †

An important point was reached, in the 16th report (pp. 97–98), in the separation of the Ogishke conglomerate from the greenstone agglomerate on which in some places it must lie unconformably. They seem to have both been affected by the gabbro epoch of disturbance, and the gabbro was found in different localities to lie on the gently inclined strata of one and the nearly vertical strata of the other.

Facts confirmatory of the origination of crystalline acid eruptive rock, both *in situ* and in form of overflow, from fragmental strata, as before reported in the 15th report, are given again on pp. 104–108 in the 16th. These fragmental strata seem to be some part of the Keewatin, and were originally conglomeritic.

Bearing on the question of the age of the gabbro-red-rock flood, which is taken by the Wisconsin geologists to be the base of the Kewenawan, or Cupriferous, of the lake Superior region, some facts were reported in the 16th report (pp. 85, 87, 88) which show that the gabbro began to be extruded during the deposition of the great quartzyte which overlies the Animike, and that the great mass of the gabbro is of not much later date, i. e., of the age

* My brother, however, regards the Keewatin schists as bearing no relation to the Serpentine group of Rominger. See p. 343.

† On the other hand my brother is disposed to regard the Gogebic ore-bearing rocks as having about the same horizon as those at Marquette, which he does not admit within the Huronian; (pp. 188 and 194). The Penokee rocks, however, he would make Huronian.

of the primordial quartzyte of the Northwest which is considered to be of the age of the Potsdam of New York and the "Granular Quartz" of the Taconic.

2. THE VARIOUS STEPS OF PROGRESS.

If we revert now to the list of problems that were unsolved touching the crystalline rocks of the state in 1872, when this investigation began, we shall see that, by the aid of the geologists of Wisconsin and Michigan, great advance has been made in settling some of the questions then pending.

1. The uncertainty respecting the possibility of making a stratigraphical subdivision of the "Azoic" of Foster and Whitney, or the "Archæan" of J. D. Dana, exists no longer. There is a more or less extended subdivision, sometimes into only two parts but more frequently into three or more, which is accepted not only by the geologists of the Northwest but by geologists who are at work on this group of rocks throughout America and Europe. So far as Minnesota is concerned this subdivision can be carried still further, and six members of the "Azoic" (if the Huronian be included in it) can be described which maintain a constancy of character and stratigraphic position extending into Wisconsin, Michigan and Canada, such that they have to have individual description.

2. The terms Huronian and Laurentian were applied to two of these parts by the Canadian geologists. Though misunderstood, by reason of the contradictory and varied definitions that have been given these terms by geologists later than the descriptions of Murray and Logan, when they are compared with the typical regions in Canada they are found to have definite and easily recognizable application to stratigraphical horizons which are extended over the whole Northwest, if not over the world.

The Huronian formation is satisfactorily established as the equivalent of the Lower Cambrian of Sedgwick. This conclusion is not wrought out in any of the annual reports of the Minnesota survey. It is an inference, however, from two other facts which have been indicated in the foregoing synopsis of the Minnesota annual reports, and it has been urged elsewhere by the writer. These two facts when united constitute a demonstration as incontestable as any mathematical formula, viz.:

The Lower Cambrian is equal to the Taconic,

The Huronian is equal to the Taconic,

ergo

The Lower Cambrian is equal to the Huronian.

We shall not stop here to bring forward anew the evidences on which these premises are based, but will proceed to mention other advances that have been made since 1872 in a knowledge of the crystalline rocks of the Northwest.*

4. The foregoing conclusion involves premises which themselves were doubtful in 1872, and which, in the opinion of the writer, are sufficiently established to be admitted as truths. The first is, that the Huronian of the Canadian geologists is the same formation which was named Taconic by Dr. Emmons of the New York geological survey. It makes no difference except in the greater difficulty involved in making this fact appear to the satisfaction of geologists, how long and how honestly the Huronian has been sustained by competent geologists, nor how long the Taconic has been as honestly ignored by the majority of opinion; if these names were actually applied to the same formation, the sooner it be acknowledged by American geologists and the proper adjustment be made in nomenclature, the better it will be for American geology and the credit of American geologists.

5. The other doubtful premise involved in the conclusion (3) above mentioned, can be considered doubtful no longer, viz.: The Lower Cambrian is the equivalent of the Taconic. There are some who bring trifling objections to the actuality of the Taconic at the horizon of the Lower Cambrian, but the evidence is so strong and is based on so large a mass of concurrent fact and testimony that it is practically demonstrated.

6. The Animike rocks having been shown, first by Prof. R. D. Irving, and subsequently by the Minnesota survey, to be the

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* On the identity of the Lower Cambrian with the Taconic, see the writer's papers:

Notes on classification and nomenclature. *Amer. Naturalist*, August, 1887.

Some objections to the term Taconic considered. *Amer. Geologist*, March, 1888.

A great primordial quartzyte. *Amer. Geologist*, March, 1888.

Report of the American sub-committee on the Lower Paleozoic, to the London International Congress of Geologists. *Amer. Geologist*, September, 1888; also the report of the Congress.

The same view has long been held by Jules Marcou, J. Barrande, and by Dr. E. Emmons, and by other geologists later. Compare S. A. Miller. The Taconic system as established by Emmons and the laws of nomenclature applicable to it. *Amer. Geologist*, April, 1888. Also A. Winchell. The Taconic question. *Amer. Geologist*, June, 1888. C. D. Walcott. *Bulletin No.* 30, *U. S. Geol. Survey*, and *Amer. Jour. Sci.*, March, April and May, 1888. Mr. Marcou's principal papers are: The Taconic system, and its position in stratigraphic geology. *Proc. Am. Acad. Arts and Sci.*, Vol. XII, 1884. American geological classification and nomenclature, May, 1888.

On the identity of the Huronian with the Taconic; see, The crystalline rocks of the Northwest, N. H. Winchell, vice-presidential address, A. A. A. S., 1884. At a much earlier date the same view was held by E. Emmons, and by J. Marcou. It has also been stated by A. Winchell in the 16th report, p. 170.

equivalent of the original Huronian, it follows that they are also the equivalent of the Taconic and of the Lower Cambrian, and belong within the primordial zone of Barrande, although the distinctive fauna of the primordial has not yet been found in the typical Animike region.

7. The Laurentian rocks, of the Canadian geologists, are divisible into three parts, having different genesis and age. This fact has not been recognized, so far as the writer is aware, except by the Minnesota survey. These three classes of Laurentian (because they have all been so styled by the Canadian geologists) have been separately recognized by different geologists, both Canadian and American, and conflicting inferences have been drawn from them, which have tended to unsettle the whole foundation on which the Laurentian rests. Some have seen valid reasons for supposing the Laurentian older than the "Huronian" and conformable with it, and have given the details of the facts which show it. But others have seen another class of evidence, equally valid, that tends to make the "Laurentian" rocks of eruptive origin and more recent than the Huronian. And again some similar syenitic rocks have been described by the Minnesota survey* mingled in great masses and areas with the Mesabi gabbro. These three classes have been observed and described in Minnesota, as rehearsed in the foregoing synopsis of the Minnesota work. It is believed that these distinctions are fundamental, and that they extend throughout the Northwest, and that when they are recognized generally by observers many of the apparent discrepances that have been noted respecting the Laurentian will disappear.

8. The Laurentian, then, is easily divisible into three parts, but it would not be claimed, probably, by any one, that the same stratigraphic term should be applied to them, and the question may fairly be considered to which of them does it belong.

Besides the subdivision of the "Laurentian" into three parts, as above noted, a different separation has been recognized by some, viz.: into *gneiss* and *crystalline schists*, on the assumption that the original Laurentian contained such schists. This is a necessary and valid subdivision, from that point of view, and was adopted by Prof. R. D. Irving. It is also approved by my brother, A. Winchell, in the 16th report.

9. The "Laurentian" is therefore partly the result of change

*It seems very likely that this so-called Laurentian has also been described in Canada in the regions where the eruptive gabbro is found.

in situ from old sedimentary strata of Laurentian age, and partly the result of eruptive forces which have caused an extrusion and partial overflow over later sedimentary strata of some of the fused material of the same old strata. Such extrusion has taken place at least at two epochs, and the later one is of the age of the gabbro and may have not risen from so great a depth as the former.

10. For reasons which have been mentioned elsewhere* it appears that by hydro-thermal fusion the deep-seated sediments of the super-crust became crystalline; also that the normal super-crust is necessarily acidic; also that any eruption from the fused portions of the super-crust would not only produce an acid eruptive rock when cooled, but that in the later history of the earth (Cretaceous and Tertiary) such acid extrusions could rarely if ever reach the surface of the earth, but would form laccolites amongst the strata overlying the zone of complete fluidity.

3. The results of the investigation so far as they appear at present.

If these steps of progress be applied specifically to the crystalline rocks of the state, we shall find some such history as the following delineated therein with greater or less distinctness.

The Laurentian age.

The name Laurentian is applied here essentially to the "fundamental gneiss." It does not go so far back as to include the first rigid primeval crust that formed from cooling nor so far subsequent to it as to embrace any noteworthy strata of basic minerals that might indicate a formation different in nature, or manner of genesis from the gneiss. In other words it does not include the "crystalline schists." The rock is essentially gneiss, either granitic or syenitic. It resulted from the fusion and recrystallization of the earliest sediments. It occupied a long period, and one that must have been marked by profound quiet, and by uniform conditions. The siliceous accumulations that were the product of oceanic waves and beaches, began in the shoal parts of the ocean and widened as the dry land increased in area, forming the nuclei of the continents. These sediments must have been siliceous, because such only would remain undissolved by the hot and finally alkaline waters of the ocean. When they

* Compare "Some thoughts on eruptive rocks with special reference to those of Minnesota." N. H. Winchell, A. A. A. S., 1888.

had accumulated to a great thickness they were buried under sediments of another kind, those of the "crystalline schists," marking the opening of another epoch in geological time. Wherever they had been raised above the level of the ocean they constituted the only land areas that existed, and perhaps till this day those areas, or some of them, have not again been submerged.

Distribution of the Laurentian in Minnesota. A large part of Minnesota is occupied by this fundamental gneiss. It is not to be supposed that all the area now occupied at the surface by this gneiss, was originally the land area of the state at the time of the close of the Laurentian age. The lapse of time has brought the earth through many vicissitudes. The original area of the Laurentian has been increased at the surface by the growth of the continent which has steadily expanded and risen higher above the ocean's level. As the later strata have successively been elevated to dry land they have been subjected to such destructive action, first of the ocean's beach-line, and afterward by the agency of the atmosphere, that they have been worn back and have uncovered the gneiss over extensive areas where it was at first hid.

In Minnesota this gneiss must have extended diagonally across the state from N. E. to S. W., crossing the Mississippi river and occupying the region of its headwaters about Itasca lake, and including the region of the upper waters of the Minnesota river. There may be spots, or considerable areas, within this original gneissic belt, where by subsequent deep-seated hydrothermal fusion these primitive Laurentian sediments have been rendered plastic and then fluid, and have by pressure been extruded through fissures in the crust to the surface, or have been uncovered as laccolites by the destruction of the overlying strata; but wherever these exist they are presumed to show their later origin by their non-gneissic structure, or by their overlying some later sedimentary strata. The distinction, however, between the eruptive condition of the fused Laurentian sediments, and the primitive sediments that have been converted *in situ* into the fundamental gneiss is one that requires more study before it can be defined. That both conditions exist there is no question; that they can always be distinguished is not to be affirmed.

This Laurentian gneiss is represented by the Basswood lake and perhaps the Saganaga lake granites, and probably by the gneisses that are found in the Minnesota valley from near Morton northwest to Big Stone lake. Northwestwardly from the Basswood area are others of similar gneiss, which have their extension northeast and southwest, nearly parallel with the extension of the other areas. Indeed the geographic distribution, no less than the geological facts that are observed in the field, favors the supposition that these alternating gneissic belts in the northwestern part of the state show either simply the denuded crests of stratigraphic anticlinals or of upward swells of the iso-hydrothermal fusion that has affected the ancient Laurentian sediments. This question is one that requires further investigation. It is referred to again uuder the head "Problems still unsolved."

Eruptive Syenite. Closely associated with these belts of fundamental gneiss are areas of massive eruptive syenite. It is a fortunate circumstance that the apex of one of the anticlinals of the gneiss runs near the present natural surface, and its manner of transition from sedimentary to crystalline rock can be observed. It would be more consistent with the tilted, even vertical, portion of the beds at the points where this transition has been observed, to suppose the change was due to the varying depths at which planes of equal hydro-thermal fusion ran below the surface at the time it took place, than to suppose it is due to an actual undulation in successive anticlinals of the same stratigraphic horizon. This favorable apex for observing the genesis of gneiss is in the line of the gneissic belt that runs southwestward from the west end of Gunflint lake, and which apparently is continued in the form of erupted syenite in the Giant's range southwestward from Birch lake. It was observed particularly on the Kawishiwi river (15th report, p. 353) and about the south shore of lake Kekekebic (15th report, p. 367; 16th report, p. 103–107). Whether that part of this gneissic belt which is referable directly to a change *in situ* in sedimentary materials be of the same age, i. e., on the same stratigraphic horizon within those sediments, as others that exist further northwest or not, they are here considered to belong to the Laurentian age in so far as they have not been entirely fused and extruded in a liquid state so as to form erupted rock.

It has already been remarked that the erupted massive form of the acid Laurentian is closely associated geographically with the gneissic. Whether they were of contemporaneous origin is not certain. But that the erupted condition was in some cases produced subsequent to the age of the "crystalline schists" is evident from the fact that such rock replaces and cuts those schists. This fact has been recorded many times. One of the most remarkable replacements of the dark schists by the bodily transference of syenite is seen north of Gunflint lake, and is described and mapped by Mr. Grant in this (17th) report. That some other areas of syenite were of considerably later date, possibly so late as to have flowed over the Keewatin (greenish, or hydro-mica) schists is indicated by observations made by H. V. Winchell along the Giant's range southwest from Birch lake, and by myself on the shores of Kekekebic lake, where a conglomerate porphyroidal rock passes into gneiss, and directly overlies some Keewatin schists. That other of the erupted syenites of the state are as late as the gabbro, and hence overlie the Animike, is shown not only by the syenites associated in mutually intermolten sheets with the eruptive gabbro that overlie the Animike, but also by the observations made at the Aurora mine in Michigan (16th report, pp. 58 and 187). This is indicated also by the observations and conclusions of Maj. T. B. Brooks and by Dr. C. Rominger in respect to the age of some of the granite rocks of Michigan.*

The age of the Vermilion schists, or "crystalline schists."

It has been remarked† that the mineralogical difference bebetween the gneisses and the dark "crystalline schists" is so great that it is allowable to attribute to the latter a different method of genesis, one sufficiently distinct to have introduced a different geological time or age. This fact was recognized in 1886, and the rocks that mark the opening and continuance of this new epoch of time were separated under the name "Vermilion group." A similar series of schists had been noted by Lawson in the region of the Lake of the Woods in 1885,‡ but, while separated by him into two parts, viz., "Schistose hornblende rocks," and "mica schists," had been by him embraced under the general term of "Keewatin series," and considered as the basal part of that series, and assigned to extra-Laurentian time. Subsequently Mr. Lawson identified the mica-schist group

*T. B. Brooks, on the youngest Huronian rocks south of lake Superior. *Am. Jour. Sci.* (3), xi, 206.
Carl Rominger. *Geological Survey of Michigan*, Vol. IV, p. 22.

†A. Winchell.

‡Report on the geology of the Lake of the Woods region. Report C. C. of the Canadian survey, 1885, pp. 37, 54.

and the basal portions of it (the hornblendic schists and the eruptive features that characterize the horizon) in the region of Rainy lake, and has given a description and a name for the mica schists. (*Am. Jour. Sci.* June, 1887, p. 473). He includes the mica schists under the term *Coutchiching*, and supposes the changed eruptive rocks which intervene geographically between them and the belt of Laurentian gneiss lying next north (along the northern shores of the southern part of Rainy lake) to be of later date than the schists.

A similar group of mica and hornblendic schists had been noted in Michigan by Brooks and in Wisconsin by Irving and been placed in the Laurentian. Rominger included the same in his "granitic group" (Geol. Mich. Vol. IV, p. 17–18). Higher in the stratigraphic series, i. e., between the magnesian soft schists and the gneiss and gabbro of the post-Huronian rocks,* another formation of mica schist was observed by them, which they placed near the summit of the "Huronian." They gave neither of these any special designation. In New Hampshire the "Montalban series" is one essentially of mica schists, but† whether it can be parallelized with either of the northwestern horizons of mica schist is a question which the future alone will be able to answer.

Hornblende schists converted to mica schists. To the writer, however, the micaceous and the hornblendic characters seem to be so blended, and the one so frequently substituted for the other, that the two parts described by Mr. Lawson appear to be only phases of the same set of rocks. The hornblendic condition, as schists, is without doubt the fundamental and primary one; and that one is found nearest the gneiss of the Laurentian. Hornblende is easily converted into biotite; biotite has so close relations with muscovite that it is sometimes twinned with it in the same crystal; muscovite is replaced both across the bedding and along the strike by hydro-mica or pearl-glimmer, and the last passes insensibly into the talcoid "Keewatin stuff"‡ of the Keewatin series. There is a conformable succession, both genetico-mineralogical and stratigraphical, from the hornblende schist through the mica schist into the hydro-mica schist, by which these are bound fundamentally into one group, as placed by

* Geology of Wisconsin, Vol. III, 1873–79, pp. 93, 145, and table between pages 436 and 437.

† Geology of New Hampshire. C. H. Hitchcock, Vol. II, p. 112.

‡ A. Winchell. Sixteenth report, p. 343.

Lawson, and no other sort of transition is known or indicated. On the other hand, bearing in mind the strong mineralogical break, or contrast, between the gneiss and the hornblende rock, there is not so close a mineral relationship with the Laurentian. There is also, in some places, as profound a stratigraphic break and non-agreement. This is shown in numerous descriptions and illustrations not only of Mr. Lawson, but also by the 15th and 16th reports of the Minnesota survey. Mr. Lawson emphasizes this fact by a remarkable inference, viz., that the Laurentian is eruptive and of later date than the Keewatin schists. Not to dwell on this inference at this time it is sufficient to call attention to it to show the probability of a plane of profound discontinuity between the Laurentian, as here defined, and the Vermilion group.*

Nature of the transition from the Laurentian to the Vermilion. As to the nature of the dynamic agent which introduced this change in the crystalline rocks at this horizon, it is indicated by the nature of the rocks themselves. Primarily they are characterized by the minerals that constitute a basic eruptive. They are found to exist at first as structureless knobs of dioryte or doleryte. These lie nearest the gneiss (15th report, p. 330). They are flanked by basic rocks of various modifications, among which hornblende schist is predominant. Gradually, on receding from these black knobs, a sedimentary structure becomes apparent, and the hornblende is replaced partially or wholly by black mica. At last the rock is changed to a nicely stratified mica schist which at first is perhaps very dark-colored and firm, with little free silica, and subsequently, with an increase of silica, is striped with distinct strata of granular silica. As the dark mica still further fades out the mass is converted to a fine granulyte or quartzyte, or a light-colored mica takes its place and the whole passes into sericitic schist or graywacke.

It is not always the case that all evidence of molten condition is wanting at this horizon of transition from the gneiss. But it is very slight at most of the sections which have been described.* If, however, but a single unquestioned occurrence of eruptive conditions be found at this point it is sufficient to warrant the hypothetical introduction of a general eruptive epoch,

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*Compare, A. Winchell; 15th Report, pp. 41, 43, 87, 97, 180: H.V.Winchell; 16th Report, pp. 407, 416, 417, 419, 455, 456: N. H. Winchell; 15th Report, pp. 291, 338, 349; 16th Report, pp. 76-77: M. E. Wadsworth; 15th Report, p. 331.

*Compare, however, Lawson, Can. Rep. 1885. C. C. p. 41; Am. Jour. Sci. June, 1887, p. 477.

so widespread as to constitute a change from one system of rocks to another. No one can read the descriptions given by Mr. Lawson, or some of those contained in the 15th and 16th reports of the Minnesota survey, without recognizing not only one point but numerous points where eruptive characters are stamped at this horizon not only on the basic rocks of the Vermilion but also on those of the acidic "Laurentian." They mutually interpenetrate each other in the form of transverse dykes and mutually embrace isolated fragments separated each from the other. It seems to be abundantly demonstrated that some sort of dynamic change was introduced. The only inference that such a demonstration points to, in the light both of the contrasted lithology and the interrupted stratigraphy, is that of volcanic action.

Having now fairly stated the nature of the change which is presumed to set off the Vermilion rocks from the Laurentian, it is necessary to consider, further, whether the gradual and conformable conversion of the Laurentian beds into the Vermilion, such as has been seen at many places, and which indeed is the most frequent manner of transition,* is consistent with the hypothesis of an epoch of eruption. It should be remembered that the beds do not now hold the position they had when they were deposited. They stand now nearly vertical. While this upturning facilitates the deciphering of their history, it has been accompanied by such changes in the crystalline condition of their elements that a screen that partially conceals their history has been thrown over them all; yet through this screen can be seen the outlines of their historic and dynamic genesis.

Admitting the actuality of a period of volcanic action at the opening of the Vermilion age, it is evident that the eruptions would take place only at centers of intensity of pressure. Once located, such vents would for longer or shorter periods continue to send forth the eruptive matter. In the presence of the almost world-covering ocean these materials would be at once distributed, dissolved, deposited, in the same manner as sediments at the present day, excepting only that probably the solvent power of the ocean's waters was greater than at the present time. The former sediments having been almost wholly of an acid nature,†

* Mr. A. C. Lawson has described such in his report on the region of the Lake of the Woods, pp. 73, 76, 83. See also A. Winchell; 15th Report, pp. 97, 101, 178; 16th Report, pp. 264: H. V. Winchell; 16th Report, pp. 405, 415, *et passim*: N. H. Winchell; 15th Report, pp. 296, 298; 16th Report, pp. 69, 70, 76.

† That is, containing over 60 p. c. of silica.

such that when crystallized again they constitute the fundamental gneiss, they must have been accumulated slowly. But on the advent of this new supply of material, which is so rapid that it can not all be worked over by the ocean so as to be dissolved and its alkaline elements extracted, the erupted materials are thrown down in the condition of stratified sediments, retaining to a great extent their chemical composition. In the periods of comparative quiet these basic materials are interbedded with more siliceous materials, such alternations taking place as long as the supply of basic material is intermittent. Thus might be formed a great series of strata, surrounding the volcanic centre, thousands of feet in thickness, which would be made up of variously interstratified or mixed siliceous and basic sediments. Sometimes there would be intrusions of purely basic doleritic rock among these sediments, at different horizons, due to the bodily overflow of sheets of lava among the sediments,* in a manner similar to the interbedding of trap rock in the Kewenawan at a later date. In other places these eruptions might take place somewhat later, involving in fracture, upheaval and mixing the last made strata in forms of various fragments and breccia in the molten rock that escaped.** Such an epoch of disturbance, sufficient in its force to cause the outflow of basic rock from a deep source, would probably be sufficient to fuse and cause the outflow of some of the sedimentary rock that already had been formed. Thus the basic and acid rock would mutually interpenetrate, and a series of fractures which would be filled by the injection of any fused material that was adjacent, would be perpetuated to the remotest time in the form of transverse and more or less concordant dikes and by breccias composed of the two rocks.

It is manifest, therefore, that the supposition of the advent of a characteristically eruptive era, closing the quiet Laurentian sedimentary age, will account for both an unconformable and a conformable transition, such as are seen, from the Laurentian to the Vermilion.

Effect of hydrothermal fusion. It is necessary, before proceeding to the consideration of the next age, to call attention to another great fact in connection with the history of the Vermilion. Nothing is more evident to the geologist who carefully

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* H. V. Winchell seems to have encountered such in that great extension of the Vermilion northwestward from Vermilion lake to Rainy lake. See, specially, 16th report, p. 425.

** See the 15th report, p. 333, and p. 337.

inspects the Laurentian and Vermilion strata, than that they have had, in some respects, a common experience. This, however, is subsequent to the date of the origination of the rock masses, and has had a tendency to so unify their mineral characters as to blend them, in the opinion of some geologists, indissolubly into one system. They contain, excepting the eruptive diabases, etc., at the base of the Vermilion,— essentially the same mineral components; but those components are differently distributed and exist in very different proportions. These minerals are interlocked with each other in crystalline contact. It is very difficult to affirm, in many places, any fragmental grains. They lie in such continued parallelism in long sheets that there is no natural agent except sedimentation that can be appealed to to account for the stratification. The strata do not consist of individual minerals, that is, any single stratum may contain several minerals, but they change in relatively proportionate amounts in a direction across the strike, and this slow change, which on weathering brings out either light or dark bands, is so gradual that some of the strata or some parts of the strata, can not be separated from the others by any accepted designations. Within the same band the gneissose aggregation changes to a schistose. While in a general way it may be said that the mica schist alternates with what Mr. Lawson has conceived to be a series of thin gneissic dykes in as many sedimentary beds of mica schist, it is equally true, and equally as evident on inspection, that the schist fades out across the beds, into gneiss by a change in the relative amounts of the constituent minerals. It is very certain that if the schist, in such places, be attributable to sedimentary origin the gneiss is equally so.* Indeed often within the gneiss itself are distinguishable narrow, parallel belts of varying color and lithology at some distance from the horizon at which the general gneiss mass began, which must be attributed, as certainly to the same cause as in the schist. These only lack the dark coloring minerals to show their nature more evidently, and their similarity of origin with those unquestioned parallel belts that mark the schist.

This crystallizing and unifying of the mineral characters must have taken place in these strata while they were yet buried at considerable depth below the surface, or at least at such a depth that they were affected simultaneously by hydro-thermal fusion.

* Compare H. Reusch, *Boemmeloen og Karmoen med omgivelser geologisk beskrevne* (English summary), p. 389, 1888.

Whether before, during, or subsequent to the process of upturning which has brought them both to a vertical attitude, it is not necessary here to inquire. Indeed, this is yet one of the "unsettled problems."

The Keewatin schists.

This term is here used in a sense somewhat restricted from that in which Mr. Lawson first applied it, inasmuch as it does not include the crystalline schists. This change, however, will doubtless be considered allowable, since Mr. Lawson himself seems to have separated the original group into two series by the application of a distinctive term to the mica schists — the Coutchiching.*

Conformable transition from the Vermilion. It has already been stated that structurally there is a conformable transition from the Vermilion to the Keewatin. This has been found to be the case without exception, so far as the Minnesota survey is concerned, and it seems not to be contradicted by any facts reported by Mr. Lawson. Indeed, so far as Mr. Lawson has reported any facts,** they tend to harmony with the facts and conclusions of this survey. Very favorable opportunities have been afforded for the minute inspection of these beds where they pass to the Vermilion, in many places, and they are reported in the fifteenth and sixteenth reports. There have been five different geologists, engaged within the last three years by the Minnesota survey, who have made independent examinations at this horizon of transition, and at separate places, and in every instance they have reported a gradual and conformable transition from the Vermilion to the Keewatin.

There is also a corresponding gradual change in the crystalline condition and the composition of the beds. While the materials are referable very largely to the same source as the materials of the Vermilion, there is an increase of quartz and a loss of mica in ascending in the strata. The schists become sericitic, or chloritic, or argillitic, and are interbedded with graywackes and agglomerates; the last prevail near the top and indeed seem to have introduced the marked eruptive characters that distinguish the next formation.

Nature of the Keewatin rocks. It appears, from the character of

* Am. Jour. Sci., June, 1887, p. 477.

**Am. Jour., June, 1887, p. 477.

the rocks of the Keewatin, that active volcanic vents existed throughout the whole period, and that the ejectamenta were received in the waters of the surrounding sea. The strata contain much silica, in rounded grains and pebbles, indicating the waning of the volcanic supply and the influx of sedimentation similar to that accumlated during the Laurentian. There are dykes and various diabasic rocks associated with the Keewatin strata, some cutting transversely and some nearly, but not quite, parallel with the strike, some of which are certainly of a later date, but of which some seem to belong to the age of the Keewatin. Whether any of these have any possibly traceable connection with some of the old volcanic vents, existing within Keewatin time it is not now possible to state, but it is very likely that such connections will ultimately be established. At any rate the Keewatin closed by a renewal of active eruption as profound in its energy and its effect on the pre-existing strata as that which marked the close of the Laurentian. In the vicinity of Tower and thence eastward the rocks that evince this epoch of volcanic eruption have been insepcted at many places, and they are described with accompanying illustrations showing the crumpled and faulted condition of the earlier aqueous strata, in the fifteenth annual report (pp. 223–275). The rocks which resulted from this renewal of igneous forces form a conspicuous series and they have been traced almost continuously from Tower to the vicinity of Gunflint lake where they pass below the Animike. They show the same confused blending of stratified with massive rock as has been mentioned at the base of the Vermilion. In many places they constitute hills that rise one hundred to three hundred feet above the adjoining lowland levels, and consist of a greenstone that exhibits all the outward characters of diabase or doleryte. At many places this greenstone is agglomeritic, some of the stones showing, by a periphery of amygdaloidal structure, that they were immersed in a magma that differed from them in the amount of contained heat, or in their capacity for receiving and transmitting heat. The massive structure sometimes embraces large fragments rent from beds of stratified structure, and the massive structure itself sometimes acquires a faint lining and then a distinct banding which cannot be attributed to any other known agent than sedimentary action. The greenstone is frequently jointed in a columnar manner, forming basalt, in which cases it seems necessary to regard it as a primary basic eruptive. All the other modifications and exceptions which this greenstone exhibits causing a departure from the characters of a normal basic eruptive are to be referred to the action of the ocean on the erupted materials, or on the local rupture of the pre-existing strata and the mingling of the fragments with the new materials. It is evident that in some places these fragments would be gently covered and inclosed by new sedimentation (and such instances are shown on the south shore of Vermilion lake) producing the curious alternations of breccias and parallel strata, all of the same kind of rock, which have excited the wonder of more than one geologist. It is equally evident that in other places these fragments would be covered by an overflow of erupted material that did not come into contact with the ocean's distributing action, and there would result a basalt containing angular masses of fragmental strata. It has been observed that apparently the most massive rocks of this epoch change by weathering into a green chlorite or even a sericitic schist, when they occupy the lower levels and come into contact with water, or where they are subjected to unsheltered exposure to alternating frosts and moisture. In this case the original rock shows, sometimes, a sedimentary banding, and the schistosity that results may or may not coincide with the direction of this banding. Throughout nearly all the region where this greenstone prevails, the schistosity has a prevalent direction northeastwardly, and that is also the direction of the general strike of all the sedimentary rocks; but there are exceptions in the case of the sedimentary strike, which are more numerous and extensive than any that have been found in the direction of the schistosity. The ease with which this schistose structure is developed on weathering, seems to vary with the composition of the rock, or at least with its original structure. Where the greenstone is evidently a true eruptive basalt which has never been subjected to the distributing action of sedimentation the schistose structure is faint, or is wanting, and rounded knobs of structureless massive rock rise above the general level of the country. When there is an intimation of the primeval action of water on the constituents of the rock at the time of their deposition, evinced either by the presence of siliceous grains, the inclosure of fragments of stratified masses, a generally lighter green color in the whole mass, or in an indistinct banding like sedimentary structure, the schistose structure is more quickly developed.

Vermilion iron ores. The Keewatin is the iron-bearing formation of the region of Vermilion lake. It contains the jaspilyte lodes which have been described at Tower in the 15th annual report. But it should be stated that these lodes seem to prevail in those parts of the formation that show most evidently the characters of massive and original eruptive rock, i. e., in the later portion. The knobs of jaspilyte at Tower are embraced in and penetrated by a green schist which at the surface is easily excavated, when a schist, but which at greater depth sometimes becomes a massive green rock, and which in the main must be considered an original eruptive. At short distances from the knobs, even on the slopes an evident sedimentary structure supervenes, the beds being nearly or quite vertical.

Origin of Jaspilyte. It is not necessary here to reconsider fully the question of the origin of the rock known as jaspilyte. Various considerations are given in the 15th report that go to show that it is of sedimentary origin, embraced as foreign masses in the green eruptive rock of the region. Much more study has since then been given to the subject, and while the facts and arguments then relied on are still valid some other problems have arisen which need to be solved in order to make the hypothesis of its sedimentary origin entirely satisfactory. They can be briefly referred to, viz.:

Why is the silica of the jaspilyte so uniformly of very fine grain, and of so uniform a grain?

Why does the jaspilyte accompany the most evidently eruptive parts of the Keewatin, and why is it not found in important masses in those parts that have plainly a sedimentary structure?

It seems quite remarkable that the jaspilyte, on the sedimentary hypothesis of its origin, should not vary perceptibly in the size of its siliceous grains. Reference is here made to the ultimate quartz grains into which it disintegrates on being long-weathered. When, in the stratified schists, some small pebbles from the jaspilyte are disseminated in the manner of sedimentation, the pebbles themselves, as constituent elements in the stratified mass, are seen to vary in size considerably, some of them being no larger than the eye of a needle, and others as large as pease, or even much larger. The same is true of pebbles of other silica, such, for instance as those of segregated or chemical silica which does not show the finely granular structure. But when these pebbles of jaspilyte are examined more closely they are found to be made up of almost microscopic quartz grains of the same size. The question refers to the size of these

If they are the product of sedimentation, it would be in accordance with usual observation that they would have been collected and deposited under the action of varying currents and would vary in size from place to place, or from structure to structure (within certain limits) and some of them would be expected to be mingled with other sorts of sedimentary materials. Some observations have been made, indeed, which indicate the mingling of fine siliceous grains, supposed to be the same as the fine grains of the jaspilyte, with the sedimentary green schists in the vicinity of Tower,* but in these cases, and especially in the case of principal masses of jaspilyte that are mined at Tower, it is not yet sufficiently shown that the ultimate grains of which the jaspilyte consists, manifest such a variation as is here indicated. Indeed it is quite possible that all the siliceous grains that are seen disseminated through the green schists, as seen at Tower, are compound grains, derived as fragments from jaspilyte that preexisted as such, and that each one can be reduced, on examination, to the same minute granules as the jaspilyte itself. Therefore the question remains unanswered—why are the ultimate granules of the banded jaspilyte of so uniform a size, and so uniformly fine?

Again, it seems quite remarkable, on the sedimentary hypothesis of the origin of the jaspilyte, that it should be found, in its most typical forms and largest amounts, embraced in a rock which manifests the least of the characters that indicate sedimentary forces, and surrounded by rock that manifests unquestioned, or almost unquestioned, eruptive forces in its manner of origin.† This association is hard to explain except on the eruptive hypothesis for the origin of the jaspilyte. It might be said, with much reason, that in the midst of the basic eruptions, or at intervals of rest from basic eruptions, some acid eruption took place, and that the erupted matter assumed such forms, and such relations to the basic, whether in the presence of oceanic waters or on land, as the circumstances required, in just the same manner as the materials of basic eruption. To this the mineral nature of the jaspilyte is the greatest obstacle.

Name. The massive "greenstone" stage of the Keewatin has no distinctive name. It has sometimes been referred to as the

* Fifteenth report, pp. 226-230.

† Attention has been called to the distribution of the jaspilyte masses by Mr. H. V. Winchell *American Geologist*, January, 1889. *The diabasic schists containing the jaspilyte beds of northeastern Minnesota.*

"Kawasachong rock," since it forms the falls of that name at the mouth of the Kawishiwi river, on the south shore of Fall lake. But it is not desirable that such a name be perpetuated. *Kawishiwin* would be better, and it would be appropriate since this river runs for many miles, and some of its tributaries for many more, over rock belonging to this epoch of the Keewatin.

Parallels of the Keewatin. The writer has seen at but one place in the Northwest, outside of Minnesota, what he believes is the stratigraphic equivalent of the Keewatin. This belief rests entirely on lithological resemblance, with some general stratigraphic parallelism. In general, the groups which Dr. C. Rominger has described as "serpentine group" and "dioritic group,"* in the region of Marquette, exhibit the characters of the Keewatin. There may be, as thought by him, an essential difference between the dioritic and the serpentine groups, but their affinities are very close, and indeed nearly all the characters, in limited areas, are found in the Keewatin. The serpentine rocks may ultimately be found to consist of the old volcanic cones, now tilted to lie at an angle of 90 degrees, more or less, from the position they originally occupied, from which issued the ejectments that were consolidated to form the dioritic schist group. In that case they would fundamentally be of about the same age as those schists. However that may be, no one can read the careful description of the dioritic group by Rominger, be he familiar with the Keewatin, without being struck with the great mineralogical similarity. (See also 16th report, pp. 47–48.)

There is, however, an important evidence of this parallelism to be drawn from a comparison of the stratigraphy. In the Marquette region the mica schist group is but feebly represented, and is not at all shown by Rominger on his map of the region. It is included by him in his granitic group. But the dioritic group comes at once into contact with the granitic rocks of the "granitic group." This is shown to be interbedded sometimes with the base of the dioritic group, and the granite to be apparently produced sometimes by the fusion and extrusion of some of the beds of the dioritic, or from some of the lower strata, forming knobs and sudden enlargements of granitic rock within the schists of the dioritic group.† The same kind of indistinct, incipient crystallization as described by him has been noted at about the same horizon in the schists of the Keewatin north of

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* Geol. of Mich., Vol. IV, pp. 22, 24, 26, 27.

† Geological survey of Michigan, Vol. IV, 1881.

Gunflint lake, and between Ogishke Muncie and Kekekebic lakes, and the same gradual inter-bedded transition from the schists to a sub-granitic rock. In the same way also great overflow areas of acidic syenite or "granite" are found in connection with both.*

But the most remarkable stratigraphic coincidence is the relation of the Keewatin and the dioritic group to the overlying formation. In Minnesota it is the iron-bearing Animike, and at Marquette, it is the "iron group," of Rominger. This relation is one of unconformity. For evident reasons, which need not be elaborated here, the "iron group" of Rominger is considered to be on about the same stratigraphic horizon as his "arenaceous slate group." They are not shown by him to be distinct, although he supposes them to be separated by the "quartzyte group," and in both of them are found important bodies of ore in the Marquette district. They have the same relations to the dioritic group, as described by him. and their geographic distribution, as separately delineated on his geological map, especially when taken in connection with his geological descriptions, is inexplicable on the supposition of their separate identity.

In the light of what has been published by the Minnesota survey respecting the unconformable superposition of the Animike over the Keewatin, nothing further need be said as to that fact. But when this unconformity is extended to the Marquette region, and the iron-ore beds there so much worked are placed above that line of unconformity, it may need a concise statement of the evidence to make it appear plausible. While it is in perfect accord with the published conclusions of the Michigan and Wisconsin geologists, to put the ore-bearing rocks of those states in the "Huronian," it is not in accord with them to separate that horizon from the dioritic schists which really embrace an ore horizon of an older date, by a plane of unconformity; but under the term "Huronian" have been grouped, in one essential concordant series of strata, all the rocks of the district younger than the fundamental gneiss or the Laurentian. Later Dr. Rominger has stated that some of the granite of the district is eruptive and of later date than the associated schists. (Geol. of Mich., Vol. IV, pp. 17 and 22.)

The reader is therefore referred to the following quotations

* The hematite lodes at Tower seem to have their representatives in the dioritic group of Rominger, but they have not proved productive enough to support regular mining. Such are mentioned by him on pp. 25, 27, 29, 30.

from the descriptions of Dr. Rominger of the relation of the "dioritic group" to the overlying "iron group" and "arenaceous slate group."*

Page 72; Speaking of the surface rock of the environs of Negaunee and Ishpeming, which belong to the "iron-ore group," he says: "The strata are in an exceedingly disturbed condition * * * These disturbed beds lie, in every instance, directly, but very often unconformably, on chlorito-hydro-micaceous schists, or on crystalline dioritic masses which are constant associates of these chloritic schists." * * * "Overlooking the extremely plicated and corrugated condition of the strata, they form, considered in their totality, a synclinal basin, hemmed in between dioritic ridges."

Page 76; "The discordance existing between the dioritic and the iron-bearing rock groups is obvious in the majority of natural or artificial exposures, although it often occurs that they adjoin each other in parallelism."

Page 82; "The ore-bearing beds in the lake Superior mine lie in a steep inclination, with northern dip directly on the diorite, or on schistose beds belonging to this group, but in other parts of the mine the strata are seen to be bent and folded repetitiously, and to dip in the most irregular way."

Page 83; "The deposits visibly underlie the jaspery massive rock-ledges and repose in a much corrugated condition on the schists of the diorite group."

Page 86; "In the abandoned pits of the old Tilden mine, and in several neighboring natural exposures, the ore-formation is found to repose on the diorite, or on the schists belonging to this group, but, as it seems, always in discordance."

Page 108; Speaking of the "arenaceous slate group," he says: "The strata lie on the side of a diorite hill dipping under a low angle toward it in a northern direction, and a few hundred steps further east another body of these ledges lies in a slanting position on the diorite."

Page 114; "On the south side of the large cluster of diorite knobs, north of the New York mines, we generally see the ore-formation in direct contiguity with the diorite; but on the higher part of one of the rock bluffs another kind of stratified rock [i. e., the arenaceous slate group. N. H. W.] is found to repose on the diorite in seemingly discordant position."

These statements are sufficient to show that in the Marquette region there was a profound break, or unconformity, that separated the dioritic group from that next succeeding, as marked and as general, as that which separated the Keewatin from the Animike. The fact that it has not generally been recognized, and when so observed that its significance was not noted, may be explained by the great confusion that prevails at Marquette in all the dip and strike of the rocks, due to disturbances that involved both the older and the later terranes.

Further evidence of this parallelism is found in the fact that,

* Geology of Michigan, Vol. IV, 1881.

in the same manner the Keewatin, and the "dioritic group" of Rominger, are unconformably overlaid by a more recent quartzyte, as will appear later in this review.

Jaspilyte is in the Keewatin and the dioritic group. There is a general lithological resemblance as already noted. It will be necessary here only to call attention to one. The Keewatin contains the typical jaspilyte deposits of Minnesota—i. e., those that have chalcedonic silica as their chief characteristic, and occur in curiously ribboned contorted bands or masses, affording a hard specular hematite. Although Dr. Rominger does not employ the term *jaspilyte*, he seems to make several references to it in connection with his account of the dioritic group. Such references may be found on pp. 27, 29, and 30. In other places it seems as if the descriptions that he has recorded of the phenomena of the iron mines, all of which he supposes to be in the "iron group," and not in the dioritic group, can apply only to the dioritic group. This is true particularly of some of those in the vicinity of Ishpeming. Dr. M. E. Wadsworth's observations and figures* seem to indicate the same. The manganesic soft hematite, and the limonitic ores, which are also "jaspery," are not believed to belong to the same formation as the hard jaspilyte-hematite, but to the overlying "iron group." It is true, however, that it is impossible, at present, to indicate fully the petrographic difference that may distinguish the jaspilyte-hematite of the Keewatin from the jaspery beds of the iron-ore group. That will be subject for further study.†

Possibility of rocks younger than the Keewatin, before the beginning of the Taconic. We have seen that the Keewatin was terminated by an increased eruptive activity, producing distinctively, in Minnesota the "greenstone range," or the Kawishiwin rocks. We have no distinct knowledge of any later sedimentary beds prior to the unconformably overlying Taconic (or Animike). There are, however, some problematical rocks that different members of the Minnesota survey have noted whose position in the stratigraphic column has not been determined. They have been designated *muscovado rocks*, and in some places they hold a position

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* Notes on the geology of the copper and iron districts of lake Superior. *Mus. of Comp. Zoology.* Geol. Series, Vol. I.

† The reader is referred to the rock "talcose conglomerate," described by Dr. E. Hitchcock in the *Geology of Vermont*, for a probable New England representative of the Stuntz conglomerate of the Keewatin. Indeed there is great reason to suspect that the Keewatin horizon in all its features exists in the "talcose slates" of western New England.

some distance south of the strike of the Kawishiwin and spread over several miles of area. It is not intended to discuss them here at any length. They may be some part of the Taconic, and it is only suggested that they may be a sedimentary formation that accumulated subsequent to the Keewatin before the submergence that brought the Taconic unconformably over it.

The age of the Taconic (Animike, Huronian).

How long an interval of time passed, and what its events were, separating the Kawishiwin epoch from the Taconic, it is impossible to state. But it is evident that there was a great change in the surface of the earth, wherever this succession is found, which tended to allow not only submergence of some of the pre-existing land area, but such general quiet, speaking broadly, as would allow slow sedimentation, and apparently the growth of plants and animals. The black carbonaceous shales and slates, or in other places the graphitic character of the rocks of the Taconic, where, as on Pigeon point, they have been metamorphosed, sufficiently indicate the presence of plant life in the Taconic. In other places faint tracings of rude forms, apparently of vegetation, have been observed on the sides of some of the black slates. But of these forms none from Minnesota have been carefully examined and described.* Of animal remains none have been found in Minnesota that belong in the black slates, but in the quartzyte overlying, some primordial fossils have been found† corresponding with the fauna of the Paradoxides horizon of eastern North America, indicating, so far as this evidence goes, the age of the "Granular Quartz," and of the Red Sandrock of Vermont. This formation seems to be represented in the Rocky mountains, where the primordial fauna has been mentioned by Mr. R. G. McConnell ‡ along the line of the Canadian Pacific railroad. Still earlier Mr. C. D. Walcott described it in Nevada. § There is no doubt that this formation is widespread. The coincident identity of the old Taconic with the "Lower Cambrian" and the Huronian need not be discussed here, and those who believe that these represent different rock-horizons will, of course, not accept the generalized

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* Sixteenth report, pp. 78, 239.

† Thirteenth report, p. 65.

‡ Geol. Sur. of Can., 1886. Rep. D., pp. 29-30. Am. Geol., January, 1889.

§ Thirtieth bulletin, U. S. Geol. Survey.

history that is here indicated. To the writer there seems to be no way to group the terranes that are found in the Northwest, subsequent to the Keewatin, belonging in that general horizon that has been accepted widely as "Huronian," except to make them the parallel of that earlier-named system which was so long studied by Dr. Ebenezer Emmons, and by him named Taconic.

The opening of the Taconic. So far as we know the Taconic was characterized, from New England to the Black Hills, by an epoch of increased submergence beneath the ocean. There is great reason to believe that all the earlier formations of the super-crust had been subjected to great flexure and uptilting before this submergence. In Minnesota the underlying beds are almost vertical, nearly everywhere, and the Taconic beds dip at angles generally less than 30°. It can hardly be supposed that throughout so great an area the subjacent strata could by any transformation be placed in verticality beneath the Taconic since the deposition of the latter, without equally disturbing the Taconic also. Indeed when such rupturing of the strata, since the deposit of the Taconic, has been observed, as in the region between Ogishke Muncie lake and Gabemichigama lake, the disturbance has involved the Taconic rocks also, and has turned them into various and excessive dip. Such exhibitions, however, are exceptional, so far as observations already made in Minnesota indicate. The Taconic strata maintain, both in Minnesota and Wisconsin, as in the Mesabi and Gogebic-Penokee ranges, a regularity of dip and strike, and a low angle of inclination which are not seen in any of the older rocks.

There is a conglomerate at the base of the Taconic. This is a fragmental, sedimentary conglomerate, embracing numerous rounded fragments from the earlier formations of the region. The lowest stratum seen in the Huronian, in the region north of lake Huron, is reputed to be a quartzyte which varies to a quartzose conglomerate, and by the accession of organic matter assumes a dark color, becoming a "slate conglomerate." In the latter form it has a wonderful development, both in Canada and in Minnesota*. It is the Ogishke conglomerate, of the Minnesota reports. It seems to be the Missasaugui quartzyte and the slaty conglomerate of the original Huronian area. This conglomerate is followed by an immense thickness of dark slaty

* On the passage of the quartzose condition into the slaty, each being pebbly, see Logan, 1863, Geology of Canada, pp. 55, 56, 594.

rocks, often cherty, or flinty, frequently very dark-colored, generally siliceous, alternating with thin quartzytes, and grayish feldspathic quartzytes, all in conformable stratification, as a whole. Variously interbedded with these slates and quartzytes, from bottom to top, are beds of basic eruptive rock, and it is necessary to suppose that such eruptions must have been accompanied, in some places, by extensive disturbance and metamorphism. As a group, however, the Taconic strata sustain a uniformity of lithology, within allowable limits of variation, which marks them as one great series, which experienced essentially the same history over very extensive parts of America, and in that respect they show the same individuality as the Keewatin and the Vermilion, which names cover respectively the subcrystalline (earthy) and the crystalline schists of the Northwest. The Taconic is essentially the Olenellus group of strata of the primordial.

The iron ores of the Taconic. The Taconic is the chief iron-bearing formation of the Northwest. It is the "Huronian" iron-group of the Marquette region, the Penokee-Gogebic range in Wisconsin, and the non-titanic ores of the Mesabi range in Minnesota. The writer is not familiar with the Menominee iron district in Michigan and Wisconsin, but the described characters and the parallelisms that have been claimed of the Menominee rocks by Brooks, Rominger and Irving, with those at Negaunee, sufficiently show that, as claimed by Emmons and Houghton in 1846, the Menominee rocks are also of the Taconic.* The numerous important iron-ore deposits that have long been known, and formerly extensively exploited in eastern New York and western Vermont, Massachusetts and Connecticut, embracing hematite and limonite, often manganesic, afford parallels with the iron-ore deposits of the Northwest that are here classed in the Taconic. Some of the descriptions of the ore-pits of Washington, St. Lawrence and Dutchess counties, of eastern New York, recorded by Mather and Emmons in their reports on the geology of those counties are applicable, in many respects, to those of the Penokee-Gogebic and the Mesabi ranges in the Northwest.

The Granular Quartz. As used here the term Taconic does not embrace the "Granular Quartz," of Emmons, as there is sufficient evidence, in the writer's opinion, for making that the par-

*Agriculture of New York, 1846, Vol. I, p. 101.

allel of the true Potsdam of New York state.* The chief reasons for this separation may be given.

(a) *The stratigraphic relations of the Granular Quartz and the Potsdam of N. Y. are the same.* In the first place they are seen to lie unconformably on the older "granite," one on the west flank of the Green mountains, and the other on the northern and eastern flanks of the Adirondacks; and in the second place they bear the same relation to the Red sandrock of Vermont. By Dr. Emmons the Red sandrock was regarded the equivalent of the Potsdam and Calciferous sandrock, but it is described by the Canadian and Vermont geologists as Potsdam. Emmons, Logan, Hitchcock and Marcou agree in making it unconformable on the underlying slates,† but Mr. Walcott fails to find the unconformity at the point described by Marcou.‡

It seems, however, that the preponderance of evidence is in favor of such unconformity, especially when it is further considered in its agreement with observations supposed to be at the same stratigraphic horizon in the Northwest and in the Black Hills. The Potsdam is therefore here the Red sandrock, and unconformable on older slates. But by the discovery of the same fauna in the Granular Quartz and in the Red sandrock Mr. Walcott has shown that these are stratigraphically the same formation. Therefore the Granular Quartz must lie unconformably on other terranes than the "Primary" of the Green mountains.

(b) *While the fossils of the Granular Quartz are cognate with those of the Red sandrock, they are also cognate with all that have been found in the true Potsdam.* They are, however, essentially different from those of the so-called Potsdam of the Mississippi valley. This need not be amplified. It is based on one of the cardinal distinctions that subdivide the primordial fauna.

(c) *The Red sandrock overlying the Georgia group unconformably, as already stated, the Granular Quartz and the Potsdam must have the same stratigraphic position.* While this has not been observed in New York and Vermont (or when so seen the overlying strata were considered to belong to the Red sandrock) it has been observed to be the relation subsisting between an identical quartzyte in the area of the original Huronian, in northern

* Bull. No. 30, U. S. Geol. Sur. p. 18.

† Geology of Vermont, Vol. I, pp. 260, 317. The Taconic of Georgia and the report on the geology of Vermont, *Mem. Boston Soc. Nat. Hist.*, *Vol. IV.*

‡ American Geologist, March, 1888. A great primordial quartzyte.

Michigan, and in northeastern Minnesota, and a series of slates underlying. In other words; The Thessalon quartzyte of the Huronian overlies (probably) unconformably the Plummer argillytes. The Pewabic quartzyte and the Wanswaugoning quartzyte overlie the Animike in northern Minnesota, but the exact contact has not yet been observed; while in the Marquette region the "quartzyte group" of Rominger overlies unconformably his "iron group."*

If we carry the comparison further:—

(d) *The stratigraphic relations of the Granular Quartz and Potsdam to the "granite" are the same as those of a great primordial quartzyte of the Northwest to the "granite."* This western quartzyte has been designated, not only Potsdam, but Sioux quartzyte, Baraboo quartzyte, New Ulm quartzyte, Barron county quartzyte, Wanswaugoning quartzyte, as well as Pewabic quartzyte, and in numerous instances it has been observed to lie unconformably on the granite supposed to be of Laurentian age.

This comparison could be extended to include the Black Hills of Dakota and the primordial section of Nevada, and it would appear that the relations here pointed out for this quartzyte are of wide application and mark it as a formation of continental extent.

(e) By Mather, Rogers, and others who have opposed the Taconic system the Granular Quartz was referred to the Potsdam sandstone.

These considerations seem to justify the conclusion that, contrary to the opinion of Dr. Emmons, the Granular Quartz should be placed at the top instead of at the bottom of the Taconic system, and that the Taconic black slate underlies it unconformably. This does not disturb his general idea that the Taconic is a sub-Potsdam formation, even using the term Potsdam in its original sense as here defined. It is, furthermore, in accordance with the views of the Swedish geologists to find the quartzyte (Paradoxides) horizon, lying above the Olenellus beds, and indicates that the Braintree (Mass.) quartzytes overlie the Braintree slates.

[NOTE.—The only intimation that the writer has been able to find that the Granular Quartz and the Red sandrock had ever been regarded the same formation by the early geologists is a statement in the "Geology of Vermont," Vol. I, 1861 (issued in 1862, Walcott), p. 346. It is by Dr. Edward Hitchcock, and in the following words: "A narrow strip of impure limestone partially sepa-

*Sixteenth report of the Minnesota survey, pp. 45, 46.

rates the quartz rock from the Red sandrock in Monkton. The limestone gradually thins out, and is finally lost, so that the quartz rock and the sandrock unite with each other; and probably the line of junction is only a line separating different degrees of metamorphic action upon the same formation;" but by different geologists both the Potsdam and the Granular Quartz have, on what seemed good evidence, at different times been regarded as the equivalent of the Red sandrock. Some confusion has arisen, as it seems, in the use of the word Potsdam, by the geologists who have examined the Champlain valley in the same manner as in the Mississippi valley.* Some have applied the term to the great quartzyte (the "Granular Quartz" in its different positions) and some to the later, looser sandrock, and Calciferous sandrock, that lie unconformably on the quartzyte, and some to both varieties. The former is the horizon of the Paradoxides fauna, from New England to Minnesota, and the latter is the horizon of the Dicellocephalus fauna. It will require a re-examination of the "sandstone of Potsdam," at the typical locality, to determine the question — which is the true Potsdam sandstone?]

The age of the Potsdam.

Equivalent names. Under this heading are included here several local designations which have been applied by geologists to a formation that extends widely over the United States and Canada, the uniform characters of which, as well as its fossils and stratigraphy, indicate that they all belong to one great quartzyte horizon. Some of these various names are: Granular Quartz, Red sandrock, Thessalon quartzyte (of the original Huronian), Teal lake quartzyte, No. 3, or quartzyte group (of Dr. Rominger), Baraboo quartzyte, Wanswaugoning quartzyte, Pewabic quartzyte, Sioux quartzyte. Further east, it may be represented by the quartzyte at Braintree, Mass., and the Paradoxides beds of Newfoundland. Further west it seems to exist in the Mt. Stephen section, and contains the fauna of the Bow River group, and of the "Prospect Mountain" quartzyte. It is unquestionably found in the Black Hills, but fortunately it has not there received a special name, but is embraced under the term Potsdam. This is essentially the horizon of the Paradoxides strata of the primordial.

Unconformable on the Taconic. It has been stated that this quartzyte is unconformable on the Taconic. This is sufficiently established in Vermont, in Michigan, Wisconsin and in the

* Emmons noticed the difference of lithology, but not the unconformity of stratification. *Geol. of N. Y.*, Vol. II, 1842, p. 269.

Dr. Edward Hitchcock seems to have figured this unconformity in Vol. I, p. 265, of the *Geology of Vermont*, but he considered the "quartz rock" here to belong to the Laurentian. At Chazy Mr. Jules Marcou states that he observed an unconformity between the Potsdam and the Chazy strata, the divergence of dip being 15 degrees.—*The Taconic system and its position in stratigraphic geology.* Proc. Am. Acad. Arts & Sci., Vol. XII, p. 190.

Black Hills of South Dakota. It is presumably so in the area of the original Huronian.* Such a widespread non-conformity indicates that the Taconic was closed by a widespread epoch of disturbance. Since the Potsdam is carried over the edges of the Taconic, and in many places is brought into contact with the "granite," which may be supposed to be older than either, it is evident that this disturbance was followed by a still further inroad of the oceanic waters on the land area of the continent. This submergence has effectually hid the Taconic formation from sight over very extensive areas, and led the geologists who saw the Potsdam lying on the Primary, in New York, to question the possibility of a formation several thousand feet in thickness belonging between them. It also produced a conglomeritic composition in the bottom of the Potsdam at nearly all places where the bottom beds have been seen.

Further evidence of disturbance during the Potsdam. The gradual or paroxysmal sinking of portions of the continent below the ocean during the Potsdam age was accompanied by other evidences of disturbance that have remained undeniable witnesses to this day. There were both basic and acid eruptions of great volumes of molten rock, which in some cases were interbedded in the Potsdam, and in others are found overlying it. These molten rocks are found generally to lie on the Taconic and the Potsdam both, but their date of outflow is fixed later than the beginning of the Potsdam by their stratigraphic relation to the Potsdam. Beds of gabbro are evenly spread with quartzyte strata above and below them, in the Pewabic quartzyte in northeastern Minnesota. In general the gabbro lies on the Animike (Taconic) in Minnesota, but a favorable observation made at Chub (Akeley) lake† demonstrates that this quartzyte was partially deposited over the Animike before the great gabbro flood occurred. The usual immediate overlie of the gabbro on the beds of the Taconic, is due to the fact that those beds were nearer adjacent at the points of issue of the molten rock. It also lies on the Keewatin as well as on the Laurentian; while the Potsdam is overwhelmed and nearly lost by the great mass of lava that issued from the interior of the earth during the time of its deposition. While the gabbro outflow seems to have been the most voluminous and remarkable in Minnesota, and to have been the

* In the St. Louis valley, near Thomson, the basal conglomerate of the Potsdam is unconformable on the Thomson (Taconic) slates. Tenth Minnesota report, p. 33.

† Sixteenth report, pp. 85 and 87.

earliest of the basic Potsdam eruptions, in the area of the original Huronian the Thessalon quartzyte is generally cut by and buried under an eruptive of a slightly different kind, more resembling some of the "traps" of the later epoch. There is reason to suppose this may be due to one of two causes. 1st. That at the time of the gabbro flood in other regions the area of the original Huronian was exempt (or nearly so)* from eruptive disturbance, and that the later basic outflows took place there after the region was elevated above the ocean; or 2nd. That while typical gabbro rock was being extravasated in Minnesota, and in some other portions of the country, a slightly different basic eruption was taking place in the area of the original Huronian. From the fact that some gabbro rock is found in the region of the original Huronian, it appears that the former of these hypotheses is more probably correct, and that there as well as in north-eastern Minnesota, the basic diabase and finer trap-rock characteristic of the most of the Kewenawan, were of somewhat later date than the gabbro. That these darker, diabase traps issued at some date after the gabbro flood, is evinced not only by the dikes of the former that cut the latter, but also by the remarkable puddingstones of gabbro that are formed by the inclosure of isolated, transported masses within the diabasic sheets,† seen in the vicinity of Beaver Bay.

This basic eruption characterizes this geological horizon throughout its extent in Minnesota, but toward the east it seems not to have been so characteristic. It prevailed in some parts of Canada‡, and disturbances in the so-called "Quebec group" appear to involve this horizon of rocks. The Adirondack region has not been examined except about its margin. It is believed that this quartzyte exists in many places involved with the gabbro rocks of those hills. Its outcrops about the flanks of these hills have been described at places where most accessible and named Potsdam sandstone. These descriptions are applicable to this quartzyte in Minnesota—even to the vitrified surfaces that are so common in the west,§ and which are not known to

*One small knob of gabbro was seen near Otter Tail village. Compare 16th report, p. 29.

† Norwood, in Owen's report on Iowa, Wisconsin and Minnesota, p. 366; also Ninth Rep. Minn. Sur., pp. 30-31; Tenth Rep. Minn. Sur., pp. 112-113.

‡ Geology of Canada, 1863, p. 483, 865, 875, 879; Geology of New York, 1843, Mather. Part I, p. 444.

§ Geology of Minnesota, Vol. II, 1888, page 516, foot note. Geology of New York; Second district, Emmons; p. 269.

have been seen on any other formation though exposed in similar circumstances.

Post-gabbro eruptions of the Potsdam age. It has been difficult to affirm, until recently, the age of the gabbro outflow. It has generally been considered to have followed the Animike (Taconic) but that it was later than the commencement of the Potsdam was not known to the writer till he made the observations referred to above.* What were the relations of the later basic eruptions of the "Kewenawan" to the gabbro has been described by Prof. Irving and by numerous other observers. There is no reason to affirm a long lapse of time between them, sufficient to allow the formation of an oceanic terrane requiring special designation. The later eruptive rock embraced and probably transported loosened masses from the gabbro, as evinced in the "feldspar masses" described by Norwood near Beaver Bay on the north shore of lake Superior, and the puddingstones observed by the writer. But this, rather than indicating a long intervening time, seems to imply a quick succession in the eruptions, or else a continued elevation above the sea so as to prevent the accumulation of intervening sediments. That there was no exemption from sedimentation after the gabbro is shown by, (1) the absence of any sign of ancient land surface, (2) by the continued and frequent interbedding of eruptive and sedimentary rocks through the entire Kewenawan (Geol. of Wis. Vol. III, p. 403), and (3) by the gradual transition of the basal conglomerate of the Potsdam, in favorable places, from a siliceous, or pebbly-quartzose, character, through a siliceous sandrock to a feldspathic sandrock, and to a pebbly volcanic tuff. Such transitions are frequent on the north shore of lake Superior. One of the most important observations was recorded in 1879,† when the basal quartzose conglomerate of the Potsdam was found, dipping in consonance with the shales and tufaceous conglomerates of the overlying Kewenawan, in the St. Louis valley, unconformable over the Thomson slates, and embracing lenticular spots of shaly rock and red (Kewenawan) conglomerate as constituent and conformable parts of itself. This shows a conformable, though somewhat intermittent, course of sedimentation from the basal conglomerate into the typical detritus of the overlying beds of the Kewenawan; the interruptions and the changes in the nature of the sedimentation being attributable to

*Sixteenth annual report, pp. 85 and 88.

†Tenth report, pp. 11, 32, 33.

the eruptive disturbances that took place in the adjoining regions. It will be seen at once that this links the Kewenawan to the gabbro, and both to the Potsdam.

Acid eruptions during the Potsdam. The dynamic forces that operated to bring molten basic rock to the surface of the earth in northeastern Minnesota also softened the acidic strata of the super-crust, which in some places seems to have culminated in the molten protrusions and lateral displacements of large masses. These acid eruptions, ranging from felsitic to granitic, are of limited amounts in Minnesota and Wisconsin. Sometimes they are in contact with the Taconic strata as at Duluth (10th Rep. p. 108), sometimes with the Potsdam,* and sometimes with the basic eruptions of the Potsdam.† They are seen in contact with the Taconic slates of the original Huronian (16th Report), and there seem to be the direct result of change from some sedimentary, siliceous strata.

Whether this feature of the Potsdam is persistent through eastern Canada, and in New England, is uncertain, owing to the prevalence of definite "Laurentian" theories as to the age of most of the granitic rock that geologists have studied in that part of the country. There is, however, every reason to affirm a widespread and profound volcanic disturbance, extending from the Black Hills, at least, to Vermont and eastern Canada, that began in the Potsdam era and closed with that era, and that some of its results in the forms of acid as well as basic eruptive rock, as mentioned above for the Northwest, must characterize this formation in New England, there is good reason to expect. Indeed some descriptions of such phenomena have been published. Dr. Hitchcock mentions some Potsdam schists that contain "veins of granite whose feldspar is labradorite" (Geol. of Vermont, Vol. I, p. 264). There are many instances published where the slates of the Taconic including the granular quartz are so placed as to run beneath masses of granitic rock, but such a possibility has been negatived promptly by resort to that easy hypothesis of a fault, to bring up the "Laurentian." Dr. Emmons describes such instances.‡ Similar facts have been mentioned by Prof. C. H. Hitchcock§ in New Hampshire,

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*Geology of Wisconsin, Vol. II, pp. 251, 506, 522.

†Tenth Minnesota report, p. 110.

‡Geology of New York: Second district, 1842, pp. 141, 145, 159. Agriculture of New York 1846, Vol. I, pp. 63, 94.

§American Geologist, April, 1889, p. 254. Geology of New Hampshire.

although there is no certainty that the slates described by him are of the age of the Taconic. Prof. Hitchcock makes it very apparent that the granites of New England cannot all be placed in the Laurentian any more than they can in Minnesota.

The Potsdam age closed, therefore, with the cessation of the disturbances and volcanic eruptions which introduced it. The beds that were formed were left in upturned and fractured attitudes for the attacks of the succeeding St. Croix age. These strata embraced not only the basal quartzyte of the Potsdam, but the gabbro, and all the succeeding eruptions that are found in the Keweenawan. Here would necessarily appear a marked and extended plane of unconformity, and this fact, when sufficiently recognized, will be found to distinguish the rocks at many places — whether Potsdam or St. Croix — and be a criterion by which to judge of their stratigraphic place in the geological column. In other words, the Potsdam is unconformable on the older gneiss and slates and schists, and is cut and covered by eruptions of the same age as itself. It would not normally be found unconformable on rocks of its own age over wide areas, although contemporaneous disturbance might certainly produce local non-conformity. The later formations may show non-conformity over wide areas of the rocks of the Potsdam, and such we find to be the fact.

The age of the St. Croix sandstone.

That it may be made plain to the reader just what strata are considered by the writer the Potsdam sandstone, this history may be carried one step further. This is the more necessary inasmuch as some of the steps in the history which are well known in the Northwest, have not yet been recognized, or have not been admitted as facts, by most of those who have examined the geology of the Champlain valley. It appears that a very widespread succession of physical changes affected the lower paleozoic and crystalline terranes in America with a uniformity of effect that is surprising, and which leads to very serious questioning of the doctrine that formations can not be recognized by their lithology from place to place because of the liability to physical change. There is, in fact, a remarkable persistence of lithologic characters, and of stratigraphic relationship, between Minnesota and New England. The satisfactory establishment of some points in the geology of the Northwest throws much light on moot points in the geology of the east. While most of these coincidences and identities have to be reserved to a later discussion, one of the most interesting concerns immediately the formation which is under consideration — the *St. Croix sandstone* of the Mississippi valley, and its relation to the Potsdam.

The separateness of the St. Croix from the Potsdam. It has already been stated that some confusion has been introduced by the use of the term Potsdam by different writers in different senses. This began with the early descriptions of the geology of eastern New York, Vermont and Canada. This confusion was one of the most obtrusive problems that confronted the writer in 1872 in the preparation of his first annual report. In order that a more definite understanding might attach to whatever he should be called on to publish respecting this horizon he chose to designate the lower formation Potsdam and the upper one St. Croix, and this distinction has been observed in the later publications. If not correct it has at least served to give definiteness to all his descriptions.

This problem was given pointedness a short time prior to the beginning of the Minnesota survey by the writings of Prof. R. D. Irving, who had shown that in Wisconsin the upper formasion was unconformable on the lower.* Irving's papers on the Wisconsin quartzytes proved the existence of two formations in places where hitherto, by some, there had been supposed to be but one, and, assuming the upper, or horizontal, beds to be the Potsdam, based on the conjectures of Prof. James Hall published in the Sixteenth (N. Y.) Regents' report, he announced the upper one to be the equivalent of the New York formation and the lower one he relegated to the "Huronian," that convenient limbo to which it has been customary to consign uncertain stragglers from the upper "Silurian" and from the nether "Laurentian." It was not presumed at that time that the geology of the Northwest would be found to tally closely with that of New York, and as there was no mention of such a great "Huronian" quartzyte there, nor in New England, the presumption was that the "Huronian" was a formation that affected Canada and the Northwest, and that, therefore, this great northwestern quartzyte would not be found further east than the northern shore of lake Huron. Only the "Potsdam" was described in eastern New York.

Upon pushing the distinction further east, however, and upon making a wide study of the older terranes, which, when better

* Am. Jour. Sci., Feb., 1872; April, 1872.

understood, are found to exhibit a surprising concord of essential features with those of more eastern as well as western regions, it is found that there is every reason to believe, not only that there exists the same great underlying quartzyte in New England and eastern New York, but that there are unmistakable evidences of the same non-conformity between it and the overlying horizontal, or nearly horizontal, beds. Moreover, it is equally plain, on making an examination of descriptions that have been published by the eastern geologists, that both the formations have been with great positiveness called Potsdam sandstone. It is very evident that no little misunderstanding has resulted from a failure to observe and acknowledge this important line of non-conformity. But wherever it has confronted the geologist in Vermont or eastern New York, it has been glided over indifferently or has been accounted for by some outre hypothesis, such as "overturn" or "fault," or temporary "non-deposition," or "metamorphism from contact with the Primary."

In order to support this statement some references will be made to the published descriptions of the "Potsdam" in New York. No reference will be made to the Granular Quartz nor the Red sandstone, both of which the writer believes, as the reader will have observed, are identically and only, the Potsdam formation; but to some statements concerning the "Potsdam sandstone" as understood by the geologists who made them.

Emmons. In his report on the geology of the Second District, 1842, Dr. Emmons uses these words in describing the Potsdam in Essex county —"In consequence of this rock presenting two quite distinct varieties, and those varieties being well developed, the one at Potsdam, St. Lawrence county, and the other at Keeseville, I have sometimes given it a compound name — the *Potsdam and Keeseville sandstone;* for the reason that at the former place a beautiful granular variety, and at the latter a harder and more crystalline mass predominates, which resembles the granular quartz of the Taconic system." Near Keeseville the rock that outcrops he describes as exhibiting some interesting changes upon the surface of the layers, presenting "a smooth and semi-vitreous surface — a kind of glazing;" by which he seems to have meant the same polished or glazed surface that appears frequently on the Potsdam in Minnesota. It is plain, therefore, that Emmons noted the contrasting lithology, but, so far as the writer has observed, he did not recognize any unconformity in the "Potsdam," or between it and the Calciferous.

E. Hitchcock. There is not much doubt that Dr. Hitchcock noted exactly an unconformity between the two formations at West Haven (Geol. Vermont, Vol. I, p. 265), but he regarded the lower one as a part of the "Laurentian," and the upper as the Potsdam. He states that "the only way of distinguishing the Laurentian character of the [lower] deposit is by the higher dip of its strata, upon which the Potsdam sandstone rests unconformably. A section passing across the south end of West Haven, in fig. 168, represents the unconformable relations of the Laurentian rocks and the Potsdam sandstone to each other. Were it not for this discordance in the stratification we should regard the lower rock as Silurian because it does not differ lithologically from the sandstone above. But in following the strata northwardly the quartz rock becomes more gneissoid. Some of the specimens in the cabinet are very distinct gneiss, one of them with the labradorite, the characteristic species of the feldspar of the Laurentian series."

Let the reader compare the description of the "quartz rocks" of the Laurentian with the following description of the "Potsdam" *at the same place.*

"The third variety very closely resembles the Laurentian gneiss. It seems to pass into it by insensible gradations. The specimens obtained are from the southwest part of West Haven. All the constituents of this rock are very small, and occasionally the feldspar or the mica may be wanting * * * Associated with these crystalline schists are veins of granite, whose feldspar is labradorite. This mineral is mostly confined to rocks below the Silurian system; and in West Haven it extends only a few feet into the base of the Silurian, and that in small veins from three to ten inches wide.

"The unconformability of the dip of this rock to the Laurentian beneath [sic] may be seen at the extreme southern point of West Haven. Upon the lake, opposite the termination of the railroad the dip of the older rock is 36° East, and only a few rods east the dip of the sandstone is only 9° East. As the south part of West Haven terminates in a cliff this section can be seen distinctly from quite a distance. The rock with the greater dip is as distinctly quartz rock as the other, and there is also a large ledge of quartz rock upon the west side of lake Champlain with the same inclination. Hence the sudden change in the dip is to be regarded as a safer distinction between the Silurian and Laurentian series than a difference in lithological character."

Setting aside Dr. Hitchcock's identification, either of the following interpretations of the facts, in the light of what has since been learned of the geology of the Taconic and the granular quartz, would be possible. (1) The lower rock is the Potsdam (granular quartz) and the upper is the St. Croix; or (2) The supposed unconformity is only an illusive appearance in the same formation, perhaps false bedding, or oblique stratification, or a sheeted disintegration which sometimes is superinduced by weathering even in the firmest crystalline rocks. In the light of further considerations the latter explanation seems most probable.

(a) Prof. C. B. Adams had stated in his first annual report that the Potsdam sandstone only reached within half a mile of the state line near Whitehall, and did not enumerate it at all in his table of Vermont formations.* If this were true it would be necessary to consider this West Haven quartzyte as the Red sandrock or the granular quartz. Either of these explanations, to so strong an opponent of the Taconic as Hitchcock was at that time,† would be avoided if possible. For, to class it as a part of the Red sandrock spur that shoots southward from the town of Monkton, the last remnant of which his map represents on the south line of Orwell, bearing in a direction toward West Haven, only seventeen miles distant, would be to bring the "Medina sandstone" below the Calciferous which exists in the immediate vicinity and into contact with the Laurentian; which would necessitate the abandonment of the "metamorphic" idea that the Red sandrock and all the Taconic rocks were changed conditions of the Lower and Upper Silurian of the Champlain system of New York. Also, to admit that it is an outcrop of the Granular Quartz of Dr. Emmons, would in like manner bring the Granular Quartz beneath the Calciferous and even unconformably beneath another sandstone that might be the Potsdam; this would substantially confirm everything that Emmons claimed for his Taconic. These alternatives were clumsily obviated by introducing the Laurentian. That this "Laurentian" is the gabbro of the Potsdam age is probable from the nature of the feldspar which it is said to contain.

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*First annual report, Geology of Vermont, 1845, p. 61.

†It is evident that a change of opinion was accomplished in Dr. Hitchcock's mind during the preparations of this report. This is intimated in Vol. I, p. 435.

W. W. Mather. So far as discoverable all the descriptions of Potsdam by Prof. Mather* apply to the lower or quartzyte division. He notes repeatedly his belief that the Granular Quartz is a metamorphic condition of the Potsdam.

L. Vanuxem distinctly mentions the same varieties of rock in the Potsdam as Dr. Emmons, and employs the double designation "Potsdam and Keeseville sandstone," but he mentions no unconformity. He intimates, however, that the Potsdam, in its loose-textured variety, is with difficulty distinguished from the Calciferous sandrock. The latter he describes at numerous places in immediate contact on the primary.

Sir Wm. Logan. In the *Geology of Canada*, 1863, this formation is amplified into "Potsdam group," and includes a thickness, on the St. Lawrence river, of 540 feet. This group embraces not only the true Potsdam but several beds of conglomerate, white sandstone suitable for glassmaking, fucoidal beds, limestones and a singular breccia like that described by Emmons at Chazy and said to separate the Potsdam from the Calciferous. The fauna which appertains to the upper layers is that characteristic of the Calciferous. It is evident that the true Potsdam is here confounded with the overlying St. Croix-Calciferous, and that the Calciferous is restricted in the words of Logan, essentially, to "a granular magnesian limestone or dolomite, which from its rough weathered surface and slight effervescence with acids may have suggested the name of Calciferous sandrock." In the annual reports the Potsdam had not been recognized about lake Huron; but the lower great quartzyte had been included, along with all the strata equivalent to the Taconic under the term Huronian. His opinion of some quartzyte beds on Murray bay which at first Logan regarded as Potsdam, and which he so described (*Geol. of Can.*, 1863, *p.* 96), he modified by adding a footnote stating that it had been ascertained by Dr. Dawson that "these quartzytes really belong to the Laurentian series."

James Hall. The Potsdam sandstone does not occur in the Fourth District, on which Mr. Hall reported, but he examined it on the north side of lake Ontario, and subsequently on lake Superior and in the Mississippi valley. His general description in the report on the Fourth District is such as would apply to the lower quartzitic portion.

In the lake Superior report of Foster & Whitney (1851) the step which was inaugurated by Logan in the creation of the

*Geology of New York, First District, 1843.

"Potsdam group," embracing the quartzyte and the overlying sandstone in one designation, was completed by the entire severance of the lower formation from the name, and its application only to the upper or nearly incoherent sandstones. At the same time the quartzyte, along with all the strata of the Taconic associated with it, were included in the "Azoic," embracing both the Laurentian and Huronian. This upward movement of the names of the New York formations, is shown by the following words (p. 114): "The Potsdam sandstone of New York is a quartzose rock whose particles are firmly aggregated, while the the same rock, on the northern slope of lake Michigan, is so slightly coherent, that it may be crushed in the hand. The Calciferous sandstone of New York, when traced west, passes into a magnesian limestone." This supposed change in the nature of the formations toward the west is largely imaginary; the change seems to consist rather in the transference of the original names to strata higher in the scale, and the creation of new names for the abandoned strata. All the authors of this report, including Prof. James Hall, apply the name Potsdam only to the friable sandstones which are unconformable with the Copper-bearing traps and basalts which, as already shown, are of the age of the lower quartzyte.

As to the paleontology of the Potsdam in New York, which is quite meagre if the more recent additions from the Calciferous be disregarded, an interesting problem centres on the fossils Lingula (Obolella) prima and (Lingulepis) antiqua. By Prof. Hall these are assigned to the Potsdam. In respect to L. prima it is reported at Keeseville on the authority of Dr. Emmons, and it is reported from the Mississippi valley on the St. Croix river. To the writer the St. Croix beds have been known for some years as belonging about to the horizon of the Calciferous, and they have been so parallelized by Irving.* The Calciferous, here including the magnesian limestone known as Lower Magnesian, is unconformable on the trap rock, and, in common with the sandstone underlying it, becomes conglomeritic by reason of such unconformable contact. The beds here exposed are not so low as the lower layers at Stillwater where the first specimen of Dikellocephalus was discovered by Dr. Owen. It would seem, therefore, if we can depend on the indications of paleontological evidence, that the Potsdam at Keeseville, containing Lingula prima would be considered substantially the parallel of the Calcif-

*U. S. Geol. Sur. Monogr. V. Copper-bearing rock, of lake Superior, p. 446.

erous beds at Taylor's Falls in the St. Croix valley. What are the facts? On re-examining Dr. Emmons' description of the sandstone on the Au Sable river in his report on Essex county, he says that this general range of sandstone, containing the Lingula prima according to Hall, *reposes against the hypersthene rock*, (i. e., the gabbro) and contains Lingula antiqua; and Prof. Hall corrects this indentification of Emmons by saying the species figured by him from this place is not L. antiqua but L. acuminata of Conrad, which is a Calciferous species, and does not occur, to his knowledge, in the Potsdam.* Therefore all the evidence from paleontology and from stratigraphy, so far as it can be gathered from the report of Emmons and the first volume of the Paleontology of New York, indicates that the beds on the St. Croix are the equivalent of those described at Keeseville, and that both belong to the Calciferous; at least that they are both later than the eruptive epoch of the Potsdam as here limited.

This brief examination of some early descriptions of the Potsdam of New York, which might be extended to include several other names, is sufficient to prove the truth of the foregoing statement that the distinction which has been made in the Northwest could with propriety also be made in the East, and that a plane of non-conformity between the Potsdam and the Calciferous extends through eastern New York and Vermont, and that there, as in Minnesota, the upper (St. Croix) sandstone has greater affiliations with the strata that succeeded the break than with those that preceded it.

In this review it is assumed that the "sandstone at Potsdam" preceded this non-conformity. It is evident that some re-examination should be made of the region before this can be considered established. Dr. Emmons, in his section passing from Canton to Parishville (Plate ix. *Geol. of New York*) shows that *gneiss* exists at Potsdam below the sandrock, and this rock he always keeps definitely distinct from *hypersthene rock*, which he argues was elevated at a later date than the Green mountains. The parallelism of position between the Potsdam sandstone at Potsdam, and the Granular Quartz, in this respect, both lying upon the gneiss, not only indicates a possible parallelism of age, but that they are possibly older than the Keeseville sandstone which rests against the hypersthene rock.

It is further assumed, in this review, at least in making the

*It is put in the "Potsdam group" by Logan, Geol. of Can., 1863, p. 102.

extension of the western parallels to the east, that the gabbro of the Northwest is the chronologic analogue of the hypersthene rock of the Adirondacks. The lithology is identical, except that various "limestones" are mingled with the hypersthene rock which have not, so far as known, any parallels in the gabbro of the Northwest. This assumed parallelism may also be set down as not sufficiently established.

It is also assumed that the Pewabic quartzyte of northeastern Minnesota, with which gabbro is interbedded and which lies below the great gabbro overflow, is the equivalent of the Wauswaugoning quartzyte and of the Pipestone quartzyte of the southwestern part of the state carrying a primordial fauna, which last is very certainly the equivalent of the Thessalon quartzyte of the original Huronian. Still the Pewabic quartzyte may not hold this relation to the Wauswaugoning beds; the connection has not been traced; yet they seem to be similarly situated with respect to the gabbro sheet, and are not widely separated from each other.

The writer has attempted to indicate such general equivalency as has appeared to him probable, and which embraces a greater fund of concordant fact and testimony than any other scheme of chronologic succession. He may be wrong in some parts of this history, and especially in the extension of the story as made out in Minnesota to eastern states, and holds it, in large measure, as tentative at this stage of the investigation. When facts can be found out sufficient to correct it in any way, he will be glad to welcome them, for he freely admits that there are questionable steps and missing links in the history, which have to be bridged by hypothesis and nothing else. That is, however, the nature of all investigation, and especially of all attempts to formulate any general truth.

PROBLEMS THAT NEED FURTHER INVESTIGATION.

As already stated, as this investigation has proceeded, no sooner did we surmount the difficulties which immediately beset the first attempts than new difficulties appeared. The solution of one problem seems to serve for vantage ground to behold others in the greater distance. It will be desirable to mention some of the questions that appear at present to require further study, and further field-work. This will distinguish more exactly the status of our present knowledge, or body of truth on which we rely, from the realm of hypothesis or of unfinished work and research, to which it will be necessary to devote the efforts of the survey at some future date.

Eruptive and sedimentary Laurentian. Beginning with the Laurentian, as defined above, one of the unfinished courses of study relates to the distinctions, both geographic and structural and petrographic, between the eruptive masses of syenite, or granite, and those that are supposed to have resulted from change *in situ* of the oldest sediments. This will involve the further question whether the "gneissic structure" is necessary, or even possible, in a truly eruptive rock. But first of all it will necessitate a correct definition of the term "gneissic structure."

There are three distinct ideas that have been confused under the term gneiss, or gneissic structure. No reference is made here to the use of the term gneiss as a rock species, but to the structure which is supposed to distinguish it, the proportionate amounts of the usual mineral ingredients being variable, and sometimes constituting a dark-colored, perhaps basic, rock, and at other times an acidic one. Referring only to *structure*, therefore, a rock has been said to be gneissic when *foliated;* but it is plain that there may be different kinds of foliation, (a) that lamination which consists of an undulating layered structure, the mica element not being unevenly distributed, but all the scales being parallel with the sheeting, and all the grain of the rock having a uniform structural rift which facilitates quarrying. If there be a finer lining or sheeting of the mica element the lines or sheets are not continuous far, and may be seen to fade out within a distance of a foot or two. That is to say this foliation does not indicate a profound separation of the minerals of the rock into layers or long continuous sheets. (b) A second sort of foliation is that which arises from a distinct separation of the minerals of the rock, or different proportions of the constituent minerals, into sheets or strata that continue over long distances. Such separation is indicated on the weathered surfaces by color-bands, and by petrographic differences of grain and composition. In short this foliation is plainly a modified sedimentary structure. The sheets, or layers, or strata, into which the rock is separated, are traceable over large surfaces. The crystalline condition of the grain here may be as perfect as in the last, and this constitutes the "crystalline schists;" but in many places there is seen an imperfect, or interrupted, crystallization, the various grains blending round their borders into each other, or being lost in an indefinite matrix, or developing porphyroidally. (c) Still another structure has been styled gneissic. A massive homogeneous rock, which may have neither of the foregoing kinds of foliation, but which exhibits the micaceous or hornblendic element evenly distributed in isolated individual grains throughout the whole, yet is seen to have a uniform elongation of the separate crystals, of all kinds, in the same direction. This furnishes also a kind of rift or grain which pervades the mass, rendering it easier to break in the direction parallel with the greater diameters of the crystals than in any other, but it is essentially a massive non-foliated rock. A massive structureless granite, or syenite, is rare to see. Hence by far the greater part of the Laurentian, whether eruptive or sedimentary, is properly styled gneiss. It is obvious, however, that these three structures should not all be described by a single term.

When these structures are once sufficiently differentiated in the mind of the observer, and are carefully applied in descriptions, there will still remain to ascertain what relations they separately sustain to the supposed two sorts of Laurentian rocks, i. e. whether one or the other may be found to characterize the actually eruptive acid Laurentian, or the metamorphosed sedimentary Laurentian.

Planes of hydro-thermal fusion, and their relation to the origin of the crystalline schists. A second problem connected with the Laurentian, and which appears prominently in the horizon of future research, relates to the origin of the crystalline schists.

It has been stated above that there is every evidence to suppose that the eruptive epoch which introduced the Vermilion age (i. e. the crystalline schists) continued into the Kewatin (i. e. the sericitic schists and graywackes) by an unbroken and uniform succession of events and oceanic deposits. This binds the Vermilion and the Kewatin, historically, closely together. It has been said also that the mineral characters of the Vermilion fade out very slowly into those of the Kewatin, but that when fully established the change is so great that the formations have great mineralogical contrasts. In other places the crystalline schists have a very feeble development at the horizon where they would be expected to appear, and the Kewatin graywacke-like sediments pass into the Laurentian sediments through a gradual change from graywacke to gneiss—a gneiss having the second kind of foliation described above.

The crystalline schists seem to be, nearly always, as completely crystalline as the gneiss. If the origin of the basic sediments of the crystalline schists be akin to that of the sericitic sediments of the Kewatin, viz. from volcanic ejectamenta, the query quickly arises — why are they not similar in the resulting rocks? Why are the crystalline schists so uniformly composed of the same minerals as make up gneiss, though differing from gneiss in the relative amounts of those minerals and in the evident sedimentary structure, while the Kewatin, sericitic schists are only sub-crystalline and are often earthy? Is it not plausible to suppose that the crystalline schists are but a phase of the earthy Kewatin schists, due to the encroachment of hydro-thermal fusion-planes upon them? At the present time these beds all stand nearly vertical. If this fusion affected them after this verticality was attained, it may be supposed that the approach of the fusion-plane toward the surface of the earth would be nearer in some places than in others. When the fusion was accompanied by fracture more or less of the fused rock-matter would be thrust through the fissures and would appear as eruptive rock. Since there are certainly places where in the Kewatin sediments such fusion, and even such eruption, seems to have resulted from the Kewatin itself; and since in the immediate vicinity the sediments adjoining take on over a greater or less width, the characters of the crystalline schists, and at other places the crystalline schists do not appear where the Kewatin sediments exhibit that peculiar semi-crystalline condition which has been mentioned as "porphyrel," it has appeared to the writer that very likely the crystalline schists have no constant stratigraphic place, any more than the Laurentian gneiss, and that the "crystalline" phase has been superinduced *in situ* on basic (or acid) sediments in strata of different ages, according as, after being deposited, and even after being tilted to verticality, the level of hydro-thermal fusion was able to reach them or not. Therefore, without any undulating of the actual strata in anticlinal and synclinal folds (a supposition which seems to be precluded in some places by the extensive present vertical position of all the strata), there still might result, superficially, successive belts of rocks of different kinds. The belts would express the effects of hydro-thermal fusion, perhaps on the same sort of sediments, in different degrees of intensity. Wherever erosion and denudation may have been sufficient to bring the present surface down to the level where the fusion-plane operated in its full intensity, there we should find the present surface rock to be gneiss if the sediments were acidic, crystalline schist if the sediments were partially basic and stratiform, or eruptive rock if there were fissures through which such could and did escape. Where the surface erosion has not been sufficient to expose the upward (or the downward) undulations in the plane of perfect fusion, we find the earthy, or volcanic, or siliceous, sediments more nearly in their original condition.

Date of upheaval of the crystalline schists. Intimately connected with the question of the origin of the crystalline schists is the question of their date relative to the epoch of their upheaval, and the further, or prior, question as to the cause of the very general and extensive verticality of all the sedimentary strata that precede the Taconic (Huronian).

Nature and origin of jaspilyte. Attention has been called to some points in the investigation of this question which need further examination.

What is the "muscovado rock?" and, particularly, does it represent a sedimentary formation younger than the Kawishiwin and older than the Taconic.

COMPARISON OF THESE RESULTS WITH THOSE REACHED ELSEWHERE.

Following is a tabulated statement of the general stratigraphy supposed to exist in Minnesota, according to the foregoing sketch.

Calciferous. Magnesian limestones and sandstones	Dikelocephalus horizon.
St. Croix. Sandstones and shales	(Dikelocephalus horizon.)
Overlap unconformity.	
Potsdam. Quartzyte, gabbro, red granite and Kewenawan	Paradoxides horizon.
Overlap unconformity.	
Taconic. Black and gray slates and quartzytes, iron ore, (Huronian, Animike)	Olenellus horizon.
Overlap unconformity.	
Kewatin (including the Kawishiwin or greenstone belt, with its jaspilyte), Sericitic schists and graywackes	Archean.
Vermilion (Coutchiching), crystalline schists	(Archean.)
Eruptive unconformity.	
Laurentian. Gneiss	(Archean.)

Comparing this with the results reached by the late Wisconsin survey, it is found to differ considerably from the table of formations published by Prof. Irving, in the third volume of the final report of that survey, pp. 92 to 211. Prof. Irving describes the Laurentian as composed of "dark-colored and altered (chloritic) hornblende-gneisses and pink quartzose granites." These he considers very evidently originally clastic rocks, without any recognizable eruptive portions, and to lie unconformably below the Huronian. The last he divides into twenty-one parts, in the same manner as major Brooks, in his report on the geology of Michigan. The aggregate thickness is supposed to be about 12,800 feet. But in this thickness he includes all the strata from his Laurentian to his Kewenawan, viz. in descending order:

XXI. Mica schist, with intrusive granite.

XX. Probably mica schist, like XXI.

XIX. Greenstone schist.

XVIII to XV. Alternations of black mica-slate and dark gray quartzyte, or quartz schist.

XIV. Black mica-slate. This and the last are carbonaceous.

XIII. Chloritic dioryte.

XII. Black magnetitic mica-slate.

XI. Probably mica-slates.

X. Mica-slate.

IX. Chlorite dioryte.

VIII. Probably mica-slate, like VII.

VII. Mica-slate.

VI. "Peculiar hornblende rock," containing also quartz, apatite, milky orthoclase and rare plagioclase; also biotite, cut by pinkish, coarse, granite veins.

V. Black feldspathic slate, carbonaceous.

IV. The magnetic belt; made up of banded magnetitic quartzyte, magnetitic quartzyte, magnetitic quartz-slate, actinolitic magnetitic quartz-slate, arenaceous to compact and flaky quartzyte, thin-laminated, soft, black, magnetitic slate, hematitic quartzyte, garnetiferous actinolite-schist or eclogite schist, and dioryte.

III. Siliceous slate or schist, a light-gray, soft, mica-schist, sometimes a fine quartzyte.

II. Arenaceous quartzyte.

I. Crystalline limestone.

For greater details respecting these parts the reader is referred to Vol. III, Wisconsin geological report, pp. 106–166.

The Kewenawan system Prof. Irving here describes as consisting of a "lower division, embracing chiefly great flows of gabbro, diabase, and melaphyr, and an upper division composed chiefly of reddish feldspathic sandstone, subordinate to which are heavy beds of boulder-conglomerate, indurated gray and brown quartzless sandstone and black shale." Among its eruptive rocks he includes gabbro, diabase and diabase amygdaloid, melaphyr, granite and porphyry, the last being possibly clastic. Among its fragmental he notes boulder-conglomerate, black and gray shales, gray and brown quartzless sandstone and red sandstone and shale.

Unconformable over the last he places the light-colored "lake Superior or Potsdam sandstone," which he considers either the "equivalent or downward extension of the Potsdam sandstone series of the Mississippi valley."

It is evident that in this description there is included nothing that answers to the Kewatin and Kawishiwin. It appears that a feeble representatiou of the crystalline schists is noted in connection with the Laurentian, as "dark hornblende gneisses." Essentially all of these parts, from No. I to No. XX inclusive, are the Animike of northeastern Minnesota, the real Huronian without the overlying Thessalon quartzyte. According to observations already recorded this overlying unconformable quartzyte is in northern Minnesota interbedded with gabbro sheets, and the great gabbro flood lies on the lower portions of it. It is a natural inference that in an epoch of successive volcanic eruption like that which followed the gabbro outflow, a quartzyte would locally lose its typical character, and would be converted to feldspathic sandstones, conglomerates and shales, and that these would be interbedded with the eruptive sheets. Such seems to have been the case in northern Wisconsin and in northeastern Minnesota within the area affected by this remarkable series of eruptions. But in central Wisconsin, as well as in southern Minnesota, and in S. Dakota, the normal conditions again prevailed, and a similar quartzyte is found to exist, repeating the sedimentary succession that obtains in the area of the original Huronian.

The peculiar "mica schists" cut by intrusive granite, represented to overlie all the rest of the Huronian, seem not to have been identified in Minnesota. There is, in connection with the gabbro, in northeastern Minnesota a large amount of red granite, passing to felsyte such as that seen at the *Great Palisades*, on the north shore of lake Superior. It is possible that in connection with this granite will yet be found some micaceous schists answering to these in Wisconsin, the result of metamorphism from some of the Animike beds.

Prof. Charles E. Wright and major T. B. Brooks, who report, in the same volume, on some of the crystalline rocks of Wisconsin, present substantially the same classification. But they distinctly include the "crystalline schists" in the Laurentian. Brooks, who made out this order first in the Marquette region, and gave the parts similar numerical designations, groups them in three principal parts, viz.:

Upper Huronian, Beds XIV to XX.

Mica slates, mica schists, granites and gneisses.

Middle Huronian, Beds VIII to XIII.

Quartzytes, clay slates and obscure soft schists.

Lower Huronian, Beds I to VII.

Quartzyte, marble, iron ore, novaculite.

Brook's stratigraphic scheme is subject to criticism, and is ambiguous and certainly incomplete, although for a pioneer attempt to set the stratigraphy of the region of Marquette into a semblance of chronological succession it deserves great praise, for it supplies the first general classification and gives form to a tangled mass of variant and unfinished observations and isolated facts that had been published before. Since the examinations made by Brooks the whole country has been much cleared up, many new openings have been made and the geology is much easier to ascertain with certainty than ever before. Dr. C. Rominger, in a later survey, was aided by some of these advantages, and in some instances he was enabled to correct the stratigraphic scheme of major Brooks. His report, however, is, as it professes to be, mainly a description of facts, without much effort to decipher the stratigraphy.

Dr. Rominger hesitated about placing the granitic rocks of the Marquette district as the parallel of the Laurentian of Canada, although he regards the rest of the series, with some noteworthy differences, as the Huronian. He rejects the twenty subdivisions made by Brooks, as altogether too numerous and somewhat vague, and some of them he omits from the succession, regarding them as intrusive masses belonging really to lower horizons. The two quartzyte members, of Brooks, he considers but one. With slight exceptions Dr. Rominger's descriptions and classification are in accord with the general stratigraphy and all the geology of the Northwest as now held by the writer. Those exceptions consist, principally, in dividing the strata concerned into two distinct formations, separated by a plane of unconformity which exists everywhere and is observable (and has also been mentioned many times by him), in the iron regions of both Minnesota and Michigan. Brooks paid but very little attention to the rocks embraced by Rominger in his serpentine and dioritic groups. But these constitute, in accordance with the conclusions of this report, the basement floor on which the true iron-bearing formation makes an unconformable overlap succession, and are the southern representatives of the sericitic and chloritic schists and graywackes of the Kewatin. Another important difference concerns the great quartzyte of the Marquette region. Dr. Rominger considers it a constituent part of the conformable strata of the Huronian. I think sufficient evidence exists for removing it from the system that embraces the ore beds, and placing it as an unconformable overlying stratum, the equivalent, nevertheless, of the great upper quartzyte member of the original Huronian. Again, the arenaceous slate group, and the iron group, appear to the writer to be, if not identical, very closely associated members of the grand series, and not worthy of separate designation. One may overlie the other, in general, but they probably graduate into each other lithologically and stratigraphically.

In making comparisons, however, the most interesting are found to subsist between this work and that of Mr. A. C. Lawson, of the Canadian survey. In the examination of the geology of the Lake of the Woods Mr. Lawson encountered a series of rocks, which, while included by his predecessors in the Huronian, differed markedly from the descriptions of the original rocks of the Huronian as published by the Canadian survey, and he gave them the name which is used by the Minnesota survey,—the "Keewatin." These he inferred to lieun conformably below the Animike, found further southeast, and they were subsequently traced continuously to the north side of Gunflint lake, and found to become there the very same strata which the Minnesota survey had already described as unconformable below the Animike, but which, however, were not fully wrought out by the Minnesota survey, nor identified as different from the Huronian. In the later prosecution of the work in Minnesota this wide-spread unconformity has been fully recognized, and the separateness of the strata above it from those below has been established beyond all question.

A still further interesting parallel between the work of the Minnesota survey and that of Mr. Lawson consists in the separation of the crystalline schists from the Kewatin, under a distinct name, and the recognition of some (at least local) unconformity due to eruptive action between them and the Laurentian gneiss. Mr. Lawson gave them the name Coutchiching, not including in them the basic eruptive rock associated at this horizon, and this survey, about the same time applied to them the name Vermilion, but included in them all the eruptive basic rock which appeared to grade off into dark and hornblendic schists and to micaceous schists. By Mr. Lawson this eruptive belt is considered as of later date than the schists, and perhaps as late as the Kewenawan, but by the writer it is regarded, so far as seen in Minnesota, as having actually preceded the crystalline schists, and really to be the most obtrusive agent in the introduction of the lithology that characterizes the crystalline schists. The principal eruptive rock was the acid Laurentian gneiss, according to Lawson, but according to this survey it was the basic doleryte.

There are minor differences, such as that touching the eruptive nature of gneisses, the later date of the Laurentian, the character of the thin, interleaved, gneissic strata between thin sheets of mica schists, sometimes reaching 100 or more alternations, and others, which will furnish subjects for future research. But the general concord, in the main results, between the conclusions of Mr. Lawson, and those expressed already, in this report, on the succession of the principal steps in Archean stratigraphy, is certainly a cause of satisfaction, and gives corroborative evidence of the correctness of the conclusions arrived at.

It is not necessary to make comparisons between these results and those of New England geologists. There is not sufficient evidence yet that the New England crystalline rocks can be assigned unexceptionably to the Archean. It has not escaped observation, however, that there are many general concordances. Especially is this true of the report on the New Hampshire crystalline rocks by Prof. C. H. Hitchcock. It is believed by the writer that the same strata extend, with characteristic lithology, through the Archean terranes of New England, and that they will be identified by and by with all the necessary evidence.

REPORT OF H. V. WINCHELL.

III.

REPORT OF FIELD OBSERVATIONS MADE DURING THE SEASON OF 1888, IN THE IRON REGIONS OF MINNESOTA.

By H. V. Winchell.

The object of this report is simply to place on record the facts observed and noted during the summer of 1888 regarding the geology of the region east of Tower, paying particular attention to the iron ore deposits. During the months of July, August, September and October an attempt was made to visit all the outcrops of iron ore east and south of Ely, for the purpose of making notes, collecting specimens* and learning the relation of the ore to the rocks of the region, as well as its extent and probable value. In many cases reported by explorers and so-called "experts" it was found that their accounts either exaggerated greatly the amount of iron ore to be found at any specified place, or else that there was no iron ore there at all—nothing but iron-rusted rocks or beds of heavy dark dioryte, or even no signs of iron at all.

Region traversed. The first month was spent in examining the magnetic ore belt which lies along the north edge of the gabbro and the south side of the Giant's range. A party consisting of the writer and Mr. W. D. Willard, of the State University, with Indian packers, went overland from Birch lake to the Duluth and Iron Range railroad along the Giant's range, making frequent cross-sections of the rocks and examining all the workings in the magnetite prosecuted there in past years. After returning to Birch lake the same belt of ore was followed northeastwardly into Twp. 63–10 on the Kawishiwi river.

During the remainder of the season the party led by Mr. Uly. S. Grant, assisted by Mr. A. D. Meeds was also engaged on the investigation of the iron ores. A trip southward to lake Superior was taken through an unexplored part of the country, and the various lakes along the route were examined. The parties

* The specimens collected by H. V. Winchell are numbered in pink shellac and alcohol, and have the letter H following the numbers.

then proceeded to Gunflint lake and worked for a month southwestwardly. Mr. Grant's party made two or three extended trips to the south for the purpose of visiting reported iron locations, reaching Brule lake and lake Alice and making notes on the geology of their shores. The other party followed the northern edge of the gabbro to connect with the observations made from Birch lake northeastward, closing by examining some of the jasper and ore beds in the vicinity of Snowbank lake.

All the outcrops of magnetic ore that could be learned of were visited,—with the exception of one or two remote places difficult of access and which were in all probability in the gabbro. Also a great many exposures of hematite were examined and many new facts obtained regarding its occurrence and relations to the surrounding rocks.

The importance assigned by many of the explorers to a small bed of jasper, or jasperoid rock in the crystalline or earthy schists, is often amusing. On the strength of such a discovery they will recommend the purchase of extensive tracts of land and the operation of a diamond drill on the spot or in the vicinity; being certain that the presence of the jasper—not always even *in situ*—is a sure indication of the proximity of a valuable body of ore. They do not seem to realize that jasper is not iron ore and that a mountain of jasper is no sign, in itself, of iron ore any more than of any other mineral.

Another erroneous idea which has gained prevalence is that a bed of ore is sure to improve the farther it is followed toward the center of the earth. The contrary is often true, and it is evident that while the grade of the ore *may* improve and the quantity of it *may* increase with the depth of a shaft, yet there is no reason to expect such a thing. Therefore it is a poor investment to buy land—or rock—which contains a small per cent of iron on top, and base hopes of a paying investment on the expectation of finding it to be high grade ore 50 or 100 feet from the surface.

It is surprising what credit is given by capitalists to any man, who, with no knowledge whatever of mineralogy or geology, and therefore no judge of the probability of finding ore in a certain locality, has, however, the assurance to tell them that there is iron in such and such a place if they will only put in a shaft and "open up the mine." On the strength of such recommendations as these thousands of acres of land have been bought at a high price, which are utterly destitute of iron ore and are, perhaps, nothing but cedar swamps or hills of bare rock; and in many places there are abandoned pits and machinery where not only shafts but fortunes have been sunk in hasty and profitless prospecting and blasting. The machinery and supplies have been "packed" thither at great expense, and men employed at high wages to dig for iron when a person who is at all acquainted with the geology of the region would have told in a short time that there was no use whatever in spending a cent. In two or three places shafts were seen sunk in greenstone where there was not the slightest indication of iron nor even a bit of jasper to mislead the anxious searcher for wealth; all because it was "on the iron range."

Such hasty, ill-advised proceedings always serve to bring a region, no matter how valuable in reality, into disrepute, and to weaken the confidence of capitalists all over the country who attribute these losses and failures to the wrong cause and are, therefore, deterred from investing their own capital in the really valuable and profitable localities.

But however much money may have been hopelessly squandered in the search for iron in barren regions, yet a great deal has been employed in the development of new and rich iron deposits during the past year. The D. & I. R. R. has been extended 25 miles to Ely, south of Long lake, from which place were shipped 1,200 tons of ore daily for about two months of last season. This ore all came from the Chandler mine, which has put in a fine plant of machinery and hoisting apparatus and will be ready for much larger shipments next year. The Pioneer and Zenith mines will also be in a condition to produce a large amount of high grade ore in 1889. These mines are located east of the Chandler at Ely. At several other places in the same vicinity large crews of men have been at work uncovering and opening up promising deposits of iron ore.

There has also been some attention paid to the Animike magnetite, and in several places around Birch lake shafts and drillings have been made. None of these, however, seem to have met with success, as the ore is not found in paying quantity.

More extensive ore-beds have been found west of Gunflint lake in Twp. 65–4 than elsewhere in this formation. Work will be commenced in this region as soon as railroad facilities can be obtained. In the following notes each of these outcrops and workings is described in detail.

Principal varieties of iron ore. It is well known by those familiar with the geology of northeastern Minnesota that there are three principal kinds of iron ore. These are found in connection with three different formations. The first kind is red hematite which is found interbedded with jasper in folded and crumpled beds that occur in what has been called the Keewatin formation. This is the ore which has been mined so extensively and is in such demand by the manufacturers of steel using the Bessemer process. Many analyses have been published heretofore. The second kind is a fine-grained glistening magnetite which is generally found in nearly horizontal beds of quartzyte supposed to be a part of the Huronian formation. This is the ore which was first worked before the Vermilion lake ore had been thoroughly tested or investigated. It has not been found in quantities sufficient to pay for mining until quite recently when large beds of it, west of Gunflint lake, have been penetrated by diamond drills. This is a high grade ore and contains no titanium. An analysis of a specimen from N. E. ¼ sec. 23, 60–13 gave the following, according to Mr. C. F. Sidener:

	Per cent.
Silica, SiO_2	11.89
Alumina, Al_2O_3	.34
Magnetic oxide of iron, Fe_3O_4	87.00
Lime, CaO	.20
Magnesia, MgO	.80
Titanium, Ti	None
Phosphorus, P	.056
Sulphur, S	Traces
	100.246
Metallic iron, Fe	63.07

The third variety of iron ore is also magnetite. It is coarse and has a duller lustre than the Animike ore and is not so strongly magnetic. It is found in many places in the gabbro, which sometimes contains so much of it that it seems to be pure magnetite. This ore almost always contains a large amount of titanic acid which ruins it for merchantable ore, with only present methods of reduction. Immense deposits of this titaniferous ore are found, and most of them have been purchased from the U. S. government in the hope of being able to conduct remunerative mining operations. When a method for reducing titaniferous ores cheaply is discovered such iron ore will be valuable; but until then it is worthless.

An analysis of a sample of this ore from sec. 36, 63–10 as reported by Mr. C. F. Sidener is:

	Per cent.
Silica, SiO_2	11.37
Alumina, Al_2O_3	1.32
Magnetic oxide of iron, Fe_3O_4	53.33
Protoxide of iron, FeO	14.42
Oxide of titanium, TiO_2	16.03
Lime, CaO	.10
Magnesia, MgO	2.73
Phosphorus, P	.01
Sulphur, S	Traces
	99.31
Metallic iron, Fe	49.40

These are the principal kinds of ore. But there are various modifications and combinations of them which would not come strictly under any one of the three heads. There are, for instance, magnetite beds in the Keewatin; sometimes mixed with hematite; sometimes all magnetite. On the other hand there is hematite and even limonite in the Animike; and there are extensive fragments of the Animike formation inclosed in the gabbro which thus appears, on a hasty examination, to contain non-titaniferous, fine-grained magnetite. The gabbro is thus found to be the only rock which always contains the same kind of iron ore—(titaniferous ?) magnetite.

GIANT'S RANGE.

The first work of the season was done, as above stated, on the syenite range south and southwest of Birch lake. The trail which leads from the lake to the Duluth and Iron Range R. R. starts from the sandy bay in sec. 32, 61–12. It runs nearly south for two or three miles after becoming established. It is a poor trail but grows better as the railroad is approached. South from Birch lake the country rises rapidly, and the aneroid indicated a hight of 225 feet at a point a mile and a half from the lake. Ridges composed of drift containing syenite boulders are crossed until in the S. W. ¼ sec. 8, 60–12 a ridge of massive syenite rises quite suddenly over 200 feet more. This is the Giants' range, 480 feet by aneroid above Birch lake. Before reaching the ridge some huge boulders of syenite and dioryte are seen. This ridge is here composed of coarse reddish syenite containing much blue, chalcedonic quartz in grains one-quarter of an inch in diameter. The pink orthoclase is frequently porphyritic. The hornblende is somewhat decayed in all the specimens observed, probably because they came from near the weathered surface. Samples of this rock are 357.

The drift on the north side of the ridge is reddish and contains many boulders. On the south side of the syenite ridge the land is from 100 to 150 feet lower than the summit of the ridge. Some immense boulders are seen.

At ¼ mile south of the S. E. corner sec. 7, 60–12 there are seen numerous angular fragments of olivinitic magnetite projecting through the moss. These pieces contain thin strata of good iron ore; they seem to lie just on top of the solid rock and to have been moved from their original place by the action of frost. Samples are numbered 358.

The trail leads through a swamp for the next half mile. Just north of the small creek which crosses the line between secs. 17 and 18, 60–12 there is an exposure of solid rock. It lies in strata which dip S. S.E. 10°–12°. The rock is olivinitic and contains considerable magnetite both as a constituent of the rock itself and in veins which coincide nearly with the direction of the bedding. This rock looks much like a quartzyte but contains a large proportion of olivine. Samples from here—S. W. ¼, S. W. ¼ sec. 17, 60–12—are 359. The rock is fine-grained and greenish; it is overlain by a very light covering of drift.

Rock similar to the last is exposed in places as far south as the E. quarter post sec. 19, 60–12. The needle dips about N. 50° over this entire distance.

In the N. E. corner of sec. 19, 60–12 is a shaft about ten feet deep. Indian John Beargrease says it was dug about 14 years ago by Peter Mitchell. After penetrating about five feet of drift the bed rock is encountered. It is the same greenish, olivinitic quartzyte containing magnetite. The needle dips N. 57°. Specimens from here are 360. Some of this rock is slaty; 361.

Another shaft has been made in N. W. ¼ of N. E. ¼ sec. 19, 60–12. The rock here is quite similar to the last; some of it is very thin-bedded. A sample from this shaft showing fine stratification is 362. There is very little good ore visible here, though the needle dips 90°.

A smoothed, black exposure of ferruginous quartzyte several acres in extent, appears on the surface of the ground in the N. W. ¼ of N. E. ¼ sec. 19, 60–12. The rock and magnetite both weather shiny black, and the metallic lustre gives one the idea that he is standing on a hill of pure iron. Sample of good ore from here is 363.

In the N. W. ¼ sec. 19, 60–12 there is a ridge composed of syenite boulders three to ten feet in diameter. This ridge is 50 feet high and extends for half a mile at least running nearly east and west. It is wonderful to see these immense rounded masses of syenite (one boulder of quartzyte was seen among them) piled up on top of each other with crevices ten or fifteen feet deep between them. No rock is seen in the woods on the south side of this ridge, with the exception of a few boulders. This moraine seems to lie just south of the magnetic quartzyte.

Iron lake. This small lake is one of the few bodies of water that lie south of the summit of the Giant's range and yet nearly as elevated as the range. It is situated in secs. 13, 14, 23 and 24, 60–13. Its shore is surrounded by boulders, mostly syenite, from the ridge north of the lake. There are also, however, many angular pieces of magnetitic quartzyte. This rock contains less olivine here than a few miles further east. A few boulders of a quartz conglomerate with a green matrix were seen on the east side of the lake in the N. W. ¼ sec. 24, 60–13, No. 364.

A short distance east of the lake, in the N. W. ¼ sec. 24, 60–13 the bed rock was exposed in the hillside by a windfall. It is the usual black, magnetitic rock lying in nearly horizontal strata. Some of the rock here is reddish and jaspery; there is also a conglomeritic aspect in places. Sometimes the rock is slaty in thin, black, parallel strata that are quite straight for a rod or more. Again the iron seems to be in veins which do not conform strictly to the general planes of stratification. The following cut is from the perpendicular face of a ledge in N. W. ¼ sec. 24, 60–13.

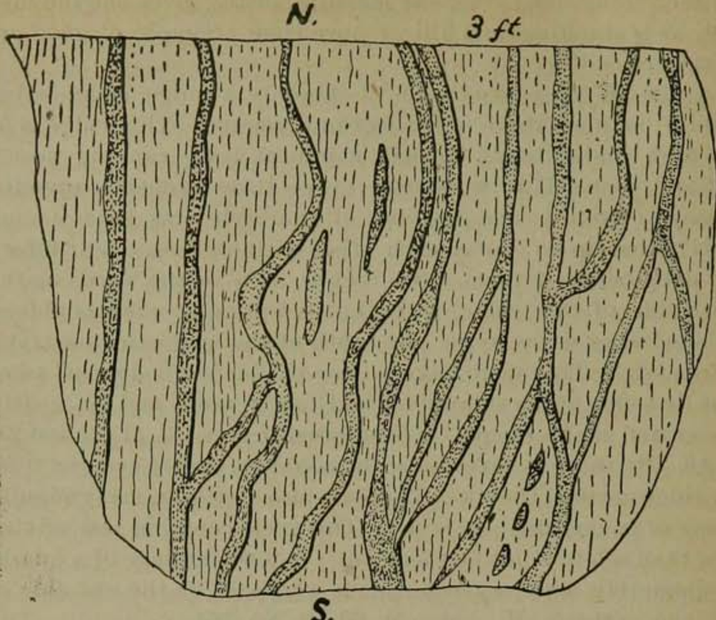

Fig. 1.—*Veins of magnetite in greenish Animike rock.*

A short distance N. W. or N. of last the ledge is exposed in a perpendicular wall 8 feet high and a couple of rods long. It is in thick black beds that have a high specific gravity and are crystalline with a dark mineral that may be hornblende, No. 365.

Near the north end of Iron lake, in S. W. ¼ sec. 13, 60-13, the magnetitic quartzyte undergoes a queer metamorphosis. It still lies in nearly horizontal beds; but it gradually becomes less highly charged with magnetite, acquires feldspathic and quartzose materials and finally is changed to a regular, reddish crystalline rock which is the syenite of the Giant's range. The lowest beds are the most perfectly crystalline. Before the transition becomes complete the Animike rock appears to be feldspathic in spots as if there were boulders of syenite in it, but lower down the beds become wholly syenitic. The quartz grains that are first seen in the greenish Animike rock have the same bluish translucent appearance as those in the syenite which lies just north. This change is illustrated by specimens numbered 366.

The quartz grains are seen before the feldspar. There are also portions of the Animike which are conglomeritic and are the same as the peculiar conglomerate, 364. A sample which contains part of a felsitic boulder is 367. The dip needle is but slightly affected here.

North of Iron lake the land does not rise suddenly; but there is a gradual upward slope for about half a mile when the summit of the range is reached and there is an abrupt descent of 200 feet or more. Syenite containing a little biotite is seen in the bluff on the north side of the range. One sample from the N. E. ¼ sec. 14, 60–13 is 368.

There are no exposures of solid rock on the N. W. side of Iron lake. On the S. W. side in the N. E. ¼ sec. 23, 60–13 there is a ledge of black magnetic rock, 369. It presents the usual characteristic aspects of this formation; lying in nearly horizontal strata and containing more or less magnetite which gives a dark color to the rock.

Iron lake is nearly as elevated as the summit of the Giant's range. The black rock on the north side of the lake is close above the syenite; and the change which was observed to have taken place must be mainly in the nature of a fragmental transition rather than a metamorphic one, i. e., the gradual increase within the Animike of the feldspathic and quartzose materials must be due to the fact that there was more or less debris derived from the crystalline ridge on the north which was covered up by the Animike deposits and by subsequent metamorphism incorporated closely into them. That this metamorphosing process was in the nature of a slow rearrangment and reuniting of the mineral constituents rather than of a violent and more sudden disturbance seems to be indicated by the comparatively undisturbed position of the strata.

Mr. Willard went south from the lake through the S. W. ¼ sec. 23, and the W. ½ sec. 26, 60–13. He reports fragments and low outcrops of the dark iron ore rock all the way to the swamp in the N. W. ¼ sec. 35, 60–13. Sample from that locality is 370. It is tough, black, heavy rock and contains probably 45 per cent (?) of iron.

The percentage of iron in the rock appears to grow less going westward from Dunka river; toward the northern edge and westward there is also less olivine and more quartz. Fragments of red jasper are seen all along the trail. These may have been transported from north of the Giant's range, although red jasper and quartzyte have been seen in the Animike formation in this region. Pieces of porphyritic rock that look as if they belong to the same formation near its contact with the syenite are also seen along the trail.

Some pure quartzyte containing, however, a small amount of magnetite, is found in angular fragments. A sample of reddish-gray quartzyte from N. W. ¼ sec. 32, 60–13 is 371.

The bed rock is seen to be just beneath the moss and light drift covering for two or three miles in sections 28, 32 and 31, 60–13. Ridges composed of granite and syenite boulders are seen at intervals, and evidently form part of a morainic system. The drift deposits become thicker toward the west.

Just south of the trail in S. W. ¼ of N. W. ¼ sec. 32, 60–13 is a large exposure of the semi-crystalline fragmental rock which intervenes between the regular Animike and the syenite, and grades into the latter. This rock is exposed here to a depth of 12 or 15 feet. At the top it contains considerable green, uncrystallized material, and the feldspar crystals are not so well formed as farther down where there is less of the green matter. There is an indistinct gneissic structure which seems to lie nearly horizontal; there is also a coarse schistosity which runs N. E. and S. W. At the top is a conglomeritic layer which contains pebbles of quartz and some of greenish rock, some of them two inches long, but mostly less than an inch in length, No. 372.

The rock at the bottom of this exposure is almost wholly crystalline with the usual constituents of syenite. The hornblende crystals are the last to be developed; large crystals of feldspar appear in the green matrix before it begins to show any other signs of crystallization. These feldspar crystals are orthoclase and are sometimes blood-red.

Peter Mitchell uncovered the iron ore beds in several places in the S. W. ¼ sec. 32, 60–13. Some of the rock thus exposed is quite slaty, 373. The shaft in the S. E. ¼ S. W. ¼ sec. 32, 60–13 is about 8 feet deep. It penetrates solid, black rock containing magnetite in grains and poorly defined layers or bands all through it. It is poor ore. On the surface a short distance northwest of the shaft the rock is more unevenly bedded and consists of thin veins of black ore in a gray rock. No. 374. The needle dips at all angles in a very small radius here. Glaciation is about N. N. E. Some of the rock is fine and jaspery with a reddish tinge, No. 374 A.

This is in a low ridge trending N. E. and S. W. or thereabouts. Sometimes similar ridges are seen made of boulders, and sometimes of syenite. In the S. W. ¼ sec. 31, 60–13 is a small ridge composed of iron ore rock. It has been broken off and the land east and north is lower. The east face of the ledge is smooth and vertical and can be followed for half a mile on the north side of the trail. The grayish, quartzose rock lies in nearly horizontal beds, all of which contain magnetite. This rock always weathers shiny, smooth and black and has the appearance of solid iron. There is very little pure ore in these beds. A sample from the S. W. ¼ sec. 31, 60–13 showing the weathered surface is 375.

There is a large exposure of the Animike rock and a shaft dug down about ten feet by the side of the vertical exposed wall of rock in the N. E. ¼ sec. 11, 59–14. There is here seen a thickness of 15 feet of the usual dark-colored rock. It is, however, reddish in streaks and contains a little hematite with the magnetite. At the bottom of the shaft, particularly, the rock is soft and hematitic. At the surface of the ground the rock is harder and seems to be composed of reddish quartz in fine grains strongly resembling the "chalcedonic" quartz of Vermilion lake, 376. Hematitic rock from the base of the shaft is 376 A. There are thin bands of good ore contained in the rock here; but there is not enough to pay for working. This ledge is on the west side of a ridge which trends to the northwest. The strata have a little higher dip than usual toward the southeast. Some of the ore is seen to be further altered to limonite.

In the N. W. ¼ sec. 11, 59–14 is a small outcrop of Keewatin rock.* It lies in vertical beds striking N. 80° E. Sample is 377. In the S. E. ¼ of the same section and particularly in the S. E. "forty" there is a great deal of this rock. It rises in a ridge 15 feet above a cedar swamp. It is feldspathic or felsitic and stands in vertical strata having the usual strike for this formation. Samples are 378.

Prof. A. H. Chester, in the Eleventh Annual Report Geology of Minnesota, p. 156, speaks of hematite boulders in a layer of black sand, which he observed at the bottom of a shaft 15 feet deep in Animike, a short distance north of here. Perhaps they were on top of the Keewatin and were covered up by the Animike sediments.

The Animike beds appear to be considerably broken in this region. Several very large masses of strata were seen that were

* This is believed to be the first observation reported of the existence of the green schists of this formation south of the Giant's range.

in horizontal position and evidently but slightly disturbed from their original position. Some of them are on the hill above the Keewatin and only about 200 feet away from exposures of it in the S. E. ¼ sec. 11, 59-14. There seems to be no reason to doubt that the black iron ore rock lies horizontally and unconformably on the upturned edges of the Keewatin. We dug a shaft by the side of a large, flat-lying mass of Animike here. It was not proven to be certainly *in situ*; but had evidently been but slightly disturbed. In this same section in various other places Animike in place is found lying above exposures of Keewatin quite near; but no actual contact was seen.

There is another shaft in the iron ore rock in the N. W. ¼ sec. 14, 59-14. It lies nearly horizontal and the rock has the usual gray, arenaceous, magnetitic appearance. It is glaciated on the surface but the direction could not be taken owing to the magnetic disturbance. One sample from here is 379.

The black slates and quartzytes in sec. 22, 59-14 do not seem to be so magnetitic, but contain veins or bands of blackish quartz or jasper. This jasper is granular and upon being pounded it crumbles and displays many white grains. The rest of the rock is grayish and is penetrated by fine needle-shaped crystals of hornblende (?) No. 380.

In the S. E. ¼ sec. 17, 59-14 there is an outcrop of the schist which is supposed to be Keewatin. It is in vertical beds which strike N. 75°—N. 80° E. It is dark gray and soft but siliceous and sericitic, 381. This is only about one mile south of Hinsdale and is remarkably close to the syenite ridge which rises 150 feet or more higher, a mile north of this exposure. The syenite appears only half a mile north of here. The dip of the schists is vertical or at a high angle to the south.

The rock which forms the highest part of the Giant's range at Hinsdale is syenite which frequently has a distinct vertical gneissic structure. This syenite is reddish near the surface, but is gray about 30 feet below. It contains porphyritic crystals of pink orthoclase, which become deep red in places. There are lenticular masses of dark, hornblendic rock inclosed in this syenite at all depths. Some of these inclusions are five or six feet in diameter. They are always elongated perpendicularly and consist generally mainly of hornblende, 383.

A few intrusions of fine gray granite and pink granulyte are seen to penetrate the syenite. Epidote colors the rock in the proximity of veins and faults or fractures. Quartz and feldspar veins of limited extent are not uncommon.

The rock is a handsome one for ornamental purposes, and columns or blocks of any required dimension quite devoid of flaws or cracks can be obtained. It has been quarried for the manufacture of paving stones. It is also being employed in the erection of the Round house of the D. and I. R. R. at Two Harbors. Twenty-five samples of this rock were obtained, 382. Glaciation is very fine on top of the ridge, N. 22° E. The summit of the range is 120 feet by aneroid above the station at Hinsdale.

North of Hinsdale there is a rapid descent in the level of the country. At one mile and a quarter from the station is a low outcrop of syenite. It is quite similar to that in the ridge. It outcrops again at 2 miles and still again at about 3 miles north of Hinsdale station. At the last place it is red and dark and the hornblende is decayed. Small geodes of quartz and calcite crystals are seen in it here. One sample is No. 385. The level here is 180 feet below the top of the ridge at Hinsdale. There is considerable drift mixed with numerous boulders of syenite at this place and all along back to the ridge.

The last syenite seen on the railroad north from Hinsdale is about five miles from the summit of the Giant's range. It is reddish and lies in low outcrops. For the next mile or two the country is low, flat and swampy. Then come knolls and ridges of Keewatin dipping about N. 75°. The dip is lower than on the south side of the ridge or at Tower. Veins of calcite are noticed in the rock.

It is noticeable that no Animike either in place or as boulders is seen north of the Giant's range. The ridge of syenite is about six miles wide from north to south where the railroad crosses it.

John Mallmann in charge of a crew of 25 men was at work in sec. 29, 59–14 sinking shafts through the drift and down to the underlying rock in search of iron ore. He finds the rock to contain both hematite and magnetite. Some of it is colored quite red by sesquioxide of iron. At depths below the surface varying from 15 to 40 feet the bed rock is encountered. It consists of thin strata of grayish rock which might be termed ferruginous quartzyte, but it is not pure quartz and iron ore. Some of it has an indistinct conglomeritic appearance, the pebbles being fine, grayish or greenish or sometimes hematitic. The beds are not as a rule more than 6 or 8 inches thick and have a low dip to the south or southeast. The syenite is said to lie about ¼ mile north of here. Much of the hematite found in these shafts shows a further alteration toward limonite.*

Red, hematitic rock having the usual dip and appearance of hematitic Animike strata is seen in a shallow railroad cut about ¼ mile south of Mallmann's camp.

Mr. Willard visited Partridge river and examined some exposures of rock in the neighborhood. Gabbro was seen in a railroad cut ¾ mile north of Beaver creek, sec. 5, 58–14. It was exposed for 150 feet along the track. It was somewhat decomposed and weathered into rounded, boulder-like forms, 386. One-quarter of a mile farther south is another cut through gabbro. The same rock is seen on the south side of Beaver creek about a hundred paces from the railroad track, and in fact forms all of the knolls and is seen in all of the cuts for some distance south of Beaver creek.

On the south side of Partridge river, about in the N. E. ¼, S. W. ¼ sec. 9, 58–14 just above a small creek is a low outcrop of black or dark-gray, siliceous, thick-bedded slate which seems to dip about 20° N., 80° E. A system of vertical joints pervades this rock, the general direction of which is about east and west. About 200 feet down stream from here the river runs over the edges of these beds of slate. Following the rock for some distance down stream an old shaft is seen but no interesting features are exposed by it. It is in a ridge whose course is nearly north and south. Exposures of this same rock were noticed in several places in this vicinity; the ledges rising about 8 feet above the general level. The gabbro overflow surrounds and nearly covers this rock. The strike of the slates where the strata have been broken or lie in ridges for any distance, is N. 10° W. This rock is not exposed over a region exceeding 350 feet in diameter. It seems to be a little of the Animike formation which was not

* An analysis of this limonite, made by Mr. C. F. Sidener, gave the following:

Silica, SiO_2	3.52 per cent.
Sesquioxide of iron, Fe_2O_3	87.10 per cent.
Manganese	traces.
Lime and Magnesia	traces.
Phosphorus, P	.023 per cent.
Sulphur, S	traces.
Water, H_2O	9.70 per cent.
	100.343
Metallic iron, Fe	60.97 per cent.

covered by the gabbro overflow. It is not iron-bearing here to any appreciable extent as are the strata generally farther north. It occurs in thick, homogeneous beds in which the sedimentation is quite evident. It is silico-argillaceous and seems to be carbonaceous. Samples are numbered 387. The rock lies in lower ground than the surrounding gabbro knolls, between which and the slate a swamp intervenes.

In the N. E. ¼ of the S. E. ¼ sec. 11, 59–14 is a shaft five feet deep. No rock *in situ* appears to have been encountered in it; but many fragments of reddish-gray, quartzose rock are seen in the sides of the shaft and on the surface round about. This land is 140 feet lower than that ¼ mile north of here. Samples of reddish hematitic ore from here are 388.

About 250 paces west of the east quarter post of sec. 11, 59–14 is a shaft dug to a depth of ten feet by the face of a north and south ledge of rock. The strata here dip about 15° slightly to the south of east. Good iron ore is seen in veins or bands 2 or 3 inches thick in the face of this ledge. This wall of rock is exposed for several rods north and south of this shaft. It is noticeable that the prevalent direction of the joints in this formation is north and south.

In a part of sec. 11, 59–14 which was visited on our return to Birch lake, near the center of the section, Keewatin rock is found standing as usual in vertical strata. It is quite feldspathic. Above it, separated by a few feet only of unexposed rock covered by drift, are masses of Animike strata 15 feet long and 8 feet thick which seem to have been but slightly disturbed from their original position. A sample of the Keewatin rock is 389. There are quartz veins in it which contain talc-like scales. 389 A. Some of this vertical schist is graywackenitic and some granulitic. Some resembles the rock found at Partridge river supposed to belong to the Animike, 390.

Outcrops of felsitic, siliceous schist in vertical strata with a strike N. 80° E. are seen in N. E. ¼ sec. 15, 59–14 near the north section line; 391.

Southeast from the last about 200 paces and 40 feet higher is found a large solid outcrop of iron ore rock. It rises five or six feet and is seen for four or five rods. It is horizontally stratified or has a dip of less than 10° to the east. This is considered as certainly lying unconformably on the vertical Keewatin. No. 392 is from here.

There is another ledge of iron ore rock (Animike) in N. W. ¼

N. W. ¼ sec. 14, 59–14 near the center of the quarter section. Some good ore is found here, 393. From the way in which the Keewatin schists are found to underlie all this Animike an observer receives the impression that an iron mine or iron lands in this formation *here* are not of much value, for it is doubtful whether a shaft 40 feet deep could be made in the iron ore rock anywhere in this township without passing through it and reaching the Keewatin.

Fragments of the Keewatin rock are seen all along the trail in Twp. 60–13, indicating that it outcrops somewhere and perhaps at several localities between the trail and the syenite ridge. The number of rough pieces of Animike rock that are everywhere seen along this trail show what was the entire surface of the land south of the Giant's range and indicate that the region immediately south of the ridge was to a great extent protected from the force of glacial erosion.

A sample of quartzyte which was seen in angular fragments in 60–13 was obtained as showing fine stratification. It contains a little magnetite in bands which fade out completely in this specimen. No. 394. Deposits of magnetic sand are seen on the shore of Birch lake where the trail starts out, S. W. ¼, S. E. ¼ sec. 32, 61–12. No. 395.

BIRCH LAKE REGION.

Tonga or Dunka (sand) river. This name is bestowed by the Indians on account of the extensive banks of reddish sand and gravel which form the shores of the lake near the mouth of the stream and also compose the bed of the river for a short distance above the lake. Mingled with this red sand is more or less black magnetic sand sometimes in such quantity as to make the beach black. An instance of this is in the S. W. ¼ sec. 33, 61-12.

For a mile up this river there is a large amount of drift containing many boulders. The land rises in east and west ridges 100 feet or more above the river. Near the south side of sec. 4, 60–12 the ridges seem to be composed almost wholly of large granite and syenite boulders. It can not be ascertained certainly whether they are underlain by rock of the same nature *in situ* or not.

South of this ridge is another in S. ½, N. W. ¼ sec. 10, 60–12* which has, exposed on the surface, many angular fragments of

* This ridge is referred to by N. H. Winchell, in his fifteenth annual report, p. 341.

semi-stratified rock consisting mainly of magnetite and olivine with some quartz. This rock appears to be *in situ* at two or three places on the north side of this ridge and to dip S. 70°–80°. Syenite is found in ridges south of here, and some distance south of them is found the gabbro. The Animike, therefore, has here a range of syenite between it and the gabbro. Samples of the iron ore rock from 400 paces east of the west quarter post sec. 10, 60–12 are 356. The needle dips N. 60° to 70° here.

Other localities around Birch lake. Pursuing a trail which leads south from the lake, starting in the N. E. ¼ sec. 26, 61–12 toward some claim cabins in sec. 35, 61–12 some interesting rocks were seen. A short distance from the lake is a knoll of fine-grained crystalline rock which is generally considerably decomposed and yellowish in color. It has the composition of gabbro and is apparently the rock that first cooled on the outer edge of the gabbro overflow. It contains both biotite and hornblende sparingly, also olivine and magnetite, but is principally made up of labradorite. There are spots in it of light-colored feldspathic rock which appear to be boulders whose outline is not distinguishable from the rock mass. A sample of the fine gabbro or muscovado-like rock is 396. A sample from one of the boulder forms is 396 A. These are from the N. E. ¼ sec. 26, 61–12. This gabbro appears in small, detached knobs lying on the Animike iron ore beds. These beds are somewhat disturbed and broken and vary in dip to the southeast from 12° to 30°. Near these knolls of gabbro the iron ore rock is semi crystalline, containing porphyritic crystals of hornblende sometimes two and a half inches long. Specimens from here are 397, 397 A, and 397 B. There are large outcrops of this Animike rock here. Sometimes the stratification is not very evident, but generally it is distinct and well-marked, 398.

The beds here have the same vertical joints running north and south; and present east and west vertical faces from four to fifteen feet high such as are seen south of the Giant's range. Loose, angular fragments of Keewatin schist are seen here and probably lie near the surface in the vicinity under the Animike. Some of the Animike is almost all quartz which forms a coarse granular sandstone on decomposing. A specimen from the E. ½, N. W. ¼, sec. 35, 61–12 is 399. Glaciation here is about N. 15° E.

In the S. E. ¼, N. E. ¼ sec. 35, 61–12 are several ridges of magnetitic quartzyte having vertical faces 15 feet high on the west side. A few feet west of one of these walls of rock there is a knoll of syenite. The latter is porphyritic with pink and white feldspar and contains both biotite and hornblende, together with a considerable proportion of quartz. It rises in the knoll as high as the top of the quartzyte ridge but slopes down and runs under it. The syenite is 400. The quartzyte is in beds which are nearly horizontal and seem to have about the same texture and composition where it lies on top of the syenite as they have ten feet higher up, 401. A claim cabin is located on the syenite ridge only a few rods from the quartzyte ledge. The syenite is cut by a few veins of fine, pink granulyte. The situation is shown in Fig. 2.

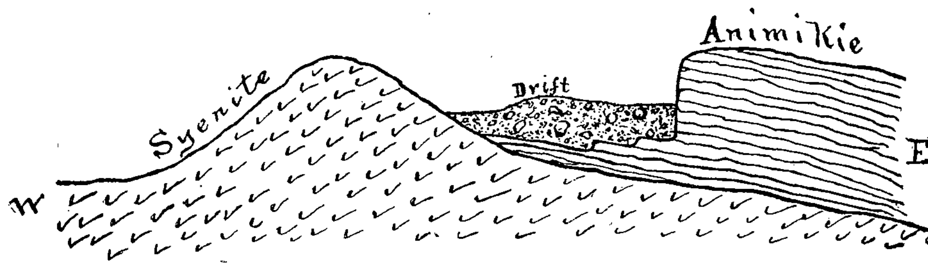

Fig. 2. Relation of syenite and Animike ridges. The little valley between the two ridges is about 12 feet deep and 35 feet across. The west face of the quartzyte is perpendicular. The land is covered with small pines.

A trench was made with some labor from the quartzyte to the syenite thus exposing the manner of contact. The Animike was found to lie on the syenite in a thin, hard, hornblendic stratum about six feet from the main mass of exposed syenite. It was buried under about five feet of till with hardpan at the bottom. Samples of the layer of Animike rock found lying on the syenite are 406.

In the first shaft that was dug down at the foot of the Animike bluff a large mass of greenish Keewatin rock was encountered that prevented further excavation at that place. This rock, which was supposed to be a drifted fragment, was coated with a crust of calcite crystals all over the top. In several places the syenite was seen to have a thin layer of the hardened Animike rock adhering to it which had not been removed by glacial scraping. From the appearance of such rock it seemed as though the abrading action of the ice was not so violent as is generally supposed.

In the N. E. ¼ of S. W. ¼ sec. 35, 61–12 the magnetitic quartzyte is exposed in many places. It seems to have been affected by some metamorphosing agent which has produced large crystals and masses of crystals of hornblende in it. Some of these crystals are three inches long. They frequently are rounded or lenticular as a whole mass and suggest included boulder forms, 402.

West and northwest from the last locality the ground rises and syenite is found outcropping in quite extensive ridges. This is near the west quarter post of the section.

Toward the S. W. ¼ sec. 35, 61–12 the land rises until it is 200 feet above Birch lake. On this high land many large, smooth-topped exposures are produced by recent extensive wind-falls. The strata seem to have been disturbed and slightly elevated by some force from beneath. The usual dip—less than 30° to the southeast—is, however, still maintained. This rock is coarse and more quartzose and has quartz veins penetrating it. Glaciation is finely exhibited in many places and seems to vary, as near as could be estimated, by comparison with the section lines, from N. 12° E. to N. 30° E. Syenite is reported to outcrop about one-half mile west of the S. W. corner sec. 35, 61–12. Some of the beds of this Animike rock are but slightly iron-bearing and are almost wholly composed of olivine, 404.

In the N. ½ of the S. E. ¼ sec. 24, 61–12 there are several exposures of Animike rock in shafts which have been dug in the search for iron ore, as well as on the surface. The rock is dark, heavy and magnetitic and exhibits fewer sedimentation bands than usual. But it has the general dip of this formation and is rich in olivine. There have been six or eight shafts sunk at this place; some of them are nine or ten feet deep and furnish good sections of the rock strata. Some thin strata of rich magnetite are seen in the rock; but they are always separated from each other by beds of poor ore or of quartzyte, 405. Much of this rock is hornblendic; the crystals appear right in the middle of olivinitic and finely granular strata containing more or less magnetite. These crystals of hornblende are in the strata ten feet below the surface beds, and are sometimes two inches long or more, 405 A. In places the rock has been moved on itself and has thus formed fine slickensided surfaces, 405 B.

There is a heavy covering of drift sand and boulders here. Granite in place and gabbro lying on it were seen a short distance farther east in the S. E. ¼, N. W. ¼ sec. 24, 61–12. The Animike beds seen in the vicinity were in knolls that rise above the granite and gabbro and are estimated to be 150 feet above Birch lake. A thickness of about 25 feet of the iron-bearing strata was seen in the various shafts.

This same rock outcrops on the west side of the little bay in S. E. ¼, S. W. ¼ sec. 24, 61–12, a short distance back from the shore. At this place it is much decayed and jointed.*

Vicinity of Kawishiwi river. Going south on the range line between townships 62–10 and 62–11 on the south side of the river in S. E. ¼ sec. 13, 62–11, search was made for the iron ore reported by Mr. Lorenzo Cleaves. Nothing was found for half a mile except syenite in a ridge about 75 feet, by aneroid, above the river. Then there is a swamp and a creek, and gabbro hills are reached in S. W. ¼ sec. 19, 62–10. These hills are but a little over 100 feet above the Kawishiwi. The gabbro is seen in bare knobs and vertical bluffs 20 to 40 feet high. Some masses of gabbro 30 feet in diameter have been pushed up on top of the smoothed knolls of solid rock and left there by the ice.

In the S. E. ¼ sec. 30, 62–10 are several shafts, some more than 20 feet deep, in magnetite ore. The magnetic attraction is very strong here and the needle dips 90°. There being more than a mile and a half of gabbro north of this place and this iron ore itself being in hills of gabbro 100 feet high it would naturally be supposed that this ore is gabbroitic magnetite and therefore titaniferous.

But the ore is olivinitic and generally quite fine-grained, and the rock which contains it is not a massive crystalline rock like gabbro, but stands in beds which are nearly vertical, though the dip is not constant. These strata are olivinitic and besides being finely granular, possess a banded structure and are evidently *transported beds of Animike strata contained in the great gabbro overflow.* Whether they are between overflows of different dates or were surrounded and taken to their present position at the time of a single eruption was not evident, but the latter is more probable. The gabbro itself being also largely composed of magnetite here renders it more difficult to distinguish between the two kinds of rock. Samples from the S. E. ¼ sec. 30, 62–10, showing banded structure supposed to be due to sedimentation are 407. Specimens of the coarse gabbro magnetite are 410. The Animike is quite hornblendic here as at the locality north of Birch lake, sec. 24, 61–12. The gabbro which forms massive knolls all around this place is not so much decayed as the iron

* N. H. Winchell, Fifteenth annual report, p. 335.

quartzyte, nor does it display any banding nor any other signs of bedding as do the enclosed strata of Animike.* The general strike of the latter is east and west.

A trip was made from the Kawishiwi river in N. W. ¼ sec. 25, 63–10 southeastward into sec. 36. Gabbro ridges and knolls from 70 to 100 feet above the river are crossed. Many large fragments of greenish schist from farther north lie on the surface, also boulders of syenite and amphibolyte or dioryte. This gabbro is rather coarse and is magnetitic in spots and streaks; 412. There are belts of coarse hornblende and labradorite found in it. 412 A. Included in the gabbro are irregular masses of all sizes of fine, grayish rock that seems to be composed of rounded grains and resembles Animike. There is no evidence left of former stratification, and in places where it has been highly altered this rock has the composition of a fine gabbro. But the transition from it to the gabbro is always abrupt and the outlines of the included masses of it are plainly seen. 413. This rock is slightly ferruginous if at all; but the gabbro contains much shining, coarsely crystalline magnetite. 414.

In the S. E. ¼, S. E. ¼ sec. 25, 63–10 the gabbro contains some large masses of very coarse hornblende. There are places in the gabbro four to six feet in diameter which contain or are wholly made up of black hornblende crystals six inches long. There is a little mica in connection with it, also some coarse labradorite. 415.

Vicinity of Long Lake. The hills in the N. W. ¼ sec. 20, 63–12 are composed of diabasic rock. They rise about 100 feet above

*An analysis of the magnetite supposed to belong to the enclosed beds of Animike and therefore to be non-titaniferous, was made by Mr. C. F. Sidener. No titanium being found in it the effect of the gabbro does not seem to have been intense enough to invest the magnetite with harmful ingredients.

Silica, SiO_2	11.39 per cent
Alumina, Al_2O_3	Traces.
Magnetic oxide of iron, Fe_3O_4	85.55 per cent
Titanium, TiO_2	None.
Lime, CaO	.22 per cent
Magnesia, MgO	3.44 " "
Phosphorus, P	.02 " "
Sulphur, S	Traces.
	100.62 " "
Metallic iron, Fe	61.95 " "

the lake, and in them are seen the same coarse boulder forms* as have been noticed in this rock farther east, also at the railroad cut near the Chandler mine, on the south shore of the lake in sec. 28, and in the N. E. ¼ sec. 5, 62-12. On the north side of the first ridge north of the lake the rock is not so diabasic, but is the usual more or less fissile sericitic schist.

In the N. E. ¼ sec. 9, 63-12 the sericitic schist changes rapidly across the strike, going north, into granite, becoming first siliceous, then felsitic or feldspathic and finally micaceous. Specimens illustrating this are Nos. 416 to 416 E. The granite still preserves in places a coarse vertical schistosity. North of this granite, which continues only for a short distance, is hornblendic biotite schist crossed by veins or intrusions of syenite and granite; 417. This dark schist is in vertical strata having the usual strike of about N. 60° E. The lake which lies in sec. 4, 63-12 is about 75 feet higher than the lake just south of it.

Going overland from the lake to the N. W. corner sec. 4, 63-12 the rock is found to be hornblende-biotite schist dipping north at an angle of 75° or more. Most of it is very dark colored and heavy, 418. Nothing was seen of the belt of magnetic iron which had been reported to exist in this section.

Going south from Ely into sec. 4, 62-12 the rock is found to be mostly covered by a thick deposit of drift until the N. W. ¼ sec. 4 is reached. Here there is seen an abrupt ridge of sericitic green schist striking N. 60° E. and having a vertical dip. This ridge rises 75 feet above the swamp on the north side of it. The rock contains considerable calcite as at Ely. 419. Going west several pits are seen dug in the low ground north of the ridge. All of them penetrate a soft reddish rock strongly impregnated with iron similar in appearance to that in the mines at Ely. It seems probable that the depression north of this ridge may have been produced by reason of the softer nature of the iron ore beds which may lie in there. And it is not at all unlikely that rich beds of soft ore underlie the swamp referred to. In the N. E. ¼ sec. 5, 62-12 a large, glaciated surface of the green rock is exposed. There is here a fine exhibition of the coarse agglomeritic structure mentioned above. A diamond drill just east of this place has gone down 60 feet in the same rock.

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*This is referred to by Mr. A. C. Lawson in his report on Lake of the Woods as a "concretionary (?) trap structure."

LAKE SUPERIOR TRIP.

The country south and east of Bald Eagle lake (the Indian name for this lake is *Mishiwishiwi sagaegan* or Beaver-house lake) has been burnt over and is now covered by a small growth of aspens, birch, jack pine, spruce, etc. It is rocky and hilly, the hills of gabbro rising 100 feet or more above the general level. The route to lake Superior lies up the river which enters the south side of Bald Eagle lake. This stream is smooth for a short distance and has low swampy banks. A rapid where the river falls 50 feet is then encountered and above it again the smooth, currentless stream. The solid rock is all gabbro and most of the boulders are of the same material, though there are a few boulders of Keewatin greenstone and of granite. On the first portage there are seen some large pieces of white vein quartz. The gabbro for a mile or two is almost wholly composed of labradorite. In one place was seen quite an accumulation of boulders of siliceous greenish rock like that at the west end of Knife lake.

The land in the S. W. ¼ of township 62–8 is quite uniformly level. The lake in sections 29 and 32 has low shores, mostly marshy. The rock is gabbro, many boulders of which lie around. The lake and river seem to be almost on top of the gabbro ridge, the hills around them are so low.

Lake Isabelle. The shores of the west side of this lake are composed of gabbro. They are generally about ten feet high, but sometimes rise to forty feet. The gabbro is very much decayed near the surface. It is composed principally of labradorite; but contains some biotite and a little magnetite. There are occasional small pieces of granular olivinitic rock, supposed to be Animike, enclosed in the gabbro. They are hard and sometimes have a basaltic structure. A sample of gabbro from N. W. ¼, S. E. ¼ sec. 35, 62–8 is 420. There are numerous boulders of fine siliceous greenstone from farther north seen lying around the shores of the lake. The Indians call this lake by the same name as Gabbro lake, viz.: *Kazushkonabigka-gamak*, the lake-with-the-shores-of-shelving-rock. On the east side of the point last mentioned is a beach of sand and pebbles. The latter consist of siliceous greenstones, porphyrytes, granites and gabbro, 421.

The gabbro in the bay east of this point is smoothed by glaciation and considerably decayed. It contains in one place ten feet of hard, greenish rock in a dyke or bed about a foot wide, which seems at first to be trap, but is not massively crystalline and seems to contain some rounded grains, and therefore may be Animike rock hardened by the action of the gabbro.

In the S. W. ¼ of S. E. ¼ sec. 36, 62–8 there is a dyke 16 inches wide exposed for 30 feet. It is perfectly straight and is composed of tough green rock. The dyke walls are well-defined and it maintains the same width for the whole distance of its exposure. This rock hardly appears like trap; it is too granular and not sufficiently crystalline. Neither can it be said to resemble the Animike rock. The direction of this dyke is N. 64° E. 422.

In the S. E. ¼ sec. 36, 62–8 the gabbro stretches out in long, low reefs into the lake. Beds of sand which is the result of rotting gabbro occupy the hollows. There seem to be layers or beds in this gabbro that are like the rock found in the dyke, 422. The question arises whether this rock was igneous and flowed over on the gabbro or whether it is changed Animike enclosed in it. Glaciation is N. 24° E.

Some of the gabbro is fine grained and brown and contains more biotite than the gray. Perhaps this is what has been called "muscovado." One sample from the south shore of the lake just east of the range line in Twp. 62–7 (unsurveyed) is 423.

Swamp Lake river (*Maskigo-sibi*) enters lake Isabelle on the east side. This river is a series of lakes connected by a small stream. About two miles up this stream a change takes place in the gabbro. It is found to be composed of reddish feldspar and much hornblende with a little biotite, magnetite, pyrite and sometimes galena. Streaks of this reddish gabbro are first seen running through the gray and then it all becomes red, and large massive knolls are formed of it. Nos. 424, 424 A. and 424 B. illustrate this change.

The route to lake Superior lies through the series of small lakes connected by a stream which comes from the east and southeast. This stream is very rocky and full of rapids and comes from Kaminisabikokak lake which has been re-named lake Bellissima. This lake is about two and a half miles across from east to west and four miles long from N. W. to S. E. It is situated in the southeast part of Twp. 61–7, and perhaps extends into Twp. 61–6. Notwithstanding the rapids in the river a person receives the impression that the country is unusually level. No hills of any considerable hight are seen, and at times the stream is merely a narrow lake a mile or more in length with a low rapid at each end and shores not over 20 feet high. The country has all been burnt over and the only trees are small poplar, birch, willow and jack pine. A great many boulders principally of gabbro are seen on all hands. There are also boulders of trap and red Cupriferous rock for two or three miles west of Bellissima lake. The solid rock is all gabbro. West of the lake it is nearly pure labradorite, but toward the east it is associated with a larger proportion of magnetite. It decays rapidly and crumbles apart forming beaches of sand which is nothing but decomposed labradorite feldspar. The Indian name for this lake is applied with reference to the large number of boulders which line the shores and stand several feet out of water at some distance from the shore all around the lake.

There are sand and gravel beaches, beaches of small cobble stones, beaches of moderate sized boulders, and beaches where the boulders average more than six feet in diameter, while some are fifteen to twenty feet. The largest boulders are of gabbro; but many of the smaller ones are greenstone or red amygdaloidal trap. There are comparatively few exposures of solid rock around this lake, but all the rock that is seen is gray gabbro.

The stream which enters the southeast corner of the lake is canoeable for only a short distance, about half a mile above Bellissima lake. A portage of a half a mile is then made to a small lake and then another portage of one and a half miles south to lake Gaokakag, or lake Harriet. The country has a heavy covering of drift sand and gravel and but little rock is exposed. Many of the pebbles and boulders are from the Cupriferous. Occasionally there is seen an outcrop of gabbro, quite coarse and containing considerable magnetite. The surface is rolling and open, having been burnt but a few years ago.

Lake Harriet is about two miles long. It is a beautiful body of water set in hills heavily covered with white pine around the south half of the lake. High water is maintained in it by a beaver dam at the outlet. The long portage necessary to make in order to reach the lake from the north cuts off an impassable part of the river. This lake is 70 feet higher than the small lake at the north end of the portage. The country between these two lakes is good farming land, but is now nearly bare, having been burnt recently.

At the outlet of lake Harriet there is a massive exposure of reddish-gray rock, which crosses the river and forms a rapid.

This rock is a phase of the gabbro. Some of it is fine and hard and very tough. It is composed of hornblende, biotite and red feldspar. A little farther south the rock is coarser and contains a small amount of gray labradorite. Then the two kinds of feldspar occur in equal proportions. From here the red feldspar fades out until the usual condition of the gray gabbro is reached. Where the fine, hard, reddish-black rock is first seen it does not look at all like gabbro. Nos. 425 to 425 C illustrate the change.

Hornblendic gabbro is seen in a low exposure not far east of the north end of the lake. No. 426.

This lake is situated in secs. 20, 29 and 28, 60–6. Very few exposures of rock are seen around it, the shore being mostly composed of the drift which supports such a fine growth of pine. Hills of drift 60 feet high surround the lower end of the lake. A few boulders are seen on the lake shores, but they are mostly sandy. There is an immense accumulation of boulders just north of the lake — large bare ridges of all sorts of boulders, trap, gabbro, Cupriferous, Keewatin, porphyry, granite and Animike slate. These ridges are evidently morainic deposits.

A short portage of 285 paces leads southeast from lake Harriet to Pine lake just east of it. Some trap and a peculiar rock of various colors and texture were seen on this lake. The notes here were taken by Mr. Grant.

A half mile portage leads across the divide from Pine lake to a small, nameless lake 30 feet lower. No rock was seen around this lake.

A long portage, over two miles, leads south to *Kapokegamak or Crooked lake*, in Twp. 59–6. The country is all covered with a fine growth of green timber. The drift is rich and evenly distributed and the land is good for farming.

In sec. 15, 59–6 some fine-grained, olivinitic gabbro was found. It is cut by extensive dykes of green trap.

A sample of gabbro which was found in place on the west side of Crooked lake is 428. Steep hills of trap occur just west of the northern narrows, sec. 15, 59–6. This trap is porphyritic with green feldspar(?). It outcrops in several spots around the lake south of here. 429. Glaciation is N. 6° E.

From Crooked lake a short portage leads south to a small nameless lake on which no rock was seen. From here a portage of one-half mile leads to Nine Mile lake, so-called because it is nine miles by trail to lake Superior and no more canoeing. On the north and west sides of this lake are exposures of rather fine-grained, olivinitic gabbro. 430.

Following the nine mile portage trail south a distance of one mile a small pond less than one-fourth mile long is encountered. This is 75 feet lower than Nine Mile lake. In the next half mile the trail rises 220 feet and reaches a pond 205 feet above the last small lake. Lake Superior can be seen from the hills surrounding this pond, which rise 75 feet above it. The land on the south shore of the great lake can also be seen with the naked eye. This pond is supposed to be in sec. 35. 58–6.

The creek which flows from the pond runs in a deep gorge. The east wall of this gorge is Cupriferous and the west wall is fine-grained olivinitic gabbro or trap. This is the first true Cupriferous seen on this route. It rises in high, precipitous hills consisting of a reddish felsitic rock very much jointed and containing light and dark spots and streaks. Several shafts have been dug at the foot of the gabbro ridge on the west side of the gorge mentioned above. Fragments of the reddish Cupriferous rock were thrown out from all of these pits; and in fact that is apparently the only rock found in digging them. In one of these shafts the red rock seems to be in place. This is just below the lofty bluff of gabbro which therefore seems to lie upon the Cupriferous here. Still they may be side by side and neither one be above the other. The gabbro contains more olivine and less magnetite than that seen six miles north of this place. The general boundary line between the gabbro and Cupriferous runs through the south tiers of sections in the east half of township 58–6. Samples of the gabbro are 431. The Cupriferous is 432.

Between this high ridge and the range of hills just north of the lake there is a low, broad valley heavily timbered. The trail does not cross the highest part of the ridge along the lake shore, but follows the valley of a small stream which seems to have cut a gorge through the ridge, but probably followed a natural depression. No rock was seen exposed south of the gabbro ridge. The trail descends 1125 feet between the small pond mentioned last and lake Superior. There are hills around this pond 100 feet high, and the gabbro ridge is therefore 1225 feet by aneroid above lake Superior, or 1827 feet above sea level. This trail comes out at Pork bay. The hills at the west side of this bay rise 330 to 460 feet above the lake.

GUNFLINT LAKE.

A small stream from the north enters the east end of the lake just north of the boundary river. A few rods west of the mouth of this creek gabbro is seen lying in Animike slates. About one-eighth of a mile up the creek rock in place is noticed. This is a ridge of vertically bedded rock supposed to be Keewatin. Strike is N. 80° E. Dip is not constant. Some of it is fine-grained and flinty and resembles the Knife lake rock. 433. Farther up on the east side of the creek the same rock is coarser and not so siliceous, but contains chlorite or sericite. No. 434.

It was because of reports of red jasper being found here that a visit was made to this creek. This jasper was found to be in beds of Animike lying horizontally on the opposite side of the bed of the creek from the Keewatin. The bed of this stream lies in the line of contact between these two formations. The Animike is flinty and becomes more reddish farther up the creek, 435.

About one-quarter of a mile up the stream the creek spreads out into a marshy lake. A north and south Canadian survey line between 297 T and 298 T crosses the creek at the head of the rapid water. At this place, on the east side of the stream, are thick beds of horizontal Animike. It has here the nature of a somewhat decomposed, fine, dark conglomerate. The pebbles in it are iron rusted; they are sometimes an inch long, but generally less than half an inch. They are flattened horizontally, 436. On a knoll above this conglomerate, a short distance east of it is found another outcrop of schistose Keewatin. It is greenish and somewhat sericitic, 437.

In the bed of this same creek there is found the contact between Keewatin and Animike. The two rocks are very similar in appearance and texture at the point of contact, and it is only by following up what is plainly Keewatin on one side and what is known to be Animike on the other until they come together that the junction could be determined. Even then the actual line of contact could not be seen, being in the bed of the creek of running water; but a person can stand with one foot on rock that is plainly horizontally stratified and is magnetitic, and the other foot on a slightly different rock that is lighter colored, contains no magnetite and has vertical bands of sedimentation. The space between is occupied by rock that may belong to one formation or to the other and is somewhat broken up. The best place to observe this contact is at the water's edge on the east side of the brook. The Keewatin strikes N. 80° E. and has a high dip to the north or is vertical; a little farther down the creek, however, it dips S. 75°. A ridge of the Keewatin on the east side of the stream rises above the Animike which lies unconformably in almost flat beds upon and against it. The Animike is 438. Specimens of the Keewatin are 439.

Going south from Gunflint lake to Loon lake a ridge of gabbro 300 feet high is crossed. Loon lake is 195 feet above Gunflint by aneroid. Mayhew lake is 110 feet above Loon lake. It is surrounded on the west side by low gabbro hills. This gabbro contains considerable magnetite. Several claim cabins are located on this gabbro ore. The gabbro in Tucker lake just west of Mayhew lake is also magnetitic. It is quite coarse and decayed and presents a gneissic or foliated appearance. A sample from N. E. ¼, N. W. ¼ sec. 2, 64-3 is 440. In the S. W. ¼, N. W. ¼ same section there is some fine dioritic looking gabbro which also contains magnetite. 441. This lake being 305 feet above Gunflint it is not likely that there is any Animike exposed on its shores; and indeed none was seen.

In the S. E. ¼, N. W. ¼ sec. 2, 64-3 the gabbro contains parallel bands of magnetite which dip S. 40° and give the rock a decidedly stratified aspect. Some of the beds or bands of magnetite are four or five inches thick, others only a fraction of an inch. No. 442.

The gabbro on the south side of Tucker lake presents a basaltic structure. It is very coarse and the planes of intersection are nearly at right angles with each other. One set dips S. 20° W. 45°; the other set is vertical. The gabbro here is unusually biotitic. It also contains white feldspar equal in amount to the labradorite in places. No considerable amount of magnetite was seen around the lake. It was all mixed in with the gabbro.

The point that runs through sec. 35, 65-3, on Loon lake, is highest in the N. W. ¼ sec. 35. It is made up of hills of Animike capped by trap or fine gabbro. There is here a thickness of about 150 feet of black Animike slate dipping S. 30° or more, and 30 feet or more of trap rock on top. The slate and trap are represented by 443 and 444 respectively. There is a gradual transition between these two rocks, the slates having been somewhat metamorphosed. Large pieces of coarse porphyry are seen on top of this hill. One large mass had trap rock stuck fast to one side of it. This rock was not seen in place here, but evidently belongs in the vicinity. Nos. 445 and 445 A. are the porphyry and trap. The Animike here appears remarkably thick and the gabbro on top of less depth than supposed.

In the N. W. ¼, N. W. ¼ sec. 23, 65–4 is a pit 12 feet deep which goes down through highly magnetitic beds of Animike for nine feet and then into the granite. This is nearly as high as the top of the Giant's range. The Animike is fine-grained and contains less olivine than that south of Birch lake, but has very much the same general appearance and lies like it, in strata dipping S. 15° to 30°. The best ore here is quite pure. About four feet thickness of this good ore is seen at the top of the shaft. 446. This ore possesses very strong magnetic properties. The beds of Animike which lie upon or closely above the syenite and granite seem to be very generally ferruginous and sometimes excellent ore.

The rock of the Giant's range here is very similar in texture to that south and west of Birch lake,—only it seems to contain mica here instead of hornblende. The gneissic structure, however, the color and the abundance of large bluish grains of quartz are suggestive features and remind one instantly of the Giant's range at Birch lake and at Hinsdale.

Gunflint lake to Ogishke Muncie. In the N. E. ¼ sec. 25, 65–4, just at the upper end of the first portage on the river above Gunflint lake is a bluff of Animike slates on the south side of the stream, 75 feet high. The northern face of the bluff is perpendicular, exposing finely the edges of the nearly horizontal strata of black slate. This bluff of slate is seen to lie upon trap rock into which it grades by the metamorphism of its lower beds. This trap or greenstone extends in a bare exposure for 20 rods or more north of the river. It is seen to be at least ten feet thick and has a surface dip the same as the slate beds. In some places it is porphyritic with white feldspar in spots or streaks: it then looks like the porphyry, 445, found south of Loon lake. There is a great exposure of this massive rock here, and it is plainly seen to run under the slate bluff. Some of the Animike is a breccia containing angular pieces of some sedimentary rock and of a crystalline rock as large as six inches in diameter.

The greenstone which is probably part of the Keewatin, is cut by a fine trap dyke 8 to 15 inches wide, exposed for 150 feet running N. 10° E. It contains pieces of the Animike or some other sedimentary rock. Two or three smaller dykes run at right angles to this one. Nos. 447 to 447 H are from here, also No. 448, which represents the brecciated Animike.

On the trail which runs west through sections 26, 27 and 28, 65-4, no rock other than Animike is seen. The country is elevated, 400 feet at least above Gunflint lake, and yet the nearly horizontal beds of slate are found all the way up to the top. Some of it is quite magnetic, but most of it is dark carbonaceous slate. Boulders of conglomerate apparently belonging to this formation but not seen in place are No. 449. Pebbles of quartzose and feldspathic rocks an inch and a half long are found in this conglomerate.

A diamond drill has been operated on the north side of the creek in N. W. ¼ of sec. 28, 65-4. There has also been made a cross cut here up on to the hill. The beds of Animike slate and olivinitic magnetite have here a much higher dip than usual, —S. 60°—S. 75°. There is considerable good magnetite here, but the beds are not thick enough to pay for working, 450. The tilted condition of the Animike seems to be accounted for by the rock which lies under it and which rises about 100 feet above it in the ridge north. This rock is a kind of greenstone (Keewatin), in some places looking a little like fine decomposing gabbro, containing considerable biotite at this locality. It contains labradorite and olivine and very little magnetite. The Animike is plainly seen to lie upon this rock which has slightly metamorphosed the nearest or bottom bed of quartzyte and iron ore. The lower beds of the iron bearing formation here are often exceedingly pyritous. Nos. 451 and 452 are from here. The latter number is applied to drill cores from here. These show the gradations and changes of the Animike beds as they become crystalline toward the bottom and pass through metamorphosed strata into the greenstone. The manner in which the drill penetrated the beds of Animike is shown by the following diagram.

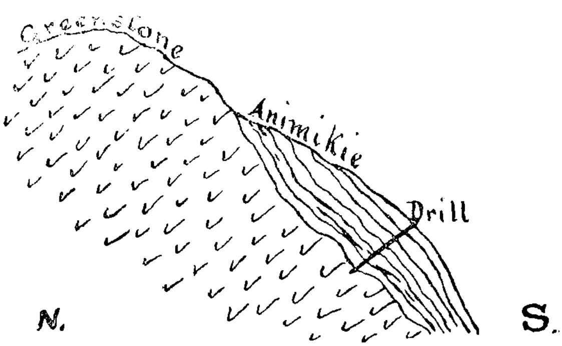

Fig. 3. *Animike beds on greenstone.* West of Gunflint lake. East of Chub lake.

This greenstone-gabbro ridge runs west of here for several miles, and the Animike is found to lie on it in several other localities much the same as it does here.

Another drilling was made about ⅛ mile south of the camp in sec. 28, 65–4. Samples from here are 453. These drill cores show the streaks and bands of hornblende crystals which are found in the lower beds of the Animike quartzyte; also the pyritiferous strata. Some of them contain biotite also and are partially metamorphosed into the underlying greenstone. This drilling according to Mr. John M. Millar of Grand Marais, one of the owners of the land, went through the ore in which it started, and about 12 feet into the "north quartzyte;" by which he must mean the underlying greenstone.

The same parties who did the work mentioned above also drilled in the N. E. ¼ sec. 29, 65–4 a short distance west of the first drillings. According to Mr. Millar the record for this working, which is near Chub lake,* is as follows: Quartzyte 36 feet, clean ore 15 feet, mixed ore 17 feet, clean ore 10 feet, greenstone 12 feet. Mr. Millar calls the last "the north quartzyte," but he evidently must refer to the greenstone on which the ore and quartzyte beds lie.

From this record it seems that there is a large quantity of magnetite at this place which will probably prove to be valuable. The parties who own this property are waiting only for the advent of a railroad to commence extensive mining operations. This is the first deposit in the Animike in Minnesota known to

* Mr. Millar states that the name "Akeley" was applied to this lake several years before it was called "Chub lake." No map, however, has been seen to have that name and as it has already been referred to in published reports as Chub lake, the name is retained.

be of sufficient extent and richness to repay investment and development.

The usual route to Ogishke Muncie was not followed here, but the more circuitous one through the lakes southwest of Chub lake was taken. I can not refrain from stating here by way of parenthesis that the township plat of 65–4 is the most unreliable of any it has ever been my misfortune to be misled by. The lakes in the southwest part of the township are delineated by guess-work and very poor at that.

In the N. W. ¼ sec. 35, 65–5 is a knoll of Animike quartzyte. It has an elevation of about 50 feet on the south side of the stream. It dips south about 75° and strikes east and west. It contains thin beds of good magnetite, 454. Across the valley which lies on the south side of it, is found gabbro.

About a quarter of a mile west of the last is a portage of 100 paces around a rapid in the small stream. It is here seen that the knoll spoken of above is a part of a ridge of Animike that is found all along the south side of this marshy stream. On the south side of this portage trail, N. W. ¼ sec. 35, 65–5, is a precipitous bluff about 40 feet high, facing north. The lower half or perhaps one-third of this bluff consists of greenstone similar to that north of Chub lake, but containing less biotite. The upper half or two-thirds is Animike quartzyte and iron ore tilted up so as to dip S. 70° or more and striking about east and west. There is an abrupt line of contact here shown to exist between the quartzyte and the Keewatin (?) greenstone and the impression made upon an observer of the situation is that the greenstone is the cause of high dip of the quartzyte and iron ore beds.

This is a very fine contact. The stratified quartzyte is seen for several feet lying directly upon the massive greenstone. At this place then the Animike is but very slightly modified by the igneous rock beneath it, and on that account it seems as though the strata must have been deposited in a horizontal position on the greenstone and that both were folded and tilted at a later period. But at other places east of here a few miles the Animike is greatly metamorphosed so that the line of contact is not discernible, and the greenstone might be supposed to be all modified Animike. The greenstone near the contact is a little finer-grained and less massive than it is two feet below; but no other change is apparent. Specimens of the Animike from the contact are 455. The contact was seen again 150 paces west of this place; but it is not so plainly visible. Samples of the Animike from the western contact are 455 A. Specimens of the greenstone from the eastern place are Nos. 456 to 456 C, taken in order receding from the line of contact. Greenstone from the western contact is No. 456 D.

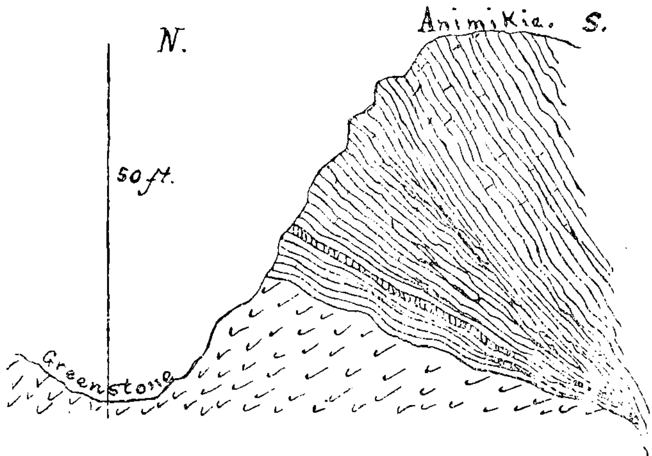

Fig. 4. *Animike lying on greenstone*, Township 65–5.

At the upper end of the portage are some large masses of greenstone, not in place, which are conglomeritic. Rounded pebbles and boulders of light and dark colored rock—some of them six inches in diameter—occur in it. This rock seemed to be very much like the conglomerate of Ogishke Muncie lake, 457.

On the north side of the creek from the bluff where the contact is seen there is a higher ridge than on the south side. The rock composing it does not appear to be so tough and basic as most of the rock which is subjacent to the Animike quartzyte in this region, 458. It is a fine, greenish-brown, crystalline rock containing feldspar, mica, olivine (?) and a little magnetite.

Iron ore is marked on the plat as existing in large quantities on the line between sections 12 and 13, 64–6. This locality was visited and the rock was found to be magnetitic gabbro. No good magnetite was seen. Some of the gabbro from this place is very coarse and contains coarse hornblende, 458 A.

Gabbro is the only rock found along the shore of Gabemichigama lake for some distance from the N. E. corner sec. 6, 64–5,

459. It is quite fine grained and somewhat decayed. On the south side of the island in N. W. ¼ sec. 6, 64–5, however, was found a bluff of rock rising 20 feet out of the lake, which may be modified Animike. It has gabbro on top and to the north of it. It is apparently not connected with the trap dyke which crosses the point southwest of the island on the main shore.

Iron ore being reported in the S. E. ¼ sec. 1, 64–6, this place was visited. No extensive deposits of high grade or even medium grade ore were found. The rock is gabbro which is ferruginous in spots, 461. A rock was found here, lying under the gabbro, which may be Pewabic quartzyte. It is gray and fine-granular and when decomposed resembles a sandstone. So little of it crops out of the hill here, and it is so covered by debris from above that but little could be learned concerning its relation to the gabbro, 462.

OTTER TRACK LAKE.

Red jasper and vertical magnetitic schists having been reported from this lake a visit was made to it. The lake is surrounded by high hills of siliceo-felsitic rock standing in vertical beds which strike on the average N. 65° to N. 70° E. on the south side of the lake. The strike, however, is not constant in all parts of the region bordering on the lake. In some places near the west end of the lake the evidences of aqueous deposition are unmistakable and exist in the shape of parti-colored bands running through the flinty rock. These bands do not always coincide with the schistosity which is a more general structure and subject to fewer deviations from the usual direction.

In the N. W. ¼ sec. 33, 66–6 the hills are very high, being 290 feet above the lake by aneroid. Near the lake the rock is feldspathic and graywackenitic. Farther south it becomes almost aphanitic and is flinty. One sample which shows a conglomeritic aspect of this rock is 463. A sample which is very much like the magma of the Ogishke conglomerate is 463 A. Other specimens showing the graduation into flint are Nos. 464, 464 A and 464 B.

In the bottom of the valley in N. W. ¼, N. W. ¼ sec. 33, 66–6 some of the rock is magnetitic. It stands like the rest of the rock and the ferruginous strata are very limited in extent. 465. Up on the hill east of the last are seen a couple of short twisted jaspilyte beds inclosed in the rock. They are not over a foot or eighteen inches wide and but a few feet long. They stand vertical. The iron ore in them is magnetite. No. 466. The contact between the jaspilyte and Keewatin is abrupt. 466 A.

On the north side of Otter Track lake in what would be the N. W. ¼ sec. 27, 66-6 if the U. S. survey lines were extended across into Canada, is a perpendicular bluff of rock 120 feet high and rising still much higher a short distance back from the lake. This bluff consists of sericitic or chloritic schists in vertical beds — as far as any bedding was observed — and striking N. 75° E. At the top this rock is seen to be a coarse green agglomerate like that in the Keewatin at Long lake, made up of coarse boulders of the same material as the formation in general. It is also calciferous, and the boulders are amygdaloidal, particularly around their periphery. In fact the rock is macroscopically identically the same in every respect as that around Ely. Samples of the boulders which contain amygdules are 467. Specimens from boulders which were not amygdaloidal are 467 A. The rock between and around the boulders is calciferous and sometimes quartzose, and is very frequently a breccia, 468. This rock appears very much like the regular Keewatin schists which grade into it in this region and which grade in the other direction into the fine vertically bedded siliceous rock of Knife lake, and the same rock on the north side of this lake both of which show indisputable sedimentary banding. It is impossible to separate or distinguish a line of separation between these rocks. They grade conformably into each other.

Just east of the perpendicular bluff mentioned above, the bluffs are lower. The next one east is a cliff of magnetitic jaspilyte. The beds of ore and jasper are very much crumpled and distorted; but in spite of the folding and doubling the strata are always nearly vertical. The jasper is colored various shades of red to nearly or quite black, and the iron ore does not amount to much. There is, however, a large body of these iron schists inclosed in the green schists here, the jaspilyte continuing for 100 paces along the shore and 40 paces back from the brow of the cliff. The green schist runs into and around parts of the jaspilyte in long elbows and tongues. The contact between the two was seen in several places. It was always abrupt and vertical and the change was not gradual but immediate from one to the other. The contact lines are in all directions of the compass. The jasper soon becomes narrower and stops suddenly at both ends in the line of strike. It is a little peculiar that such a crumpled mass of jasper and magnetite should occur in the green schists here and have no continuation in the line of strike nor any connection with the Keewatin. Samples of the jaspilyte are 469. The magnetite is 469 A. Specimens of schist and jaspilyte from a contact are Nos. 470 and 470 A. The strata in the jasper and iron cliff are generally less than half an inch thick but sometimes a stratum of jasper two inches wide is seen. Glaciated surfaces are observed on the side walls of these bluffs both at top and bottom.

The following figure shows how the jaspilyte beds are crumpled.

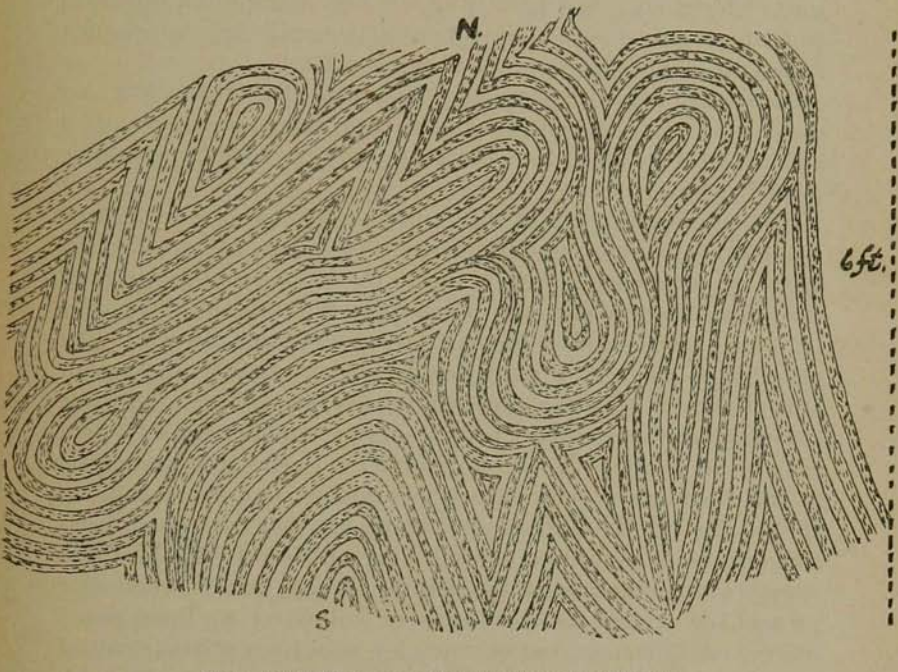

Fig. 5. Distorted beds of jaspilyte; north shore Otter Track lake.

There is a trail running north from Otter Track lake about one mile and a half from the western end. The country is surveyed and good lines are cut. The hills crossed by the trail are very high, some of them being the most elevated land in the entire region, commanding a view of the country for miles around. They are all heavily timbered and have some good white and Norway pine.

The rock is the same for at least a mile and a half north of the lake. That is, it all belongs to the same formation, supposed to be the Keewatin. It stands in vertical beds which strike N. 50° to N. 75° E. Some of it is quite finely schistose and chloritic and some becomes hard and feldspathic and semi-crystalline. A tough, green sample of the latter kind of rock is 471. It is from the corner marked "R 333" and "R 337," about half a mile north of the lake.

One high ridge consists of this green rock in a porphyritic state. The feldspar crystals are large but are not pure nor angular in shape. In fact they appear more like rounded lumps of white felsyte, but are evidently crystalline. Samples of this rock from the north side of a lake about half a mile long which lies near Otter Track lake on the north, are 472.

Coarse agglomeritic greenstone similar to that at Ely was also seen here. It always presents the fine amygdaloidal cavities and small calcite amygdules around the peripheries of the boulder forms inclosed in it.

In many places north of this lake there may be seen beds of red and black jasper and magnetite enclosed in the green rock. These deposits vary in extent and in the richness and purity of the ore which they contain. Sometimes the rock itself seems to fade into jasper and to become ferruginous and banded. At other times the rock is quite massive in appearance and has an abrupt contact with the enclosed masses of jaspilyte. The fact that some of the jaspilyte beds seem to graduate into the green rock seems to afford some support to the theory that some beds of the Keewatin formation are ferruginous, and that owing to their different composition they were not rendered hard, massive and semi-crystalline nor soft and schistose by the heat and pressure attendant upon the folding of the earth's crust, but present the evidence of having been subjected to these same forces and influences in the crumpled condition of their strata. It is very seldom that the beds of jaspilyte are straight for any considerable distance. They are almost always folded and bent as in the foregoing diagram.

Samples of the rock which seem to be grading into red and black jasper are Nos. 473 and 473 A. A sample in which the magnetite appears in the green rock and not in jasper is 473 B. The jaspilyte is 474. An average sample of the non-schistose variety of this rock is 475.

This green rock is all very much jointed and decayed far into the seams and it is difficult to obtain fresh samples. No extensive iron ore deposits were seen. The beds of jasper and magnetite all seem to be quite limited in extent both as to length and thickness, and what there is, is at least half jasper and the other half but poor iron ore.

LAKE VIRA.

This lake is reached by a portage of 900 paces from the southwest end of Knife lake. It lies in sections 1, 2 and 3, 64–8 and is surrounded by vertical schists and argillytes. A sample of argillyte from the N. W. ¼ of S. E. ¼ sec. 2, 64–8 is a fair illustration of most of the rock surrounding this lake, 476. The strike is N. 80° E.: dip at a high angle to the north: glaciation N. 40° E. This lake does not differ much from Knife lake in hight: but it is 40 feet by aneroid above Ensign lake into which it flows by a good-sized stream.

There are high precipitous bluffs of schist and graywacke at the west end of the lake. We cut a portage of 1150 paces from lake Vira to Ensign lake. The country between Knife lake and Vira lake is burnt over, but that from Vira lake to Ensign lake is covered with green timber.

In the N. E. ¼ sec. 10, 64–8 on Ensign lake the rock is a soft, fissile argillitic schist showing no bands of sedimentation but having a wavy schistose structure trending N. 80° E. The dip is about vertical or at a high angle to the north. Glaciation is N. 24° E.

DISAPPOINTMENT LAKE.

This lake is reached by a portage of 1150 paces from Snowbank lake. There are two other ways to reach it by good portage trails. The physical aspect of the country around this lake is quite different from that around Snowbank lake. It is in a burnt region where the bare and dead tree trunks are still standing. This lake is 75 feet by aneroid above Snowbank.

About 450 paces from Snowbank lake a ridge of mica schist is crossed by the trail. The mica is in small glistening scales. The strike of this schist is N. 45° E. A sample from S. W. ¼, S. W. ¼ sec. 32, 64–8 is 477.

This mica schist is cut and penetrated by intrusions or veins of fine-grained, red granite. This appears in the next ridge east of last, 478. Large masses of conglomeritic mica schist appear here on the surface but do not seem to be in place. This rock however is found *in situ* at the east end of the portage in S. E. ¼ sec. 32, 64–8. The schist is hornblendic and appears to be hardened. It is full of boulders of various kinds of crystalline rocks in masses of all sizes up to a foot in diameter. There is a great deal of this rock here. No. 480. A sample of mica schist from here which is not from conglomeritic beds and is more schistose than that which is, is 479. The conglomeritic mica schist is also penetrated by the red granite intrusions. 480 A. These are of all thicknesses up to 20 feet and run in all directions.

There is a dyke of trap rock on the north side of the portage at this lake. It is about 10 feet wide, and runs N. 30° W., 481. The strike of the schists here is not that of the formations generally in this region. It varies from N. E. and S. W. to N. and S. In the N. W. ¼ sec. 5, 63–8, the strike is N. 16° E.

The schist is decidedly conglomeritic in the N. E. ¼ sec. 5, 63–8. Most of the boulders are lenticular, but many of them are nearly round. The general strike, where there is any strike apparent, is N. 30° E. One sample of finely conglomeritic mica schist is 489.

In the S. ½ N. W. ¼ sec. 4, 63–8 the mica schist seems to undergo a decided change, going east along the lake shore. It becomes less schistose, contains less mica and occurs in hills and knolls of uneven hight which do not display any strike or evidence of sedimentation or schistosity. In the S. E. ¼, N. E. ¼ sec. 4, 63–8 the rock does not seem to contain any mica, but is a fine-grained, grayish-brown rock like what has been termed in some former reports of this survey "muscovado." It lies in round-topped knolls which have the shape and appearance, at a little distance, of gabbro hills. Some of it is peculiarly mottled.

Going south from Disappointment lake into the N. E. ¼ of S. W. ¼ sec. 4, 63–8 a ridge of magnetite and quartzyte is crossed. It is about ten rods wide: the strata stand nearly vertical and strike, as nearly as could be estimated, for the needle is reversed, N. 70° E. This rock is supposed to be Animike. It is olivinitic and fine-grained and the iron ore is brilliant and granular and very magnetic like the other ore from the same horizon. The only reason for doubting that it is Animike is that it stands on edge and has the "muscovado" or altered mica schist on the north of it.

Mr. H. W. Cheadle owns a claim here. He has done some stripping which gives a good section of the rocks up the slope of the hill. Fine-grained gabbro is seen lying on the up-turned edges of the iron ore beds. This forms a small ridge. The next ridge to the south is composed of coarse gabbro containing a large per cent of titaniferous (?) magnetite. South of here are high ridges of this same gabbro. Nos. 490, 490 A and 490 B show the transition from mica schist to muscovado; 491 is the Animike iron ore and quartzyte. This rock is much decayed and broken. It has suffered the effects of frost and forest fires as well as of upturning, gabbro overflow and glaciation. Fine-grained gabbro from on top of the ore beds is 492. Coarse gabbro is 493. There is quite a deposit of good magnetite here which may prove to be valuable.

The muscovado schist or rather the mica schist has somewhat the aspect of an altered igneous rock. It is not regularly schistose nor very micaceous but is full of holes and furrows, etc. The muscovado again grades into mica schist which is so feldspathic as to be almost gneiss, east of here. It is also generally conglomeritic; in some places almost entirely composed of small pebbles and boulders, in others not any being seen. Specimens of this rock from the N. E. ¼ sec. 4, 63–8, are numbered 494.

The mica schist in the S. W. ¼ sec. 34, 64–8 approaches gneiss in texture and composition. It is hardly at all schistose and in places is almost massive but has the cleavage and color of mica schist. It contains fine hornblende crystals. Some of it is firm and brittle and may be called fine syenite, 495.

In the S. W. ¼ sec. 34, 64–8 the mica schist becomes much more regular and loses its conglomeritic aspect. It is hard and fine-grained. No definite and permanent strike or dip is discernible.

Near the west quarter post of sec. 34, 64-8 the mica schist has a kind of structure which runs N. 10° W. It also becomes conglomeritic, containing flattened boulders of granite and other varieties of crystalline rock eight inches long. The longer axes of these boulders point N. 10° W. This is regular mica schist conglomerate not like the many boulders and fragments of diabasic and porphyritic agglomerate which abound in this place.

There is a great exposure of conglomeritic mica schist in the N. E. ¼ sec. 33, 64–8. It all has a general strike N. 10° W., and seems to be regular mica schist, 496.

In the N. W. ¼ sec. 34 and the S. W. ¼ sec. 27, 64–8 there is a most wonderful exhibition of conglomerate and diabase. Going east from the point in the N. E. ¼ sec. 33 the conglomeritic mica schist becomes coarser and more full of boulders. These consist of various kinds of light-colored crystalline and dark hornblendic rocks; and are many of them a foot long. The mica schist gradually becomes harder and less siliceous until it is diabasic. East of the lake there are high ridges rising 75 to 150 feet above the water. These become more and more diabasic until they culminate in a high ridge of nearly massive diabase about a quarter of a mile from the lake. There is a coarse schistosity seen in this ridge in places. The strike of the rocks as shown by the schistosity, the direction of the longer axes of the boulders and the foliation of the mica schist are all *about northwest.* These ridges offer one of the finest exposures of conglomerate and agglomerate seen in this entire region. The rock in places is just as full of boulders as it can be. These become smaller and more compressed toward the east, and disappear altogether in the vicinity of the diabase ridge. Some of the diabasic schist is porphyritic. Samples of the conglomerate are 497. Diabasic schist is 498. Diabase is 499. Gneissic schist from the edge of the lake showing foliation which was northwest is 500. Biotite schist from a well-defined dyke about a foot wide which cuts the diabasic agglomerate, running about east and west, is 501.

It is quite remarkable that there is here a gradual transition from mica schist to diabase. There is no place where there is an abrupt change. The mica schist is conglomeritic and the diabase is agglomeritic. They are both schistose and have the same trend and seem to be vertical, as far as bedding is indicated by foliation and schistosity. It is a very thick conglomerate too: fully two miles across the strike. No attempt will be made to account for this transition here nor to prove whether there are two conglomerates here or not.

In the N. E. ¼, S. W. ¼ sec. 27, 64–8 the rock is very fine and even-grained, and so siliceous as to be flinty, 502. Glaciation is N. 34° E. No regular bedding or schistosity is seen here.

In the north end of the bay in the S. W. ¼, N. W. ¼ sec. 27, 64–8 the siliceous rock becomes porphyritic with small imperfect white and yellow feldspar crystals. It is indistinctly conglomeritic in places and is coarsely schistose, 503. Large masses of hydro-mica schist are seen here and indicate beds of this rock in the vicinity.

West of here the rock becomes a porphyritic conglomerate and in places over quite a wide extent is micaceous porphyritic conglomerate. Many of the included boulders are more porphyritic than the magma. The strike is N. 10° W. All of this rock is more or less hornblendic. Around the lake shores the rock is peculiarly pitted and full of holes where some of the softer boulders have been washed out. No pieces of red jasper were noticed in this conglomerate, such as are seen in the Ogishke Muncie conglomerate. Wherever the rock is decidedly micaceous it is intersected and penetrated by *red* granite or syenite intrusions. This is especially the case on the large island in the S. E. ¼ sec. 32, 64–8.

ROUND LAKE.

This body of water lies west and southwest from Disappointment lake, the waters from which flow through Round lake before reaching Snowbank lake. It is 30 feet lower than Disappointment lake, and is reached from it by a portage of 540 paces. Mica schist is seen on the trail. It is more feldspathic and compact or gneissic than that farther northeast. In the N. E. ¼ sec. 6, 63–8 the mica schist changes to gneiss or syenite gneiss. There is but a small quantity of this rock here, however, most of it being a mixture of mica and hornblende gneiss and mica schist. The beds have been considerably crumpled so that no general strike is observable. A sample of mica schist from the S. E. ¼ of N. E. ¼ sec. 6, 63–8 is numbered 482. Syenite gneiss from the N. W. ¼, N. E. ¼ sec. 6, 63–8 is 483.

The west side of Round lake has syenite around the shores. This becomes dark and siliceous and changed into a peculiar rock that seems to have been affected by the proximity of some igneous rock or other metamorphosing agent. 484.

In the N. W. ¼, N. E. ¼ sec. 7, 63–8 the syenite lies under a hill of gabbro which has a bold face on the north side nearly or quite 100 feet high. This syenite is sometimes micaceous enough to be called hornblendic gneiss. It has been somewhat broken up here and the contact between it and the gabbro is not visible. The latter rock is somewhat finer near the contact with the syenite than at the top of the hill. Syenite is represented by 485: the gabbro by 486.

In the S. E. ¼ sec. 6, 63–8 the rock is mica schist hardened by the vicinity or contact of the gabbro. The gabbro ridge runs south of the lake and really does not appear at any point on the lake shore. Samples of mica schist from the above-mentioned locality are 487. Some of it is flinty and has very little if any mica in it.

To the northeast of the last is a knoll of fine red quartzyte or syenite. It is probably part of a large intrusion in the mica schist. 488.

The mica schist in the southeast part of section six is much twisted and varies greatly in its strike and in the composition and texture of its strata. Some are hard and siliceous and others are soft and iron-stained. It is cut by numerous veins or intrusions of granite and is slightly conglomeritic in places.

TOWNSHIP 63–9.

On the portage trail from Snowbank lake to the Kawishiwi river gneiss and mica schist are seen in a few outcrops within three-quarters of a mile from Snowbank. About a mile from the lake the trail passes within ten feet of a bluff of gabbro which faces east. This is in the S. W. ¼ of S. W. ¼ sec. 11, 63–9. The rock is the regular coarse labradorite gabbro. About 200 paces south of this gabbro, on the section line between ten and eleven is found a ridge of biotite, olivine schist. This has the usual strike, N. 60° E. and dips S. 75°. It is conglomeritic in many places and bears a striking resemblance to the conglomeritic mica schist found at the southeast corner of Disappointment lake. 504.

A ridge of gabbro is again crossed 450 paces south of the N. W. corner sec. 14, 63–9. This is a high ridge with a steep bluff of the coarse light-colored gabbro on the north side. Three hundred paces farther south the rock is all "muscovado" in a great ridge. No structure or bedding of any kind is visible in it. It is simply in large hills and ridges, and is fine-grained and homogeneous in texture.

A short distance north of the "quarter-post" between sections 14 and 15 this ridge of muscovado is bounded on the south by a swamp. Along the south side of the ridge, next to the swamp, is a considerable deposit of magnetite. It is the regular coarse, dull-lustred, gabbro magnetite. The rock can not be distinguished from the gabbro nor from the muscovado either. Number 505 is the muscovado. 505 A is the magnetite.

The Kawishiwi is about 12 feet above Snowbank lake where the portage from the lake strikes it. The trail passes across and by the side of gabbro ridges for half a mile before reaching the river.

Going north on the west line of sec. 16 the gabbro disappears a short distance north of the river. The rock next north of the gabbro is the muscovado-like mica schist with the usual strike and vertical dip. It is conglomeritic a short distance farther north and is hornblendic like that on Disappointment lake. It loses its similarity to muscovado and becomes regular mica schist, though more or less gneissic and conglomeritic, about the west "quarter-post" of sec. 16. Sample is 506.

At 340 paces north of the "quarter-post" mentioned above, a swamp intervening, a ridge of diabase is encountered. This runs along the north side of the swamp in a N. E.–S. W. course. It is probably part of the same diabase eruption as that east of Disappointment lake, 507. Many fragments of porphyritic conglomerate are seen lying about on the surface at this place.

This ridge keeps on rising with a gentle slope until its summit is reached at the N. W. corner of section 16. From here the descent is gradual toward the north, but not so gradual as on the south side. The diabase is massive for some distance from the place where it was first seen. Then it begins to show a coarse schistosity and has a coarse agglomeritic appearance as in the rock at Ely, the boulders being all of greenstone and indistinctly outlined on the surface. The rock is strikingly similar to the Ely rock as far as the agglomeritic appearance goes; but is not soft and chloritic like that, nor does it appear to be calciferous. It is simply regular diabase, 508.

At 375 paces north of the southwest corner of section nine the diabase has changed from a massive rock to a fine, schistose, diabase agglomerate. The direction of the very evident schistosity as well as of the lenticular pebbles of greenstone in it, is E. 16° S. This is on the northern slope of the great diabase ridge, and the rock has been examined at many places so there is no doubt as to its being part of the same diabase. The coarse agglomerate has become a fine schistose pudding-stone and is rapidly changing into green chloritic schist toward the north. Samples of diabase conglomerate are No. 509.

This fine greenstone agglomerate continues to be exposed for some distance toward the north. The direction of the schistosity swings around to N. W. and S. E. which is the general direction of it in sections 8 and 9.

Some distance south of the east "quarter post" of sec. 8 a ridge of porphyritic rock which contains grains of vitreous quartz is encountered. It is a light colored rock and when first seen it appears perfectly massive. It has an abrupt contact with the diabase which is also more massive at this place. The porphyry appears to run in N. W.-S. E. ridges. North of here it is seen to be mixed up in every way possible with the diabase and finally, in the N. E. ¼, N. W. ¼ sec. 8, becomes the prevailing country rock.

Toward the north still farther this porphyry becomes coarsely schistose and acquires more of the green uncrystalline elements. It also loses its decidedly porphyritic aspect as the distance from the diabase ridge increases. It is slightly conglomeritic; in one place red jasper was seen in it and in another a pebble of greenstone. Nos. 510, 510 A and 510 B show these various conditions of the porphyritic rock.

The diabase continues to abound and ridges of porphyry, or porphyrel and greenstone are strangely mixed up together. In the N. E. ¼ sec. 8 are seen large ridges of jaspilyte, consisting of red and black jasper, hematite and magnetite in crumpled vertical beds running about N. 60° E. After a long and extensive examination the state of affairs seemed to be as follows: There is a large amount of this jaspilyte here. Some of these lenticular masses of jasper and iron ore were traced continuously for half a mile or even more. These masses lie in the diabase and have an abrupt contact with it. Many pieces and masses of jaspilyte of all sizes from that of a pea to the large ridges spoken of above are seen to be enclosed in massive or only slightly schistose diabase, not in any general line of strike, but at intervals separated from each other across the strike by various distances less than a mile.

Sometimes the diabase is quite coarse and appears more like dioryte with white feldspar crystals on the surface.

In some places the porphyry approaches quite near to these jaspilyte masses; but that is not to be wondered at, inasmuch as the ridges of porphyry run all through the diabase without any definite order or direction. This jaspilyte is more hematitic toward the north and west where it is identical in appearance with that at Tower. Places were seen where the diabase is quite schistose at the contact with the jaspilyte and even as soft and greasy feeling as the soft schists in some of the Tower mines. The beds of jaspilyte are nearly as much distorted as at Tower. This diabase is seen on both sides of the iron ore and cutting across the beds. It also seems to contain fragments of the porphyry and becomes porphyritic itself in the vicinity of the porphyry ridges. Specimens of the diabase, which is found enclosing the large and small masses of jaspilyte in the N. E. ¼ sec. 8, are 511. Contact specimens with the jasper are 511 A. Samples of diabase containing small masses of jaspilyte are 511 B. Porphyritic diabase containing a piece of porphyry is 511 C. Samples of the soft sericitic or talcose rock are 512. This rock being so soft is always found in low places and could not be seen to be certainly part of the diabase. Sometimes the rock next to the jaspilyte is not green and does not look like diabase but is gray and somewhat schistose, 513. Samples of the jaspilyte are seen in 514.

The porphyry becomes more and more prevalent toward the N. E. "forty," sec. 8 until there is no more diabase nor jaspilyte. There is, however, a dyke of green trap that runs under Hugh Copeland's cabin in the N. W. ¼, N. E. ¼ sec. 8. It is about 30 inches wide and can be traced for 200 paces or more running about north and south through the porphyry. It is not perfectly straight but curves some and is faulted in two or three places. The course of it is also interrupted at one place north of the cabin by strings and branches from the porphyry mass which make it appear as if they both were plastic about the same time. Sample of the porphyry is 515. The dyke rock is 516.

The above observations are considered to be of importance as they seem to prove beyond doubt that *the jaspilyte beds are enclosed in basic rock of igneous origin.*

This region and these beds of iron ore contain some of the most promising deposits seen during the past season. There is good reason for believing that there are valuable and extensive beds of iron ore in the northern part of this township.

The ridges of diabase and porphyry alternate southeast of Copeland's cabin. A sample of rock composed of a tenacious green mineral is 517.

In some places the diabase is agglomeritic in close proximity to the enclosed masses of jaspilyte, the diabase all around such a mass containing the forms and outlines of greenstone pebbles. There is also conglomerate closely interbedded with this diabase agglomerate and apparently of a later date. It has for a magma the earlier fine agglomerate (?). These two sometimes come into direct contact, standing side by side. No. 520. This later conglomerate contains almost exclusively fragments of the porphyry and of the jaspilyte. It is never very thick and generally lies between the greenstone and the porphyry.

There are occasional tendencies toward a micaceous nature in the porphyry, and a thin stratum of schist bedded by sedimentation is seen here and there, 518.

Some of the fragments of jaspilyte seen enclosed in the greenstone are perfectly white jasper or quartzyte which crumbles into fine grains upon hammering, 519. This also is like the same fine granular quartz beds in the jaspilyte north of Tower.

In only one place was the iron ore and jasper seen in contact with the porphyry. At this place a bed of jasper three inches thick has porphyry on one side and diabase on the other. They come very close together in many places, but in all other cases observed there was a thin wall or flow of diabase between them.

A vertical bluff of greenstone 20 feet high was seen in one place with a thin coating of the light colored porphyry plastered over the entire face of the bluff. A contact specimen from here is 521.

In one place the coarser diabase which when weathered shows small white feldspar crystals on the surface, was cut by a small trap dyke. The coarser, older diabase is 522. The dyke rock is 522 A.

Going north on the line between sections nine and ten the first rock is seen quite near the river. This is fine-grained mica schist which may contain olivine, 523. This rock is conglomeritic in places and particularly in a small ridge not far north of the river. The small enclosed pebbles are compressed with their longer axes pointing N. W. – S. E., 523 A. There is next a ridge of diabasic mica schist, 523 B.

Some of the beds of mica schist are siliceous and felsitic and are iron-stained, 524. At 300 paces north of the S. W. corner sec. 10, there is quite a ridge of mica schist. It strikes N. W. and dips S. W. 70°. Samples showing lines and bands of sedimentation are 525. At 400 paces there is a contact between the beds of mica schist and diabase which latter has been more or less affected by the proximity of the schist and has a less massive appearance than usual. The mica schist too has been somewhat altered; but the change is abrupt and distinct between the mica schist on the S. W. and the greenstone on the N. E.

In this place therefore the mica schist has an abrupt contact with the greenstone and does not grade into it as it appeared to on the east side of Disappointment lake. The schist here seems to have been affected by the greenstone eruption: its strike and schistosity have been bent around nearly 90° from the usual direction. The mica schist has been hardened and rendered more like the diabase so that upon a casual inspection the two might seem to run together. Mica schist from the contact is 526. The diabase is 527. A specimen of peculiar, dark mica schist which has gray figures and lumps like drops of mud all over the surface is 526 A.

This was not the main ridge of diabase but only a subordinate branch or large dyke of it. The mica schist and greenstone seem to have had quite a struggle for supremacy in this region; first one prevailing and then the other. The general strike is N. W. and the dip varies from S. W. 45° to vertical. There is a ridge of coarser diabase in the N. W. ¼, S. W. ¼ sec. 10. It is quite near a contact with mica schist. 528.

In many places the mica schist is full of light gray grains of soft material which weather out and leave the surface of the rock pitted with small holes. This schist is darker and less micaceous than some of the rest, but it always conforms with the general strike and seems to be a part of the general mica schist formation. 529.

The mica schist contains thin beds of green diabasic rock which run with the other beds and are also schistose. These beds are decidedly basic and only a few inches thick, but are quite persistent and maintain their general appearance and width as far as they can be followed. 530.

Going farther north the mica schist becomes harder and more feldspathic and appears to be incipient porphyry, showing how the extensive porphyry belt north of here may be altered mica schist. 531.

Some specimens of agglomeritic diabase in which the pebbles seem to have been pasted together in a very plastic state are 532. The mica schist and incipient porphyry have also a conglomeritic structure though it is rather indistinct.

A little jaspilyte is found enclosed in the greenstone in the N. W. ¼, N. W. ¼ sec. 10. The diabase is softer and chloritic and possesses the coarse agglomeritic or concretionary (?) structure seen in it so often.*

The observations made in going north on this section line simply confirm those made on the line a mile west, and demonstrate that the coarse, chloritic, schistose agglomerate is part of this

* Report of H. V. Winchell. Fifteenth annual report, p. 404.

great diabase eruption and that the jasper and iron ore beds are contained in it.

A ridge of mica schist is again encountered just south of the quarter post between sections 3 and 4. A large exposure of this rock is found here. It is quite hard and contains a little of the diabasic rock in these beds. 533. Strike is N. 16° W.

At the N. E. corner sec. 4, the porphyry is met with, and is the same in appearance as that found in the N. E. ¼ sec. 8. The relation between the porphyry and mica schist is not evident here, but they seem to have a more or less abrupt contact. Samples of porphyry are 534. The mica schist has been becoming more argillaceous and less micaceous. Here there is a large ridge of it in which the strata are greatly crumpled and the principal strike has been changed to N. 10° E. It here seems that the porphyry is not a part of the mica schist formation, but that it was protruded into the schist beds and caused all of this disturbance. Argillitic mica schist from here is 535.

Going west from here along the north line of sec. 4 a swamp is crossed, and on the west side is found a diabase ridge. Just west of the north quarter post of sec. 4 is more porphyry in knolls and ridges which penetrate and are surrounded by the diabase. They always have an abrupt contact. This porphyry is conglomeritic, containing felsitic and siliceous boulders a foot in diameter. Samples from the S. E. ¼, N. W. ¼ sec. 4 are 536. A basaltic structure is frequently seen in the porphyry.

In the S. W. ¼, N. W. ¼ sec. 4, on the ridge which lies between two small lakes is quite an exposure of red jasper and hematite. This is seen to be in beds of various thickness up to four or five feet, which do not have a common strike. Some strata, enclosed in diabase, strike east and west; while other beds only a few rods away strike E. 30° S. The beds all stand vertical and *are very little crumpled*, 537.

The diabase has a tendency to become coarsely schistose where it lies in contact with the iron and jasper, but farther away it is very hard, tough and massive. It has also a coarse agglomeritic structure, very indistinct at this precise spot, but quite noticeable a short distance east of here, and is chloritic. Nos. 538–538 C represent these rocks.*

* An analysis of this green rock, 538 B, made by Mr. C. F. Sidener shows, as was expected, that it is basic. The full record is as follows:

Silica, SiO_2	50.47 per cent.
Alumina, Al_2O_3	18.45 per cent.

There is also some black jasper and magnetite at this place enclosed in the greenstone in the same manner. The beds are thicker and seem to contain purer ore than the hematite beds. No. 539.

Between the N. W. corner sec. 4 and the east quarter post sec. 8 a decided change takes place. The diabase around the south side and west end of the small lake on the north line of sec. 4 assumes a schistose structure which becomes finer and more universal toward the southwest. At first it is a fine agglomeritic diabase schist; then it becomes more and more siliceous until it is flinty and actually resembles the Knife lake rock. From this place, where the rock was found to be very siliceous, a set of specimens was procured from every outcrop south as far as the E. quarter post sec. 8. This siliceous schist stands in vertical beds which strike N. W.–S. E., and sometimes swing around to N.–S. The rock becomes more and more flinty until at the N. E. corner sec. 8 we have the regular siliceous schist of Knife lake. From here south to the E. quarter post sec. 8, this siliceous schist is seen to grade into the porphyry which was found there before. In one or two places the siliceous schist seemed to be going back to diabase; and ridges of diabasic schist and agglomerate were crossed on this line; but they seem to be part of the intruded diabase which comes into contact with this porphyry farther south. Thus we have diabasic schist and even massive diabase becoming siliceous and even flinty and then porphyritic, and finally coming into contact again with another part of itself farther south. Nos. 540–540 J show this transition.

Going east from the N. E. corner sec. 8, mica schist is met with at less than a quarter of a mile. It has an abrupt contact with porphyry. 541.

The mica schist seen in this township is fine-grained, almost always argillaceous, poor in mica, which is always in very small glistening scales, and generally hornblendic.

Sesquioxide of iron, Fe_2O_3	2.13 per cent.
Protoxide of iron, FeO	7.74 per cent.
Lime, CaO	6.61 per cent.
Magnesia, MgO	6.90 per cent.
Potassa, K_2O	.30 per cent.
Soda Na_2O	2.58 per cent.
Phosphoric acid, P_2O_5	traces.
Water, H_2O	2.34 per cent.
	97.52 per cent.

The mica schist formation becomes hornblendic and massive in the N. W. ¼, N. E. ¼ sec. 9. Fine dark syenite from same place is 542.

On the north side of the Kawishiwi river, on the line between sections 19 and 20 the mica schist is only two rods wide. On the north side of it is the coarse diabase agglomerate.

PRAIRIE RIVER FALLS.

A visit was made at the end of the season to Pokegama falls and the region of Prairie River falls for the sake of comparison with and verification of notes made previously.

No new facts were noticed, the report of last year containing all of the points which were noted this season.

Some work is being done east of the lower falls by Minneapolis parties who are searching for iron ore; although no large body of ore has yet been encountered, the prospect is encouraging.

Specimens of magnetic ore were seen at Grand Rapids which came from the property of Mr. Kearny situated about 45 miles north of Grand Rapids in Township 61–24. It seems to belong to the Keewatin and is reported to exist in paying quantities. The locality was not visited.

Mr. Chas. F. Howe, of Duluth, has explored for iron ore in Minnesota for several seasons and is very well posted on the geology of iron ores. He reports the magnetitic quartzyte of the Huronian outcropping in Twp. 59–18. It has the usual dip of about 10° to the S. S. E. and lies near the syenite which is north of it.

The facts and observations given in scattered detail in the foregoing notes if amplified and dicussed at length with all of the careful consideration which they merit would far exceed the limits assigned to this report. But a brief allusion to some points which seem to furnish clues to the solution of a few of the unsettled problems in the geology of this region may be made here without attempting anything like a full discussion or even mention of all the theories upon which the facts before us have a bearing.

The lowest or oldest formation to which these notes make any reference is probably the syenite and gneiss ridge constituting the Giant's range. Observations on this rock were made at various points between Hinsdale, on the Duluth and Iron Range railroad, and Snowbank lake: also at a few localities in the vicinity on what is supposed to be the northeastward continuation of this range. The general characteristics of the rock of this ridge are quite persistent. The vertical foliation, the unusually large grains of bluish quartz which it contains and the general aspect of the orthoclase serve to remind an observer in the Gunflint region of the same features in the rock southwest of Birch lake. Mica, however, frequently replaces hornblende or *vice versa;* and sometimes both are present. Near the surface and for fifteen or twenty feet below, this rock has a reddish or pink color; but at a greater depth it is gray.

A coarse conglomeritic structure is noted in the syenite-gneiss of this range at Hinsdale. Lenticular masses of dark hornblendic rock are seen at all depths in the gray rock at the quarries. These masses are generally more than eight inches in length, and the direction of their longer axes is vertical or nearly so. There is sometimes a foliation or schistosity in these inclusions, and this also is vertical.

A series of vertical crystalline schists is generally found next the older crystallines in other parts of this region; but north and south of the Giant's range at Hinsdale are found exposures of the sericitic or chloritic schists of the Keewatin so close to the syenite as to make it seem improbable that any crystalline schists intervene between them here. If the high ridge is the middle of an anticlinal, as seems to be indicated by the presence of the vertical Keewatin schists on the south side of the ridge, having the same strike as those on the north, what has become of the crystalline schists which lie next above the granites and syenites? Were they so highly metamorphosed and affected by pressure to such an extent that they were incorporated into the more gneissoid rock beneath them, or were they not a widespread and universal deposit? Were there elevated portions of the sea-bottom which were not covered by the sediments from which have resulted the crystalline schists, but which were later covered by the sediments of the Keewatin age? Considering this ridge to be the back-bone of an anticinal the latter supposition seems more probable.

If this be not an anticlinal how can the presence of such an extensive range of crystalline rock in the midst of greenish, chloritic, more or less argillaceous and siliceous schists be accounted for? If the vertical foliation be evidence of some former bedding structure, the only way to explain it seems to be on the supposition that a portion of these schists themselves were metamorphosed by some unusual disturbance along the line of this range, either by the proximity of some great vent below or intense pressure at this place combined with chemical and hydrothermal forces.

The next formation is that already mentioned, the crystalline schist or Vermilion series. I wish to call attention to the fact that in Twp. 63–9 this series of rocks is found to be conglomeritic over a wide area, and has been rendered hard and porphyritic by some adjacent eruption, probably that great diabase outburst of the Keewatin age. Boulders of a large variety of rocks are seen enclosed in the mica schist around Disappointment lake. This fact alone serves to distinguish it from the diabasic agglomerates in which all of the pebbles, with hardly an exception, are of greenstone and jaspilyte.*

In connection with the crystalline schists "muscovado" should be mentioned. It seems probable that this term has been employed in the 15th and 16th reports of this survey, to designate the rotted granular condition of two or three different rocks. Dr. Alexander Winchell has applied it to a rock which he identifies with the Animike. It seems to have been used also to describe fine decayed gabbro as well as an altered condition of gneiss and the mica and hornblende schists.

As far as my observation goes it has been found quite easy to recognize decayed, rusted Animike and fine rotted gabbro such as is frequently found at the northern edge of the gabbro overflow. But in several localities, notably on the south shore of Disappointment lake, there are found large exposures of a granular, yellowish-brown rock which does not possess any distinct signs of bedding or schistosity and which yields to a blow of a hammer much as semi-hardened putty would. It contains fine scales of biotite and grains of feldspar and olivine. It lies at the north edge of the gabbro in rounded knolls which resemble gabbro hills at a little distance, and when its direct connection with the surrounding rock is obscured it can not be recognized as belonging to any of the usual formations of the region nor as being anything but "muscovado."

On the south shore of Disappointment lake there is a great deal of this rock. To the south of it are masses of olivinitic

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* In his report on the Lake of the Woods, Geol. of Can. CC., Mr. A. C. Lawson says that the agglomerates of that region grade into conglomerates along the strike of the formation. This has not been observed to be the case in Minnesota.

iron ore standing in nearly vertical beds, capped with fine, decayed gabbro and having coarse labradorite gabbro on the south of it. Fortunately the lake shore affords a nearly continuous exposure of this rock in both directions in the line of strike. It was here traced very carefully, on two different occasions, and was found to pass by insensible gradations into mica schist which became more and more micaceous and typical as the distance from the gabbro increased. This mica schist is the northeastern extension of the crystalline schists which are found north of the Kawishiwi river in townships 63–9 and 63–10, and have been followed continuously from there to this lake. The syenite of the Giant's range is known to have formed the northern shore of the Animike ocean. This range is low and narrow at this place and the Animike evidently was deposited on top of the syenite and up to or perhaps upon some of the mica schist which lies to the north of the syenite. Then came the gabbro eruption and overflow and with it a crumpling of the strata and uptilting of the Animike beds. The gabbro also altered the mica schist where it lay upon it, to muscovado, destroying the schistosity and bedding and even altering the mineral constituents of the rock, heating them so that they formed new combinations, the iron and magnesia of the biotite combining to a large extent with the free quartz to make olivine, though there are some minute scales of biotite left. The same explanation of muscovado appears to answer in other places where it was seen. It seems, therefore, that the term "muscovado" is rather an ambiguous one but would be more appropriately applied to mica schist altered by gabbro than to iron-bearing Animike rock.

Conformable with the crystalline schists are the grauwackes, chloritic schists, diabasic schists and siliceous schists of the Keewatin series. The foregoing notes give numerous detailed facts which it was my good fortune to observe in localities particularly rich in instructive geological phenomena. These facts have a decided bearing on the nature and origin of the Keewatin group and the iron ores and associated jaspilytes which are enclosed in it.

In townships 63–9 and 64–8 immense ridges of diabase and basic agglomerates were found. These form a part of the Keewatin formation. They pass conformably into the siliceous and argillaceous schists of that series, and become themselves soft, greenish chloritic schist which retains but slight resemblance to the massive eruptive rock into which they grade and of which they are a part.

In the *American Geologist* for January, 1889, the writer gave a short resumé of the conclusions which had been reached as to the origin of these basic portions of the Keewatin. The observations which forced him to the conclusions there stated were made but a short time before; and when the article was written the fact that Mr. A. C. Lawson of the Canadian geological survey had described similar rocks in the Keewatin of the Lake of the Woods and had termed those aggregations in which the boulders are of the same material as the magma, "agglomerates" was unknown to him. Mr. Lawson also had previously offered an explanation similar to that given by the writer, of the surprising gradations observed between eruptive and fragmental rocks, viz., an alternation of "volcanic ejectamenta (both flows and tuffs) and aqueous sedimentation."

Dr. G. M. Dawson had also presented the same views and says in speaking of similar rocks in the vicinity of the Lake of the Woods, "Volcanic action would appear to offer the most reasonable explanation of their origin and distribution." *

These observations appear to parallelize our green chloritic and diabasic schists and agglomerates very closely with those of Mr. Lawson's original Keewatin. We find in them the same lenticular, basic fragments, the same "concretionary?" and associated amygdaloidal structures and the same transitions into siliceous, fragmental rocks.

It is gratifying to know that the views of these experienced geologists confirm the conclusions mentioned above. The opinion primarily held by the geologists of the Minnesota survey, with the possible exception of N. H. Winchell, and which view is still maintained by Dr. A. Winchell in the 16th Annual report, was that these rocks were of sedimentary origin and that the semi-crystalline, diabasic character was the result of intense metamorphism. The view now held is not wholly in conflict with that. It admits that portions of the Keewatin formation were purely sedimentary; but claims that the larger part of it consists of a mixture of eruptive and sedimentary materials, and is in many places extensively and wholly igneous.

In the opinion of the writer this has considerable bearing on the question of the origin of the jaspilytes embraced in the green schists of the Keewatin. They are supposed to be of some

* Geol. and Resources, Forty-ninth Parallel, p. 52.

sedimentary formation which was broken up and involved in the eruptions of Keewatin age. The masses of jaspilyte are angular and have abrupt contacts with the basic schists; they are highly siliceous and are of all sizes and shapes. When the masses are large they are usually in vertical position and somewhat elongated in the direction of the schistose structure in the surrounding rock. Examples of a precisely similar disruption of a sedimentary formation and its involution in an eruptive ejection are given in the foregoing pages in referring to the masses of Huronian quartzyte and magnetite enclosed in the gabbro. In several places chalcedonic quartz similar to that in the jaspilyte of the Keewatin, was found as part of the Animike. This fact is an indication of the fragmental nature of the jaspilyte; as they cannot be separated from each other,—if one is sedimentary the other must be—and there is not much doubt that that in the Animike is.

The most recent fragmental formation found in northeastern Minnesota is the Huronian. Many observations were made upon a quartzyte belonging to this formation which seems to lie above the Animike slates and is the rock which contains the non-titaniferous magnetite. This quartzyte has been called Animike quartzyte: but seems to lie above the Animike proper. It is perfectly conformable with the slates and sometimes grades into rock which is feldspathic and argillaceous rather than siliceous. It was observed to lie unconformably upon the rock of the Giant's range in two or three places. The most interesting contact observed was where this rock—the semi-siliceous, feldspathic Huronian—is seen to lie unconformably upon the vertical Keewatin beds. This was announced to be the case by Dr. A. Winchell in the 16th report but no actual contacts were mentioned. Considering the greenstone upon which the Animike was found to lie west of Gunflint lake as Keewatin—which it undoubtedly is—three or more fine contacts of the Animike upon the Keewatin are reported in these notes. The significance of this fact has been pointed out before.

A peculiar transition was found south of the Giant's range, in sec. 13, 60–13, where the Animike is seen to grade downward into the syenite. The character of this transition, however, does not seem to be metamorphic, but rather fragmental. There seems to have been a certain amount of the loose, crystalline material which had resulted from the decay and erosion of the syenite lying on top of the solid rock in the bed of the sea. The

Animike sediments were deposited upon and around this syenite stuff. At first the material was mainly crystalline, the sediments forming but a very small part of the whole and only filling the cracks and cavities. A few feet farther up the materials were about evenly divided, the fine detritus filling large spaces between the elevated portions of the larger pieces of syenite. As the sediments increased and grew deeper the crystalline material was completely buried and no traces of the underlying rock were left except here and there a small fragment of syenite or an orthoclase crystal which came rolling in from above and settled down on the sediments. Sometimes these crystals are quite perfect and look strangely out of place in a rock which is so plainly sedimentary and so little altered.

As a rule there is a decided difference in the texture and appearance of the Animike and Keewatin rocks; the former having a smaller proportion of feldspathic and greenish, basic material, and usually containing more quartz and some magnetite. The slates too of the Animike are darker and appear to be carbonaceous; while the slates and schists of the Keewatin are argillaceous and hydromicaceous. These differences are so general that a person who has spent a season comparing and examining these rocks can usually tell at a glance to which formation a specimen belongs. In the vicinity of the east end of Gunflint lake, however, the Animike has a marked resemblance to the Keewatin and it is difficult to distinguish them. They both have somewhat the appearance of grauwacke and are less schistose and slaty than usual. They are of a dark gray color, have a rough surface on fresh fracture and show fewer bands of sedimentation than elsewhere. The Animike, however, contains fine grains of magnetite disseminated through it with a tendency toward a banded arrangement, and the Keewatin has none.

Although the Huronian quartzyte with which is associated the non-titaniferous magnetite lies unconformably upon the syenite of the Giant's range it is believed to lie above the Animike slates and to rest conformably upon them. The rock which was deposited at the border of the ocean upon the syenite seems to have been more siliceous than those portions of the same strata which were farther from the shore. Thus the rock which lies directly upon the syenite would be a quartzyte and would pass into the less acidic rocks farther south. This condition of things is believed to have been observed in Twp. 60–13. Still there is probably an extensive quartzyte which is later than the Animike and which lies directly upon the syenite because the land was slowly becoming more submerged and the sediments kept accumulating and extending farther and farther over the range of rock which constituted the northern limit to the ocean and the strata formed in its depths. The dip of the quartzyte corresponds with that of the slates wherever seen, and although the latter were not seen at any place underlying the former, yet their relative positions and mutual relations seem to indicate that they do so.

The gabbro has been so fully discussed in previous reports of this survey that it is necessary to say but a few words concerning it. The fact that it is found to embrace large fragments of the Huronian quartzyte and slates proves it to be of later origin. It is intersected by dykes of greenstone which are of still more recent date,—perhaps of the Cupriferous age, as that is said by the State Geologist in the Tenth annual report, p. 112, to be of more recent date than the gabbro. However, the appearance of these rocks in sec. 35, 58–6 gave me the impression that the gabbro is on top of the Cupriferous and hence more recent.

A coarse basaltic structure was seen in the gabbro on the south side of Tucker lake. There was also an appearauce of sedimentary structure in the gabbro in N. W. ¼ sec. 2, 64–3, caused by parallel bands of magnetite several feet in length. It shows how one may be deceived by similar banded structure in other places.

Coarse hornblende, believed to be the largest ever found in this state, was found in the gabbro in the S. E. ¼ sec. 25, 63–10. Crystals six inches long were obtained. Many seen in the same place were even larger.

LIST OF SPECIMENS COLLECTED BY H. V. WINCHELL DURING THE SUMMER OF 1888.

354. Hydrated hematite. John Mallmann's working. Sec. 29, 59–14.

354 A. Gray, feldspathic rock, to which is attached a pebble(?) of hematite. Same locality.

355. Gray rock containing magnetite. Short distance west of last.

355 A. Gray rock containing limonite. From main shaft at same place.

356. Magnetitic chrysolyte. 400 paces east of the W. ¼ post sec. 10, 60–12.

357. Syenite. S. W. ¼ sec. 8, 60–12.

358. Olivinitic magnetite. One-fourth mile south of N. W. corner sec. 17, 60–12.

359. Greenish, magnetitic, olivinitic quartzyte. S. W. ¼, S. W. ¼ sec. 17, 60–12.

360. Dark, siliceous magnetite. N. E. corner sec. 19, 60–12.

361. Slaty, carbonaceous rock. Same locality.

362. Stratified magnetite and quartzyte or siliceous schist. N. W. ¼, N. E. ¼ sec. 19, 60–12.

363. Magnetite. N. W. ¼, N. E. ¼ sec. 19, 60–12.

364. Quartz conglomerate with a green matrix. From boulders seen east of Iron lake. N. W. ¼ sec. 24, 60–13.

365. Hornblendic Animike slate. A short distance north of last locality.

366. Samples showing the transition from Animike to the syenite of the Giant's range. North end of Iron lake, S. W. ¼ sec. 13, 60–13.

367. Greenish Animike rock containing a felsitic boulder. Same locality.

368. Coarse, micaceous syenite, N. E. ¼ sec. 14, 60–13.

369. Black, magnetitic rock, S. W. side of Iron lake. N. E. ¼ sec. 23, 60–13.

370. Tough, dark magnetitic rock. N. W. ¼ sec. 35, 60–13.

371. Reddish-gray quartzyte. Found in fragments on the trail in N. W. ¼ sec. 32, 60–13.

372. Samples from the bottom of the Animike where it passes into and rests upon the syenite. South of the trail. S. W. ¼, N. W. ¼ sec. 32, 60–13.

373. Black, carbonaceous slate rock containing magnetite. S. W. ¼, S. W. ¼ sec. 32, 60–13. From a shaft.

374. Grayish rock containing bands of magnetite. A little N. W. of last.

374 A. Reddish, jaspery rock. Same locality.

375. Weathered samples of magnetitic rock. S. W. ¼ sec. 31, 60–13.

376. Sample of reddish, decomposed jaspery rock from top of a shaft in N. E. ¼ sec. 11, 59–14.

376 A. Hematitic rock from bottom of the same shaft.

377. Feldspathic Keewatin schists. N. W. ¼ sec. 11, 59–14.

378. Feldspathic, gray, Keewatin schist, S. E. "forty" sec. 11, 59-14.

379. Olivinitic, magnetitic rock. From a shaft in N. W. ¼ sec. 14, 59–14.

380. Dark, slaty rock containing needle-shaped crystals of hornblende and bands of black jasper. Sec. 22, 59–14.

381. Grayish, soft, sericitic schist, S. E. ¼ sec. 17, 59–14.

382. Gray syenite of the Giant's range, Hinsdale.

382 A. Red syenite containing decayed hornblende. Found near seams or faults in the syenite at Hinsdale.

383. Hornblende schist from included boulder-forms in the syenite, Hinsdale.

384. Fine, gray granite, found cutting the syenite at Hinsdale.

385. Dark, red, decomposed syenite. Three miles north of the Giant's range on the railroad.

386. Gabbro. Sec. 5, 58–14. In a railroad cut three-fourths of a mile north of Beaver creek.

387. Dark, silico-argillaceous rock apparently carbonaceous. N. E. ¼, S. W. ¼ sec. 9, 58–14. On Partridge river.

388. Reddish, hematitic, quartzose rock. From a shaft in N. E. ¼, S. E. ¼ sec. 11, 59–14.

389. Feldspathic Keewatin schist. Near the centre of S. E. ¼ sec. 11, 59–14.

389 A. Quartz from veins in last. Containing talc.

390. Dark, carbonaceous (?) rock supposed to be Keewatin. Same locality.

391. Felsitic siliceous schist. N. E. ¼ sec. 15, 59–14.

392. Magnetic, olivinitic iron ore, about 200 paces southeast from last and 40 feet higher.

393. Magnetic iron ore. N. W. ¼, N. W. ¼ sec. 14, 59–14.

394. Pinkish quartzyte. Found in angular fragments on the trail in Twp. 60-13.

395. Black magnetic sand. Birch lake, S. W. ¼, S. E. ¼ sec. 32, 61–12.

396. Fine, muscovado-like gabbro. N. E. ¼ sec. 26, 61–12.

396 A. Specimen of a boulder (?) enclosed in last.

397. Animike or Huronian quartzyte. S. E. ¼, N. E. ¼ sec. 26, 61–12.

397 A. Hornblendic quartzyte. Same locality as last.

397 B. Quartzyte containing unknown mineral. Same place.

397 C. Magnetitic quartzyte. Same locality.

398. Stratified quartzyte and magnetite. S. E. ¼ sec. 26, 61–12.

399. Olivinitic quartzyte. E. ½, N. W. ¼ sec. 35, 61–12.

399 A. Coarse quartzyte and magnetite. Same locality.

400. Syenite, pink and rather coarse. S. E. ¼, N. E. ¼ sec. 35, 61–12.

401. Quartzyte, containing much magnetite. Same locality.

402. Hornblendic, olivinitic magnetite rock. N. E. ¼, S. W. ¼ sec. 35, 61–12.

403. Coarse quartzyte and fine chrysolyte. S. W. "forty," sec. 35, 61–12.

404. Chrysolyte. S. W. ¼ sec. 35, 61–12.

405. Olivine bearing magnetitic quartzyte. N. ½, S. E. ¼ sec. 24, 61–12.

405 A. Hornblendic samples of last.

405 B. "Slickensides." Same locality.

406. Hard, hornblendic Animike found lying upon syenite. S. E. ¼, N. E. ¼ sec. 35, 61–12.

407. Magnetite and quartzyte in banded alternation. S. E. ¼ sec. 30, 62–10.

408. Granular olivinitic rock. Same locality.

409. Fine grained olivinitic magnetite. Same locality.

410. Titaniferous (?) magnetite. Same locality.

411. Hornblendic olivinitic quartzyte. Same locality.

412. Coarse gabbro. S. E. ¼, N. E. ¼, sec. 36, 63–10.

412 A. Coarse hornblende and labradorite. Same locality.

413. Altered Animike from fragments enclosed in the gabbro. Same locality as 412.

414. Coarse magnetite. Same place.

415. Very coarse hornblende. From the gabbro. S. E. ¼, S. E. ¼ sec. 25, 63–10.

416 and 416 A to 416 E represent a transition from sericitic schist to granite.

417. Micaceous hornblendic schist. Same locality.

418. Biotitic hornblendic schist. N. W. forty sec. 4, 63–12.

419. Calciferous sericite schist. N. W ¼ sec. 4, 62–12.

420. Gabbro from lake Isabelle. N. W. ¼, S. E. ¼ sec. 35, 62–8.

420 A. Gray, fine granular rock contained in last.

421. Pebbles from a point just east of last.

422. Dyke rock. S. W. ¼, S. E. ¼ sec. 36, 62–8.

423. Fine, brown gabbro containing biotite. East of lake

Isabelle in T. 62–7.

424. Gray labradorite rock. Two miles up Swamp-lake river from lake Isabelle.

424 A. Gray gabbro with a streak of red in it. Same place.

424 B. Red gabbro. Same locality as last two.

425.
425 A.
425 B.
425 C.
} Specimens illustrating a change from gabbro to dark, tough hornblendic rock.

426. Hornblendic gabbro. East of the north end of lake Harriet.

427. Gabbro. From a small island near the south end of Nine Mile lake.

428. Gabbro. From west side of Crooked lake.

429. Trap rock. Sec. 15, 59–6. West of the narrows.

430. Fine grained, olivinitic gabbro. West side of Nine Mile lake.

431. Gabbro. Sec. 35, 58–6.

432. Red, impure felsyte. East of last a few rods.

433. Siliceous Keewatin schist. About 40 rods up the creek which enters the east end of Gunflint lake from the northeast.

434. Sericitic schist. Farther up the creek on east side.

435. Reddish, jaspery Animike rock. Bed of same creek.

436. Dark, ferruginous conglomerate. About one-fourth mile up the creek.

437. Greenish, sericitic schist. East of last a few rods.

438. Animike from near a contact with Keewatin. Bed of same creek.

439. Keewatin rock from same place.

440. Magnetitic gabbro. N. E. ¼, N. W. ¼ sec. 2, 64–3.

441. Dioritic. magnetitic gabbro. S. W. ¼, N. W. ¼ sec. 2, 64–3.

442. Titaniferous magnetite. S. E. ¼, N. W. ¼ sec. 2, 64–3.

443. Black carbonaceous slate. N. W. ¼ sec. 35, 65–3.

444. Greenstone. Found lying on top of 443 (H).

445. Porphyry or porphyrel. Loose mass at same place.

445 A. Trap found stuck fast to 445.

446. Very strongly magnetic iron ore. N. W. ¼, N. W. ¼ sec. 23, 65–4.

447 and 447 A to 447 E illustrate a transition from Black Animike slate to greenstone. N. E. ¼ sec. 25, 65–4.

447 F. Porphyritic trap rock. Same locality.

447 G. Dyke rock. Same locality.

448. Brecciated Animike slate. Same locality.

449. Quartz conglomerate not seen in place. From sec. 28, 65–4.

450. Magnetite. N. W. ¼ sec. 28, 65–4.

451. Biotitic altered greenstone. Same locality.

452. Diamond drill cores. Same locality.

452 A. Pyritous quartzyte from bottom of Animike at same place.

453. Drillings from about one-eighth mile south of the "camp" in sec. 28, in 65–4.

454. Quartzyte and magnetite. N. W. ¼ sec. 35, 65–5.

455. Animike from next to a contact with underlying greenstone. N. W. ¼ sec. 35, 65–5.

455 A. Animike rock from a similar contact 150 paces west of last.

456 and 456 A to 456 C are samples of the greenstone from the eastern contact taken in order receding from the line of contact.

456 D is a sample of greenstone from the western contact.

457. Conglomerate greenstone. 250 paces east of last.

458. Fine, crystalline, grayish-brown rock composed of plagioclase, mica, olivine and magnetite. North of last in a high ridge.

458. A. Coarse, hornblendic gabbro. S. line sec. 12, 64–6.

459. Gabbro. Gabemichigama lake. N. E. ¼ sec. 6, 64–5.

460. Modified Animike. South side of the island in N. W. ¼ sec. 6, 64–5.

461. Magnetitic gabbro. S. E. ¼ sec. 1, 64–6.

462. Decomposed gray quartzyte. Under the gabbro at same locality.

463. Conglomeritic grauwacke. N. W. ¼ sec. 33, 66–6. South of Otter Track lake.

463 A. Rock resembling magma of Ogishke conglomerate. Same locality.

464, 464 A and 464 B illustrate the passage of grauwacke into flint.

465. Magnetitic siliceous schist. N.W. ¼,N. W. ¼ sec. 33, 66–6.

466. Magnetitic jaspery rock. On hill east of last.

466 A. Contact specimen between 466 and siliceous greenish Keewatin schist. Same locality.

467. Amygdaloidal calciferous rock from boulders enclosed in

green chloritic schist. North side of Otter Track lake. N. W. ¼ sec. 27, 66–6, as in Minn.

467. A. From similar boulders not amygdaloidal. Same place.

468. Calciferous breccia found immediately surrounding the boulder forms.

469. Jaspilyte. Short distance east of last.

469. A. Magnetite. Same locality.

470. Green schist from near a contact with 469.

470. A. Jasper from same contact.

471. Feldspathic, semi-crystalline schist. From the corner marked "R 333" and "R 337" about half a mile north of Otter Track lake.

472. Coarsely porphyritic green rock. North side of a lake which lies on the north side of Otter Track lake.

473 and 473 A. Keewatin rock turning into red and black jasper. North of Otter Track lake.

473 B. Magnetite in green schist. Same locality.

474. Jasper and magnetite. Same locality.

475. Average sample of the non-schistose Keewatin from north of Otter Track lake.

476. Argillyte. N. W. ¼, S. E. ¼ sec. 2, 64–8. Lake Vira.

477. Fine mica schist. S. W. ¼, S. W. ¼ sec. 32, 64–8. Between Snowbank and Disappointment lakes.

478. Red, fine syenite. Cutting last.

479. Mica schist. S. E. ¼ Sec. 32, 64–8.

480. Conglomeritic mica schist. Same locality.

480. A. Red granite from intrusions in 480.

481. Trap rock from a dyke cutting 480.

482. Mica schist. S. E. ¼, N. E. ¼ sec. 6, 63–8. Round lake.

483. Syenite gneiss. N. W. ¼, N. E. ¼ sec. 6, 63–8. Round lake.

484. Dark siliceous syenite. West side of Round lake.

485. Micaceous syenite. N. W. ¼, N. E. ¼ sec. 7, 63–8. Round lake.

486. Gabbro. Found lying on 485.

487. Hardened mica schist. S. E. ¼ sec. 6, 63–8.

488. Fine red syenite. Intrusion in last.

489. Finely conglomeritic mica schist. N. E. ¼ sec. 5, 63–8. Disappointment lake.

490, 490 A and 490 B represent a transition from mica schist to muscovado. N. E. ¼, S. W. ¼ sec. 4, 63–8.

490 C. Mottled muscovado. Same locality.

491. Olivinitic magnetite and quartzyte. Same place.

492. Fine gabbro found lying upon 491.

493. Coarse labradorite gabbro. South of last.

493 A. Titaniferous (?) magnetite. Found in last.

494. Feldspathic, muscovado-like mica schist. N. E. ¼ sec. 4, 63–8.

495. Fine, micaceous syenite. S. W. ¼ sec. 34, 64–8.

496. Conglomeritic mica schist. N. E. ¼ sec. 33, 64–8.

497. Diabasic conglomerate. From N. W. ¼ sec. 34 and S. W. ¼ sec. 27, 64–8.

498. Diabasic schist. Same locality.

499. Diabase. Same locality.

500. Gneissic schist from lake shore having a foliation from N. W. to S. E., N. W. ¼ sec. 34, 64–8.

501. Biotitic trap. S. W. ¼ sec. 27, 64–8.

502. Siliceous greenstone. N. E. ¼, S. W. ¼ sec. 27, 64–8.

503. Porphyritic mica schist conglomerate. S. W. ¼, N. W. ¼ sec. 27, 64–8.

504. Conglomeritic mica schist. S. W. ¼ sec. 11, 63–9.

505. Muscovado. North of quarter post between sections 14 and 15, 63–9.

505 A. Titaniferous (?) magnetite. Same locality.

506. Fine, gray, hornblendic mica schist. S. W. ¼, N. W. ¼ sec. 16, 63–9.

507. Diabase, 340 paces north of W. quarter post sec. 16, 63–9.

508. Diabase. N. W. corner sec. 16, 63–9.

509. Fine conglomeritic diabase. 375 paces north of the S. W. corner sec. 9, 63–9.

510. Porphyrelle. N. E. ¼ sec. 8, 63–9.

510 A. Porphyrelle containing red jasper. Same locality.

510 B. Porphyrelle containing greenstone. Same locality.

511. Diabasic rock found enclosing jaspilyte. N. E. ¼ sec. 8, 63–9.

511 A. Contact specimens of diabase and jaspilyte. Same locality.

511 B. Diabase containing fragments of jaspilyte. Same locality.

511 C. Porphyritic diabase containing fragments of porphyrelle. Same locality.

512. Soft talcose rock. Same general locality.

513. Gray schistose rock found in contact with jaspilyte. Same locality.

514. Jaspilyte (jasper and magnetite). Same locality.

515. Porphyrelle. N. W. ¼, N. E. ¼ sec. 8, 63–9.

516. Trap rock. Cutting last.

517. Rotted diabase. Southwest of last some distance.

518. Micaceous diabasic schist. Same general locality.

519. White, crumbling jasper. Sec. 8, 63–9.

520. Dark, ancient conglomerate in contact with the porphyrelloid conglomerate. Sec. 8, 63–9.

521. Contact specimen. Diabase and porphyrelle. Sec. 8, 63–9.

522. Coarser diabase than usual, having white crystals of feldspar on weathered surfaces.

522 A. Fine diabase cutting 522.

523. Fine grained olivinitic mica schist. S. W. forty sec. 10, 63–9.

523 A. Conglomeritic mica schist. Same locality.

523 B. Diabasic mica schist. North of last.

524. Rusty, decomposed mica schist. Same locality.

525. Mica schist showing stratification. At 300 paces north of the S. W. corner sec. 10, 63–9.

526. Mica schist from a contact between it and diabase. 100 paces north of last.

527. Diabase from same contact.

528. Diabase. N. W. ¼, S. W. ¼ sec. 10, 63–9.

529. Dark, pitted mica schist. Same locality.

530. Diabasic strata in mica schist. Same locality.

531. Porphyritic mica schist. North of last.

532. Diabase conglomerate. Same general locality.

533. Mica schist, somewhat diabasic. Just south of the quarter post between secs. 3 and 4, 63–9.

534. Porphyrelle. N. E. corner sec. 4, 63–9.

535. Argillitic mica schist. Same locality.

536. Porphyrelloid conglomerate. S. E. ¼, N. W. ¼ sec. 4, 63–9.

537. Jaspilyte. S. W. ¼, N. W. ¼ sec. 4, 63–9.

538. Diabase from contact with Jaspilyte. Same locality as last.

538 A and 538 B are from a distance of five and ten feet respectively from this contact.

538 C. A phase of the diabase which does not look so basic. Same place.

539. Black jasper and magnetite. Same locality.

Nos. 540 and 540 A to 540 J illustrate a transition from fine diabasic schist through siliceous argillyte to porphyrelle which takes place between the N. W. corner sec. 4 and the E. quarter post sec. 8, 63–9.

541. Mica schist. N. W. ¼, N. W. ¼ sec. 9, 63–9.

542. Fine, dark syenite. N. W. ¼, N. E. ¼ sec. 9, 63–9.

ELEVATIONS DETERMINED BY ANEROID BAROMETER BY H. V. WINCHELL.

	Ft. above L. Superior.
Devil's Track river at the crossing of the county road north of Grand Marais	1000
Top of "Pine Mountain," 12 miles from the lake	1550
South Brulé river at the crossing of county road	1000
Birch lake, Twp. 65–2	1220
Duncan's lake	1205
Rose or Mud lake	1060
South lake	1085
North lake	1085
Gunflint lake	1080
Loon lake	1275
Mayhew lake	1385

Lake Vira is about the same hight as Knife lake.

Ensign lake is 40 feet lower than Knife lake.

Snowbank lake is 45 feet higher than Knife lake.

Disappointment lake is 120 ft. higher than Knife lake.

Round lake is 90 feet higher than Knife lake.

Kawishiwi river is 57 feet higher than Knife lake where the portage from Snowbank lake strikes it. N. W. ¼ sec. 15, 63–9.

CONTACTS OBSERVED.

Animike on the syenite of the Giant's range, north of Iron lake; also west of Gunflint lake, N. W. ¼ sec. 23, 65–4; also S. E. ¼, N. E. ¼ sec. 35, 61–12.

Gabbro on Animike, N. E. ¼ sec. 26, 61–12 south of Birch lake; also south side of Disappointment lake. Gabbro on syenite, N. W. ¼ sec. 24, 61–12; also N. E. ¼ sec. 7, 63–8. Fine-grained gabbro or trap on Animike slate, east end of Gunflint lake, and around Loon lake. Animike on Keewatin, creek bed at east end of Gunflint lake; also N. W. ¼ sec. 35, 65–5; also N. E. sec. 25, 65–4.

Trap rock on porphyrel, Loon lake; also sec. 8, 63–9. Jaspilyte and porphyrel, Twp. 63–9, many places. Jaspilyte and diabase, many places in Twp. 63–9. Mica schist and diabase, S. W. ¼ sec. 10, 63–9. Mica schist and porphyrel, N. E. corner sec. 4, 63–9.

TRANSITIONS OBSERVED.

From Animike to syenite. North of Iron lake.

From Keewatin hydromica schist to granite. N. E. ¼ sec. 9, 63–12.

From black Animike slate upward to fine gabbro or trap. South side of Loon lake.

From black Animike slate downward to trap. N. E. ¼ sec. 25, 65–4.

From mica schist to "muscovado" and back to mica schist. N. E. ¼ sec. 4, 63–8.

From mica schist to diabase. N. W. ¼ sec. 34, 64–8.

From diabase through diabasic agglomerate to chloritic schist. Twp. 63–9.

From diabasic schist through siliceous schist to porphyrel. Twp. 63–9.

CONGLOMERITIC STRUCTURE OBSERVED IN

Keewatin, in schistose, porphyrelloid and diabasic portions.

Animike, in various places.

Syenite of Giant's range, at Hinsdale.

Mica schist and porphyrelloid mica schist. S. E. ¼ sec. 32, 64–8.

Gabbro, containing fragments of Animike. N. E. ¼ sec. 26, 61–12.

REPORT OF ULY. S. GRANT.

IV.

REPORT OF GEOLOGICAL OBSERVATIONS MADE IN NORTHEASTERN MINNESOTA DURING THE SUMMER OF 1888.

By Uly. S. Grant.

I. General Statement.

During the latter part of June, all of July, and the greater part of August a party was employed in collecting sets, of twenty-five specimens each, of the typical rocks of northeastern Minnesota. Besides the writer, the party consisted of Mr. A. D. Meeds, of the University, and two Indians, Charley and Nick Sucker, from Vermilion lake. The traveling was done entirely by canoe, as is usual in this region. The town of Ely, which is now the northern terminus of the Duluth and Iron Range railroad, was used as a supply point, and from here three trips were made eastward and south-eastward,— each trip taking about three weeks. Most of the country from Vermilion lake east to Gunflint lake, explored by the survey during the last two summers, was passed over, and rock samples collected from various localities designated by Prof. N. H. Winchell. The samples are of museum size — three by four inches — and bear the numbers given by Prof. Winchell in the tenth, fifteenth and sixteenth annual reports of the survey. In all forty-five sets, or over eleven hundred specimens, were collected; these, together with those collected in 1886 and 1887, form quite a complete series of typical rocks of that part of the state lying north of lake Superior. The specimens were shipped to Minneapolis and are now in the rooms of the survey,—but as yet they have not been unpacked and labeled.

While collecting the rock samples some attention was paid to the geology; thus a few additional facts were noted, and several places, not before visited by the survey, were examined. But these observations were not very extensive, as the time was limited and the main object was to collect the samples wanted. This fact, together with the inexperience of the writer in the line of geology, will perhaps account for discrepancies in the following pages. The only place where any detailed observations were made was on the north shore of Gunflint lake while trying to discover the western extension of the belt of hornblende schists (Vermilion series) which lie between the vertical earthy schists (Kewatin) on the south and the gneiss on the north.

During the latter part of August, all of September and the first half of October the writer was engaged, under the direction of Mr. H. V. Winchell, in examining reported outcrops of iron ore. While thus employed, two separate trips were made,—one from Gunflint lake south to Brulé lake, and one along the Kawishiwi river in T. 63–7 and 62–9. A few notes, concerning the general geology of the country thus passed over, are given; but it should be remembered that the main object of these trips was to examine into the richness and extent of the iron ore outcrops. Notes on a few of the lakes passed through on a trip from Kawishiwi lake south to lake Superior are also given; but a full account of this trip will be found in the report of Mr. H. V. Winchell.

Owing to the numerous heavy spring rains, all the lakes and rivers were very high,—from two to five feet higher than during the summers of 1886 and 1887; this rendered examination of rock exposures along the lake shores more difficult than formerly, as in many cases the water extended back over the rocky shores to the soil. The insect pests (black-flies and mosquitoes) were also very numerous and troublesome.

The Canadian side of the boundary lakes and rivers from Gunflint lake to Ottertrack lake, seems to have beeu surveyed during the last year.

The rock samples, which illustrate the following notes, are numbered from 1 up to 298, the letter G being placed on each specimen, after the number. The figures are green,—paris green and shellac dissolved in alcohol being used.

The township, section and quarter section, where each specimen was found, is given. The township (in this report) is always north and the range west of the fourth principal meridian, Minnesota.

Appended to this report will be found (1) a brief summary of observations, (2) a list, with notes, of the typical rocks of which 25 specimens were collected, (3) a table of barometric elevations and (4) a catalogue of rock samples to illustrate the writer's notes.

Magnetic bearings were taken roughly in the field; these have not been corrected either for general or local variations.

II. Geological Notes.

OTTERTRACK LAKE.

This is one of the boundary lakes, and extends north-east and south-west in T. 66–6. On the north shore of the lake in N. E. ¼ of N. W. ¼ sec. 27, T. 66–6 (if the Minnesota sections were extended northward to the Canadian shore) is a cliff about forty feet high; this cliff is composed of magnetic iron slates banded with red and black; the red bands are jasper and the black ones are composed mostly of magnetite. The banding is twisted and bent in every direction, but is almost always in a vertical plane. Mr. J. F. Conniff of Duluth tells me that on the south side of the lake in the N. ½ of sec. 33 (80 rods south of the lake shore), there is an exposure of these vertical iron slates; he says they appear in the form of a "vein," from four to twelve feet wide, and strike east and west. No. 1 and No. 2 are specimens he gave me from this locality; No. 3 is from the cliff on the north shore of the lake. The first outcrop on the shore west of these slates is represented by No. 4, and the first east of them by No. 5, both of which are graywacke-like rocks. A full account of this place will be found in the report of Mr. H. V. Winchell; also see the sixteenth annual report, p. 210, for the geology of Ottertrack lake.

GUNFLINT LAKE AND VICINITY.

This lake lies on the boundary in the north part of T. 65–3, and extends eastward into T. 65–2; it also touches the eastern side of T. 65–4.

On the small island in S. E. ¼ of S. E. ¼ sec. 13, T. 65–4, were found five elongated pieces of a dark schist, which is composed principally of hornblende and feldspar, the latter weathering pinkish; these pieces are in the syenite of which the island is composed; the largest piece was five feet long and seven inches wide; the long axis of each piece extends in the same direction, —i. e. N. 85° W. (Mag.). All the pieces, except one, thin out into wedge-shaped ends. No. 6 represents the syenite, and No. 7 the schist. The largest of these pieces is shown in Fig. 1.

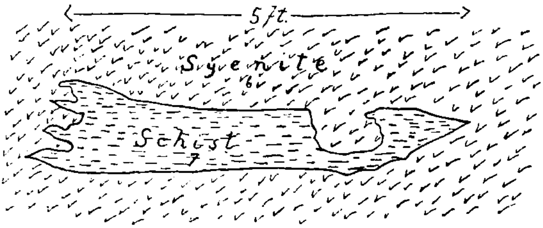

Fig. 1. Hornblende schist inclosed in syenite, Gunflint lake.

Sections north of Gunflint lake. Three sections were made north from the lake near the centre of the northern shore, the object being to discover what becomes of the hornblende schist belt (the Vermilion series of the survey) that was found north of the lake near its eastern end in 1887. If this belt continues in the same strike as there seen, it should appear again in Blackfly bay north of the narrows of the lake; but no trace of it is here found. The measurements in these sections are only roughly estimated, the ground being too rough and too much covered with underbrush to allow pacing. The location of the observations is given as accurately as possible, supposing the section lines of the Minnesota townships to be extended to the Canadian side. Fig. 2 shows the relations of this belt of crystalline schists and of the Kewatin slates to the syenitic gneiss. For the description of this belt of hornblende schists the reader is referred to the sixteenth annual report, pages 68–77, 262–6, 337, and the map on page 255.

SECTION I: North from the lake shore a little west of the line between secs. 14 and 15, T. 65–3. This would be directly north of the east end of the island in sec. 15—the only island in this part of the lake.

The first rock exposed is a vertical sericitic schist, on the lake shore; it extends east and west about 200 yards; this is the most westerly, but one, exposure of vertical schists on Gunflint lake. This rock is represented by No. 11; the exposure continues north 100 feet, and rises 8 feet above the water. After passing a swamp 250 feet wide, a hill rises 60 feet above the lake; this hill is composed of schist or slate similar to No. 11, but it is growing harder and more flinty (No. 12); this hill is 200 feet across. Beyond is another swamp about 200 feet wide, and then rises a second ridge, 400 feet in width; the first exposure is of a fine porphyrelloid rock (No. 13) with small crystals of white feldspar; these crystals are arranged more or less in layers corresponding to the strike. The rest of the hill is composed of alternating beds of black slate (No. 16) and porphyrelloid rock represented by No. 13; the latter rock varies from that in which the feldspar crystals are quite conspicuous, ⅛ inch or more in diameter (No. 14), to that in which they are quite small (No. 15). Near the top of the hill and lying in a small depression is a mass of dark trap (No. 17); the contact between the trap and slate was covered by soil. Nearer still to the top of the hill are two dikes, one and four feet in width; these dikes run parallel with the beds of slate and are exposed for over 20 feet; in the larger are fragments of baked slate; and the outer portion of this dike is very much finer-grained (No. 18) than the inner (No. 19); Nos. 18 and 19 seem to be about the same as No. 17. On the summit of the hill in the porphyrelloid schist is an elongated mass of a soft schistose rock (No. 20) running N. 70° W. (Mag.), diagonally across the bedding; this rock was traced ten feet before disappearing under the soil; the schist is in no wise changed near the contact, and near by it is bent around some smaller lenticular masses of the same rock (No. 20).

Going north for the next half mile the following country is passed over:—

Swamp;—no exposures.

Ridge, about 200 feet above the lake, composed of black slate and fine porphyrelloid schist. On the north side of this hill gabbro, similar to that on the lake shore, was found.

Rock covered.

Very hard black slate (No. 21), containing specks of iron pyrites; also porphyrelloid schist.

Rock covered.

Black slate.

Gabbro; contact with slate not seen.

Rock covered.

Gabbro represented by No. 22.

Rock covered for 50 feet.

Black slate, No. 23; strike N. 85° E. (Mag.).

Rock covered for about 150 yards, and ground rapidly descending toward the north.

At the foot of the descent was a rather coarse porphyrelloid schist (No. 24) largely composed of a soft mineral, probably sericite.

Now comes a rather level, almost swampy, place with a few small hills; it extends for about a third of a mile, as follows:—

Rock covered; swamp, about 1,000 feet.

Black slate.

Rock covered.

Micaceous schist (No. 25); this is probably in place.

Rocks covered for about 300 feet.

One hundred feet of a heavy black hornblende schist; vertical, strike N. 85° E. (Mag.). At the south side of this exposure the rock is represented by No. 26; this seems to be composed of hornblende with some feldspar; the schistose structure is very pronounced. This rock soon grades into No. 27, which is heavier and has better developed hornblende crystals; the schistose structure is not very evident, except on the weathered surfaces.

The rock was now covered for about 200 feet, and then came an exposure of a very hard, dark, fine-grained mica-schist (No. 28.). This exposure was 20 feet wide (N. and S.) and 40 feet long; strike E. and W. (Mag.); vertical.

After another swamp, 400 feet wide, came an exposure, 50 feet wide, of vertical schist; this consisted of parallel bands of several kinds represented by Nos. 29, 30, 31 and 32. No. 29 is light colored, composed mostly of feldspar, which weathers pinkish, and a small amount of mica; bands of this were of all widths up to one foot; this rock made up about one-half of the exposure. No. 30 is darker and contains much hornblende. No. 31 contains still more hornblende; bands of this and the preceding were not over six inches wide. No. 32 is a very dark, fine, mica-schist; no bands of this over two and a half inches in width were seen. Samples could be found all the way between No. 29 and No. 32, but the outlines of the different bands were very distinct. The bands would often run out to needle-points and disappear.

Beyond another swamp, about 400 feet wide, was a small hill, covered by soil, but on removing the thin layer of soil the solid rock was exposed; this rock (No. 33) is composed of hornblende and feldspar; it is quite firm and on fresh surfaces appears rather massive, but on the weathered surfaces the schistose structure is plainly seen; this schistosity is vertical and strikes N. 85° E. (Mag.). The rock contained a few small areas in which the hornblende seemed to be collected in great quantity.

Beyond the last exposure was a swamp extending northward; no hills could be seen for three-fourths of a mile.

Taking the sum of the foregoing distances, roughly estimated, we have a section, straight across the strike of the slates and schists, of 6,790 feet, or somewhat over a mile and a quarter. This would give the belt of earthy schists and slates (Kewatin) a width of 4,810 feet; and the crystalline schist belt (hornblende and mica-schists), extending north from No. 26 (No. 25 not being included, as it was not positively determined to be in place), would have a width of 1,220 feet. The width of the latter belt is probably greater than 1,220 feet, as the northern limit may not have been reached and there are 670 feet between the slates and the southern outcrop of crystalline schists where no exposures were seen.

SECTION II: This section runs directly north from the lake, and is about three-fourths of a mile west of section I, or very near the line between secs. 15 and 16, if this line were extended northward from the Minnesota side. For the first half mile from the lake there is a well-cut surveyor's line.

At the lake shore there are Animike slate fragments, and just beyond this and 15 feet above the water is a ridge of gabbro, which is about 200 feet across. A swamp extends for one-half mile from the shore; beyond this swamp is about 700 feet of dry, level ground with no rock exposures. Then comes a low ridge, 50 feet across, on which are many granite boulders and a few gabbro fragments, but no rock was seen in place. After crossing 500 feet of lower ground we came to a small ridge of gneiss (No. 34) composed of quartz and feldspar, with some hornblende and a small quantity of a light-yellow mineral.

After passing over two other small ridges of gneiss there comes a range of large hills of the same gneiss; from the first appearance of this rock to the range of large hills is about 600 feet. The gneissic structure can be plainly seen on the weathered surfaces; it is vertical and runs about E. and W. (Mag.). This range is from 40 to 75 feet above the swamp, and extends eastwardly,—the southern front being precipitous and running N. 55° E. (Mag.); south of it is a valley surrounded by hills; the location is shown in Fig. 2.

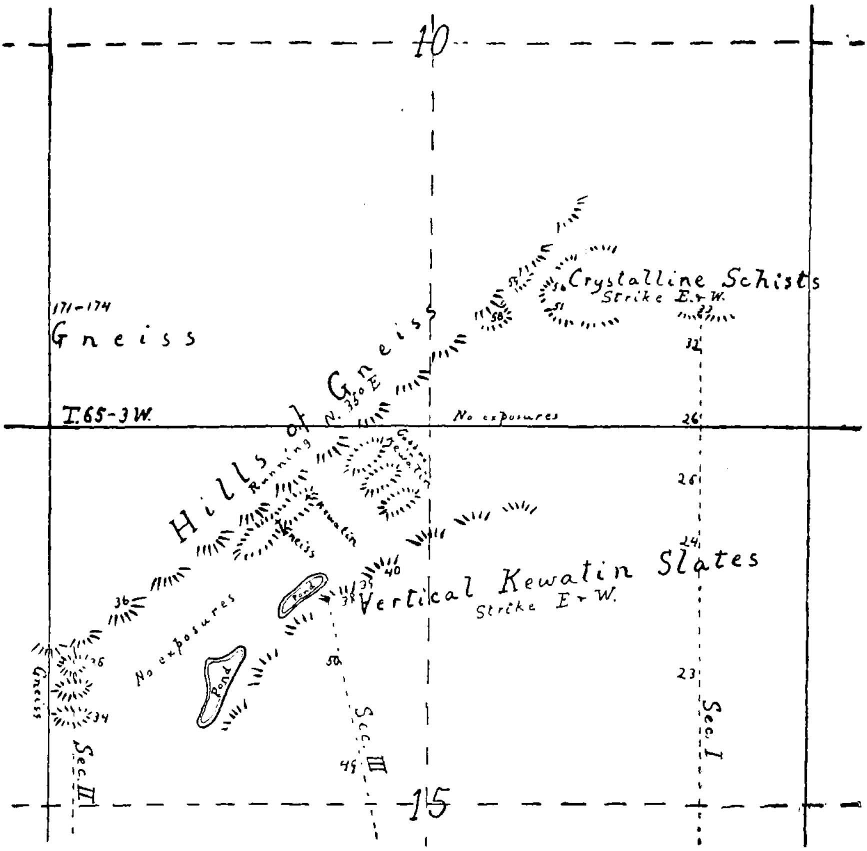

Fig. 2. Sketch showing the relation of the crystalline schists (Vermilion series) and Kewatin slates to the gneiss north of Gunflint lake.

Several pieces of micaceous schist were found in this gneiss; they were lenticular in shape and ran with the gneissic structure. The largest piece of schist was 10 feet long and 18 inches wide, and one end was irregular instead of running out to a point; No. 35 is from this piece.

A short distance east of the first observed gneiss is a trap dike, 20 feet wide, running N. 83° E. (Mag.) through the gneiss hills; this dike was traced for over 200 feet. The trap contained a few scattered crystals of feldspar, some of which are a quarter of an inch long; this rock is represented by No. 36. A mass, 3 feet in diameter, of trap quite rich in magnetite (No. 37) was found in this dike.

South of this range of gneiss hills is another range of hills made of Kewatin slates. At the place marked 38 in Fig. 2 the slates dip northward about 80°; the strike of all the slates is E. and W. (Mag.). Here the slate (No. 38) is interbedded with porphyrel (No. 39). About 100 feet east of this there is a dike of a soft schistose rock (No. 40) running parallel with the slate and porphyrel; this dike is 4 feet wide and was traced for 25 feet; it had split and inclosed a mass of the porphyrel (No. 42) which seems to have been changed by heat; the porphyrel at the con tact has the same appearance as the inclosed mass. A part of the dike is much finer-grained than the rest, — this is shown by No. 41. This dike rock seems to have changed to a micaceous schist; the schistose structure runs with the length of the dike.

Extending from the slate hills to the gneiss range are three low hills composed of vertical slate, on top of which is gabbro; here the slate had been somewhat bent and broken, but the general strike was E. and W. (Mag.). Just west of these are two low hills running parallel with the gneiss range; near the eastern end of these hills is an exposure of vertical slate, striking E. and W. (Mag.); and between the two hills, and almost directly in the strike of the slate, is an exposure of gneiss. The last mentioned exposure of slate was within 100 feet of the gneiss hills. (See Fig. 2.)

Here we find a range of gneiss hills directly in the strike of the Kewatin slates; and the slate comes up to the gneiss, thus leaving no room for the belt of crystalline schists; subsequently the crystalline schists were found a short distance northeast of this place.

SECTION III: About 15° west of north, from the end of Kewatin bay (see map on page 255 of 16th An. Rep.) to the gneiss in the N. W. ¼ of sec. 15.

Forty feet from the lake is a hill, 200 feet wide, rising 40 feet above the water; the rock here is a vertical reddish-weathering schist (No. 47), striking N. 80° E. (Mag.). Six hundred feet beyond this is is another hill 300 feet wide; this is composed of vertical black flinty slate (No. 48) which weathers whitish; the strike on the south side of the hill is N. 78° E. (Mag.), and on the north side it is N. 82° E. (Mag.). After crossing a swamp we come to another hill about half a mile from the lake; here is a rather light-colored sericitic schist (No. 49) striking N. 85° E. (Mag.). About 600 feet beyond this is a large mass of gabbro (No. 50), very much decayed. And a few rods further are vertical slates striking E. and W. (Mag.). This brings us to the valley shown in Fig. 2.

Crossing over to the gneiss hills on the north of this valley and following them northeast for about 1,000 feet, we come to a large hill which is 400 feet wide (N. and S.); on the western and northwestern sides of this hill are numerous outcrops of vertical crystalline schists, striking E. and W. (Mag.). The specimens collected here are No. 51 to No. 56; these were found interbedded in the same manner as described in section I. No. 51 is a hornblende schist with a large quantity of feldspar. No. 52 has more hornblende. No. 53 is a fine dark mica-schist. Nos. 54, 55, and 56 are composed mostly of hornblende which is in quite large crystals. Directly west of this hill of crystalline schists is the gneiss range, and the outcrops on the lower ridges of this range are within 150 to 200 feet of the crystalline schists. One hundred and fifty feet W. S.-W. of 51 (Fig. 2) there is an outcrop of reddish syenite (No. 57), and 40 feet north of No. 57 the syenite is represented by No. 58; No. 57 does not show any decided gneissic structure, but this structure is very evident in No. 58; it is vertical and runs N. 85° E. (Mag.); No. 58A shows this very well. Two hundred feet from the schists and directly in the strike, the gneiss (No. 59) is again seen; the gneiss of the range of hills at this place is represented by this specimen.

The range of gneiss hills here extends northeastwardly and outcrops of gneiss can be seen for a quarter of a mile in that direction. The exact contact between the schists and gneiss could not be found.

Later in the summer, while at Gunflint lake, another trip was made to the locality described above. From the last mentioned exposure of crystalline schist I followed west over the gneiss range for nearly a mile and a half; thence south half a mile, and also north for a short distance; all the rock seen (there were many exposures) was the gneiss with the gneissic structure vertical and running nearly E. and W. At only one place was there any other rock seen; this was about three-fourths of a mile west of the schists; here the gneiss held many small pieces of dark homblendic rock represented by Nos. 170, 171, and 172. No. 170 is a dark, rather fine micaceous schist. No. 171 is coarser and shows no schistose structure. No. 172 is still coarse, have large crystals of hornblende; this rock is very similar to Nos. 27, 55, and 56. All of these specimens seem to be the same as the rock composing the crystalline schists. The pieces are mostly lenticular in shape, having the long axis east and west, but some were angular; they are collected quite thickly in a rather distinct area; on one side they disappear within ten inches, thus making a rather well defined line between the patch holding the foreign pieces and the rest of the gneiss; the other side of this patch is covered by soil, but 15 feet beyond the gneiss appears again. The rock in between the fragments contains no quartz (No. 173), but this rock gradually passes into the ordinary gneiss (No. 174) which contains large grains of quartz. This occurrence of foreign pieces in the gneiss much resembles the "conglomeritic syenite" of Saganaga lake described by Dr. Alexander Winchell in the sixteenth annual report, pages 219 and 334; also in the *American Geologist*, vol. III, No. 3, p. 153.

The facts noted in these three sections may be summarized as follows:

The crystalline schists show no evidences of having been twisted and bent,—the strike is quite constant and continues so up to within 200 feet of the gneiss; no outcrops were seen between this and the gneiss, low ground intervening. The slates in one place near the gneiss are somewhat crumpled, but this is only for a short distance and may have been caused by the gabbro which is found at that place. The crystalline schists (Vermilion series) and the slates (Kewatin) are cut across by a range of syenite gneiss hills which run N. 55° E. (Mag.). This syenite seems to be the same macroscopically as that, into which the crystalline schists pass conformably a few miles further east. The belt of crystalline schists, if continued in their strike would appear again, either on Gunflint lake north of the "narrows" or on the boundary river flowing north from the lake; but the schists are not seen here; all the rock seen for a number of miles north of the line between secs. 18 and 19, T. 65–3, along the lake and river shores (except a small area on the east side of Blackfly bay, which is Animike) is syenite, and there is no trace of the schists, unless, perhaps, it be a very few lenticular pieces of hornblende schist scattered in the syenite,—but these are found elsewhere in the syenite, far removed from any quantity of similar rock. From the facts noted it seems that the syenite has been pushed over or has flowed over the crystalline schists, or that there was a fault running N. E. and S. W. and the schist beds on the west side of this line have been pushed southwestwardly and now lie under the lake, or even further south than that. The situation of the rocks as shown by these sections is given in Fig. 2.

Iron location at Chub lake. This is in the N. E. ¼ of sec. 29, T. 65–4, and was visited in 1887 (see sixteenth annual report, pages 82 to 86). Since September, 1887, there seems to have been no working in the opening into the bluff on the north shore of the lake; No. 44 is a fair sample of the iron ore found at this place. A few rods west of this there is a steam engine and a large quantity of drill pipe. A diamond drill was worked here during the winter of 1887–8 by Mr. Millar of Grand Marais. The drill has gone down through the Pewabic quartzyte into the greenstone. A few pieces of the drill core (No. 45) were lying about; all of these seemed to be quartzyte, which in some places contained bands of a dark mineral, probably hornblende.

First falls north of Gunflint lake. These falls are in the boundary river in the N. E. ¼ of N. E. ¼ sec. 13, T. 65–4. The rock making the falls is the syenite gneiss (No. 62) of the region, with the gneissic structure running No. 80° E. (Mag.). On the Canadian side of the river is a diabase dike running N. 5° W. (Mag.); this is first seen at the waters edge on the upper (south) side of the falls. The dike rock is fairly represented by No. 61, but in some places it is finer grained, as shown by No. 61 A. After running north about 50 feet the dike suddenly ends,

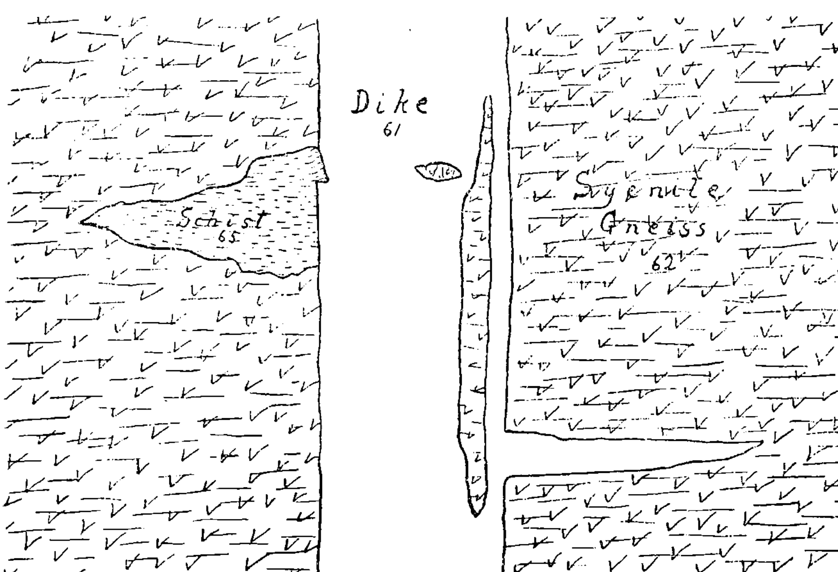

Fig. 3. Diabase dike in the syenite at the falls of the Boundary river, N. E. ¼ of N. E. ¼ sec 13, T. 65–4.

but a few feet east of this it is seen again and was traced northward for about 150 feet; here the rock contains more of a yellowish-green mineral, as is shown by No. 63; and in some places the surface is pitted (shown by No. 64) by the decay of one of the mineral constituents.

From this dike a spur, four inches wide, runs out into the syenite for four feet and ends in a point (see Fig. 3). Here is a piece of the syenite in the dike; this piece is eight feet long and four inches wide; the gneissic structure is parallel to that of the syenite through which the dike cuts. There is also a small lenticular piece of syenite in the dike, but in this the gneissic structure is at right angles to the other. A mass of hornblende schist (No. 65) is inclosed in the syenite, and one end of it is in contact with the dike, while the other end runs to a point; the schistose structure runs with the gneissic structure of the surrounding rock, but at one point (A, Fig. 3) it is slightly bent. By the firmness with which the piece of schist is connected with the syenite and by the looseness of its joint with the dike one concludes that the schist was in the syenite before the dike cut it; there is no part of the piece of schist on the other side of the dike. Several other smaller, lenticular pieces of hornblende schist, resembling the one above described and in no way connected with the dike, were found in the syenite near by.

OGISHKE-MUNCIE LAKE.

This lake lies in secs. 13, 23, 24, 26, and 27 of T. 65–6. The geology of its shores has been described in the former reports of the survey, but a few additional notes from one place are here given.

The place where these notes were taken is on the southeast shore of the lake, opposite the north end of the small island which lies just north of the narrows in sec. 24; or in the S. E. ¼ of N. E. ¼ of N. W. ¼ sec. 24. At the water's edge is a gray quartzyte (No. 76), probably the same as the gray quartzyte in the section given on page 371 of the fifteenth annual report; no bedding was seen in this quartzyte. A few feet from the shore are some vertical black slates (No. 77), striking N. 40° E. (Mag.); the contact between the slates and quartzyte was very distinct, and in one place the quartzyte extended across the strike of the slates. On the shore a few feet east of this place the quartzyte held a bed of slate about one foot wide and striking in the same direction as the other slates; on one side the slate bed by gradual change passed into the quartzyte, while on the other side the two were separated by a sharp line. These black slates contained many siliceous bands (shown in the specimens collected) which sometimes are an inch in width. No. 78 is from one of these bands; this seems to be a gritty sandstone with some calcareous matter in it; it effervesces slightly with cold hydrochloric acid. Going from the lake these bands increase in size and frequency and the black slate gradually disappears. The rock then grades through Nos. 79, 80, and 81 to No. 82 which contains some quartz grains but is chiefly made up of calcareous or dolomitic matter. The last four specimens were taken in a distance of fifteen feet; the rock all weathered with a vertical schistose structure which ran parallel to the strike of the black slate,—i. e. N. 40° E. (Mag.). Three feet beyond No. 82 the conglomerate (No. 83) occurred; the contact between the two was covered; the conglomerate seems to contain some of the dolomitic matter. The distance from the lake shore to the conglomerate was not more than thirty feet.

BIRCH LAKE.

This lake extends through the western part of T. 61–11, and the southern part of T. 61–12. During the summer of 1886 some observations were made along the Dunka river (see the fifteenth annual report, page 340), but there was not time to visit the high ridge south of the lake in secs. 7, 8, and 9, T. 60–12, and trace it eastward to the river; consequently the writer was instructed to examine this locality. The high ridge, which is made up of syenite, was visited by Mr. H. V. Winchell, and a full account of it can be found in his report. The notes here given were taken along the trail that runs south from the lake.

The mouth of Dunka river is near the centre of sec. 33, T. 61–12; the river is canoeable for about half a mile from the mouth; at the first rapids there is a trail running south. This trail crosses the river in the S. W. ¼ of sec. 10, T. 60–12; here the river flows over gabbro (No. 117) which contains some biotite. In one small area (about ten feet square) on the surface of the gabbro there are numerous, narrow dark bands; these are brought out very plainly by unequal weathering. The bands are parallel and vertical, running N. 35° W. (Mag.). Nos. 118 and 118A show these bands; the latter specimen was taken from a loose piece. About half a mile south of this place are many gabbro fragments (No. 119) which evidently came from rock in place near by. At the next crossing (S. W. ¼ of N. E. ¼ sec. 15) there are also some large gabbro fragments (No. 120). The river at this place flows through a swamp and no rock is exposed. Between the two crossings the trail is in many places covered with fallen trees and is difficult to follow.

Just west of the crossing in sec. 10 there is a low drift ridge; this runs a little south of west; it was followed one-fourth of a mile, where it turns more to the south and seems to disappear. A swamp extends westward from this hill, and about half a mile west of the crossing there is a low ridge, ten feet high and 300 feet long, running N. 20° E. This ridge is composed of a dark heavy quartzyte with bands of magnetite; the banding is quite regular and parallel and gives the rock a decidedly bedded appearance. The ridge runs with the strike of the quartzyte. The dip is S. 20° E. at an angle of about 30° (the direction of the dip is only estimated, as the needle was much disturbed). The specimens collected here are No. 115. This rock is probably the same as the olivinitic iron (No. 116) found on the trail in the N.W. ¼ of sec. 10 and mentioned on page 341 of the fifteenth annual report. What I have spoken of as a quartzyte is probably composed largely of olivine. The rock is a part of the Animike formation.

KAWISHIWI RIVER.

In T. 63–9. From the little bay in the S. W. ¼ of S. E. ¼ sec. 15, T. 63–9 there is a trail running northeast to the quarter post between secs. 14 and 15. On the shore the ordinary gabbro (No. 132) was found; it here held a few grains of magnetite. A quarter of a mile from the shore the trail crosses several small exposures of iron ore; these are surrounded by the gabbro; the ore is magnetite represented by No. 133, which was taken from the first of these ore exposures.

About sixty yards northwest of the quarter post between secs. 14 and 15 is a hill composed of a fine-grained rock (No. 134), which seems to be what the survey has called "muscovado." The east side of the hill is rather steep and here is some more of the magnetite (No. 135); this seems to lie under the muscovado, as it is exposed all along the base of the hill (about 250 feet) and just above and within ten feet of it the muscovado occurs in place. The contact between the two was not found. This outcrop of ore seems to be almost pure magnetite, but it occurs in the gabbro and very probably contains quite a large per cent of titanium, as all the gabbro ores do, and so would be comparatively worthless. The ore is exposed for about 250 feet and the exposure is ten feet high; the iron seems to extend under the hill indefinitely. The specimens collected fairly represent this ore.

After reaching the quarter post between secs. 14 and 15 the trail runs north on the section line to the northwest corner of sec. 14 and then east one mile, and then north on the line between secs. 11 and 12 to Snowbank lake. There are numerous exposures of rock, but it is all the ordinary gabbro. At one place a few small pieces of magnetite were seen in the gabbro. Iron was reported just west of the quarter post between secs. 11 and 12, but after search in this locality none was discovered.

Mr. Wm. Diarmid who has a claim in the N. ½ of S. W. ¼ sec. 3, T. 63–9, says that there is an outcrop of magnetite in the gabbro near the quarter post between secs. 13 and 14, T. 63–9; also one in the S. E. ¼ of sec. 7, T. 63–8. He also mentioned outcrops of jasper in the N. E. ¼ of sec. 8, T. 63–9 and in the N. W. ¼ of sec. 4. These localities were not visited by the writer, but Mr. H. V. Winchell examined the jasper in T. 63–9 later in the season.

South of Mishiwishiwi lake. The Indians apply this name to the lake, which the survey called Bald Eagle lake in the fifteenth annual report; the lake lies mostly in secs. 25, 26, and 36 of T 62–10. A river flows into the southeastern corner of the lake, and about a mile from the mouth of the river, or in the N. W. ¼ of sec. 5, T. 61–9, there is a stream flowing into the river from the south; this stream is canoeable for about a mile and a half. On the right bank of the stream and an eighth of a mile south of its mouth is a hill of gabbro, which appears to be the west end of a low ridge running east and west. This gabbro (No. 136) has a gneissic structure, which is vertical and runs N. 15° W. (Mag.), making the rock break more readily in this direction than in any other. In some places the gabbro lies in horizontal beds from two to four inches thick. The rock seems to be almost entirely composed of a feldspar (probably labradorite) and a mineral which is probably olivine; this, when not decayed, is of a yellowish-green color, but its hardness is below 6. A few rods further south, on the left bank of the stream is a small hill of the some gabbro showing the gneissic structure running in the same direction,—i. e. N. 15° W. (Mag.).

About a third of a mile south of the last mentioned hill is another gabbro hill on the left bank of the stream. The rock here is similar in composition to that above described, but is coarser grained and does not have the gneissic structure seen in the other; but many of the weathered surfaces have a peculiar banding, which is caused by the feldspar crystals being aggregated in certain lines that are vertical and run N. 10° W. (Mag.). No. 138 is a fair sample of the gabbro from this locality, while No. 137 shows the banding. The olivine, as it decays, loses its yellowish-green color and becomes darker (sometimes having a deep red color, like garnet) until on the weathered surface of the rock it appears as rusty spots. The decay of the olivine causes the rock to crumble and be easily shattered. From this hill a higher range, running east and west, could be seen about ten miles to the south.

A mile and a half from its mouth the stream narrows and rapids soon occur; here is a poor, not recently used, portage on the left side of the stream; beyond this portage the stream is crossed by many fallen logs, so we went no further.

About a mile and a half south of this place the low rounded hills, a form common to a gabbro country, seem to be collected into a low range that runs east and west. The country south of Mishiwishiwi lake has been burnt and is now partially covered by small poplars and birches, although many of the hills are treeless.

The small lake in sec. 32, *T.* 63–10. A small island near the southern shore of this lake is composed of a red syenitic gneiss (No. 139), the gneissic structure being very easily seen on the weathered surfaces and running N. 50° E. (Mag.). A little north of this is another island composed of about the same syenite, but this (No. 140) does not show the gneissic structure. These islands are in the N. E. ¼ of S. W. ¼ sec. 32. On the west side of the little bay, which is in the N. W. ¼ of N. W. ¼ sec. 32, the syenite is lighter colored and has large crystals of hornblende as shown by No. 141. At the portage, in the N. E. ¼ of N. E. ¼ sec. 31 there is a light gray gneiss (No. 142) with the gneissic structure running N. 60° E. (Mag.); this gneiss holds pieces of a darker rock (No. 143), and seems to be mixed in with a mica schist and a hornblende schist a few feet south of the portage. On a little point, near where the line between secs. 31 and 32 crosses the southern shore of the lake, there is red syenite like No. 139. There was not time to examine the whole lake, but the shores seemed to be made up of syenite, of which No. 140 is a fair sample.

Mr. H. V. Winchell found the rock on the southern (?) shore of this lake to be a dark hornblende rock (No. 144), which grades into the ordinary syenite through No. 145 and No. 146.

LAKE ISABELLE.*

This lake lies in secs. 25, 35, and 36 of T. 62–8 and secs. 30 and 31 of T. 62–7.

On the west shore of the little bay in the S. W. ¼ of N. W. ¼ of sec. 35, the gabbro is composed principally of labradorite with a small amount of a glassy yellow mineral (probably olivine) and magnetite, which seems to cause the rusty spots near the surface of the rock; a few scales of biotite are also present; this gabbro is represented by No. 147. A few rods further north there is an irregular vein of granulyte (No. 148) in the gabbro; the vein is eight inches wide; one of the specimens collected shows both the vein rock and the gabbro; in the vein rock there are a few scattered scales of biotite.

On the west side of the larger bay, which is in the N. W. ¼ of sec. 35, there is a perpendicular cliff (5 to 15 feet high) of gabbro (No. 149) that is coarser grained and contains considerable olivine, but some of this yellow color may be due to a decayed condition of the labradorite. At the head of this bay, gabbro similar to No. 149 occurs.

On the shore in the S. W ¼ of N. E. ¼ sec. 35 there is a dark, heavy, fine-grained trap rock (No. 150) which gives a metallic ring when struck by the hammer; this grades into No. 151 which is coarser. A few rods back from the shore Nos. 152 and 153 were found in low outcrops; these seem to be but different conditions of No. 150. No. 152 contains considerable magnetite. A little further north on the shore this rock contains small patches of biotite, as shown by Nos. 154 and 155, the latter being a decayed condition of the former. These grade into No. 156 which is coarser. On the shore, a few steps north of No. 156, this rock (trap) is found in contact with the gabbro (N. ½ of N. E. ¼ sec. 35); the line of contact was not always distinct and in some places, as near as could be determined from the smooth-weathered surface, the transition from one rock to the other occupied two

*Only the north shore of this lake is here described; for the description of the rest of the lake, and also of most of the country between here and lake Superior (this lake and the two following being the only ones here mentioned), consult the report of Mr. H. V. Winchell.

or three inches. No. 157 represents the trap near the contact with the gabbro.

The rest of the north shore of the lake has many gabbro outcrops; for long distances there are smooth, flat exposures of gabbro rising but a few inches above the water and extending back for several yards from the shore. Three dikes are found cutting the gabbro. The first is in the N. E. ¼ of N. E. ¼ sec. 35; this dike is twenty inches wide and was traced for over sixty feet; it runs N. 30° W. (Mag.); the rock is a very fine diabase (No. 158); the contact with the gabbro is distinct. This dike occurs only a few rods north of the contact mentioned, about ten lines above. The second dike is in the S. W. ¼ of sec. 30, T. 62–7, is twenty feet wide, and could be traced only twenty-five feet, as the water covered it on one end and the soil on the other; the rock is diabase and is represented by No. 159, which was taken from the centre of the dike, and by No. 160, which was taken from one side (only one side of the dike was finely crystalline); No. 160 appears to be the same as No. 158; the contact is distinct. The third dike is in the W. ½ of sec. 31, T. 62–7 and is composed of a fine diabase represented by No. 161; this dike is fourteen inches wide and can be traced only a few feet.

BELLISSIMA LAKE.

This lake lies in the southeastern corner of T. 61–7. The north shore was examined by the writer. The shore is usually lined with boulders, most of which are large gabbro boulders, the others are smaller and apparently come from the drift; some of the latter are probably from Cupriferous rocks. Wherever the rock was exposed it was found to be very coarse labradorite gabbro, as shown by No. 162, which was obtained on the shore, about half a mile east of the west end of the lake. The north shore was low and there were no hills near the lake. No glacial striæ were seen.

PINE LAKE.

This lake lies in the S. W. ¼ of sec. 21 and in the N. W. ¼ of sec. 28, T. 60–6.

On the north shore, about one-fourth mile east of the portage from lake Harriet (just west of Pine lake), is a low rock outcrop at the water's edge; this outcrop is about twenty feet square. The rock is of three kinds; (1) a gray rock (No. 163) composed mainly of a gray feldspar; (2) a red rock (No. 164) made up of quartz and red feldspar; (3) a very fine dark trap (No. 165) holding crystals of red feldspar. No. 164A shows a darker and more siliceous condition of No. 164. Nos. 164 and 165 are very much mixed, each containing pieces of the other (see Nos. 164, 165, 165 A, and 165B). No. 163 is not found mixed with the others, but it contains a few small pieces of a dark siliceous rock as shown by No. 163A. No. 163B is intermediate between No. 163 and No. 164. The dark trap much resembles some of the trap of the Cupriferous; it is split by numerous parallel planes that are vertical and run N. 5° W. (Mag.); these are shown by the specimens.

A diabasic rock (No. 166) outcrops on the east shore near the southern end of the lake; it holds a few scattering crystals of feldspar which are sometimes nearly an inch long. This outcrop and the one mentioned above are the only two outcrops on the north and east shores of the lake.

Mr. H. V. Winchell reports several outcrops of fine diabase on the west shore of the lake; Nos. 167, 168, and 169 represent this; they seem to differ only in fineness, and all of them are much finer than that from the east shore.

The notes from Mayhew to Flying Cloud lake (inclusive) were taken on a trip from Gunflint lake south to Brulé lake and then north and west through townships 63–4, 64–4, 65–4, 65–5, and 65–6 to Ogishke-Muncie lake. The object of this trip was to examine reported iron ore locations, most of which were not found as reported,— there usually being no ore to be seen. The country passed over is one not usually traveled by white men and is seldom used by Indians except in winter; consequently the portages are very poor and badly cut, it oftentimes being necessary to go ahead and recut a portage before the canoe could be taken across. This fact, together with the fact that the township plats were very inaccurate, caused much unavoidable delay and waste of time. There are, however, some fair portages; those from Gaskanas lake to Brulé lake are quite good, and the portages from lake Ida Belle north to the lake in the S. W. ¼ of sec. 35, T. 65–4 are wide and well cut out, being used as winter roads by the Indians.

Several of the lakes on this trip were given names, as they have none on the township plats nor on any of the maps accessible. It must be admitted that this is rather a bad principle to follow, the right way being to give them the names by which they are known to the native Indians or, better still, to give the English equivalents of the Indian names; but, as the Indian names were not obtained, it was thought best to have some name by which each lake could be known. The lakes thus named are Straight, Meed's, Stray, Sham, Lost, Georgia, Surveyor's, Found, Ida Belle, Narrow, Round, and Draper lakes.

MAYHEW LAKE.

Mayhew lake is a narrow strip of water, about one-fourth of a mile wide and a mile long, extending east and west through the south half of sec. 36, T. 65–3. It is 305 feet above Gunflint lake. A rough, steep portage runs from Loon lake to Mayhew lake.

The ordinary labradorite gabbro (No. 175) is seen on the south shore in S. W. ¼ of S. E. ¼ sec. 36. On the end of the little point, which is in the S. E. ¼ of S. E. ¼ sec. 36, the gabbro (No. 176) has changed somewhat, and on the south side of this point it surrounds a large mass of iron ore. This ore (No. 177) seems to be principally magnetite, with a little scattering feldspar, but, as it is in the gabbro, it very probably contains a considerable amount of titanium. The exposure of ore was 30 feet wide and extended for about 300 feet along the shore, rising 15 feet above the water. The contact between the ore and gabbro was found at one place; here the gabbro does not pass into the iron ore by gradually acquiring more magnetite, but there is a sharp and distinct line between the two.

There is a trail, on the town line, running south from the lake; this trail was followed nearly three-quarters of a mile, and several gabbro ridges, running east and west, were crossed; the gabbro is much decayed and is nearly half made up of magnetite (No. 178). From the town corner (T. 65–2, 65–3, 64–2, and 64–3) a trail runs west along the line between townships 64 and 63. About a quarter of a mile west of the corner, and just south of the line, there is a small lake; here were seen many fresh beaver gnawings. Gabbro was the only rock seen on this trail (it was followed no further than the small lake mentioned above).

IRON LAKE.

This lake is a narrow body of water extending through the south half of secs. 31, 32, and 33 of T. 65–2. It is the same hight as Mayhew lake, and the two are connected by a narrow strip of water, 60 or more feet in width.

The point, which is crossed by the line between secs. 31 and 32, also the north shore of the lake in the south half of sec. 32, were examined in order to see the iron ore at these places. (This lake was described in the tenth annual report, page 80.) The point was crossed twice west of the section line and once east of it, but no ore was found except a seam of magnetite (containing a little feldspar) eight inches wide and twelve feet long, and a few small masses (No. 179) of the same in the gabbro. A low ridge of gabbro runs along the southern shore of this point, and in this ridge the magnetite was found. The gabbro is, in places, quite rich in magnetite; this is shown by No. 180, which was taken near the section line. Four sections of a quarter of a mile each were made north of the lake in sec. 32, but no ore was found. The rock was all gabbro, and none of it contained as much iron as No. 180. The shores of Iron lake are usually lined with gabbro.

PORTAGE LAKE.

Portage lake is mostly in the north half of sec. 4, T. 64–2, but an arm extends east for half a mile in sec. 5, and the line between T. 64 and 65 crosses the northern part of the lake, making a small portion of it in sec. 33, T. 65–2. It is 25 feet above Iron and Mayhew lakes.

In the S. E. ¼ of N. W. ¼ sec. 4, on the shore, is an exposure of a fine "muscovado" (No. 181); one of the specimens collected shows a porphyritic crystal which is probably labradorite. The relation of this rock to the gabbro could not be found at this place. On the south shore, in the N. E. ¼ of N. E. ¼ sec. 4, there is an exposure where the gabbro and "muscovado" were found together. The former held several large masses of the latter rock that looked like dikes, but they could not be traced far enough to determine that they were dikes. There was one lenticular piece of "muscovado" (15 inches long) in the gabbro, and in places the gabbro held pieces of the other rocks in which were small bits of the gabbro. The bottom of the exposure was entirely of gabbro. It could not be positively ascertained which was the older of the two rocks, but the "muscovado" seems to have broken up through the gabbro.

On the south shore, in the N. W. ¼ of N. W. ¼ sec. 3, the gabbro is in distinct beds from two to eight inches thick and dipping south about 30°. This bedded structure, dipping in the same direction and at about the same angle, was noticed several times, but at no other place were the beds as thin and as distinct as here. The gabbro was seen at several other places on the south shore of the lake.

POPLAR LAKE.

This lake lies mostly in secs. 1 and 12 of T. 64–2 and secs. 7 and 8 of T. 64–1; a small portion is in sec. 6, T. 64–1, and a narrow bay extends into the S. E. ¼ of sec. 2, T. 64–2. It is 20 feet below Portage lake. A portage leads from the east arm of Portage lake to the extreme northwestern point of Poplar lake; the trail is rather plain at the western end, but at the other end there is almost no trail at all. No one seems to have been over the portage for two or three years. No portage could be found leading to Duck lake (a small lake in the eastern part of sec. 3, T. 64–2) mentioned by N. H. Winchell in the tenth annual report, page 79.

Gabbro was seen in several places on the portage from Portage lake. On the little point in the N. W. ¼ of N. E. ¼ of N. W. ¼ sec. 12, T. 64–2, the gabbro is finer than is usually found. At this place it varied from No. 182 to No. 183; the former shows a gneissic arrangement of the minerals, but this is not constant. On the shore in the S. E. ¼ of N. E. ¼ sec. 12 the gabbro (No. 184) has the labradorite collected together in spots, but this soon grades into the ordinary gabbro.

STRAIGHT LAKE.

This is a small, narrow lake, half a mile long and 100 yards wide, extending northwest and south east in the S. W. ¼ of sec. 7, and the N. W. ¼ of sec. 18, T. 64–1. It is 25 feet below Poplar lake and is not shown on the township plat. The portage starts from Poplar lake on the range line and runs a little east of south; it is about one-fourth mile long. Gabbro was seen on the portage.

CARIBOU LAKE.

Caribou lake is in sec. 18, T. 64–1 and sec. 13, T. 64–2. It is ten feet below Straight lake. The portage from the latter lake is a quarter of a mile long. Gabbro occurs on Caribou lake at the portage and was also noticed in several places along the north shore. There is a claim cabin in the S. W. ¼ of N. E. ¼ sec. 13, T. 64–2, probably built within the last year, and from this cabin a line ran north for one-fourth mile; no rock was found except some gabbro at the north end of this line. The south and west shores and some of the islands of this lake have not been burnt, but all the country passed through since leaving Loon lake was burnt a number of years ago and is now covered with a not very dense growth of poplars and birches, usually not more than 25 feet high.

MEED'S LAKE.

Meed's lake is less than half a mile wide, and extends through the northern part of secs. 14 and 15 into secs. 13 and 16 of T. 64–2. It is 10 feet above Caribou lake. The timber along the shores is very dense, composed mostly of spruce, and extends down to the water's edge. No portage could be found from Caribou lake to this lake, so it was necessary to portage up the creek bed (S. E. ¼ of N. W. ¼ sec. 13, T. 64–2) for 100 yards, where the creek widens into a pond, and from the west end of this pond 200 yards more to Meed's lake. There is no high land to be seen from this lake except a hill, 90 feet above the water, in the N. E. ¼ of N. W. ¼ sec. 15.

On the geological map in the fifteenth annual report iron ore is marked all along the north shore of this lake, but, after careful search, none was found. The north shore of the lake was examined and no rock was seen except several outcrops of gabbro. Several trips were made north from the shore, as follows: (1) One-fourth mile north, a little west of the centre of sec. 15; a hill of gabbro (No. 185), mentioned above, was the only rock found. (2) Mr. Meeds went more than half a mile north about one-fourth mile west of the line between secs. 14 and 15; he reported several outcrops of gabbro. (3) One-half mile north from the little bay which extends into the S. W. ¼ of S. W. ¼ sec. 11; no rock found in place except a little gabbro at the shore. (4) From the east side of this little bay where the line between secs. 11 and 14 crosses the shore, northeast one-third mile, and then south to the lake shore. Several low ridges of gabbro, running east and west, were crossed. On the way south to the lake a small exposure of almost flat-lying (dipping S. 4°), bedded rock was found. This exposure was not more than six feet across; the rock is similar to some of the Animike beds of Gunflint lake and vicinity. One specimen (No. 186) was collected; this has a structure somewhat resembling öolite; pieces of this are quite common on the beaches of Gunflint lake. The rock is undoubtedly Animike, but I was unable to determine whether it was in place. Search was made for more of this rock, but none was found.

NORTH BRULÉ LAKE.

There is a portage starting from Caribou lake a little west of the line between ranges 1 and 2 and running south a quarter of a mile to the northwestern arm of North Brulé lake. North Brulé lake is a very irregular body of water lying in secs. 19, 20 and 29 of T. 64–1 and sec. 24 of T. 64–2. It is 20 feet below Caribou lake. Only that part of the northwestern arm lying in the N. E. ¼ of sec. 24, T. 64–2, was examined; here gabbro was seen in two outcrops. The shore has not been burnt and is covered mostly by spruce and cedar.

STRAY LAKE.

This lake is long and narrow; it lies in the north half of sec. 24, T. 64–2 and extends nearly half a mile into sec. 23. It is 30 feet above North Brulé lake. The portage leading from the last lake to Stray lake starts almost directly south of the one from Caribou lake. Gabbro was seen on this portage and also along the stream that flows from Stray lake to North Brulé lake.

GASKANAS LAKE.*

This lake is nearly three miles long, and not more than half a mile in width. It lies in secs. 22, 23, 24, 25, 26, and 27 of T. 64–2, and is 15 feet above Stray lake. We could find no portage leading south from Stray lake and so cut one to the pond which is in the S. W. ¼ of sec. 24. From this pond an old and poorly-cut portage leads to Gaskanas lake. Gabbro was seen at each end of the last portage, also on the east side of the little bay in the S. E. ¼ of N. W. ¼ sec. 26. This lake is a very pretty little sheet of water and is dotted with many green islands. The shores are densely wooded and along the south shore, especially in sec. 26 where there are two claim cabins, there is considerable good white pine.

*This name is taken from Heinze Bros.' "Map of the Vermilion Iron Range." This map gives Winchell lake as Ababikaigan lake.

WINCHELL LAKE.*

Winchell lake is a long, narrow body of water, over five miles in length and less than half a mile in width, extending east and west in the southern part of T. 64–2 and running half a mile into T. 64–3. It is 30 feet above Gaskanas lake. The portage from Gaskanas lake (this starts from the bay in S. E. ¼ of N. W. ¼ sec. 26) is very good,—the first good one seen since leaving Gunflint lake. The water of Winchell lake is deep and very clear; the shores are well covered with timber which is composed mostly of spruce and birch with some scattering white pine. The Grand Marais Indians call this Mountain lake, probably because of the high ridge that extends along the south shore.

Gabbro occurs in place at the portage in the N. E. ¼ of S. W ¼ sec. 26, T. 64–2, and there are outcrops of rock (apparently gabbro) all along the north shore, but only one of these was visited; here (S. E. ¼ of S. E. ¼ sec. 29) the gabbro (No. 187) is like the ordinary labradorite gabbro found further north, but is a little finer. We followed along the south shore of the lake, but no rock outcrops were seen until we came to the point which is crossed by the line between secs. 31 and 32, T. 64–2; here a high ridge, which extends all along the south shore of the lake and rises 50 to 100 feet above the water, comes to the shore and forms a precipitous cliff nearly 100 feet high. This cliff is composed of gabbro (No. 188) which differs from the ordinary gabbro in that it contains a considerable amount of a whitish feldspar mixed with the labradorite. The gabbro extends along the shore for a quarter of a mile west of this point.

In the N. W. ¼ of N. W. ¼ sec. 31, T. 64–2, the above mentioned ridge is cut by a small stream flowing from Sham lake, which is just south of Winchell lake. Just east of this stream is a bluff rising 80 feet above the water. The rock at the foot of the bluff is covered by large angular masses of rock that have fallen down from higher up. The first rock seen *in situ* is almost 20 feet above the water level; it is gabbro (No. 189) that is like the ordinary labradorite gabbro, except that it is more compact and contains a little light-colored feldspar. Twenty feet higher up the gabbro is represented by No. 190; this is similar to No. 189, but has more of the light-colored (pinkish) feldspar. This feldspar increased until, ten feet above No. 190, the rock was

*This name is taken from Reisenegger's map of Northeastern Minnesota.

largely composed of it. This rock (No. 191) has a red color and seems to be the gabbro changed by heat; this could not have been done by forest fires as none have passed over the shore. The feldspar crystals vary all the way from the dark (almost black) labradorite through white to a decided red. This rock is about as coarse and, with the exception of color, has the same appearance as the ordinary gabbro. None of the specimens above mentioned contain any quartz. Two feet above No. 191 the rock is very dark and tough, being composed mostly of a black mineral probably hornblende, which is not always in definite crystals; this gives the rock (Nos. 192 and 193) the appearance of having a dark compact ground mass in which are scattered blotches of pinkish feldspar; in these feldspar blotches there are numerous small quartz grains. A little higher up occurred a fine pinkish gray syenite (No. 194). No. 195 was taken just above this and No. 196 from the top of the bluff. The latter is coarser and is a distinct syenite. On examining the bluff at another place the syenite was found at the top and the gabbro near the bottom. Among the angular pieces at the foot of the bluff one (No. 197) was found which seems to be intermediate between the highest gabbro (No. 191) and the syenite; it resembles No. 191 and, like it, has labradorite (?) crystals, but it also contains numerous quartz grains while No. 191 has none. On the north end of the portage to Sham lake the rock is a condition of the gabbro,— No. 198.

The above mentioned bluff shows an apparent transition from the gabbro at the bottom (No. 189) to the syenite at the top (No. 196), *the syenite lying on the gabbro.* The change is gradual, and rapid at only one place — between No. 191 and No. 192; here the transition occurs within two feet; the quartz in No. 192 is in such small grains that it was not noticed in the field, so the exact place where the quartz first appears was not determined; however, there is no distinct contact line between these two rocks, but the change from one to the other is quite sudden. It seems that the syenite is of igneous origin and has flowed out over the gabbro, the gabbro being changed somewhat by molten rock above it. No. 191 represents the changed state of the gabbro and No. 192 is the first, or lowest, part of the syenite; at any rate the change occurs between these two,— the distinct labradorite crystals disappearing and the quartz coming in.

SHAM LAKE.

This is a small lake, less than a mile long, on the line between sec. 31, T. 64–2 and sec. 36, T. 64–3. It is 15 feet above Winchell lake and is connected with it by a small stream which is a short distance east of the range line. The portage between the two lakes is less than one-eighth of a mile in length. Sham lake has no long arm extending west through sec. 36, as is shown on the township plat.

The rock at the south end of the portage is represented by No. 199; this is similar to No. 192 except that the hornblende is in distinct crystals and the quartz is not very plentiful. On the east side of the lake, in the S. W. ¼ of N. W. ¼ sec. 31, a fine red syenite (No. 200) occurs; it is composed of a red feldspar and hornblende, the feldspar making up about two-thirds of the rock; no quartz can be seen with a hand lens, but it probably contains some. The rock is probably the same as the fine red syenite or "red rock" found by Prof. N. H. Winchell both east and west of this place. Near the southwest corner of the lake, in S. E. ¼ of S. E. ¼ sec. 36, there is a low outcrop of a rock (No. 201), apparently part of the transition from gabbro to syenite; it resembles Nos. 192 and 193 from Winchell lake.

LOST LAKE.

From the south end of Sham lake there is a portage running S. S. W. for about a mile to Lost lake. This lake is not given on the township plat, and as near as could be determined it lies in the S. ½ of sec. 1 and the N. ½ of sec. 12, T. 63-3. It is about half a mile long (N. and S.) and a quarter of a mile wide. The shores are well wooded and have considerable good white pine. This lake is 30 feet above Sham lake.

On the portage from Sham lake the fine red syenite, same as No. 200, occurs in several places just east of the trail. On the west side of the lake, in S. E. ¼ of S. W. ¼ sec. 1, there is a high bluff of this same syenite; and many angular pieces have fallen down making a large talus; at this place the rock is represented by No. 202, which is of a brick-red color and contains even less hornblende than No. 200.

BRULÉ LAKE.

From Lost lake there is a portage of a quarter of a mile running S. S.-W. to a small lake, not shown on the township plat, in the W. ½ of sec. 12, T. 63–3. This small lake is about a quarter of a mile in length. From its southern end a portage of less than a quarter of a mile leads to the bay of Brulé lake that extends into the S. W. ¼ of sec. 12, T. 63-3.

Brulé lake is the largest lake seen since leaving Gunflint lake, —in fact it is the largest lake in Minnesota south of the boundary and east of range 9. It is seven miles long, the average width being a mile, and extends through the central part of T. 63-3 and a mile and a half into the western part of T. 63-2 (that portion of the lake in this township was not visited). The north and west shores have not been burnt; here is some good white pine. The southern shore was burnt some years ago and is now covered with a second growth of birches. There is a claim cabin on the point in the N. E. ¼ of N. W. ¼ sec. 13, and from a Grand Marais Indian, we learned that there were several more about the lake. Brulé lake is 75 feet below Lost lake. The water is cle and deep.

In the S. E. ¼ of S. W. ¼ sec. 12, at the water's edge, there is a low exposure of a dark siliceous trap rock (No. 203), which appears to be perfectly homogeneous under the hand lens. This rock contains a few small crystals of iron pyrites. No bedding structure could be seen but there were many small joints cutting the rock; in one place these were parallel and dipped south about 20°. A little further south along the east shore of this bay (the bay in the S. W. ¼ of sec. 12) is an outcrop of a rock (No. 204) composed almost entirely of plagioclase feldspar crystals of all sizes up to half an inch in length; these crystals seem to be imbedded in a dark, finely crystalline matrix, but this is a very small part of the rock.

On the point in the S. E. ¼ of N. E. ¼ of N. W. ¼ sec. 13 the rock at the water's edge is a white feldspar porphyry (No. 205); the feldspar crystals run up to those an inch in length; the matrix is dark and finely crystalline; it makes up about one-half of the rock. No. 204 is probably a condition of this porphyry. Ten feet above No. 205 and 30 feet back from the shore there is another feldspar porphyry (No. 206); this seems to be different from No. 205, as the matrix is much finer, darker and apparently more siliceous, and the feldspar crystals, instead of being white, are of a dull reddish-brown color; the matrix comprises about three-fourths of the rock; the feldspar crystals weather white. The rock between these two porphyries is covered by soil.

A few yards south of No. 206 is a small exposure of a brick-red rock (No. 207) which is composed of a reddish, homogeneous and siliceous ground-mass, in which are small crystals of a brick-red feldspar, a dark mineral (probably hornblende) and quartz. This rock might be called a quartz porphyry and is entirely different from any of the others on this point. It is cut by many parallel planes (shown in the specimen) which are vertical and run east and west. On the north side of this exposure the red rock is in contact with a fine diabase (No. 208); the contact line is distinct but was exposed for only a few inches; where seen it was vertical and ran east and west. Near the contact the ground-mass of No. 207 becomes darker and more siliceous; this is shown by No. 207A.

Where the line between secs. 13 and 14 strikes the north shore the rock is similar to No. 204. This same rock occurs on the point in the N. W. ¼ of N. E. ¼ sec. 14 and also on the small island just south of this point. The shore was not examined again until reaching the large island in the centre of sec. 17; no outcrops were seen along the south shore of this island. On a small island in the S. E. ¼ of S. E. ¼ sec. 18 there is a dark, diabase-like rock inclined to be amygdaloidal (No. 209); this is quite finely crystalline and inclines to a dark purple color. In places in this rock there are small blotches of a reddish feldspar; the centre of each blotch is composed of a dark mineral, probably hornblende. This rock also occurs near the west end of the island that is cut by the line between secs. 17 and 18, and on the east end of the portage towards Georgia lake.

It is to be regretted that we were unable to more carefully examine the relations of the rocks from the south shore of Winchell lake, to and through Brulé lake, but our provisions would not warrant a longer stay.

LAKE GEORGIA.

This lake lies in the W. ½ of sec. 18, T. 63–3, and sec. 13, T. 63–4, and small bays run into secs. 14 and 24. It is 6 feet below Brulé lake. The shores have been burnt and are now covered with small birches and poplars. A stream flows from Brulé lake to lake Georgia and the portage between the two lakes is in the S. W. ¼ of sec. 18; it is only 200 feet, and not a quarter of a mile, as shown on the plat. Lake Georgia has no arm extending into sec. 12, T. 63–4, as is shown on the government plat.

In the north branch of the arm that extends into the S. W. ¼ of sec. 18, a short distance west of the portage from Brule lake, there is a rock (No. 210) which appears to be a condition of the gabbro. A little west of this, and on the north shore of this arm, is an outcrop of a feldspar porphyry (No. 211); this seems to be somewhat similar to No. 206; the feldspar crystals are reddish, but rather scattered—probably making up not more than one-tenth of the rock. On the north shore of the lake in the N. E. ¼ of S. W. ¼ sec. 13, T. 63–4, there is a trap rock (No. 212); which is in contact with the gabbro, here represented by No. 213; the two specimens were taken within three feet of each other; the contact line was covered by soil. No. 212A shows the trap further from the contact; it is much coarser than No. 212. Gabbro also occurs where the line between secs. 13 and 14, T. 63–4 touches the northern shore of the lake.

SURVEYOR'S LAKE.

This lake is in sec. 12. T. 63–4. It is shown on the township plat as an arm of lake Georgia, but there is no connection between the two except a small stream flowing from Surveyor's lake; the portage between these lakes is in the N. E. ¼ of sec. 13 and is over an eighth of a mile long. The aneroid shows no difference in hight between the two lakes, but Surveyor's lake is a little higher than the other. North and east of this lake are hills 50 to 100 feet high.

In the S. W. ¼ of sec. 12 there is a deep bay running west for nearly half a mile. At the end of this bay on the portage going west to Found lake is a fine red syenite (No. 214), similar to Nos. 200 and 202. There is a ridge extending along the north side of this bay; the red rock (syenite) in the ridge can be seen from the lake.

FOUND LAKE.

Found lake is in the S. ½ of sec. 11, T. 63–4. It is a small lake, less than half a mile long (east and west) and is not shown on the township plat. The shores have been burnt and are now covered with a second growth of birch and poplar. This lake is the same hight as Surveyor's lake.

The fine red syenite, similiar to No. 214, occurs in several places on the portage from Surveyor's lake. On the north side of the lake is a hill, 50 feet above the water, composed of a diabase (No. 215). On each side of this hill the red syenite occurs, thus making it seem as if the diabase had cut through the syenite; the two rocks were not seen in contact. The north shore of the lake is mostly made up of the fine red syenite. In one place this syenite held angular pieces (none were seen over three inches in diameter) of a fine dark rock; this is shown by No. 216, which shows both the dark rock and the syenite. In this specimen the syenite is easily seen to contain much quartz; — in the other specimens of this syenite (Nos. 200, 202, and 212) quartz can not be clearly seen with the hand lens.

LAKE IDA BELLE.

This lake is very irregular. It lies in secs. 1, 2, 3, 10, 11, and 12 of T. 63–4, while bays extend a short distance into T. 64–4, T. 64–2, and T. 63–3. It is 30 feet below Found lake. The country around lake Ida Belle, except a small portion at the northeast corner of the lake, has been burnt, and there are vast exposures of rock all around the lake not yet covered by a second growth of trees.

This lake lies in the great gabbro sheet; probably nine-tenths of the rock around the lake is gabbro, the rest being trap and fine red syenite. A belt of iron ore was reported running from sec. 1 to sec. 18, T. 63–4; the entire lake shore was examined, also part of the country southwest of the lake, but no iron ore was found;—in fact the only iron seen consisted of a few bands or seams of magnetite in the gabbro. Fresh beaver cuttings were seen along the shore in sec. 10, T. 63–4. No portage could be found from the last lake to lake Ida Belle, and so one was cut straight north for about one-third of a mile; this brought us to lake Ida Belle near the centre of Sec. 11, T. 63–4.

In the S. W. ¼ of N. E. ¼ sec. 11, T. 63–4, the gabbro (No. 217) occurs and continues along the south shore most of the way to the stream that enters the lake in the S. E. ¼ of sec. 10. In the S. W. ¼ of N. W. ¼ sec. 11, just east of the line between secs. 10 and 11, there is an exposure of diabase (No. 218). The gabbro on the little point in the S. E. ¼ of sec. 10 is cut by a dike of fine diabase (No. 219); the dike runs a little west of north; it is three feet wide and was traced twenty feet. The gabbro at this point is represented by No. 220, which is exactly similar to that found much farther north.

A trip was made south to the corner between secs. 10, 11, 14, and 15 and then west along the line between secs. 14 and 15 for nearly half a mile; the line could be followed no farther, and so we went as near west as possible until two miles west of the above corner. Many rounded hills of gabbro were crossed,—in fact all the rock seen was gabbro except a small outcrop about three-fourths of a mile from the corner; this outcrop consisted of a fine-grained rock (No. 221) which, if it were a little more decayed, would resemble what has been termed "muscovado." One of the specimens collected (No. 222) is from a vein which contained large crystals of hornblende, an inch or more long. In some places there were small patches or seams of gabbro that contained considerable magnetite, as shown by No. 223, but in no place did the magnetite make up more than one-third of the rock. At one place, one and a half miles west of the corner, there was a thin scale, not much more than half an inch thick, of magnetite lying on the gabbro; this extended only about 20 feet; No. 224 is from this scale of magnetite. From the last place (one and a half miles west from the corner) Mr. Meeds went north for half a mile, and found nothing but gabbro. A section was also made south for half a mile; the gabbro was the only rock seen.

Gabbro continues along the north and west shores of the lake in sec. 10; it was examined in several places. There is a very small bay in the N. W. ¼ of N. E. ¼ sec. 10; on the east side of the entrance to this bay there is an exposure of gabbro sloping down to the water. The surface of the gabbro is spotted with small and irregular pieces of the fine red syenite (No. 225), and there are veins of this syenite in the gabbro; there is also a large piece of syenite, 10 by 20 feet. This large piece and the smaller pieces of syenite seem to lie on the gabbro; and this, together with the fact that the gabbro is cut by veins or dikes of the syenite, would indicate that *the syenite is of later date than the gabbro.* The top of the gabbro exposure is cut by an irregular dike, which at one end is three feet wide; it then widens out to twelve feet. The direction of the dike is nearly east and west, and it was traced forty feet. The syenite at this place is represented by No. 225, the dike rocks by No. 226, and the gabbro by No. 227. This is the first place that the writer has found the fine red syenite in contact with the gabbro. The two are seen in contact again at the northwest corner of this little bay; here the contact is vertical, and is a sharply defined line, but there is only a small (four feet wide) strip of syenite exposed.

Many outcrops of gabbro are seen along the west shore of the lake till we reach a small island in the N. E. ¼ of S. E. ¼ sec. 3. On the north side of this island the gabbro and the fine red syenite are again seen in contact; *here the gabbro lies on the syenite*, which is represented by No. 228. A bluff of rock about thirty

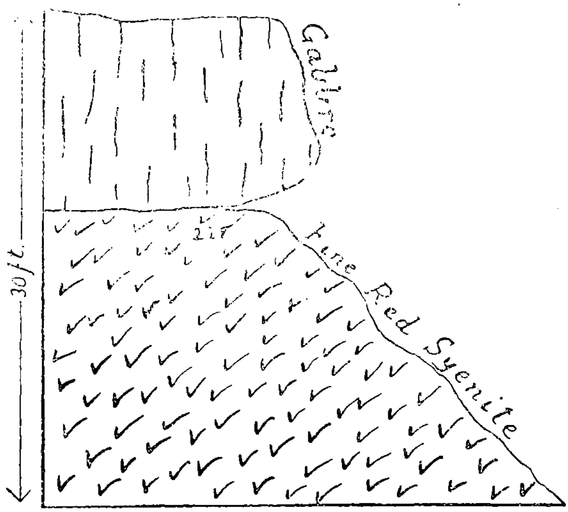

Fig. 4. Gabbro lying on fine red syenite, lake Ida Belle.

feet high is exposed; the upper part is composed of gabbro, which projects out beyond the syenite lying below. At the contact the gabbro has crumbled away, so the actual contact line could not be seen, but the two rocks were found within an inch of each other. There seems to be no change in either rock near the contact.

In the N. E. ¼ of S. E. ¼ and S. E. ¼ of N. E. ¼ sec. 3, T. 63–4, just north of the island mentioned above, there is a hill composed of a dark fine-grained rock (No. 229). This is cut through and through by numerous, irregular, branching veins of the fine red syenite (No. 230); these vary from two feet to half an inch in width, and even run out to needle-points. No. 229 seems to be a syenite, like the red syenite, but the hornblende makes up so large a part of it that the rock appears almost black. It is different from the dark rock seen in the syenite on the north side of Found lake. No. 231 shows Nos. 229 and 230 in contact; the contact is a distinct and sharply defined line, and in no place were the two rocks found to grade into each other.

The rest of the lake shore was examined; gabbro was found in many places, especially along the eastern shore. On the west shore, near the centre of sec. 2, T. 63–4, were two exposures of No. 229 cut as above described by fine red syenite similar to No. 228. At the extreme northeastern corner of the lake, in the S. W. ¼ of sec. 31, T. 64–3, the red syenite again occurs. At the portage (S. E. ¼ of sec. 35, T. 64–4) going north from lake Ida Belle the gabbro was cut by veins of fine red syenite (No. 232).

FROM LAKE IDA BELLE TO OGISHKE-MUNCIE LAKE.

Narrow lake. This is a narrow irregular lake in secs. 25, 26, 35, and 36 of T. 64–4; it is a mile and a half long (north and south), but not more than a quarter of a mile wide. It is 15 feet below lake Ida Belle. The shores are densely wooded, the timber being mostly spruce, birch and jack pine. The portage from lake Ida Belle is in the S. E. ¼ of sec. 35; it is well cut and only about an eighth of a mile in length. Gabbro occurs on the west shore in the N. E. ¼ of sec. 35. On the west shore (S. E. ¼ of N. E. ¼ sec. 26) near the north end of the lake is what seems to be a decayed condition of the gabbro (No. 233); this contains considerable biotite.

*Kiskadinna lake**. This lake is mostly in sec. 24, T. 64–4 and secs. 19 and 20, T. 64–3. It is 25 feet below Narrow lake. The shores are densely wooded. The northern arm, which is in the S. E. ¼ of sec. 13, T. 64–4 and the N. W. ¼ of sec. 19, T. 64–3, is shown on the plat as a separate lake, but it is only an arm of Kiskadinna lake. There are two short portages from Narrow lake to this lake along the stream that connects the two lakes. Not many rock exposures are to be seen along the shores of this lake; all those examined were gabbro. Gabbro also occurs on the south shore of the northern arm where the line between ranges 3 and 4 touches the shore.

Kiskadinna lake to Round lake. In the N. W. ¼ of S. E. ¼ sec. 13, T. 64–4 there is a short portage from Kiskadinna lake past a rapids in the stream† that flows from this lake through secs. 13, 11, 10, 3, and 2 of T. 64–4 into Round lake which is in the S. W. ¼ of sec. 35, T. 64–5. There are three rapids along this stream where short portages are made—in the N. W. ¼ sec. 13, S. W. ¼ Sec. 11, and N. W. ¼ sec. 2,—this last portage coming to Round

* This name is taken from Heinze Brothers "Map of the Vermilion Iron Range."

† This stream finally enters Gunflint lake at its western end.

lake. The stream is easily canoeable, being usually from 100 to 1,000 feet wide. The portages are well cut and seem to be used considerably in the winter time. The only rock seen along this stream was gabbro; this occurred in several places, as follows: near the centre of sec. 13, S. E. ¼ of sec. 11, on the portage in the S. W. ¼ of sec. 11, N. E. ¼ of sec. 10, S. W. ¼ of sec. 2, N. W. ¼ of sec. 2, and on the portage in the N. W. ¼ of sec. 2. Round lake is 60 feet below Kiskadinna lake.

Draper lake. This is a somewhat circular lake in the W. ½ of sec. 34 and the E. ½ of sec. 33, T. 65–4. It is 35 feet above Round lake. A portage of about half a mile connects these two lakes; it leaves Round lake at its northwestern corner. The gabbro occurs in several places along this portage. There are also many fragments of quartzyte on the portage, but no rock was found in place; these are probably from what has been termed Pewabic quartzyte found a short distance north of here. On the western shore of the lake, in the N. E. ¼ of sec. 33, there is an exposure of a muscovado-like rock (No. 233½).

Draper lake to Flying Cloud lake. From Draper lake we went through six small lakes to Flying Cloud lake. This plat (T. 65–4) is very inaccurate, and the route we took and the position of the lakes could not be definitely determined. Below, the lakes have been numbered from one to six, and the location given as near as possible.

Lake No. 1:—Near the centre of sec. 33, T. 64–5. Forty feet above Draper lake.

Lake No. 2:—N. W. ¼ of sec. 33, T. 64–5, not shown on the plat. Same hight as lake No. 1.

Lake No. 3:—This is probably Charley lake, which is in the N. ½ of sec. 32, T. 65–4. Fifteen feet above lake No. 2.

Lake No. 4:—Centre of sec. 29, T. 65–4. Not shown on the plat. Forty feet above lake No. 4. On the west side of the portage (this portage runs nearly north) from lake No. 3 there is a bluff 25 feet high and over 100 feet long; the front of the bluff is perpendicular. At the base near the centre there is a fine gray syenite (No. 234), forming the first eight feet of and extending for 25 feet along the foot of the bluff. Directly over the syenite and lying on it is the gabbro (No. 235) which composes most of the bluff. The change from the gabbro to the syenite was abrupt, there being no transition. The contact line was not easily seen as the face of the bluff was covered with lichens, but on chipping off small pieces of the rock the syenite and gabbro were seen within an inch of each other. The syenite is very much finer than the Saganaga syenite found on the north shore of Gunflint lake. Just across the portage-trail from this bluff of syenite and gabbro there is one exposure of "muscovado" (No. 236) similar to No. 233½. A little island in the southern part of lake No. 4 is made up of a fine gabbro (No. 237) that seems to contain considerable olivine.

Lake No. 5:—E. ½ of sec. 30, T. 65–4. Not shown on the plat. This is a small lake, not more than a quarter of a mile across. Same hight as lake No. 4.

Lake No. 6:—S. W. ¼ of sec. 30, T. 65–4, and S. E. ¼ of sec. 25, T. 65–5. 25 feet below lake No. 5.

Flying Cloud lake:—This lake is about a mile in length, and lies in the S. ½ of S. ½ of sec. 25, and a small portion is in the N. W. ¼ of sec. 36, T. 65–5. 30 (?) feet below lake No. 6.

On the south shore near the east end of the lake (S. E. ¼ of S. E. ¼ sec. 25) there is a low ridge of dark, almost black, quartzyte running east and west. This quartzyte stands vertical, and the strike, as near as could be estimated without the needle, which is here much disturbed, is about east and west. The bedding is very plainly seen, especially on the weathered surfaces; this is caused by bands, which contain varying proportions of the two minerals of the rock,—quartz* and magnetite. The specimens collected (No. 238) fairly represent the rock, which is so rich in magnetite that it would make a fair iron ore. The principal exposure is in a vertical north facing wall, 12 feet high and 40 feet long, but several other smaller exposures are seen for 150 feet east of this. At the foot of the ridge is an outcrop of greenstone (No. 239). It seems as if the quartzyte overlies the greenstone, but this could not be positively determined (however, this is found to be the case about a mile west of this point). This quartzyte is the Pewabic quartzyte described in the 16th annual report, and the greenstone is probably the same as that mentioned in connection with the quartzyte.

From Flying Cloud lake we went southwest for about two miles along a stream—making four short portages—to Kakego lake. On the north side of this stream, a short distance west of the first portage from Flying Cloud lake (probably in the S. E. ¼ of S. E. ¼ sec. 26, T. 65–5), the Pewabic quartzyte again occurs; here it is fully as rich in iron as seen at any other place. This

* It is quite probable that there is also olivine in the rock.

is shown by No. 240. It dips south about 40°. Twelve feet north of this quartzyte is a low outcrop of greenstone (No. 241); this is much darker and heavier than No. 239 and apparently contains considerable iron. The position and dip of the quartzyte would bring it over the greenstone. The contact between the two rocks was covered by soil. On the south side of the stream is a ridge, 50 feet high, of the quartzyte dipping south about 50°. No. 242.

On the east end of the second portage from Flying Cloud lake the quartzyte is again seen; here it dips south 45°. On the west end of the portage the quartzyte is found lying on the greenstone (see Fig. 5). This is probably in the N. W. ¼ of N. E. ¼ sec. 35, T. 65–5. The contact is abrupt and there is no transition from one rock to the other. Both rocks seem to be unchanged near the contact, except that the greenstone is a little decayed. The Pewabic quartzyte, dipping south 45°, is shown by No. 243, which was taken within six inches of the contact. The greenstone is shown by No. 244; this seems to be similar to No. 239.

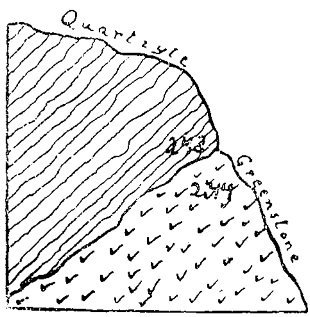

Fig. 5. *Pewabic quartzyte lying on greenstone, N. W. ¼ of N. E. ¼ sec.* 35, *T.* 65–5.

SHOO-FLY LAKE.*

This lake is in the S. E. ¼ of sec. 11 and the N. E. ¼ of sec. 14, T. 64–7. On the little point, in the N. E. ¼ of N. E. ¼ sec. 14, there is a fine-grained condition of the gabbro (No. 245), and on the east side of the lake near the southern end there is a precipitous cliff of the same rock rising 50 feet above the water,

*The following notes were taken on a trip from Knife lake through Kekequabic, Shoo-fly, Fraser, Thomas, Alice and Wilder lakes, thence along the Kawishiwi river to the S. E. ¼ of sec. 3, T. 62–9, and then through Gull lake to Mishiwishi lake.

From Shoo-fly lake a portage of a third of a mile runs south to a small lake, not shown on the plat, in the S. W. ¼ of sec. 13, T. 64–7. On the west side of this lake near the northern end there is an outcrop of gabbro (No. 246); this is finer than the ordinary gabbro. On the west side of the lake near the southern end is another outcrop of gabbro (No. 247) which seems to be a decayed condition of No. 246. From the southern end of this lake a portage runs south for about a third of a mile and reaches Fraser lake in the N. W. ¼ of N. W. ¼ sec. 24, T. 64–7.

FRASER LAKE.

Fraser lake is mostly in secs. 22, 23 and 24 of T. 64–7. On the north side of the lake in the S. E. ¼ of S. W. ¼ sec. 14, T. 64–7 there are several exposures of iron ore;* these were examined rather carefully. About 150 yards north of the shore, where it is cut by the line between secs. 14 and 23, is a small pit, four feet deep. At the bottom of this pit is found quite a rich olivinitic iron ore (No. 248); this disturbs the needle but slightly and seems to be mostly menaccanite rather than magnetite. On the north this comes in contact with a wall of rock (No. 249) composed of large crystals of hornblende (?) that is almost fibrous; in this there are parallel bands of iron ore (Nos. 250 and 251) which run east and west and dip south about 80°. No. 250 is similar to the ore in the pit, while No. 251 is distinctly a magnetic quartzyte and shows the bedding plainly. A few rods northeast of this pit, and at the top of the steep northward slope, is another exposure of olivinitic iron ore (No. 252); this appears similar to the ore in the pit, but affects the needle very strongly, thus probably being mostly magnetite. This mass of iron ore at its western edge comes into direct contact with a hornblende rock (No. 253) which is a less decayed condition of No. 249. The hornblende rock is here also in contact with a fine "muscovado" (No. 254) which shows a few large crystal faces of feldspar, half an inch or more in length. Very little of these two rocks was seen and their relation to each other was not determined. The contact line is irregular and there is no transition from one to the other, nor is there any sign of alteration in either rocks near the contact. A few small areas in this hornblende rock were quite rich in iron, as shown by Nos. 255 and 256, but the limits of these areas were rather sharply defined. The observations

*This is the place where an attempt was made to mine for gold several years ago.

were made on a ridge which runs east and west; it was examined for 100 yards on each side of the above mentioned pit. The north side of the ridge is rather steep and at its foot occurs the muscovado, here represented by No. 257. As far as exposed the top of the ridge is composed of the hornblende rock (Nos. 249 and 253); this holds many masses and bands of magnetitic quartzyte. The bedding in the quartzyte is usually very distinct; in all the places examined it runs east and west, but within ten feet the dip varies from the vertical to about 45° south. The masses of iron ore where Nos. 248 and 252 were obtained contain very little quartz and show no evidence of bedding. The line of contact between the quartzyte and the surrounding rock is usually distinct and very irregular; there was no blending of the two rocks. No. 258* shows the quartzyte, and in the specimens numbered 259 the bedding is plainly seen. No. 260 shows the contact of the quartzyte and the surrounding rock.

In the N. W. ¼ of N. E. ¼ sec. 23, about a quarter of a mile west of the previously described locality, is a ridge running east and west; this is probably an eastward continuation of the ridge mentioned above. On the south side near the base of the ridge and about 50 feet from the lake a rather fine, decayed, gabbro-like rock (No. 261) occurs; this is exposed in several places; it has a rough bedded structure (the beds being from 6 to 12 inches thick) which is nearly horizontal. On the north side of the ridge and near its foot is a small exposure of iron ore (No. 262); it has a tendency to split along parallel plains which are vertical and run east and west. Within ten feet of this ore the quartzyte is seen. The ridge at this place is made of quartzyte which was followed eastward for 50 yards, where the ridge ends abruptly. The bedding is very nicely seen along the weathered surfaces; it is caused by bands of almost pure quartz alternation with bands rich in magnetite. Some of these bands are shown by Nos. 263, 264 and 265. Throughout the fifty yards that the quartzyte was followed, except in one small area where the beds had been broken and bent, the strike and dip were constant, the former being almost east and west, and the latter south 75°. At the eastern end of the ridge a band two feet wide, of a fine muscovado-like rock (No. 266) occurs interbedded with the quartzyte; this rock was traced for over 30 feet; it has a tendency to a rough cleavage which is parallel with the quartzyte bedding. On the

*No. 268 was taken from the quartzyte near this; it is a bunch of the crystals of the hornblende rock, but they seem to be mostly magnetite.

south side of the ridge, but not within 30 feet of any quartzyte, is also found an outcrop of the iron ore (No. 267) which has weathered into thin parallel sheets conformable with the quartzyte.

The quartzyte described at these two localities on Fraser lake is decidedly like the Pewabic quartzyte. Evidently the gabbro, which covers this section of country, has been worn away and a much disturbed portion of the underlying quartzyte exposed. The quartzyte was not seen in contact with, nor in fact near any of the ordinary labradorite gabbro, but this gabbro has been seen on all sides of it at places usually less than a mile distant.

THOMAS LAKE.

This lake is in secs. 27, 28, 29, 32, 33 and 34 of T. 64–7, and secs. 5 and 6 of T. 63–7. There is some good white pine along the southern shore of the lake; several claim cabins were seen here.

The iron ore, shown on the map (in the 15th annual report) as occurring on the north side of the lake in secs. 27 and 28, was not found, although the locality was carefully examined. The only iron seen was a small amount of menaccanite in the gabbro (No. 269); this specimen was found about a quarter of a mile north of the lake in the N. E. ¼ of sec. 28.

On the north side of the mouth of the little bay, which is near the centre of the W. ½ of sec. 27, there is a bluff 40 feet high, of muscovado (No. 270) holding irregular blotches of a light colored feldspar.

On the lake shore in the N. E. ¼ of sec. 29, on a little point that is about half way between the meander corner on the line between secs. 28 and 29 and the stream that flows toward Ima lake, is a low outcrop of rock (No. 271) similar to the hornblende rock found at Fraser lake. Here were many angular fragments of quartzyte (similar to the Pewabic quartzyte); one specimen (No. 272) was taken to show how plainly the banding appears on a weathered surface. A few feet back from the shore is an outcrop, two feet high, of magnetic iron ore (No. 273);* this is composed of almost pure magnetite with a little olivine. This ore was not seen in contact with any other rock, but it contains a few of the crystals that make up the hornblende

* This is probably the ferruginous gabbro mentioned in the 15th annual report, page 360, but no hammer marks were seen here. (It was this which was intended to be represented on the map. N. H. W.)

rock. No bedding could be seen. On farther search a low outcrop of quartzyte, similar to that seen at Fraser lake, was found about 50 yards from the shore. By pulling away the moss and soil this rock was exposed for twelve feet. It lies nearly horizontal, dipping south about 10°. Nos. 274 and 275 show this quartzyte. As the shore at this point is low and there is very little rock exposed, the relations of the hornblende rock, the iron ore and the quartzyte could not be determined.

LAKE ALICE.

From the extreme southwestern corner of Thomas lake a portage, of less than a quarter of a mile, leads southwest to Gabiskamak* lake, which is an irregular lake lying in sec. 6 of T. 63-7. The shores of this lake, except a small portion at the northern end, have been burnt and are now partially covered by bushes 8 to 10 feet high. There were many rock outcrops along the shores; all of those visited were gabbro, and the others appeared to be the same.

From the south end of Gabiskamak lake a portage of half a mile leads south to the arm of Wilder lake that extends into the S. E. ¼ of sec. 7, T. 63-7. Gabbro was seen in several places on the portage; also on the west shore of the arm of Wilder lake. The north shore of the Kawishiwi river was examined from Wilder lake to lake Alice; no rock was seen except gabbro and there were many exposures of this. Between these two lakes both shores of the river have been burnt and are now covered with small birches, poplars and jack pines.

Lake Alice lies mostly in secs. 9, 10, 15, 16 and 21 of T. 63-7. It is four feet above Wilder lake and is connected with it by two miles of river in which there is one fall; this is in the N. E. ¼ of N. W. ¼ sec. 20, T. 63-7. The Chippewa name for this lake is Pe-na sagiagan or Partridge lake. The island crossed by the line between secs. 9 and 16 has not been burnt; also the N. W. ¼ of S. E. ¼ sec. 15, where there is a claim cabin and some Norway pine. The rest of the shore has been burnt and is now covered with young birches, jack pines, and poplars. From the end of the bay in the N. W. ¼ of sec. 22 there is a portage leading east; there is also one, leading east, leaving the lake in the N. W. ¼ of S. E. ¼ sec. 10. From the extreme northern end of the lake a short

*This is the Chippewa name of the lake; I do not know its meaning.

portage leads to a small lake, on the south shore of which the gabbro is exposed. Lake Alice, and especially the eastern side, was rather carefully examined, stops being made about every 200 or 300 yards (the bay in the N. E. ¼ of sec 9 was not entered); no rock was found except the ordinary labradorite gabbro; this was seen in very many places; No. 277 is a sample from the S. E. ¼ of N. W. ¼ sec. 15. In one place on the east side of the long bay in sec. 15 the gabbro (No. 276) is of a decidedly pinkish color; the labradorite crystals have a pinkish tinge and there are blotches of a very soft, brick-red mineral, probably an oxide of iron. Search was made back from the shore for more of this pink gabbro, but none was found.

LAKE ALICE TO MISHIWISHIWI LAKE.

The bay of Wilder lake which lies in sec. 13, T. 63-8, was not entered by the survey two years ago; and so it was examined on this trip; no rock was seen except the gabbro.

From Wilder lake the Kawishiwi river was followed to the little bay in the N. W. ¼ of S. E. ¼ sec. 3, T. 62-9; here a portage of about two miles was made southeast to Gull lake. There is no portage route through this way,—only a very poor trail which is used by the Indians in their winter trapping. On the way three ponds were crossed; one in the S. ½ of sec. 3, T. 62-9, one in the N. E. ¼ of sec. 9, and one on the line between secs. 9 and 16;—no rock exposures were seen on these ponds, but there were exposures of gabbro in the N.W. ¼ of sec. 10 and the N. W. ¼ of sec. 16.

Gull * lake is a narrow body of water extending northeast and southwest in sections 16, 17, 19 and 20 of T. 62-9. The shores are closely covered with spruce and jack pine. The west side of the lake was examined; all the rock seen was the ordinary gabbro. From the southwest corner of this lake a fair portage, over a mile in length, leads southwest and reaches Mishiwishiwi lake where the line between secs. 24 and 25, T. 62-10 crosses the shore. Gabbro occurs along this portage.

PINE ISLAND, VERMILION LAKE.

A section was made across Pine island, on the line between ranges 15 and 16, in order to examine a hill of jasper reported

*The Chippewa name is Gaiashk (Gi-äshk) sagaigan or Gull lake.

to be there. The writer crossed the island on this line and also went west from the line for a mile, near the centre of the island, but found no jasper hill, nor any indications of jasper. The rocks seen on the section across the island are given below.

At the north side of the island is a hill, rising 40 feet above the water; this is made of vertical, rather siliceous, sericitic schist (No. 284); the strike is E. 15° N. From this hill a swamp, where there are no rock exposures, extends for nearly one-fourth of a mile south of the corners of T. 62–15, 62–16, 63–15 and 63–16. At the south end of the swamp is a low (six feet high) ridge of sericitic schist (No. 285); strike E. 20° N., vertical. Just north of the quarter post there are three ridges running east and west. The first ridge is composed of a greenish rock, which on the north side of the ridge is quite schistose and somewhat sericitic (No. 286); strike E. 10° N., vertical; on the south side the rock is more massive and graywacke-like (No. 287). The second ridge is made of a rough sericitic schist (No. 288); strike nearly east and west, vertical. No. 289 is from the third ridge; it is harder, greenish, and perhaps somewhat chloritic. South of the quarter post, and about an eighth of a mile from the lake, the following rocks were seen; strike E. 15° N., vertical. No. 290, light gray argillaceous slate; Nos. 291, 292 and 293, coarser and rather sericitic conditions of the same; Nos.294and295, light gray arigllaceous slate. No. 296 shows a more siliceous condition of the slate. At the lake shore there are fine argillaceous slates* (No. 298); these vary from black to gray; the slaty structure and the black and gray bands are parallel; strike E. 15° N., and dip 80° to the north. No. 297 shows the gray slate a few feet from the shore.

III. Summary.

No generalization or theories would here be in place, but it may, perhaps, be admissable for the writer to give a very brief summary statement of the bearing of some of the facts in the foregoing notes upon the general geology of the region traversed. The following remarks relate, more or less, to the great gabbro sheet, which covers so much of that part of Minnesota north of lake Superior.

The fine red syenite, or "red rock" of former reports, was seen in several places on lake Ida Belle in contact with the gabbro. In one place (see fig. 4) the gabbro was in contact with

*Mentioned in 15 An. Rep., p. 303; No. 921.

and was unquestionably overlying the syenite; but in other places veins and dyke-like forms of what certainly appears to be the same syenite cut through the gabbro. The syenite has the appearance of an eruptive rock, and the general impression left on one, by seeing the outcrops on this lake, is that the syenite is of more recent date than the gabbro. The two rocks are very distinct and in no place were seen to grade into each other; where they were seen together the contact was a well defined line.

The syenite found on the gabbro at Winchell lake is not the same as that just mentioned.

The iron ore and magnetic quartzyte (of which the ore is a part) found at Fraser and Thomas lakes are undoubtedly disturbed portions of the Animike beds now included in the gabbro. It is probable that they have not been moved far from their original position, and that, consequently, at this place the gabbro sheet is of a comparatively small thickness. It seems that all the ore at this place is from the quartzyte and that that portion which is but slightly magnetic has become charged with titanium from the gabbro. In connection with this quartzyte is found a peculiar rock that is made up of coarse and almost fibrous crystals of what is probably hornblende. This rock, as far as the writer knows, has been found in this region nowhere except in connection with this quartzyte and then only when the quartzyte was close to or in contact with the gabbro. The quartzyte south of Birch lake, at Chub (Akeley) lake and at Thomas and Fraser lakes also shows this.

IV. List of, and Notes on, the Typical Rocks of each of which 25 Specimens were Collected.

These specimens are, in many cases, from the exact spot from which the original specimens were collected and described, the writer having visited many of these localities with Prof. Winchell on two of his trips through this region. Some of the specimens from localities, not before visited by the writer, may not always be exactly the same as the original specimens, but they are very nearly the same,—as near as could be found from the notes given him. Only brief descriptions of many localities were accessible in the field, as the 16th annual report had not then been printed.

After each number the place where the original description can be found, is given.*

No. 744, (84):—Ogishke-Muncie conglomerate from Camper's island, Ogishke-Muncie lake; S. E. ¼ of S. W. ¼ sec. 23, T. 65–6. The specimens were taken from the southwest corner of the island. They show the matrix of the conglomerate, with sometimes a few of the smaller pebbles. The specimens collected are coarser and not as green as the original No. 744. 10th An. Rep., p. 91.

No. 751:—Hornblende porphyry, S. E. ¼ of sec. 30, T. 65–6; Kekequabic lake. No specimens of this were collected, as the rock was not found in place by the writer. It is similar to No. 1059 (97), except that the ground mass is inclined to brownish, while No. 1059 is yellowish green. See No. 1059 10th An. Rep., p. 92.

No. 868, (278):—Green chloritic schist embracing fragments of jaspilyte, north of Cady house, Tower. This rock evidently grades into No. 908 (281). 15th An. Rep., p. 267–8.

No. 892, (279):—Rough, scarcely banded jasper, north wall Stone mine, Tower. Owing to changes in the walls of the mine, this rock was not seen 75 feet below the surface; the specimens collected were taken about 25 feet below the rock surface. 15th An. Rep., p. 256.

No. 903, (280):—Red jasper with darker bands of iron ore; Stone mine, Tower.

No. 908, (281):—Matrix of conglomerate occurring north of the Cady house, Tower. 15th An. Rep., p. 269.

No. 916, (282):—Breccia, now converted to hematite and a floury white mineral; Breitung mine, Tower. 15th An. Rep., p. 250.

No. 921, (283):—Black or purplish-black clay slate, S. W. ¼ of S. W. ¼ sec. 6, T. 62–15; south shore of Pine island, Vermilion lake, a few feet east of the line between ranges 15 and 16. See notes on Pine island in this report. 15th An. Rep., p. 303.

No. 950, (128):—Siliceous schist or bedded quartzyte from "Silver City," N. E. ¼ of sec. 32, T. 63–11. The specimens were obtained from the shore, forty feet nearer the rapids than the southern tunnel is. 15th An Rep., p. 329.

No. 954, (114):—Coarse gabbro, east side of Birch lake. The specimens were taken from the same exposure from which the

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*These are the numbers given by Prof. Winchell in the 10th, 15th and 16th annual reports. The numbers in parentheses and all under 300 are those given by the writer.

original specimen came. In the description (16th An. Rep.) this locality is given as the N. W. ¼ of sec. 20, T. 61–11, and in the catalogue of rock samples as the N. W. ¼ of Sec. 17. Judging from distances to known points (this town has not been surveyed) the writer thinks that the N. W. ¼ of sec. 17 is the right place. 15th An. Rep., p. 332.

No. 958, (121):—Breccia of mica-schist cemented by granite from the little point in the N. E. ¼ of S. E. ¼ sec. 21, T. 61–12, Birch lake. Where the mica-schist showed the schistose structure to the best advantage, the rock was too much decayed for good specimens. 15th An. Rep., p. 333.

No. 960:—See No. 1138.

No. 963, (123):—Fine-grained red syenite, resembling the "red rock" of Grand Marais, from the S. W. ¼ of S. W. ¼ sec. 24, T. 61–12, Birch lake. The specimens were collected just east of the line between secs. 23 and 24, and about 300 feet back from the lake shore. 15th An. Rep., p. 336.

No. 979, (111):—Fine syenite from the "Palisades," N. W. ¼ of S. W. ¼ sec. 4, T. 62–10. The specimens are from near the southern end of the "Palisades" and about 20 feet above the water. The rock varies some and has an almost gneissic structure. The specimens collected represent the prevailing variety; this grades into No. 112, which is gray, and into No. 113, which is coarser. 15th An. Rep., p. 342.

No. 989, (101):—Fine grained, slightly micaceous quartzose rock from the south shore of the Kawishiwi river in the N. W. ¼ of N. W. ¼ sec. 27, T. 63–10. 15th An. Rep., p. 352.

No. 991, (102):—Gray, red-weathering gneissic rock from an island in the N. W. ¼ of N. W. ¼ sec. 27, T. 63–10, Kawishiwi river. The southern part of the island is composed of this rock, but on the central and northern parts the rock has many darker hornblendic bands which show very plainly on the weathered surface (No. 103). One much darker hornblendic band, about a foot in width, was seen; this (No. 104) seemed to be distinct from the others, which graded into one another. No. 991 also showed banding on weathered surfaces. 15th An. Rep., p. 352.

No. 994, (105):—Reddish chloritic syenite; N. E. ¼ of N. W. ¼ sec. 27, T. 63–10; south shore of Kawishiwi river. This rock is hardly a red syenite like the original No. 994, but in places it is reddish,—see No. 107, which is similar to the original No. 994; not enough of this reddish rock could be found for the specimens. This rock (No. 105) seems to grade into No. 108 and

No. 109; the latter has some biotite and the exposures show a rather distinct bedding, while the exposures of No. 105 do not. Lenticular pieces of a greenish chloritic schist (No. 110) are found in a few places in No. 105. 15th An. Rep., p. 353.

No. 1044, (85):—Gneissic (syenitic?) rock, south shore of the little bay at the southeast side of Kekequabic lake, S. E. ¼ of S. W. ¼ sec. 2, T. 64–7. The specimens were taken from the only outcrop, on the south side of this bay, where hammer marks were seen. The rock contains many small dark masses, apparently chloritic, as shown by No. 85; none of these were over an inch in diameter. In a few places this dark mineral is collected into rather indistinct vein-like forms, but there is no marked contrast between these "veins" and the surrounding rock. 15th An. Rep., p. 361.

No. 1049, (87):—Biotite gabbro, somewhat pebbly, east side of sec. 4, T. 64–7, Kekequabic lake. The water was so high that the specimens could not be collected in the bay in the east side of sec. 4, so they were taken from the N. E. ¼ of the S. E. ¼ of sec. 4; here the rock seems to be the same as in the bay. The pebbly structure of the rock is shown only where it has been water worn. At this place the gabbro lies on some gray earthy slate. The slate was down at the water's edge and there was only a very small area of it, so not much could be determined concerning it. No abrupt contact could be seen between the two rocks; there was a transition, occupying perhaps two feet, from the gray earthy slate (No. 88), through Nos. 89 and 90, to the gabbro (No. 87). 15th An. Rep., p. 364.

No. 1050, (91):—Fine-grained gabbro from the top of the same bluff, as from which No. 1049 was taken. The specimens were taken about 35 feet above the water. N. E. ¼ of S. E. ¼ of sec. 4, T. 64–7, Kekequabic lake. 15th An. Rep., p. 364.

No. 1059, (97):—Hornblende porphyry from the north shore of Kekequabic lake, N. E. ¼ of sec. 36, T. 65–7. Within a few inches this rock varies much, the hornblende crystals becoming smaller and fewer in number and sometimes almost wanting, as shown by the small specimen (No. 97). The rock is very hard and tough and rings like iron when struck by the hammer; it frequently contains crystals of iron pyrites. See No. 751. 15th An. Rep., p. 367.

No. 1068, (70):—Doleryte, from N. E. ¼ of sec. 24, T. 65–6; about a quarter of a mile southeast from the shore of Ogishke-Muncie lake. This rock contains considerable of a pinkish mineral (probably calcite); this mineral also occurs in small veins or fissures in the rock, shown by No. 71. 15th An. Rep., p. 371; also, 16th An. Rep., p. 95-6.

No. 1073, (69):—Coarse-jointed massive rock, apparently igneous, mouth of Ogishke-Muncie creek, N. E. ¼ of S. E. ¼ sec. 26, T. 65-6; Ogishke-Muncie lake. This rock overlies the following, which see. In some places the rock has cherty spots, as shown in the smaller specimen (No. 69), probably pieces of the slate (No. 1074). 15th An. Rep., p. 372.

No. 1074, (68):—Fissile black slate, baked and closely jointed, mouth of Ogishke-Muncie creek, N. E. ¼ of S. E. ¼ sec. 26, T. 65-6; Ogishke-Muncie lake. No specimens could be obtained at the contact with the overflowing rock (see above, No. 1073), as here the slate was much broken; the specimens collected are from the point made by the creek and the lake shore, which point is but a few yards west of No. 1073. At this place the slate plainly dips 20° S. of E. at an angle of about 80°. No. 68A was obtained just below the contact, while No. 68 B is from a piece of the slate included in the overlying rock. The slate has, in places, a decidedly conchoidal fracture as shown by No. 68C. The weathered surfaces on the specimens marked 68 show an apparently sedimentary banding which is parallel with the slaty structure. 15th An. Rep., p. 372.

No. 1094, (86):—Gray porphyritic rock, representing an altered conglomerate, from the point which has the corners of secs. 29, 30, 31, and 32, T. 65-6; north shore of Kekequabic lake. The specimens were taken from the southeast side of the point, or in the N. W. ¼ of N. W. ¼ sec. 32, T. 65-6. No. 86 shows a small one of the greenish nodules or pebbles. 15th An. Rep., p. 368; 16th An. Rep., p. 100.

No. 1098, (96):—Conglomeritic chlorite schist, from the north shore of Kekequabic lake where it is crossed by the line between T. 65-6 and 65-7. The small amount of the rock left uncovered by the porphyry and its decayed condition made it rather difficult to get good specimens. 15th An. Rep., p. 367.

No. 1100, (93):—Reddish syenite, island in sec. 3, T. 64-7, Kekequabic lake. No. 1100 is described from the most westerly island in the lake, but this island, which is just east of the point in the S. W. ¼ of N. W. ¼ of sec. 3, is small and low and is made up of a condition of the green chlorite schist (No. 94); the small island, just northeast of the last, seems to have no rock in place, but along the shore are many fragments of feldspar porphyry

(No. 95). The specimens (No. 1100) were taken from a larger island in the S. E. ¼ of N. W. ¼ sec. 3, just west of Animike island. 15th An. Rep., p. 362.

No. 1109, (100):—Felsitic schist, from the portage from Fall lake to Newton lake, S. W. ¼ of sec. 3, T. 63–11. The specimens were collected from the south, or Fall lake, end of the portage. 15th An. Rep., p. 356.

No. 1128, (129):—"Gabbro" cut by intrusive syenite; N. W. ¼ of S. E. ¼ sec. 6, T. 62–11, White Iron lake. See No. 1129, 15th An. Rep., p. 331.

No. 1129, (130):—Intrusive granite (syenite), N. W. ¼ of S. E. ¼ of sec. 6, T. 62–11, White Iron lake. Nos. 1128 and 1129 are from the place frrom which Dr. Wadsworth took the original specimens. The "gabbro" is not similar to the ordinary labradorite gabbro; it is perhaps a biotitic diabase. No. 131 is the syenite taken from a dike in the diabase. No. 1129 (130) is, I think, a fair sample of the syenite found about White Iron lake. 15th An. Rep., p. 331.

No. 1132, (127):—Black hornblende gneiss, east shore of White Iron lake, just south of the line between secs. 6 and 7 of T. 62–11. A set of specimens could not be obtained, as the gneiss only occurred in small masses in the syenite and here the surface was worn smooth by glaciation. No. 127 shows the contact between the gneiss and the syenite. 15th An. Rep., p. 331.

No. 1134, (124):—Micaceous "gabbro," or rather biotite hornblende schist, cut by veins of granite (syenite); N. W. ¼ of S. E. ¼ sec. 12, T. 62–12, east side of White Iron lake. The specimens were collected from the place where Dr. Wadsworth obtained the original ones. About 70 yards west of this place is the outcrop described by Dr. Alex. Winchell in the 15th annual report (see p. 77, halt 211). Here the hornblende schist is represented by No. 125, and the granite by No. 126. These two outcrops are connected by a ridge, in which the rock is not exposed, but the schist found at the east end (No. 124) is probably the same as that at the other end (No. 125). 15th An. Rep., p. 331.

No. 1137, (122):—Fine-grained gabbro, looking like diabase, from a point a short distance west of the line between secs. 24 and 25, T. 62–12; north shore of Birch lake. This seems to be a finer-grained condition of the ordinary labradorite gabbro. The specimens were obtained from the west side of the little bay in the S. E. ¼ of S. W. ¼ sec. 24. 15th An. Rep., p. 332.

No. 1138. Ferruginous olivine rock, about 15 rods from the shore; S. E. ¼ of S. W. ¼ sec. 24, T. 62–12; Birch lake. No specimens of this were collected, as a set of 25 (No. 960) was collected in 1886. It is a part of the great quartzyte formation (Animike) lying along the southern side of the Giant's range. 15th An. Rep., pp. 332 and 335.

No. 1278, (8):—Kewatin schist, mouth of the creek, east end of the long bay, north side of Gunflint lake. This is the most eastern exposure of the Kewatin on Gunflint lake. The rock at the shore was so cracked and broken that only four specimens were collected; these are marked 1,278A (8A). The rest of the specimens were taken from a low outcrop about 10 rods back from the shore; the schist here is similar to that at the shore, but is not so much decayed and is apparently more siliceous. 16th An. Rep., p. 67.

No. 1282, (9):—Gray gneissoid rock, slightly porphyritic; shore of the long bay, north side of Gunflint lake. The specimens collected do not answer exactly to the description, but they are a part of the same rocks. 16th An. Rep., p. 68.

No. 1283, (10):—Porphyrel; bluff north shore of Gunflint lake. The specimens were taken from a vertical cliff on the lake shore, about three-fourths of a mile west of the east end of the long bay. 16th An. Rep., p. 68.

No. 1312, (60):—Fine-grained trap, from the west side of the narrows of Gunflint lake; S. E. ¼ of N. W. ¼ of sec. 19, T. 65–3. In places this trap holds crystals of feldspar which sometimes are an inch long.

No. 1316, (46):—Syenitic gneiss from the north side of Blackfly bay, Gunflint lake. 16th An. Rep., p. 73.

No. 1318, (61):—Diabase dike in the syenite, first falls of Gunflint river, north of Gunflint lake. See this report under Gunflint lake.

No. 1340, (43):—Purplish-gray, vitreous quartzyte (Pewabic quartzyte), ⅛ mile west of the ore pit, Chub lake; N. E. ¼ of sec. 29, T. 65–4. 16th An. Rep., p. 85.

No. 1371, (72):—"Marble" from east side of Ogishke-Muncie lake; N. E. ¼ of sec. 24, T. 65–6. The place where the specimens were collected is probably where the section (p. 371, 15th An. Rep.) was made. No. 73 shows a softer, more schistose portion of No. 72. No. 74 are some of the angular pieces included in No. 72. No. 75 shows a soft greenish (probably talc) mineral found in the "marble" (No. 72). 16th An. Rep., pp. 95 and 96; also, under No. 1069, 15th An. Rep., p. 371.

No. 1409, (92):—Chloritic schist from the small island near the north shore and just west of the narrows of Kekequabic lake. This island is in the N. W. ¼ of N. E. ¼ sec. 36, T. 65–7; there is a much smaller island just east of it and also one north of it. 16th An. Rep., p. 102.

No. 1428, (98);—Dark siliceous slate, from the E. ½ of N. E. ¼ sec. 28, T. 65–7; Knife lake. This slate varies from grayish to black; the specimens collected are gray, as this colored rock made up most of the point. 16th An. Rep., p. 109.

No. 1436, (99);—Micaceo-syenitic gneiss, from Opinin island, Basswood lake. This island is in sec. 10 (probably N. E. ¼ of S. W. ¼), T. 64–10. 16th An. Rep., p. 110.

Twenty-five specimens of the *conglomeritic syenite* from Saganaga lake were also collected. The writer numbered these 66. No. 67 shows the syenite. This rock is described by Dr. Alex. Winchell in the 16th An. Rep., pp. 219–222, and p. 334; also in the American Geologist, vol. III, No. 3, p. 153.

V. Barometrical Elevations.

On the trip from Gunflint lake south to Brulé lake and north to Ogishke-Muncie lake the elevation of each lake was noted from readings of an aneroid barometer. The following table gives the elevation of each lake above lake Superior and also above the sea level. The elevation of Gunflint lake (the starting point) above lake Superior,—1,052 feet,—is taken from the 9th An. Rep., p. 81. The highest water noted is Lost lake which is 1,427 feet above lake Superior, or 2,029 feet above the sea.

	Feet above lake Superior.	Feet above the sea.
Gunflint lake	1052	1654
Loon lake (195 ft. above Gunflint lake),	1247	1849
Mayhew lake (110 feet above Loon lake),	1357	1859
Iron lake (same hight as Mayhew lake),	1357	1859
Portage lake (25 ft. above Iron lake),	1382	1984
Poplar lake (20 ft. below Portage lake),	1362	1964
Straight lake (25 ft. below Poplar lake),	1337	1939
Caribou lake (10 ft. below Straight lake),	1327	1929
Meed's lake (10 ft. above Caribou lake),	1337	1939
North Brulé lake (20 ft. below Caribou lake),	1307	1909
Stray lake (30 ft above North Brulé lake),	1337	1937
Gaskanas lake (15 ft. above Stray lake),	1352	1954
Winchell lake (30 ft. above Gaskanas lake),	1382	1984
Sham lake (15 ft. above Winchell lake),	1397	1999

	Feet above lake Superior.	Feet above the sea.
Lost lake (30 ft. above Sham lake),	1427	2029
Brulé lake (75 ft. below Lost lake),	1352	1954
Lake Georgia (6 ft. below Brulé lake),	1346	1948
Surveyor's lake (1 ft. above lake Georgia),	1347	1949
Found lake (same hight as Surveyor's lake),	1347	1949
Lake Ida Belle (30 ft. below Found lake),	1317	1919
Narrow lake (15 ft. below lake Ida Belle),	1302	1904
Kiskadinna lake (25 ft. below Narrow lake),	1277	1879
Round lake (60 ft below Kiskadinna lake),	1217	1819
Draper lake (35 ft. above Round lake),	1252	1854
Lake No. 1 (40 ft. above Draper lake),	1292	1894
Lake No. 2 (same hight as lake No. 1),	1292	1894
Lake No. 3 (15 ft. above lake No. 2),	1307	1909
Lake No. 4 (40 ft. above lake No. 3),	1347	1949
Lake No. 5 (same hight as lake No. 4),	1347	1949
Lake No. 6 (25 ft. below lake No. 5),	1322	1944
Flying Cloud lake (30 ft. below lake No. 6),	1292	1894
Kakego lake (65 ft. below Flying Cloud lake),	1227	1829
Clothes Pin lake (60 ft. below Kakego lake),	1167	1769
Gabemichigama lake (20 ft. below Clothes Pin lake),	1147	1749
Agamok lake (3 ft. below Gabemichigama lake),	1144	1746
Fox lake (30 ft. below Agamok lake),	1114	1716
Ogishke-Muncie lake (60 ft. below Fox lake),	1054	*1656
Wilder lake,	1102	‡1704
Lake Alice (4 ft. above Wilder lake),	1106	1708

VI. Catalogue of Rock Samples to Illustrate the Foregoing Notes; Collected by Uly. S. Grant During the Summer of 1888.

Most of these rock samples are of museum size; and in many cases more than one specimen was collected, to represent a certain number. This is especially true of the iron ores, of each of which several pieces were taken for analysis. The samples have been deposited in the rooms of the survey. They are numbered from 1 up to 298, inclusive; the figures are green,—paris green and shellac dissolved in alcohol being used; after each number the letter G is placed.

Nos. 132–146, inclusive, were placed on an island which was soon after overrun by a fire, and all the labels destroyed and the specimens discolored. These specimens have not been preserved:

*From figures in the 9th An. Rep., p. 84, Ogishke-Muncie lake is 1,611 ft. above the sea; and from the 15th An. Rep., p. 384, it is 1,507 ft. above the sea.

‡15th An. Rep., p. 384.

1. Magnetic iron slate and jasper, N. ½ of sec. 33, T. 66–6; Ottertrack lake; 80 rods south of the lake shore. P. 151.

2. Same as No. 1. P. 151.

3. Magnetic iron slate and jasper, N. E. ¼ of N. W. ¼ sec. 27, T. 66–6 (if the U. S. sections were extended northward); north shore of Ottertrack lake. P. 151.

4. Graywacke-like rock north shore of Ottertrack lake. just west of No. 3. P. 151.

5. Graywacke-like rock, north shore of Ottertrack lake, just east of No. 3. P. 151.

6. Coarse syenite, small island in the S. E. ¼ of S. E. ¼ sec. 13, T. 65–4; Gunflint lake. P. 152.

7. Hornblende schist in syenite; same locality. P. 152.

8. Sericitic schist, at the shore near the east end of the long bay on the north side of Gunflint lake. Same as No. 1278 (N. H. W.). P. 199.

8A. Same as No. 8, but apparently more siliceous. P. 199.

9. Gray gneissic rock, almost porphyrel; north shore of the long bay on the north side of Gunflint lake. Same as No. 1282 (N. H. W.). P 199.

10. Porphyrel, on the shore about three-fourths of a mile west of the east end of the long bay on the north side of Gunflint lake. Same as No. 1283 (N. H. W.). P. 199.

11. Sericitic schist, north shore of Gunflint lake; section I. P. 152.

12. Earthy schist, north of Gunflint lake; section I. P. 153.

13. Fine porphyrelloid rock, north of Gunflint lake; section I. P. 153.

14. A coarser condition of 13, north of Gunflint lake; section I. P 153.

15. A finer condition of 13, north of Gunflint lake; section I. P. 153.

16. Black slate, north of Gunflint lake; section I. P 153.

17. Trap rock, north of Gunflint lake; section I. P 153.

18. Fine trap from outer edge of dike, north of Gunflint lake; section I. P 153.

19. Trap from centre of same dike, north of Gunflint lake; section I. P 153.

20. Sericitic schist, north of Gunflint lake; section I. P 153.

21. Black slate, north of Gunflint lake; section I. P 153.

22. Fine gabbro, north of Gunflint lake; section I. P. 153.

23. Black slate, north of Gunflint lake; section I. P. 153.

24. Porphyrel, north of Gunflint lake; section I. P. 154.

25. Gray, somewhat micaceous schist; north of Gunflint lake; section I. P. 154.

26. Hornblende schist, north of Gunflint lake; section I. P. 154.

27. Hornblende schist, north of Gunflint lake; section I. P. 154.

28. Mica-schist, north of Gunflint lake; section I. P. 154.

29. Feldspathic schist, north of Gunflint lake; section I. P. 154.

30. Hornblende schist, north of Gunflint lake; section I. P. 154.

31. Hornblende schist, north of Gunflint lake; section I. P. 154.

32. Mica-schist, north of Gunflint lake; section I. P. 154.

33. Hornblende schist, north of Gunflint lake; section I. P. 154.

34. Syenitic gneiss, north of Gunflint lake; section II. P. 155.

35. Hornblende schist inclosed in gneiss, north of Gunflint lake; section II. P. 156.

36. Trap from dike in gneiss, north of Gunflint lake; section II. P. 156.

37. Magnetitic portion of this dike, north of Gunflint lake; section II. P. 156.

38. Gray earthy slate, north of Gunflint lake; section II. P. 157.

39. Porphyrel, north of Gunflint lake; section II. P. 157.

40. Schistose dike rock, north of Gunflint lake; section II. P. 157.

41. Finer portion of No. 40, north of Gunflint lake; section II. P. 157.

42. Porphyrel inclosed in dike, north of Gunflint lake; section II. P. 157.

43. Purplish-gray, vitreous quartzyte (Pewabic quartzyte); N. E. ¼ of sec. 29, T. 65–4, Chub lake. Same as No. 1340 (N. H. W.). P. 199.

44. Magnetic iron ore from the pit at Chub lake, N. E. ¼ of Sec. 29, T. 65–4. P. 160.

45. Quartzyte core from drill; Chub lake, N. E. ¼ of sec. 29, T. 65–4. P. 160.

46. Syenitic gneiss from the north side of Blackfly bay, Gunflint lake. Same as No. 1316 (N. H. W.). P. 199.

47. Gray, red-weathering schist, north shore of Gunflint lake; section III. P. 157.

48. Black flinty slate, north of Gunflint lake; section III. P. 157.

49. Sericitic schist, north of Gunflint lake; section III. P. 157.

50. Gabbro, north of Gunflint lake; section III. P. 157.

51. Hornblende-feldspar schist, north of Gunflint lake; section III. P. 158.

52. Hornblende schist, north of Gunflint lake; section III. P. 158.

53. Mica-schist, north of Gunflint lake; section III. P. 158.

54. Hornblende schist, north of Gunflint lake; section III. P. 158.

55. Very coarsely-crystalline hornblende schist, north of Gunflint lake; section III. P. 158.

56. Same as 55, north of Gunflint lake; section III. P. 158.

57. Reddish syenite, north of Gunflint lake; section III. P. 158.

58. Syenitic gneiss, north of Gunflint lake; section III. P. 158.

58A. Same as 58, but showing the gneissic structure better; north of Gunflint lake; section III. P. 158.

59. Syenitic gneiss, north of Gunflint lake; section III. P. 158.

60. Fine-grained trap, from the west side of the narrows of Gunflint lake; S. E. ¼ of N. W. ¼ sec. 19, T. 65–3. Same as No. 1312 (N. H. W.). P. 199.

61. Diabase from dike in syenite, first falls of Gunflint river north of Gunflint lake. Same as No. 1318 (N. H. W.). P. 160.

61A. Fine condition of No. 61. P. 160.

62. Syenitic gneiss, first falls of Gunflint river north of Gunflint lake. P. 160.

63. A condition of No. 61. P. 161.

64. A condition of No. 61, showing pitted surface. P. 161.

65. Hornblende schist in No. 62; first falls of Gunflint river north of Gunflint lake. P. 161.

66. Conglomeritic syenite from Saganaga lake. P. 200.

67. Syenite, Saganaga lake. P. 200.

68. Black slate, mouth of Ogishke-Muncie creek, N. E. ¼ of S. E. ¼ sec. 26, T. 65–6; Ogishke-Muncie lake. Same as No. 1074 (N. H. W.). P. 197.

68A. Broken condition of No. 68. P. 197.

68B. Portion of No. 68 included in No. 69. P. 197.

68C. Showing conchoidal fracture of No. 68. P. 197.

69. Coarse-jointed massive rock, apparently igneous, mouth of Ogishke-Muncie creek, N. E. ¼ of S. E. ¼ sec. 26, T. 65–6; Ogishke-Muncie lake. Same as No. 1073 (N. H. W.). P. 197.

70. Doleryte, about a quarter of a mile southeast from the shore of Ogishke-Muncie lake; N. E. ¼ of sec. 24, T. 65–6. Same as No. 1068 (N. H. W.). P. 196.

71. Calcite from veins in No. 70.

72. "Marble" from east side of Ogishke-Muncie lake; N. E. ¼ of sec. 24, T. 65–6. Same as No. 1371 (N. H. W.). P. 199.

73. Softer and more schistose portion of No. 72. P. 199.

74. Angular siliceous pieces in No 72. P. 199.

75. Portion of No. 72 showing a soft greenish mineral.

76. Gray quartzyte, S. E. ¼ of N. E. ¼ sec. 24, T. 65–6; Ogishke-Muncie lake. P. 161.

77. Black slate, S. E. ¼ of N. E. ¼ sec. 24, T. 65–6; Ogishke-Muncie lake. P. 161.

78. Siliceous band in No. 76. P. 162.

79. Transition rock from No. 78 to No. 82. P. 162.

80. Transition rock from No. 78 to No. 82. P. 162.

81. Transition rock from No. 78 to No. 82. P. 162.

82. Rock composed mostly of calcareous or dolomitic matter; S. E. ¼ of N. E. ¼ sec. 24, T. 65–6; Ogishke-Muncie lake. P. 162.

83. Part of Ogishke-Muncie conglomerate; S. E. ¼ of N. E. ¼ sec. 24, T. 65–6; Ogishke-Muncie lake. P. 162.

84. Matrix of Ogishke-Muncie conglomerate; from Camper's island, S. E. ¼ of S. W. ¼ sec. 23, T. 65–6; Ogishke-Muncie lake. Same as No. 744 (N. H. W.). P. 194.

85. Gneissic (syenitic?) rock, south shore of the little bay at the southeast corner of Kekequabic lake; S. E. ¼ of S. W. ¼ sec. 2, T. 64–7. Same as No. 1044 (N. H. W.). P. 196.

86. Gray porphyritic rock, from the point which has the corners of secs. 29, 30, 31, and 32, T. 65–6; Kekequabic lake. Same as No. 1094 (N. H. W.). P. 197.

87. Biotite gabbro, N. E. ¼ of S. E. ¼ sec. 4, T. 64–7; Kekequabic lake. Same as 1049 (N. H. W.). P. 196.

88. Gray earthy slate, N. E. ¼ of S. E. ¼ sec. 4, T. 64–7; Kekequabic lake. P. 196.

89. Transition from the slate (No. 88) to the gabbro (No. 87). P. 196.

90. Transition from the slate (No. 88) to the gabbro (No. 87). P. 196.

91. Fine-grained gabbro, from the top of the bluff from which No. 87 was taken; N. E. $\frac{1}{4}$ of S. E. $\frac{1}{4}$ sec. 4, T. 64–7; Kekequabic lake. Same as No. 1050 (N. H. W.). P. 196.

92. Chlorite schist, N. W. $\frac{1}{4}$ of N. E. $\frac{1}{4}$ sec. 36, T. 65–7; Kekequabic lake. Same as No. 1409 (N. H. W.). P. 168.

93. Reddish syenite, from an island in Kekequabic lake; S. E. $\frac{1}{4}$ of N. W. $\frac{1}{4}$ sec. 3, T. 64–7. Same as No. 1100 (N. H. W.). P. 197.

94. A condition of the green chlorite schist, from island in the S. W. $\frac{1}{4}$ of N. W. $\frac{1}{4}$ sec. 3, T. 64–7; Kekequabic lake. P. 197.

95. Feldspar porphyry, from an island just northeast of the last; S. W. $\frac{1}{4}$ of N. W. $\frac{1}{4}$ sec. 3, T. 64–7; Kekequabic lake. P. 198.

96. Conglomeritic chlorite schist, from the north shore of Kekequabic lake where it is crossed by the line between T. 65–6 and T. 65–7. Same as No. 1098 (N. H. W.). P. 197.

97. Hornblende porphyry, from the north shore of Kekequabic lake; N. E. $\frac{1}{4}$ of sec. 36, T. 65–7. Same as No. 1059 (N. H. W.). P. 196.

98. Gray siliceous slate, from Knife lake; E. $\frac{1}{2}$ of N. E. $\frac{1}{4}$ sec. 28, T. 65–7. Same as No. 1428 (N. H. W.). P. 200.

99. Micaceo-syenitic gneiss, from Opinin island, Basswood lake; sec. 10, T. 64–10. Same as No. 1436 (N. H. W.). P. 200.

100. Felsitic schist, from the south end of the portage from Fall lake to Newton lake; S. W. $\frac{1}{4}$ of sec. 3, T. 63–11. Same as No. 1109 (N. H. W.). P. 198.

101. Fine grained, slightly micaceous, quartzose rock; south shore of Kawishiwi river; N. W. $\frac{1}{4}$ of N. W. $\frac{1}{4}$ sec. 27, T. 63–10. Same as No. 989 (N. H. W.). P. 195.

102. Gray, red-weathering, gneissic rock, from an island in the N. W. $\frac{1}{4}$ of N. W. $\frac{1}{4}$ sec. 27, T. 63–10; Kawishiwi river. Same as No. 991 (N. H. W.). P. 195.

103. Hornblendic band in No. 102. P. 195.

104. Hornblendic band in No. 102. P. 195.

105. Reddish chloritic rock, N. E. $\frac{1}{4}$ of N. W. $\frac{1}{4}$ sec. 27, T. 63–10; south shore of Kawishiwi river. P. 195.

106. Hornblendic gneiss, N. E. $\frac{1}{4}$ of sec. 27, T. 63–10; south shore of Kawishiwi river. P. 195.

107. Reddish chloritic syenite, N. E. $\frac{1}{4}$ of N. W. $\frac{1}{4}$ sec. 27, T.

63-10; south shore of Kawishiwi river. Same as No. 994 (N. H. W.). P. 195.

108. Quartzose schist, grading into No. 105; same locality. P. 195.

109. Quartzose schist, with some biotite; same locality. P. 196.

110. Chloritic schist in No. 105; same locality. P. 196.

111. Fine syenite, from the "Palisades;" N. W. ¼ of S.W. ¼ sec. 4, T. 62-10. Same as No. 979 (N. H. W.). P. 195.

112. Fine grayish syenite, a condition of No. 111; same locality. P. 195.

113. Fine reddish syenite, a condition of 111; same locality. P. 195.

114. Coarse gabbro, east side of Birch lake, N. W. ¼ of sec. 17, T. 61-11. Same as No. 954 (N. H. W.). P. 194.

115. Magnetitic quartzyte, S. W. ¼ of sec. 9, T. 60-12; south of Birch lake. P. 163.

116. Magnetitic quartzyte, N. W. ¼ of sec. 10, T. 60-12; south of Birch lake. P. 163.

117. Biotitic gabbro, S. W. ¼ of sec. 10, T. 60-12; south of Birch lake. P. 162.

118. Same as No. 117, but showing dark bands. Same locality. P. 162.

118A. Same as 118, but from a loose piece. P. 162.

119. Gabbro, N. ½ of sec. 15, T. 60-12; south of Birch lake. P. 162.

120. Gabbro, N. E. ¼ of sec. 15, T. 60-12; south of Birch lake. P. 163.

121. Breccia of mica-schist cemented by granite, from the little point in the N. E. ¼ of S. E. ¼ sec. 21, T. 61-12; Birch lake. Same as No. 958 (N. H. W.). P. 195.

122. Fine-grained gabbro, from the west side of the little bay in the S. E. ¼ of S. W. ¼ sec. 24, T. 62-12; Birch lake. Same as No. 1137 (N. H. W.). P. 198.

123. Fine-grained red syenite, from the S. W. ¼ of S. W. ¼ sec. 24, T. 61-12; just east of the line between secs. 23 and 24, and 300 feet north from the shore of Birch lake. Same as No. 963 (N. H. W.). P. 195.

124. Biotite hornblende schist, N. W. ¼ of S. E. ¼ sec. 12, T. 62-12; east side of White Iron lake. Same as No. 1134 (N. H. W.). P. 198.

125. Biotite hornblende schist, N. W. ¼ of S. E. ¼ sec. 12, T. 62-12; east side of White Iron lake; 70 yards west of No. 124. P. 198.

126. Granite cutting No. 125; same locality. P. 198.

127. Black hornblende gneiss, just south of the line between secs. 6 and 7, T. 62–11; east shore of White Iron lake. This specimen shows the contact between the syenite and hornblende gneiss. Same as No. 1132 (N. H. W.). P. 198.

128. Siliceous schist, from "Silver City;" N. E. $\frac{1}{4}$ of sec. 32, T. 63–11. Same as No. 950 (N. H. W.). P. 194.

129. Biotitic diabase (?) cut by intrusive syenite, N. W. $\frac{1}{4}$ of S. E. $\frac{1}{4}$ sec. 6, T. 62–11, White Iron lake. Same as No. 1128 (N. H. W.). P. 198.

130. Syenite cutting No. 129; same locality. Same as No. 1129 (N. H. W.). P. 198.

131. Syenite taken from a dike in No. 129; same locality. P. 198.

132. Gabbro, north side of the little bay in the S. W. $\frac{1}{4}$ of S. E. $\frac{1}{4}$ sec. 15, T. 63–9; Kawishiwi river. P. 163.

133. Magnetitic iron ore in the gabbro, S. E. $\frac{1}{4}$ of sec. 15, T. 63–9. P. 163.

134. Muscovado, S. E. $\frac{1}{4}$ of N. E. $\frac{1}{4}$ sec. 15, T. 63–9; 60 yards northwest of the quarter post between secs. 14 and 15. P. 163.

135. Magnetitic iron ore; same locality as No. 134. P. 163.

136. Gabbro, showing gneissic structure; N. W. $\frac{1}{4}$ of sec. 5, T. 61–9; hill on east bank of stream. P. 164.

137. Gabbro, showing banding in No. 138; S. W. $\frac{1}{4}$ of sec. 5, T. 61–9; hill on west bank of stream. P. 165.

138. Gabbro, from same locality as No. 137. P. 165.

139. Red syenitic gneiss; S. $\frac{1}{2}$ of sec. 32, T. 63–10; from a small island near the southern shore of the lake. P. 165.

140. Red syenite; S. $\frac{1}{2}$ of sec. 32, T. 63–10; from a small island just north of the island where No. 139 was found. P. 165.

141. Syenite, with large crystals of hornblende; west side of the little bay in the N. W. $\frac{1}{4}$ of N. W. $\frac{1}{4}$ sec. 32, T. 63–10. P. 165.

142. Light gray gneiss; at the portage in the N. E. $\frac{1}{4}$ of N. W. $\frac{1}{4}$ sec 31, T. 63–10. P. 165.

143. Hornblende schist(?) in No. 142; same locality. P. 165.

144. Dark hornblende rock, from the southern shore of the lake; S. $\frac{1}{2}$ of sec. 32, T. 63–10. P. 166.

145. Transition from No. 144 to the syenite like No. 140; same locality as No. 144. P. 166.

146. To illustrate the same transition as No. 145; same locality. P. 166.

147. Coarse gabbro; west side of the little bay in the S. W. ¼ of N. W. ¼ sec. 35, T. 62–8; lake Isabelle. P. 166.

148. Granulyte vein in the gabbro; a few rods north of No. 147. P. 166.

149. Very coarse gabbro; from cliff on the west side of the larger bay in the N. W. ¼ of sec. 35, T. 62–8; lake Isabelle. P. 166.

150. Trap rock, S. W. ¼ of N. E. ¼ sec. 35, T. 62–8; lake Isabelle. P. 166.

151. Coarser condition of No. 150; same locality. P. 166.

152. Coarser decayed condition of No. 150; same locality, but a few rods back from the shore. P. 166.

153. Coarser condition of No. 150; same locality as No. 152. P. 166.

154. Condition of No. 150, containing patches of biotite; on the shore, a little north of No. 150. P. 166.

155. A decayed condition of No. 154; same locality. P. 166.

156. A coarser condition of No. 154 and No. 155; same locality. P. 166.

157. Same trap, near contact with the gabbro; N. ½ of N. E. ¼ sec. 35, T. 62-8, lake Isabelle; on the shore, a few steps north of No. 156. P. 167.

158. Fine diabase from dike, N. E. ¼ of N. E. ¼ sec. 35, T. 62–8; lake Isabelle. P. 167.

159. Diabase from dike, S. W. ¼ of sec. 30, T. 62–7; lake Isabelle. P. 167.

160. Finer diabase from edge of the same dike from which No. 159 was taken. P. 167.

161. Fine diabase from dike, W. ½ of sec. 31, T. 62–7; lake Isabelle. P. 167.

162. Very coarse gabbro, north shore of Bellissima lake; probably from sec. 27, T. 61–7. P. 167.

163. Gray feldspathic rock, S. W. ¼ of sec. 21, T. 60–6; Pine lake. P. 163.

163A. Portion of No. 163 showing dark siliceous fragment; same locality as No. 163. P. 168.

163B. Transition from No. 163 to No. 164; same locality. P. 168.

164. Granulyte, S. W. ¼ of sec. 21, T. 60–6; Pine lake. P. 168.

164A. A darker and more siliceous condition of No. 164; same locality. P. 168.

165. Fine trap, S. W. ¼ of sec. 21, T. 60–6; Pine lake. P. 168.

165A. No. 165 containing fragments of No. 164; same locality. P. 168.

165B. A condition of No. 155 A; same locality. P. 168.

166. Diabasic rock, N. W. ¼ of sec. 28, T. 60–6; Pine lake. P. 168.

167. Diabasic rock, west shore of Pine lake; T. 60–6. P. 168.

168. Very fine diabasic rock, west shore of Pine lake; T. 60–6. P. 168.

169. Very fine diabasic rock, west shore of Pine lake; T. 60–6. P. 168.

170. Micaceous schist, from the syenite; north of Gunflint lake. P. 158.

171. Hornblendic schist, from the syenite; north of Gunflint lake. P. 158.

172. Coarse hornblendic schist, from the syenite; north of Gunflint lake. P. 158.

173. Syenite holding hornblendic schist fragments; north of Gunflint lake. P. 159.

174. Synenitic gneiss, north of Gunflint lake. P. 159.

175. Gabbro, S. W. ¼ of S. E. ¼ sec. 36, T. 65–3; south shore of Mayhew lake. P. 169.

176. Lighter colored gabbro, from end of little point in the S. W. ¼ of S. E. ¼ sec. 36, T. 65–3; Mayhew lake. P. 169.

177. Magnetic iron ore in the gabbro; same locality as No. 176. P. 169.

178. Decayed gabbro; on the line between ranges 2 and 3, just south of Mayhew lake. P. 169.

179. Magnetic iron ore in the gabbro, from the point crossed by the line between secs. 31 and 32, T. 65–2; Iron lake. P. 170.

180. Magnetitic gabbro; same locality as No. 179. P. 170.

181. Fine muscovado-like rock, S. E. ¼ of N. W. ¼ sec. 4, T. 64–2; Portage lake. P. 170.

182. Gabbro, from the little point in the N. W. ¼ of N. E. ¼ of N. W. ¼ sec. 12, T. 64–2; Poplar lake. P. 171.

183. Very fine gabbro, a condition of No. 182; same locality. P. 171.

184. Light gray gabbro with the labradorite collected together in spots; S. E. ¼ of N. E. ¼ sec. 12, T. 64–2; Poplar lake. P. 171.

185. Gabbro, from hill a quarter of a mile north of Meeds' lake, and a little west of the centre of sec. 15, T. 64–2. P. 172.

186. Rough Animike slate, N. W. ¼ of N. E. ¼ sec. 14, T. 64–2; Meeds' lake. P. 172.

187. Gabbro, S. E. ¼ of S. E. ¼ sec. 29, T. 64–2; north shore of Winchell lake. P. 174.

188. Goarse gabbro, from the point crossed by the line between secs. 31 and 32, T. 62–4; south shore of Winchell lake. P. 174.

189. Gabbro, from the bluff in the N. W. ¼ of N. W. ¼ sec. 31, T. 64–2; south shore of Winchell lake. P. 174.

190. Gabbro holding some pinkish feldspar, 20 feet above No. 189. P. 174.

191. Altered gabbro, reddish; ten feet above No. 190. P. 175.

192. Very dark syenite, two feet above No. 191. P. 175.

193. Very dark syenite, two feet above No. 191. P. 175.

194. Fine pinkish-gray syenite, just above No. 193. P. 175.

195. Pinkish-gray syenite, just above No. 194. P. 175.

196. Pinkish-gray syenite, from top of bluff; same locality. P. 175.

197. Showing change from gabbro to syenite; same locality. P. 175.

198. A condition of the gabbro, N. W. ¼ of N. W. ¼ sec. 31, T. 64–2; Winchell lake, north end of portage to Sham lake. P. 175.

199. Altered gabbro, S. W. ¼ of N. W. ¼ sec. 31, T. 64–2; north end of Sham lake, at the portage to Winchell lake. P. 176.

200. Fine red syenite, S. W. ¼ of N. W. ¼ sec. 31, T. 64–2; east side of Sham lake. P. 176.

201. Altered gabbro (?), S. E. ¼ of S. E. ¼ sec. 36, T. 64–3; near the southwest corner of Sham lake. P. 176.

202. Fine red syenite, S. E. ¼ of S. W. ¼ sec. 1, T. 63–3; west side of Lost lake. P. 176.

203. Dark siliceous trap, S. E. ¼ of S. W. ¼ sec. 12, T. 63–3, east side of bay; Brulé lake. P 177.

204. A condition of the gabbro (?) a little south of No. 203. P. 177.

205. Gray feldspar porphyry, from the point in the S. E. ¼ of N. E. ¼ of N. W. ¼ sec. 13, T. 63–3; Brulé lake. P. 177.

206. Dark feldspar porphry; same locality as No. 205. P. 177.

207. Red quartz porphyry; a few yards south of the last. P. 178.

207A. A darker and more siliceous condition of No. 207, near the contact with No. 208; same locality. P. 178.

208. Fine diabase, in contact with No. 207; same locality. P. 178.

209. Diabase-like rock, inclined to be amygdaloidal; small island in the S. E. ¼ of S. E. ¼ sec. 18, T. 63–3; Brulé lake. P. 178.

210. Gabbro, S. W. ¼ of sec. 18, T. 63–3; lake Georgia, a short distance west of the portage from Brulé lake. P. 179.

211. Dark feldspar porphyry; lake Georgia, a short distance west of No. 210. P. 179.

212. Trap; near its contact with the gabbro (No. 213); N. E. ¼ of S. W. ¼ sec. 13, T. 63–4; north side of lake Georgia. P. 179.

212A. Coarser condition of No. 212, farther from the contact. P. 179.

213. Gabbro in contact with trap (No. 212); same locality. P. 179.

214. Fine red syenite, S. W. ¼ of sec. 12, T. 63–4; Surveyor's lake, on the portage going west to Found lake. P. 179.

215. Diabase, S. ½ of sec. 11, T. 63–4; hill on north shore of Found lake. P. 180.

216. Fine red syenite holding pieces of a darker rock; S. ½ of sec. 11, T. 63–4; north shore of Found lake. P. 180.

217. Gabbro, S. W. ¼ of N. E. ¼ sec. 11, T. 63–4; lake Ida Belle. P. 180.

218. Diabase, S. W. ¼ of N. W. ¼ sec. 11, T. 63–4,—just east of the line between secs. 10 and 11; lake Ida Belle. P. 180.

219. Fine diabase from dike in gabbro, little point in the S. E. ¼ of sec. 10, T. 63–4; lake Ida Belle. P. 180.

220. Gabbro cut by the above dike. P. 180.

221. Fine-grained rock resembling "muscovado;" N. W. ¼ of sec. 15, T. 63–4, near the line between secs. 10 and 15; southwest of lake Ida Belle. P. 181.

222. Large crystals of hornblende from vein in gabbro; southwest of lake Ida Belle, near the last locality. P. 181.

223. Gabbro rich in magnetite; southwest of lake Ida Belle, near the last locality. P. 181.

224. Magnetite from the gabbro; N. ½ of sec. 16, T. 63–4, near the line between secs. 9 and 16; southwest of lake Ida Belle. P. 181.

225. Fine red syenite, east side of entrance to the small bay in the N. W. ¼ of N. E. ¼ sec. 10, T. 63–4; lake Ida Belle. P. 181.

226. Diabase from dike in gabbro; same locality as No. 225. P. 181.

227. Gabbro; same locality. P. 181.

228. Fine red syenite underlying the gabbro; north side of small island in the N. E. ¼ of S. E. ¼ sec. 3, T. 63–4; lake Ida Belle. P. 182.

229. Dark rock cut by veins of the following; hill in the E. ½ of sec. 3, T. 63–4; lake Ida Belle. P. 182.

230. Fine red syenite from veins in No. 229; same locality. P. 182.

231. Showing contact of Nos. 229 and 230. P. 182.

232. Fine red syenite from vein in gabbro; S. E. ¼ of sec. 35, T. 64–4, lake Ida Belle; on the portage going north. P. 183.

233. A decayed condition of the gabbro; S. E. ¼ of N. E. ¼ sec. 26, T. 64–4; west shore near the north end of Narrow lake. P. 183.

233½. Muscovado, N. E. ¼ sec. 33, T, 65–4; west shore of Draper lake. P. 184.

234. Fine gray syenite underlying the gabbro; probably in the S. W. ¼ of sec. 29, T. 65–4; on the portage from lake No. 3 to lake No. 4. P. 184.

235. Gabbro overlying No. 234; same locality. P. 184.

236. Muscovado; same locality as No. 234. P. 185.

237. Fine gabbro, probably in S. ½ of sec. 29, T. 65–4; from little island in southern part of lake No. 4. P. 185.

238. Magnetic iron ore from the quartzyte, S. E. ¼ of S. E. ¼ sec. 25, T. 65–5; south shore of Flying Cloud lake, near its eastern end. P. 185.

239. Greenstone; same locality as No. 238. P. 185.

240. Magnetic iron ore from the quartzyte; probably in the S. E. ¼ of S. E. ¼ sec. 26, T. 65–5. P. 186.

241. Greenstone, 12 feet north of No. 240. P. 186.

242. Magnetitic quartzyte, just south of No. 241. P. 186.

243. Magnetitic quartzyte lying on No. 244; probably in the N. W. ¼ of N. E. ¼ sec. 35, T. 65–5. P. 186.

244. Greenstone underlying No. 243; same locality. P. 186.

245. Fine gabbro, from the little point in the N. E. ¼ of N. E. ¼ sec. 14, T. 64–7; Shoo-fly lake. P. 186.

246. Gabbro, west side of the small lake in the S. W. ¼ of sec. 13, T. 64–7. P. 187.

247. Decayed condition of No. 246; west shore, near the south end of the small lake in the S. W. ¼ of sec. 13, T. 64–7. P. 187.

248. Olivinitic iron ore, S. E. ¼ of S. W. ¼ sec. 14, T. 64–7; north side of Fraser lake. P. 187.

249. Coarse hornblende (?) rock; same locality. P. 187.

250. Olivinitic iron ore in No. 249; same locality. P. 187.

251. Magnetitic quartzyte in No. 249; same locality. P. 187.

252. Olivinitic iron ore; same locality. P. 187.

253. Coarse hornblende(?) rock, not as much decayed as No. 249; same locality. P. 187.

254. Muscovado; same locality. P. 187.

255. No. 249 containing considerable magnetite; same locality. P. 187.

256. Same as No. 255 and showing a piece of No. 254; same locality. P. 187.

257. Muscovado from northern foot of the ridge; same locality. P. 188.

258. Magnetitic quartzyte; same locality. P. 188.

259. Magnetitic quartzyte showing banding; same locality. P. 188.

260. Showing contact of the quartzyte and the hornblende rock (No. 249); same locality. P. 188.

261. Fine decayed gabbro, N. W. ¼ of N. E. ¼ sec. 23, T. 64–7; north shore of Fraser lake. P. 188.

262. Olivintic iron ore; same locality. P. 188.

263. Magnetitic quartzyte; same locality. P. 188.

264. Magnetitic quartzyte, showing banding; same locality. P. 188.

265. Band of magnetite from the quartzyte; same locality. P. 188.

266. Muscovado-like rock, from a bed in the quartzyte; same locality. P. 188.

267. Olivinitic iron ore; same locality. P. 189.

268. Large crystals, apparently similar to No. 249, but containing much magnetite; same locality. P. 188.

269. Gabbro, N. E. ¼ of sec. 28, T. 64–7; a quarter of a mile north of Thomas lake. P. 189.

270. Muscovado holding irregular blotches of a light colored feldspar; W. ½ of sec. 27, T. 64–7; north shore of Thomas lake. P. 189.

271. Hornblende (?) rock similar to Nos. 249 and 253, N. E. ¼ of sec. 29, T. 64–7; north shore of Thomas lake. P. 189.

272. Magnetitic quartzyte showing banding on weathered surface; same locality. P. 189.

273. Iron ore, apparently almost pure magnetite; same locality. P. 189.

274. Magnetitic quartzyte; same locality. P. 190.

275. Same as No. 274. P. 190.

276. Pink gabbro holding small quantities of what appears to be a red oxide of iron; east side of the long bay in sec. 15, T. 63–7; lake Alice. P. 191.

277. Gabbro, S. E. ¼ of N. W. ¼ sec. 15, T. 63-7; east shore of lake Alice. P. 191.

278. Green chloritic schist; north of Cady house, Tower. Same as No. 868 (N. H. W.). P. 194.

279. Rough, scarcely banded jasper; 25 feet below the surface; Stone mine, Tower. Same as No. 892 (N. H. W.). P. 194.

280. Red jasper with darker bands of iron ore; Stone mine, Tower. Same as No. 903 (N. H. W.). P. 194.

281. Matrix of conglomerate occurring north of the Cady house, Tower. Same as No. 908 (N. H. W.). P. 194.

282. Breccia, now converted to hematite and a floury white mineral; Breitung mine, Tower. Same as No. 916 (N. H. W.). P. 194.

283. Black or purplish-black clay slate; south shore of Pine island, Vermilion lake; a few feet east of the line between ranges 15 and 16. Same as No. 921 (N. H. W.). P. 194.

284. Sericitic schist, rather siliceous; north shore of Pine island, Vermilion lake; on the line between ranges 15 and 16. P. 192.

285. Sericitic schist; Pine island. P. 192.

286. Green, somewhat sericitic schist; Pine island. P. 192.

287. Green, somewhat graywacke-like rock; Pine island. P. 192.

288. Rough sericitic schist; Pine island. P. 192.

289. Green, somewhat chloritic (?) schist; Pine island. P. 192.

290. Light gray argillaceous slate; Pine island. P. 192.

291. Coarser and rather sericitic condition of No. 290; Pine island. P. 192.

292. Coarser and rather sericitic condition of No. 290; Pine island. P. 192.

293. Coarser and rather sericitic condition of No. 290; Pine island. P. 192.

294. Light gray argillaceous slate; Pine island. P. 192.

295. Gray argillaceous slate; Pine island. P. 192.

296. A more siliceous condition of the slate; Pine island. P. 192.

297. Gray argillaceous slate; Pine island. P. 192.

298. Argillaceous slate showing both the gray and black bands; south shore of Pine island, on the line between ranges 15 and 16. P. 192.

V.

MUSEUM ADDITIONS.

Specimens Registered in the General Museum in 1887–88.

Serial No.	Obtained. When.	Obtained. Whence.	Name.	Number of Specimen.	Locality.	Formation.	Collector and Remarks.
6191	Jan., 1886......	Geol. Survey......	Gravel, largely limestone........	Indef.	Albert Lea, Minn......	Drillings from the well at Albert Lea	From Mayor A. C. Wedge, 80 feet.
6192	Jan., 1886......	Geol. Survey......	Sand and gravel..............................	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 95 feet.
6193	Jan., 1886......	Geol. Survey......	Sand, mainly quartz.........................	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 105 feet.
6194	Jan., 1886......	Geol. Survey......	Gravel and sand..............................	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 112 feet.
6195	Jan., 1886......	Geol. Survey......	Sand..	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 113 feet.
6196	Jan., 1886......	Geol. Survey......	Sand with magnesian limestone...........	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 114 feet.
6197	Jan., 1886......	Geol. Survey......	Magnesian limestone and sand.............	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 115 feet.
6198	Jan., 1886......	Geol. Survey......	Magnesian limestone and sand.............	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 115 feet.
6199	Jan., 1886......	Geol. Survey......	Sand with some limestone..................	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 130 feet.
6200	Jan., 1886......	Geol. Survey......	Magnesian limestone......	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 143 feet.
6201	Jan., 1886......	Geol. Survey......	Light-gray shale	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 155 feet.
6202	Jan., 1886......	Geol. Survey......	Light-gray shale...............................	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 160 feet.
6203	Jan., 1886......	Geol. Survey......	Battered films of metalic iron..............	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 165 feet.
6204	Jan., 1886......	Geol. Survey......	Gray shale, sandy............................	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 172 feet.
6205	Jan., 1886......	Geol. Survey......	Gray shale	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 210 feet.
6206	Jan., 1886......	Geol. Survey......	Gray shale.......................	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 213 feet.
6207	Jan., 1886......	Geol. Survey......	Calcareous shale...............................	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 220 feet.
6208	Jan., 1886......	Geol. Survey......	Compact, light-colored limestone	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 230 feet.
6209	Jan., 1886......	Geol. Survey......	Mainly magnesian limestone...............	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 234 feet.
6210	Jan., 1886......	Geol. Survey......	Mainly white quartz sand........	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 236 feet.
6211	Jan., 1886......	Geol. Survey......	Mainly white quartz sand..........	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 237 feet.
6212	Jan., 1886......	Geol. Survey......	Mainly white quartz sand..................	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 240 feet.
6213	Jan , 1886......	Geol. Survey......	Buff magnesian limestone..................	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 241 feet.
6214	Jan., 1886......	Geol. Survey......	Buff magnesian limestone..................	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 243 feet.
6215	Jan., 1886......	Geol. Survey......	Reddish-buff magnesian limestone......	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 245 feet.
6216	Jan., 1889......	Geol. Survey......	Reddish-buff magnesian limestone......	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 250 feet.
6217	Jan., 1886......	Geol. Survey......	Reddish-buff magnesian limestone......	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 254 feet.
6218	Jan., 1886......	Geol. Survey......	Reddish-buff magnesian limestone......	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 258 feet.
6219	Jan., 1886.....	Geol. Survey......	Reddish-buff magnesian limestone......	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 260 feet.
6220	Jan., 1886......	Geol. Survey......	Reddish-buff magnesian limestone......	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 265 feet.
6221	Jan., 1886......	Geol. Survey......	Reddish-buff magnesian limestone......	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 270 feet.
6222	Jan., 1866......	Geol. Survey......	Light-gray, cryst. magnesian limestone	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 275 feet.
6223	Jan , 1886......	Geol. Survey......	Buff magnesian limestone..................	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 285 feet.
6224	Jan., 1886......	Geol. Survey......	Light-buff magnesian limestone...........	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 295 feet.
6225	Jan., 1886......	Geol. Survey......	Vesicular, buff magnesian limestone....	Indef.	Albert Lea, Minn......		From Mayor A. C. Wedge, 300 feet.
6226	Oct., 1885......	Geol. Survey	Drillings, mixed, mainly quartzose sand	Indef.	4 ms. S.E. f. New Ulm.	Cret..........	From C. M Phelps.
6227	Feb., 1886......	Presented..........	Fibrous gypsum	2	Camillus, N. Y.........	....	From N. H. Winchell.

6228	Feb., 1886	Presented	Gypsum	1	Camillus, N. Y.		From N. H. Winchell.	
6229	Feb., 1886	Presented	Gypsum	1	Sandusky, Ohio		From N. H. Winchell.	
6230	Feb., 1886	Presented	Gypsum	2	Ottawa Co., Ohio		From N. H. Winchell.	
6231	Feb., 1886	Presented	Fibrous gypsum	2	Grand Rapids, Mich.		From N. H. Winchell.	
6232	Feb., 1886	Presented	Wollastonite	1	Rock Harbor, I. Royale		From N. H. Winchell.	
6233	Feb., 1886	Presented	Tufa	2	Marcellus Falls, N. Y.		From N. H. Winchell.	
6234	Feb., 1886	Presented	Calcite	7			From N. H. Winchell.	
6235	Feb., 1886	Presented	Chlorastrolites in rock	1	RockHarbor, I. Royale		From N. H. Winchell.	
6236	Feb., 1886	Presented	Niagara limestone	1	Joliet, Ill.		From N. H. Winchell.	
6237	Feb., 1886	Presented	Feldspathic quartzyte	1	Ann Arbor, Mich		From N. H. Winchell.	
6238	Feb., 1886	Presented	Aphanite	1	Ann Arbor, Mich		From N. H. Winchell.	
6239	Feb., 1886	Presented	Gneiss	1	Ann Arbor, Mich		From N. H. Winchell.	
6240	Feb., 1886	Presented	Gneiss	1	Ann Arbor, Mich		From N. H. Winchell.	
6241	Feb., 1886	Presented	Feldspathic quartzyte	1	Ann Arbor, Mich		From N. H. Winchell.	
6242	Feb., 1886	Presented	Mottled marble	1	Ann Arbor, Mich		From N. H. Winchell.	
6243	Feb., 1886	Presented	Buhr stone	1	Ohio		From N. H. Winchell.	
6244	Feb., 1886	Presented	Celestite	Indef	Pt. aux Peaux		From N. H. Winchell.	
6245	Feb., 1886	Presented	Drillings, sand, 20 feet	Indef.	Gibbon, Sibley Co.		From Andrew Erickson.	
6246	Feb., 1886	Presented	Drillings, remains of wood, fr. No. 6245	Indef.	Gibbon, Sibley Co.		From Andrew Erickson.	Under 275 ft. blue clay.
6247	Feb., 1886	Presented	Drillings, red granite, 30 ft	Indef.	Gibbon, Sibley Co.		From Andrew Erickson.	
6248	1878.	Geol. Survey.	Catlinite with glacial markings	1	Pipestone Co.	Potsdam	From N. H. Winchell.	
6249	March, 1886	Presented	Silver ore (pulverized)	1	Newburyport, Mass.		From G. R. Lumsden, Orig. No. 1.	
6250	March, 1886	Presented	Quartz crystals	Indef.	N. Stonington, Conn.		From G. R. Lumsden, Orig. No. 2.	
6251	March, 1886	Presented	Sillimanite and zircon w. crys. of mono-	Indef.	Norwich Falls, Conn.		From G. R. Lumsden, Orig. No. 3.	
6252	March, 1886	Presented	Prehnite [site	1	Hartford, Conn		From G. R. Lumsden, Orig. No. 4.	
6253	March, 1886	Presented	Asbestos	1	New Haven, Conn.		From G. R. Lumsden, Orig. No. 5.	
6254	March, 1886	Presented	Amethyst	1	Nova Scotia		From G. R. Lumsden, Orig. No. 6.	
6255	March, 1886	Presented	Brucite and chondrodite	1	Hoboken, N. J.		From G. R. Lumsden, Orig. No. 7.	
6256	March, 1886	Presented	Magnetic iron ore	1	New Jersey		From G. R. Lumsden, Orig. No. 8.	
6257	March, 1886	Presented	Micaceous iron ore	1	Africa		From G. R. Lumsden, Orig. No. 151.	
6258	March, 1886	Presented	Enstatite	1	Chester Co., Pa.		From G. R. Lumsden, Orig. No. 11.	
6259	March, 1886	Presented	Moss Agate	1	Cupar, Scotland		From G. R. Lumsden, Orig. No. 12.	
6260	March, 1886	Presented	Prismatic talc mica	1	Greiner, Tyrol		From G. R. Lumsden, Orig. No. 18.	
6261	March, 1886	Presented	Iron mica	1	Löwenberg, Ger.		From G. R. Lumsden, Orig. No. 20.	
6262	March, 1886	Presented	Rhomboidal graphite	1	Altstadt, Ger.		From G. R. Lumsden, Orig No. 21.	
6263	March, 1886	Presented	Glassy actinolite	1	Zoeptau, Ger.		From G. R. Lumsden, Orig. No. 25.	
6264	March, 1886	Presented	Quartz crystals	1	New Haven, Conn.		From G. R. Lumsden, Orig. No. 26.	
6265	March, 1886	Presented	Basaltic hornblende	1	Schima, Bohemia		From G. R. Lumsden, Orig. No. 26.	
6266	March, 1886	Presented	Selenite	3	Colorado		From G. R. Lumsden, Orig. No. 27.	
6267	March, 1886	Presented	Paraffin, from coal	1			From G. R. Lumsden, Orig. No. 30.	
6268	March, 1886	Presented	Tremolite	1	Tyrol		From G. R. Lumsden, Orig. No. 29.	
6269	March, 1886	Presented	Augite	7	Schima, Bohemia		From G. R. Lumsden, Orig. No. 31.	
6270	March, 1886	Presented	Schiller spar	1	Volpersdorf		From G. R. Lumsden, Orig. No. 32.	
6271	March, 1886	Presented	Plumbago	1	PrestonConn.		From G. R. Lumsden, Orig. No. 33.	
6272	March, 1886	Presented	Moss Agate	1	Sweet-water Co, Wyo.		From G. R. Lumsden, Orig. No. 34.	
6273	March, 1886	Presented	Prismatic Topaz	Indef.	Schneckenstein, Ger.		From G. R. Lumsden, Orig. No. 35.	
6274	March, 1886	Presented	Agate	1	Texas		From G. R. Lumsden, Orig. No. 36.	
6275	March, 1886	Presented	Zircon	1	Brewig, Norway		From G. R. Lumsden, Orig. No. 37.	

Specimens Registered in the General Museum in 1887–88.—(*Continued.*)

Serial No.	Obtained. When.	Obtained. Whence.	Name.	Number of Specimen	Locality.	Formation.	Collector and Remarks.
6276	March, 1886	Presented	Garnet sand	Indef	Roxbury, Mass		From G. R. Lumsden, Orig. No. 38.
6277	March, 1886	Presented	Iolite	1	Origarfvi, Finland		From G. R. Lumsden, Orig. No. 39.
6278	March, 1886	Presented	Erlane (Breithauptite)	1	Schwarzenberg, Ger.		From G. R. Lumsden, Orig. No. 41.
6279	March, 1886	Presented	Galena	Indef	Dubuque, Iowa		From G. R. Lumsden, Orig. No. 42.
6280	March, 1886	Presented	Asbestos	1	Toronto, Canada		From G. R. Lumsden, Orig. No. 43.
6281	March, 1886	Presented	Garnets	5	Haddam, Conn		From G. R. Lumsden, Orig. No. 44.
6282	March, 1886	Presented	Green Feldspar	4	Rockport, Mass		From G. R. Lumsden, Orig. No. 50.
6283	March, 1886	Presented	Lead Selenate	1	Durrenberg, Germ		From G. R. Lumsden, Orig. No. 51.
6284	March, 1886	Presented	Mica	1	New Haven, Conn		From G. R. Lumsden, Orig. No. 52.
6285	March, 1886	Presented	Asbestos	1	Norwalk, Conn		From G. R Lumsden, Orig. No. 53.
6286	March, 1886	Presented	Cyanite	1	Greiner, Tyrol		From G. R. Lumsden, Orig. No. 54.
6287	March, 1886	Presented	Asbestos	1	Vermont		From G. R. Lumsden, Orig. No. 55.
6288	March, 1886	Presented	Sodalite	1	Eifel, Germ		From G. R. Lumsden, Orig. No. 56.
6289	March, 1886	Presented	Hayanite	1	Laacher, Germ		From G. R. Lumsden, Orig. No. 57.
6290	March, 1886	Presented	Epidote	2	Franconia, N. H		From G. R. Lumsden, Orig. No. 59.
6291	March, 1886	Presented	Spodumene	1	Sterling, Mass		From G. R. Lumsden, Orig. No. 60.
6292	March, 1886	Presented	Cobalt	3			From G. R. Lumsden, Orig. No. 62.
6293	March, 1886	Presented	Chiastolite	1	Gefrees, Germ		From G. R. Lumsden, Orig. No. 63.
6294	March, 1886	Presented	Porcelainyte	1	Toeplitz, Germ		From G. R. Lumsden, Orig. No. 65.
6295	March, 1886	Presented	Asbestos	Indef	York Co., Pa		From G. R. Lumsden, Orig. No. 68.
6296	March, 1886	Presented	Tripolyte	1	Bilin, Prussia		From G. R. Lumsden, Orig. No. 69.
6297	March, 1886	Presented	Magnetite	1	Rhode Island		From G. R. Lumsden, Orig. No. 74.
6298	March, 1886	Presented	Graphite	1	Ticonderoga, N. Y		From G. R. Lumsden, Orig. No. 76.
6299	March, 1886	Presented	Stibnite	1	Halbermond		From G. R. Lumsden, Orig. No. 77.
6300	March, 1886	Presented	Onyx	1	Oberstein, Germ		From G. R. Lumsden, Orig. No. 78.
6301	March, 1886	Presented	Chloropal	Indef	Madura, India		From G. R. Lumsden, Orig. No. 79.
6302	March, 1886	Presented	Calamine	1	Wiesloch		From G. R. Lumsden, Orig. No. 80.
6303	March, 1886	Presented	Calamine	1	Raibel, Corinthia		From G. R. Lumsden, Orig. No. 82.
6304	March, 1886	Presented	Black mica schist	1	Ames, N. Y		From G. R. Lumsden, Orig. No. 85.
6305	March, 1886	Presented	Wolframite	1	Zirmwald, Bohemia.		From G. R. Lumsden, Orig. No. 87.
6306	March, 1886	Presented	Covellite	1	Pennsylvania		From G. R. Lumsden, Orig. No. 88.
6307	March, 1886	Presented	Iron pyrites	1	Marienberg, Germ		From G. R. Lumsden, Orig. No. 93.
6308	March, 1886	Presented	Hexahedral iron pyrites	1	Alsan, Germ		From G. R. Lumsden. Orig. No. 94.
6309	March, 1886	Presented	Iron and shale	1	York Common, N. Y.		From G. R. Lumsden, Orig. No. 96.
6310	March, 1886	Presented	Petrified cottonwood	1	Colorado		From G. R. Lumsden, Orig. No. 97.
6311	March, 1886	Presented	Hematite	1	Irgang, Bohemia		From G. R. Lumsden, Orig. No. 99.
6312	March, 1886	Presented	Zircon	Indef	Green River, Henderson Co., N. C.		From G. R. Lumsden, Orig. No. 100.

6313	March, 1886..	Presented..........	Ferruginous quartz	1	Schellerhan, Germ....	....	From G. R. Lumsden, Orig. No. 102.
6314	March, 1886..	Presented..........	Tremolite..........................	1	....	....	From G. R. Lumsden, Orig. No. 106.
6315	March, 1886..	Presented..........	Pisiform ironstone...	Indef.	Schafhausen, Germ...	....	From G. R. Lumsden, Orig. No. 107.
6316	March, 1886..	Presented..........	Magnetite.....................................	1	Philipstad, Sweden...	....	From G. R. Lumsden, Orig. No 111.
6317	March, 1886..	Presented..........	Siderite	1	Germany...........	.. ..	From G. R. Lumsden, Orig. No. 114.
6318	March, 1886..	Presented..........	Native sulphur	1	Sicily.....................	.. ..	From G. R. Lumsden, Orig. No. 115.
6319	March, 1886..	Presented........ ..	Red cobalt ochre	1	Schneeberg, Germ.....	.. ..	From G R. Lumsden, Orig. No. 119.
6320	March, 1886..	Presented..........	Copper nickel..............................	1	Schneeberg, Germ.....	....	From G. R. Lumsden, Orig. No. 121.
6321	March, 1886..	Presented..........	Variegated copper..................	1	Freiberg, Germ..........	....	From G. R. Lumsden, Orig. No. 125.
6322	March, 1886..	Presented..........	Copper pyrites.................................	1	Siegen, Germ............	.. ..	From G. R. Lumsden, Orig. No. 126.
6323	March, 1886..	Presented..........	Copper pyrites...............................	1	Alsan, Germ.............	....	From G. R. Lumsden, Orig. No. 127.
6324	March, 1886..	Presented..........	Gray copper..................................	1	Thuringia................	....	From G. R. Lumsden, Orig. No. 128.
6325	March, 1886..	Presented..........	Red oxyde of copper........................	1	Dillenberg, Nassau....	....	From G. R. Lumsden, Orig. No. 131.
6326	March, 1886..	Presented..........	Malachite	1	Dillenberg, Nassau ...	....	From G. R. Lumsden, Orig. No. 132.
6327	March, 1886..	Presented..........	Blue copper..................................	1	Rheinbreitenbach......	....	From G. R. Lumsden, Orig. No. 133.
6328	March, 1886..	Presented..........	Iron slag......................................	2	Norwich, Conn..	....	From G. R. Lumsden, Orig. No. 137.
6329	March, 1886..	Presented..........	Hepatic mercurial-ore...........	1	Iddria, Illyrien..........	....	From G. R. Lumsden, Orig. No. 138.
6330	March, 1886..	Presented..........	Argentite	1	Freiberg, Germ...... ..	....	From G. R. Lumsden, Orig. No. 140.
6331	March, 1886..	Presented..........	Williamsite	1	Rock Springs, Ind.....	....	From G. R. Lumsden, Orig. No. 142.
6332	March, 1886..	Presented..........	Nagyagite......................................	1	Nagyag, Transsylva'a	....	From G. R. Lumsden Orig. No. 143.
6333	March, 1886..	Presented..........	Native platina...............................	Indef.	Tagelsk, Ural...........	....	From G. R. Lumsden, Orig. No. 144.
6334	March, 1886..	Presented..........	Silver pyrites...............................	1	Mont. Co., N. Y.........	....	From G. R. Lumsden, Orig. No. 145.
6335	March, 1886..	Presented..........	Blue iron earth..............................	Indef.	Ebstorf...................	....	From G. R. Lumsden, Orig. No. 152.
6336	March, 1886..	Presented..........	Asbestos	Indef.	Canterbury, N. H......	....	From G. R. Lumsden, Orig. No. 153.
6337	March, 1886..	Presented..	Beryl...	1	Canada....................	... .	From G. R. Lumsden, Orig. No. 157.
6338	March, 1886..	Presented.....	Mica	1	New Jersey..............	....	From G. R. Lumsden, Orig. No. 158.
6339	March, 1886..	Presented..........	Brown chalcedony..........................	1	Madura, India..........	....	From G. R. Lumsden, Orig. No. 159.
6340	March, 1886..	Presented..........	Brown coal..............	1	Bruhl, Germ.............	....	From G. R. Lumsden, Orig. No. 160.
6341	March, 1886..	Presented..........	Peat..	1	Kloster Laach...........	....	From G. R. Lumsden, Orig. No. 162.
6342	March, 1886..	Presented..........	Native boracic acid.........................	Indef.	Vulkano..................	....	From G. R. Lumsden, Orig. No. 163.
6343	March, 1886..	Presented..........	Hayesine....	Indef.	Iquique, Peru...........	....	From G. R. Lumsden, Orig. No. 165.
6344	March, 1886..	Presented..........	Brown coal......	1	Frierdorf, Bonn........	....	From G. R. Lumsden, Orig. No. 172.
6345	March, 1886..	Presented..........	Nitratine.....................................	Indef.	Chili	....	From G. R. Lumsden, Orig. No. 176.
6346	March, 1886..	Presented..........	Celestite............	Indef.	Dornburg, Jena.........	....	From G. R. Lumsden, Orig. No. 179.
6347	March, 1886..	Presented..........	Garnet.............................	1	New Hampshire........	....	From G. R Lumsden, Orig. No. 180.
6348	March, 1886..	Presented..........	Crystals of hematite........................	1	New York................	....	From G. R. Lumsden, Orig. No. 183.
6349	March, 1886..	Presented..........	Emery..	1	Naxos (Grecian Isl.)..	....	From G. R. Lumsden, Orig. No. 186.
6350	March, 1886..	Presented..........	Asbestos.................	Indef.	Greiner, Tyrol..........	....	From G. R. Lumsden, Orig. No. 189.
6351	March, 1886..	Presented..........	Calcite..................	1	Howe's cave, N. Y.....	....	From G. R. Lumsden, Orig. No. 192.
6352	March, 1886..	Presented..........	Native lodestone............................	1	Mt. Calamite, Elba...	....	From G. R. Lumsden, Orig. No. 195.
6353	March, 1886..	Presented..........	Rutile..	5	Freiberg, Germ	....	From G. R. Lumsden, Orig. No. 195 A.
6354	March, 1886..	Presented..	Corundum (ruby)............................	Indef.	Capelan Mts............	....	From G. R. Lumsden, Orig. No. 196.
6355	March, 1886..	Presented..........	Corundum (sapphire)..............	1	Miark, Germ............	....	From G. R. Lumsden, Orig. No. 197.
6356	March, 1886..	Presented..........	Spinel (blue).................................	1	Sweden....................	....	From G. R. Lumsden, Orig. No. 199.
6357	March, 1886..	Presented..........	Spinel (ruby)	Indef.	Candy, Ceylon Isl......	....	From G. R. Lumsden, Orig. No. 200.
6358	March, 1886..	Presented..........	Tremolite.....................................	1	New York................	....	From G. R. Lumsden, Orig. No. 202.
6359	March, 1886..	Presented..........	Beryl...	1	Haddam, Conn.........	....	From G. R. Lumsden, Orig. No. 204.
6360	March, 1886..	Presented..........	Smoky quartz.................	1	N. Benton, N. H........	....	From G. R. Lumsden, Orig. No. 208.

SPECIMENS REGISTERED IN THE GENERAL MUSEUM IN 1887–88.—(*Continued.*)

Serial No.	Obtained.		Name.	Number of Specimen.	Locality.	Formation.	Collector and Remarks.
	When.	Whence.					
6361	March, 1886...	Presented	Tourmaline (red)	1	Moravia	....	From G. R. Lumsden, Orig. No. 209.
6362	March, 1886...	Presented	Smoky quartz	3	St. Gothard	....	From G. R. Lumsden, Orig. No. 212.
6363	March, 1886...	Presented	Amethyst	1	Oberstein	....	From G. R. Lumsden, Orig. No. 213.
6364	March, 1886...	Presented	Cat's-eye	1	Hoff in Bavaria	....	From G. R. Lumsden, Orig. No. 214.
6365	March, 1886...	Presented	Pyrolusite	1	New York	....	From G. R. Lumsden, Orig. No. 216.
6366	March, 1886...	Presented	Carnelian	1	Oberstein	....	From G. R. Lumsden, Orig. No. 219.
6367	March, 1886...	Presented	Andalusite	2	Lancaster, N. H	....	From G. R. Lumsden, Orig. No. 223.
6368	March, 1886...	Presented	Jasper (globular)	1	Kandem, Baden	....	From G. R. Lumsden, Orig. No. 224.
6369	March, 1886...	Presented	Muscovite	1	New Haven, Conn	....	From G. R. Lumsden, Orig. No. 226.
6370	March, 1886...	Presented	Bog iron ore	1	Ft. Plain, N. Y	....	From G. R. Lumsden, Orig. No. 228.
6371	March, 1886...	Presented	Foliated brown coal	1	Ratt, Germany	....	From G. R. Lumsden, Orig. No. 229.
6372	March, 1886...	Presented	Fire opal	Indef.	Zamapan	....	From G. R. Lumsden, Orig. No. 231.
6373	March, 1886...	Presented	Chrysolite	1	Dreis in d. Eifel	....	From G. R. Lumsden, Orig. No. 232.
6374	March, 1886...	Presented	Serpentine	1	New Haven, Conn	....	From G. R. Lumsden, Orig. No. 233.
6375	March, 1886...	Presented	Diopside	3	Rothenkopf, Tyrol	....	From G. R. Lumsden, Orig. No. 235.
6376	March, 1886...	Presented	Bastite	1	Baste in Hartz	....	From G. R. Lumsden, Orig. No. 236.
6377	March, 1886...	Presented	Andularia feldspar	1	Mt. Stella, St. Goth'd	....	From G. R. Lumsden, Orig. No. 237.
6378	March, 1886...	Presented	Actinolite	1	Connecticut	....	From G. R. Lumsden, Orig. No. 238.
6379	March, 1886...	Presented	Agate with stilbite in cavity	1	Partridge Isl., N. S	....	From G. R. Lumsden, Orig. No. 240.
6380	March, 1886...	Presented	Lazulite	1	Krieglach, Styria	....	From G. R. Lumsden, Orig. No. 241.
6381	March, 1886...	Presented	Turquois	Indef.	Khorassan, Persia	....	From G. R. Lumsden, Orig. No. 242.
6382	March, 1886...	Presented	Fluorite	1	Freiberg, Germany	....	From G. R. Lumsden, Orig. No. 243.
6383	March, 1886...	Presented	Vesuvianite	1	Monzoni, Tyrol	....	From G. R. Lumsden, Orig. No. 246.
6384	March, 1886...	Presented	Pyrope	Indef.	Meronitz, Bohemia	....	From G. R. Lumsden, Orig. No. 249.
6385	March, 1886...	Presented	Amber	2	Prussia	....	From G. R. Lumsden, Orig. No. 254.
6386	March, 1886...	Presented	Pyrites and lead	1	Mont. County, N. Y	....	From G. R. Lumsden, Orig. No. 257.
6387	March, 1886...	Presented	Galena	1	Pennsylvania	....	From G. R. Lumsden, Orig. No. 263.
6388	March, 1886...	Presented	Gold bearing quartz	1	Mariposa	....	From G. R. Lumsden, Orig. No. 269.
6389	March, 1886...	Presented	Hornstone	1	Vermont	....	From G. R. Lumsden, Orig. No. 272.
6390	March, 1886...	Presented	Beryl	1	New Haven, Conn	....	From G. R. Lumsden, Orig. No. 277.
6391	March, 1886...	Presented	Limestone crystals	1	Kentucky	....	From G. R. Lumsden, Orig. No. 279.
6392	March, 1886...	Presented	Muscovite	1	Connecticut	....	From G. R. Lumsden, Orig. No. 281.
6393	March, 1886...	Presented	Iron pyrites	1	Pennsylvania	....	From G. R. Lumsden, Orig. No. 293.
6394	March, 1886...	Presented	Galena	1	Rossie, N. Y	....	From G. R. Lumsden, Orig. No. 295.
6395	March, 1886...	Presented	Stilbite	1	Sandy Cove, N. S	....	From G. R. Lumsden, Orig. No. 297.
6396	March, 1886...	Presented	Sand (for making glass)	Indef.	Mystic, Conn	....	From G. R. Lumsden, Orig. No. 299.
6397	March, 1886...	Presented	Asbestos	Indef.	Canada	....	From G. R. Lumsden, Orig. No. 300.

6398	March, 1886..	Presented..........	Leelite..	1	Chester Co, Pa..........	....	From G. R. Lumsden, Orig. No. 301.
6399	March, 1886..	Presented..........	Allanite..	1	....	....	From G. R. Lumsden, Orig. No. 302.
6400	March, 1886..	Presented..........	Asbestos..	1	St. Albans, Canada...	....	From G. R. Lumsden, Orig. No. 304.
6401	March, 1886..	Presented..........	Crystals of beryl..............................	1	New London, N. H....	....	From G. R. Lumsden, Orig. No. 305.
6402	March, 1886..	Presented..........	Garnet sand....................................	Indef.	Sturbridge, Mass......	....	From G. R. Lumsden, Orig. No. 309.
6403	March, 1886..	Presented..........	Crystal of mica................................	1	Haddam, Conn.........	....	From G. R. Lumsden, Orig. No. 310.
6404	March, 1886..	Presented..........	Porcelain and china (from feldspar).....	3	Delaware	....	From G. R. Lumsden, Orig. No. 311.
6405	March, 1886..	Presented..........	Clay, pebbles and pyrites	Indef.	Lake Michigan...	....	From G. R. Lumsden, Orig. No. 312.
6406	March, 1886..	Presented..........	Kaolin	Indef.	Saxony, Germany.....	....	From G. R. Lumsden, Orig. No. 313.
6407	March, 1886..	Presented..........	Moon-stone..	Indef.	Haddam, Conn.........	....	From G. R. Lumsden, Orig. No. 318.
6408	March, 1886..	Presented..........	Garnets..	Indef.	Willimantic, Conn....	....	From G. R. Lumsden, Orig. No. 338.
6409	March, 1886..	Presented..........	Garnets..	1	New Haven, Conn.....	....	From G. R. Lumsden, Orig. No. 340
6410	March, 1886..	Presented..........	Piece of stalagmite...........................	1	Howe's Cave, N. Y....	....	From G. R. Lumsden, Orig. No. 350.
6411	March, 1886..	Presented..........	Foliated sulphate of lime..................	1	Connecticut..............	....	From G. R. Lumsden, Orig. No. 370.
6412	March, 1886..	Presented..........	Asbestos..	1	Norwalk, Conn.........	....	From G. R. Lumsden, Orig. No. 380.
6413	March, 1886..	Presented..........	Rose quartz.....................................	1	New Britain, Conn....	....	From G. R. Lumsden, Orig. No. 410.
6414	March, 1886..	Presented..........	Chrysoberyl.....................................	7	Haddam, Conn.........	....	From G. R. Lumsden, Orig. No. 414.
6415	March, 1886..	Presented..........	Feldspar..	1	Fort Plain, N. Y.......	....	From G. R. Lumsden, Orig. No. 415.
6416	March, 1886..	Presented..........	Volcanic glass..................................	Indef.	Crater of Owbyhee...	....	From G. R. Lumsden, Orig. No. 490.
6417	March, 1886..	Presented..........	Beryl (emerald)................................	Indef.	East Siberia.............	....	From G. R. Lumsden, Orig. No. 500.
6418	March, 1886..	Presented..........	Glassy feldspar................................	1	Drachenfels, Germ....	....	From G. R. Lumsden, Orig. No. 3.
6419	March, 1886..	Presented..........	Gypsum...	2	....	....	From G. R. Lumsden, Orig. No. 19.
6420	March, 1886..	Presented..........	Iron pyrites.....................................	2	....	....	From G. R. Lumsden, Orig. No. 22.
6421	March, 1886..	Presented..........	Chalcopyrite, galena and calcite..........	3	....	....	From G. R. Lumsden, Orig. No. 71.
6422	March, 1886..	Presented..........	Siderite..	1	....	....	From G. R. Lumsden, Orig. No. 91.
6423	March, 1886..	Presented..........	Wood opal	1	....	....	From G. R. Lumsden, Orig. No. 109.
6424	March, 1886..	Presented..........	Malachite (earthy)	Indef.	....	....	From G. R. Lumsden, Orig. No. 274.
6225	March, 1886..	Presented..........	Tremolite...	1	....	....	From G. R. Lumsden, Orig. No. 289.
6226	March, 1886..	Presented..........	Black limestone...............................	1	....	....	From G. R. Lumsden, Orig. No. 307.
6427	March, 1886..	Presented..........	Agate (polished)..............................	1	....	....	From G. R. Lumsden, Orig. No. 390.
6428	March, 1886..	Presented..........	Beryl..	5	....	....	From G. R. Lumsden, Orig. No. 460.
6429	March, 1886..	Presented..........	Wood jasper.	1	....	....	From G. R. Lumsden, Orig. No. 470.
6430	March, 1886..	Presented..........	Petrified wood	1	....	....	From G. R. Lumsden.
6431	March, 1886..	Presented..........	Concretions.....................................	4	Ill ?........................	....	From G. R. Lumsden.
6432	Jan., 1886	Presented..........	Ostrea bellaplicata...........................	10	Sherman, Texas........	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6433	Jan., 1886	Presented..........	Ostrea quadriplicata.........................	10	Denison, Texas.........	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6434	Jan., 1886.....	Presented..........	Ostrea quadriplicata (or allied species)..	5	Denison, Texas.........	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6435	Jan., 1886	Presented..........	Ostrea carinata	5	Denison, Texas.........	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6436	Jan., 1886	Presented..........	Gryphæa pitcheri..............................	20	Denison, Texas.........	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6437	Jan., 1886	Presented..........	Gryphæa pitcheri variety..................	5	Denison, Texas.........	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6438	Jan., 1886	Presented..........	Gryphæa pitcheri variety..................	5	Denison, Texas.........	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6439	Jan., 1886	Presented..........	Exogyra ariatenum...........................	15	Denison, Texas.........	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6440	Jan., 1886.....	Presented..........	Exogyra matheroniana.......................	3	Ft. Worth, Texas	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6441	Jan., 1886	Presented..........	Cordium	1	Denison, Texas.........	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6442	Jan., 1886	Presented..........	Corbula graysonensis.......................	2	Sherman, Texas........	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6443	Jan., 1886	Presented..........	Lima wacoensis................................	1	Denison, Texas.........	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6444	Jan., 1886.....	Presented..........	Neitha texana..................................	3	Denison, Texas.........	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6445	Jan., 1886.....	Presented..........	Terebratula wacoensis.	15	Ft. Worth, Texas......	Cretaceous	From F. A. Sampson, Sedalia, Mo.

SPECIMENS REGISTERED IN THE GENERAL MUSEUM IN 1887–88.—(*Continued.*)

Serial No.	Obtained. When.	Obtained. Whence.	Name.	Number of Specimen.	Locality.	Formation.	Collector and Remarks.
6446	Jan., 1886	Presented	Serpula communis	4	Denison, Tex	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6447	Jan., 1886	Presented	Serpula communis	1	Denison, Tex	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6448	Jan., 1886	Presented	Holaster elegans	2	Denison, Tex	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6451	Jan., 1886	Presented	Chonophyllum sedalienis, White	4	Sedalia, Mo		From F. A. Sampson, Sedalia, Mo.
6452	Jan., 1886	Presented	Michelina expansa, White	4	Sedalia, Mo		From F. A. Sampson, Sedalia, Mo.
6453	Jan., 1886	Presented	Michelina placenta, White	2	Sedalia, Mo		From F. A. Sampson, Sedalia, Mo.
6454	Jan., 1886	Presented	Zaphrentis calceola, W & W	10	Sedalia, Mo		From F. A. Sampson, Sedalia, Mo.
6455	Jan., 1886	Presented	Flabellum weilesii, Conr	10	Jackson, Miss	Tertiary	From F. A. Sampson, Sedalia, Mo.
6456	Jan., 1886	Presented	Turbinola machurii	2	Jackson, Miss	Tertiary	From F. A. Sampson, Sedalia, Mo.
6457	Jan., 1886	Presented	Osteodes	5	Jackson, Miss	Tertiary	From F. A. Sampson, Sedalia, Mo.
6458	Jan., 1886	Presented	Cellopora	5	Jackson, Miss	Tertiary	From F. A. Sampson, Sedalia, Mo.
6459	Jan., 1886	Presented	Cellopora informata, Lonsd	3	Jackson, Miss	Tertiary	From F. A. Sampson, Sedalia, Mo.
8460	Jan., 1886	Presented	Heteropora tortilis	5	Jackson, Miss	Tertiary	From F. A. Sampson, Sedalia, Mo.
6461	March, 1886	Exchange	Diabase	1	Near Leesburg, Va		Smithsonian Inst., Washington, D. C.
6462	March, 1886	Exchange	Diabase	1	Addison, Maine		Smith. Inst., Wash., Orig. No. 37,019.
6463	March, 1886	Exchange	Diabase	1	York, Pa		Smith. Ins., Wash., Orig. No. 37,020.
6464	March, 1886	Exchange	Diabase	1	Somerville, Mass		Smith. Inst., Wash., Orig. No. 37,633.
6465	March, 1886	Exchange	Olivine diabase	1	Lewiston, Maine		Smith. Inst., Wash., Orig. No. 37,618.
6466	March, 1886	Exchange	Norite	1	Nahant, Mass		Smith. Inst., Wash., Orig. No. 35,931.
6467	March, 1886	Exchange	Melapbyr	1	Brighton, Mass		Smith. Inst., Wash., Orig. No. 26,552.
6468	March, 1886	Exchange	Melaphyr	1	Brighton, Mass		Smith. Inst., Wash., Orig. No. 35,940.
6469	March, 1886	Exchange	Amphibolite	1	Chester, Mass		Smith. Inst., Wash., Orig. No. 37,655.
6470	March, 1886	Exchange	Hypersthene andesite	1	Mt. Shasta, Calif		Smith. Inst., Wash., Orig. No. 36,978.
6471	March, 1886	Exchange	Hornblende andesite	1	Mt. Shasta, Calif		Smith. Inst., Wasb., Orig. No. 36,977.
6472	March, 1886	Exchange	Hornblende andesite	1	Mexico, Mexico		Smith. Inst., Wash., Orig. No. 37,711.
6473	March, 1886	Exchange	Elæolite syenite	1	N'r Deckertown, N.J.		Smith. Inst., Wash., D. C.
6474	March, 1886	Exchange	Elæolite syenite	1	S. Litchfield, Maine		Smith. Inst., Wash., Orig. No. 35,935.
6475	March, 1886	Exchange	Rhyolite	1	Zacatecas, Mexico		Smith. Inst., Wash., Orig. No. 37,994.
6476	March, 1886	Exchange	Rhyolite	1	Zacatecas, Mexico		Smith. Inst., Wash , D. C.
6477	March, 1886	Exchange	Rhyolite tuff	1	Zacatecas, Mexico		Smith. Inst., Wash., Orig. No. 37,737.
6478	March, 1886	Exchange	Rhyolite tuff	1	Douglass Co, Colorado		Smith. Inst., Wash., Orig. No. 36,778.
6479	March, 1886	Exchange	Rhyolite tuff	1	Zacatecas, Mexico		Smith. Inst., Wash., Orig. No. 37,693.
6480	March, 1886	Exchange	Basalt	1	Coast of Ireland		Smith. Inst., Wash., Orig. No. 37,610.
6481	March, 1886	Exchange	Basalt	1	Zacatecas, Mexico		Smith. Inst., Wash., Orig. No. 37,786.
6482	March, 1886	Exchange	Leucite basalt	1	Vesuvius, flow of 1872		Smith. Inst., Wash., Orig. No. 36,144.
6483	March, 1886	Exchange	Obsidian	1	Mono Craters, Calif		Smith. Inst., Wash., Orig. No. 29,631.
6484	March, 1886	Exchange	Satin spar	1	Pueblo, Mexico		Smith. Inst., Wash., Orig. No. 37,815.

6487	April, 1886....	Geol. Survey......	Cryptozoon Minnesotense, Winch.........	1	Mankato...................	Shakopee...	N. H. Winchell.
6488	April, 1886....	Geol. Survey......	St. Lawrence limestone.....................	7	St. Lawrence...........	St. Law......	N. H. Winchell.
6490	Sept., 1885.....	Geol. Survey......	Orthis sandbergi, Winchell..................	1	Red Wing................	St. Croix...	N. H. Winchell from 6070.
6491	May, 1886......	Geol. Survey......	Kaolin..	Indef.	Redwood Falls....	Archæan...	N. H. Winchell (from Col. J. B. Clough).
6492	May, 1886......	Geol. Survey......	Black loam soil....................Orig. No. 1	Indef.	Tracy, Minn...........	Drillings of the Tracy deep well.	N. H. Winchell, No. ft. 1, depth 1
6493	May, 1886......	Geol. Survey......	Yellowish pebbly clay............ " 2	Indef.	Tracy, Minn.....		N. H. Winchell, No. ft. 19, depth 20
6494	May, 1886......	Geol. Survey......	Blue till.............. .... " 3	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 100, depth 120
6495	May, 1886......	Geol. Survey......	Fine gravel, nearly black......... " 4	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 5, depth 125
6496	May, 1886......	Geol. Survey......	Fine blue clay......................... " 5	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 20, depth 145
6497	May, 1886......	Geol. Survey......	Coarse gravel (similar to No. 4).. " 6	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 20, depth 165
6498	May, 1886......	Geol. Survey......	Fine blue clay......................... " 7	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 12, depth 177
6499	May, 1886......	Geol. Survey.....	Fine sandstone, homogeneous... " 8	Indef.	Tracy, Minn.....		N. H. Winchell, No. ft. 20, depth 197
6500	May, 1886......	Geol. Survey......	Dark gray shale..... .... " 9	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 213, depth 410
6501	May, 1886......	Geol. Survey......	Fine light blue or greenish sand " 10	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 60, depth 470
6502	May, 1886......	Geol. Survey......	Blue clay................................ " 11	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 43, depth 513
6503	May, 1886......	Geol. Survey......	Cretaceous grit........................ " 12	Indef.	Tracy, Minn.....		N. H. Winchell, No. ft. 32, depth 545
6504	May, 1886......	Geol. Survey......	Fine gray saudstone................ " 13	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 5, depth 550
6505	May, 1886......	Geol. Survey......	Blue clay like that of 6502....... " 14	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 30, depth 580
6506	May, 1886......	Geol. Survey......	Angular, rounded grains of sand " 15	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 7, depth 587
6507	May, 1886......	Geol. Survey......	Dark unctuous, fine clay.......... " 16	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 24, depth 611
6508	May, 1886... ..	Geol. Survey......	White, kaolinic clay................ " 17	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 8, depth 619
6509	May, 1886......	Geol. Survey......	White and gray quartz sand..... " 18	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 8, depth 627
6510	May, 1886......	Geol. Survey......	Same, but w some kaolinic m't'r'l " 19	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 10, depth 637
6511	May, 1886......	Geol. Survey......	White kaolin, with blue clay.... " 20	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 25, depth 662
6512	May, 1886......	Geol. Survey......	White angular quartz sand...... " 21	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 2, depth 664
6513	May, 1886......	Geol. Survey......	Same as last............................ " 22	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 2, depth 666
6514	May, 1886......	Geol. Survey......	Same, but finer........................ " 23	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 6, depth 672
6515	May, 1886......	Geol. Survey......	White sand w some kaolinic mt'l " 24	Indef.	Tracy, Minn..........		N. H. Winchell, No. ft. 18, depth 690
6516	May, 1886......	Geol. Survey......	Reddish orthoclastic granite..... " 25	Indef.	Tracy, Minn...........		N. H. Winchell, No. ft. 25, depth 715
6517	May, 1886......	Geol. Survey......	Drillings from Lakewood Cem't'ry well	Indef.	Minneapolis, Minn...	....	N. H. Winchell, at 2118 ft.
6518	May, 1886......	Presented...........	Trochus missouriensis (sw)..................	1	Kansas City, Mo.....	Coal meas.	From A. M. Light.
6520	Oct., 1886......	A. F. Bechdolt....	Fossil leaves..	29	Nr source Rosebud riv, Mont	....	On Tongue river slope of the Wolf Mts.
6521	Oct., 1886......	A. F. Bechdolt....	Quercus Winchellii sp. nov..................	....	" "	....	Orig. No. 1, 1a. From 6520.
6522	Oct., 1886......	A. F. Bechdolt....	Hamamelites latifolius sp. nov.............	....	" "	....	Orig. No. 2, 3d, 4, 5, 11, 11a. 19, 20, 26. From 6520.
6523	Oct., 1886.	A. F. Bechdolt....	Cratœgus Wyomingiana, Lesq............	....	" "	....	Orig. No. 2a, 2b, 7, 7a, 7b, 7c, 7e, 9, 11b, 14, 15, 18, 19a, 22a, 27, 30, and 31. From 6520.
6524	Oct., 1886......	A. F. Bechdolt....	Artocarpidium intermedium sp. nov.....	....	" "	....	Orig. No. 2c, 8. From 6520.
6525	Oct., 1886......	A. F. Bechdolt....	Ficus producta sp. nov.........................	....	" "	....	Orig No. 3, 3a, 3b, 3c, 7d, 11c, 11f, 11g, 13a, 14a, 19b, 21a, 22, 28, 29. From 6520.
6526	Oct., 1886......	A. F. Bechdolt....	Hamamelites latifolius and seed of [V'b'm.	....	" "	....	Orig. No. 6, 6a. From 6520.
6527	Oct., 1886......	A. F. Bechdolt....	Quercus ettinghausii sp. nov................	....	" "	....	Orig. No. 10. From 6520.
6528	Oct., 1886	A. F. Bechdolt....	Cornus forshammeri Heer....................	....	" "	....	Orig. No. 12, 13. From 6520.
6529	Oct., 1886......	A. F. Bechdolt....	Ficus dura sp. nov..............................	....	" "	....	Orig. No. 16, 25. From 6520.
6530	Oct., 1886......	A. F. Bechdolt....	Diospyros, calix of fruit......................	....	" "	....	Orig. No. 17. From 6520.
6531	Oct., 1886	A. F. Bechdolt....	Viburnum heerii sp. nov......................	....	" "	....	Orig. No. 21. From 6520.
6532	Oct., 1886......	A. F. Bechdolt....	Cornus? specis undeterminable...........	....	" "	....	Orig. No. 23. From 6520.
6533	Oct., 1886......	A. F. Bechdolt....	Seed of Viburnum................................	....	" "	....	Orig. No. 24. From 6520.
6534	Oct., 1886......	A. F. Bechdolt....	Apeilopsis grandifolia sp. nov..............	....	" "	....	Orig. No. 32, 33. From 6520.
6535	Oct., 1886......	A. F. Bechdolt....	Seed of Viburnum? heerii? sp. nov.......	....	" "	....	Orig. No. 34. From 6520.
6537	Sept., 1885.....	H. B. Griffin........	Concretion..	1	Long Lake, Hennepin Co....	Cret..........	Forty feet below surface. Presented.

SPECIMENS REGISTERED IN THE GENERAL MUSEUM IN 1887-88.—(*Continued.*)

Serial No.	Obtained.		Name.	Number of Specimen.	Locality.	Formation.	Collector and Remarks.
	When.	Whence.					
6538	Sept., 1887	J. W. Bird	Wood	1	Martin Co., Minn	Drift	From a well 68 feet below surface.
6539	Sept., 1887	Hon. C. B. Little	Muscovite	1	Grafton, N. H		Presented.
6540	Sept., 1887	Rev.G.H.Trabert	Agate conglomerate	1	Duluth, Minn	Drift	Presented. From a boulder.
6541	Sept., 1887	York Iron Co	Charcoal	1	Black River Falls		Presented.
6542	Sept., 1887	Exchange	Nickeliferous jasper	1	Riddle,Dougl's Co.,Or		From Wm. Q. Brown.
6543	Sept., 1887	Geol. Survey	Iron and copper	1	Tower, Minn		H. V. Winchell. Lee Mine.
6544	Sept., 1887	Geol. Survey	Hematite in quartz	1	Tower, Minn		H. V. Winchell. Lee Mine.
6545	Sept., 1887	Geol. Survey	Quartz crystals	4	Tower, Minn		H. V. Winchell.
6546	Sept., 1887	Geol. Survey	Hematite	1	Tower, Minn		H. V. Winchell.
6547	Sept., 1887	Geol. Survey	Red jasper conglomerate	1	Shores of Rainy Lake	Drift	H. V. Winchell.
6548	Sept., 1887	Geol. Survey	Coarse hornblende quartz	1	Winibigoshish dam		H. V. Winchell. From a boulder.
6549	Sept., 1887	Geol. Survey	Sand	Indef.	Rainy Lake		H. V. Winchell. Sec. 28, 71, 23.
6550	Sept., 1887	Geol. Survey	Iron from furnace	1	Black River Falls		N. H. Winchell.
6553	Nov., 1887	Geol. Survey	Hinckley sandstone	1	Cattle River quarry	Potsdam	N. H. Winchell.
6555	Jan., 1888	Presented	Coarse syenite	2	Red Wing	Drift	From Dr. G. A. Newman.
6556	Feb., 1888	Presented	Conocephalites hamulus, Hall	2	Winona, Minn	Silurian	From W. A. Finkelnburg.
6557	Feb., 1888	Presented	Platyceras minutissimum (Wal.)	3	Marine Mills, Minn	Silurian	From W. A. Finkelnburg.
6558	Feb., 1888	Presented	Bellerophon antiquatus (Wal.)	2	Osceola, Wis	Silurian	From W. A. Finkelnburg.
6559	Feb., 1888	Presented	Lingulepis pinnaformis, Owen	3	Taylors Falls, Minn	Silurian	From W. A. Finkelnburg. Short valve.
6560	Feb., 1888	Presented	Lingulepis pinnaformis	3	Taylors Falls, Minn	Silurian	From W. A. Finkelnburg. Long valve.
6561	Feb., 1888	Presented	Obolella polita, Hall	4	Dresbach, Minn	Silurian	From W. A. Finkelnburg.
6562	Feb., 1888	Presented	Chariocephalus whitfieldi, Hall	2	Wis. opp. Winona, M.	Silurian	From W. A. Finkelnburg. Glabella.
6563	Feb., 1888	Presented	Dikelocephalus osceola (Hall)	1	Osceola Mills, Wis	Silurian	From W. A. Finkelnburg. Head.
6564	Feb., 1888	Presented	Dikelocephalus osceola	1	Osceola Mills, Wis	Silurian	From W. A. Finkelnburg. Pygidium.
6565	Feb., 1888	Presented	Conocephalites minors Shum	3	Minneiska, Minn	Silurian	From W. A. Finkelnburg. Glabella.
6566	Feb., 1888	Presented	Conocephalites, Oweni Hall	4	Marine Mills, Minn	Silurian	From W.A.F'g. Glabella, fixed cheeks.
6567	Feb., 1888	Presented	Illænurus quadratus, Hall	2	Osceola Mills, Wis	Silurian	From W. A. Finkelnburg. Free cheeks.
6568	Feb., 1888	Presented	Illænurus quadratus	3	Osceola Mills, Wis	Silurian	From W. A. Finkelnburg. Glabella.
6569	Feb., 1888	Presented	Illænurus quadratus	2	Osceola Mills, Wis	Silurian	From W. A. Finkelnburg. Pygidium.
6570	Feb., 1888	Presented	Palæmæa minneiskænsis, Wal	8	Minneiska, Minn	Silurian	From W. A. Finkelnburg.
6576	Feb., 1888	Exchange	Felsyte	1	Sec.17,T.33,R.5(E),Mo		From Erasmus Haworth, Orig. No. 316
6577	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 9, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 317
6578	Feb., 1888	Exchange	Quartz-porphory	1	Sec. 16, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 318
6579	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec. 16, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 319
6580	Feb., 1888	Exchange	Granite	1	Sec. 9, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 320
6581	Feb., 1888	Exchange	Quartz-porphyry	1	Missouri		From Erasmus Haworth, Orig. No. 321

6582	Feb., 1888	Exchange	Quartz-ironstone	1	Sec. 9, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 322
6583	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 9, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 323
6584	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 18, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 324
6585	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 9, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 325
6586	Feb., 1888	Exchange	Granite	1	Sec. 11, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 326
6587	Feb., 1888	Exchange	Granite	1	Sec. 9, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 327
6588	Feb., 1888	Exchange	Quartz-orthoclase	1	Sec. 20, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 328
6589	Feb., 1888	Exchange	Porphyry-orthoclase	1	Sec. 29, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 329
6590	Feb., 1888	Exchange	Porphyry-orthoclase	1	Sec. 21, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 330
6591	Feb., 1888	Exchange	Porphyry-orthoclase	1	Sec. 28, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 331
6592	Feb., 1888	Exchange	Orthoclase-porphyry	1	Sec. 29, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 322
6593	Feb., 1888	Exchange		1	Sec. 32, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 333
6594	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec. 32, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 334
6595	Feb., 1888	Exchange	Altered dioryte (?)	1	Sec. 32, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 335
6596	Feb., 1888	Exchange	Chert	1	Sec. 32, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 336
6597	Feb., 1888	Exchange		1	Sec. 32, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 337
6598	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 31, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 338
6599	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 31, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 339
6600	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 6, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 340
6601	Feb., 1888	Exchange	Orthoclase-porphyry	1	Sec. 6, T. 32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 341
6602	Feb., 1888	Exchange	Diabase	1	Sec. 16, T. 32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 342
6603	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec. 16, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 343
6604	Feb., 1888	Exchange	Orthoclase-porphyry	1	Sec. 15, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 344
6605	Feb., 1888	Exchange	Granite	1	Sec. 15, T. 33, R. 5, Mo		From Erasmus Haworth, Orig. No. 345
6606	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 27, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 347
6607	Feb., 1888	Exchange	Diabase	1	Sec. 17, T. 33, R. 6, Mo.		From Erasmus Haworth, Orig. No. 348
6608	Feb., 1888	Exchange	Diabase	1	Sec. 17, T. 33, R. 6, Mo.		From Erasmus Haworth, Orig. No. 349
6609	Feb., 1888	Exchange		1	Sec. 19, T. 33, R. 6, Mo.		From Erasmus Haworth, Orig. No. 350
6610	Feb., 1888	Exchange		1	Sec. 19, T. 33, R. 6, Mo.		From Erasmus Haworth, Orig. No. 351
6611	Feb., 1888	Exchange		1	Sec. 5, T. 32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 352
6612	Feb., 1888	Exchange		1	Mo.		From Erasmus Haworth, Orig. No. 353
6613	Feb., 1888	Exchange		1	Mo.		From Erasmus Haworth, Orig. No. 354
6614	Feb., 1888	Exchange		1	Mo.		From Erasmus Haworth, Orig. No. 355
6615	Feb., 1888	Exchange		1	Mo.		From Erasmus Haworth, Orig. No. 356
6616	Feb., 1888	Exchange		1	Mo.		From Erasmus Haworth, Orig. No. 357
6617	Feb., 1888	Exchange	Duplicate samples	14	Mo.		From Erasmus Haworth, Orig. No. .....
6618	Feb., 1888	Exchange	Altered diabase (?)	1	Sec. 4, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 358
6619	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 19, T. 33, R. 6, Mo.		From Erasmus Haworth, Orig. No. 360
6620	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 14, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 361
6621	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 18, T. 33, R. 6, Mo.		From Erasmus Haworth, Orig. No. 362
6622	Feb., 1888	Exchange	Granite	1	Sec. 4, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 363
6623	Feb., 1888	Exchange	Granite	1	Sec. 3, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 364
6624	Feb., 1888	Exchange	Diabase	1	Sec. 3, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 365
6625	Feb., 1888	Exchange	Diabase-porphyry	1	Sec. 10, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 366
6626	Feb., 1888	Exchange	Granite	1	Sec. 10, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 367
6627	Feb., 1888	Exchange	Granite	1	Sec. 11, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 368
6628	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 11, T. 33, R. 5. Mo.		From Erasmus Haworth, Orig. No. 369
6629	Feb., 1888	Exchange	Diabase	1	Sec. 14, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 370

Specimens Registered in the General Museum in 1887-88.—(*Continued.*)

Serial No.	Obtained. When.	Obtained. Whence.	Name.	Number of Specimens.	Locality.	Formation.	Collector and Remarks.
6630	Feb., 1888	Exchange	Granite	1	Sec.14, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 371
6631	Feb., 1888	Exchange	Quartz-porphyry	1	Sec.14, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 372
6632	Feb., 1888	Exchange	Decomposed conglomerate	1	Sec.13, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 373
6633	Feb., 1888	Exchange	Quartz-porphyry	1	Sec.13, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 374
6634	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec.13, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 375
6635	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec.24, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 376
6636	Feb., 1888	Exchange	Diabase	1	Sec.25, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 377
6637	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec.25, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 378
6638	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec.26, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 379
6639	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec.35, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 380
6640	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec. 3, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 381
6641	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 3, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 382
6642	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec.10, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 383
6643	Feb., 1888	Exchange		1	Sec.16, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 384
6644	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec.21, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 385
6645	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec.21, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 386
6646	Feb., 1888	Exchange	Plagioclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 387
6647	Feb., 1888	Exchange	Altered diabase	1	Mo.		From Erasmus Haworth, Orig. No. 388
6648	Feb., 1888	Exchange	Plagioclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 389
6649	Feb., 1888	Exchange	Plagioclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 390
6650	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec.17, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 391
6651	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec.20, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 392
6652	Feb., 1888	Exchange	Marble	1	Sec.18, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 393
6653	Feb., 1888	Exchange	Limestone	1	Sec.19, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 394
6654	Feb., 1888	Exchange	Quartzyte	1	Sec.19, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 395
6655	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 7, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 396
6656	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec. 7, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 397
6657	Feb., 1888	Exchange	Orthoclase-porphyry	1	Sec. 8, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 398
6658	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec.30, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 399
6659	Feb., 1888	Exchange	Orthoclase-porphyry	1	Sec.30, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 400
6660	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec.19, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 401
6661	Feb., 1888	Exchange	Orthoclase-porphyry	1	Sec.15, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 402
6662	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec.14, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 403
6663	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec.23, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 404
6664	Feb., 1888	Exchange	Altered diabase	1	Sec.23, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 405
6665	Feb., 1888	Exchange	Plagioclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 406

6666	Feb., 1888	Exchange	Plagioclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 407
6667	Feb., 1888	Exchange	Epidote-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 408
6668	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 409
6669	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 410
6670	Feb., 1888	Exchange	Diabase	1	Mo.		From Erasmus Haworth, Orig. No. 411
6671	Feb., 1888	Exchange	Orthoclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 412
6672	Feb., 1888	Exchange	Orthoclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 413
6673	Feb., 1888	Exchange	Diabase	1	Mo.		From Erasmus Haworth, Orig. No. 414
6674	Feb., 1888	Exchange	Diabase	1	Mo.		From Erasmus Haworth, Orig. No. 415
6675	Feb., 1888	Exchange	Diabase	1	Mo.		From Erasmus Haworth, Orig. No. 416
6676	Feb., 1888	Exchange	Rewdanskite (?)	1	Riddles, Oregon		From W. Q. Brown.
6677	Feb., 1888	Exchange	Garnierite and serpentine	1	Riddles, Oregon		From W. Q. Brown.
6678	Feb., 1888	Exchange	Chrysoprase	1	Riddles, Oregon		From W. Q. Brown.
6679	Feb , 1888	Exchange	Garnierite (soft)	1	Riddles, Oregon		From W. Q. Brown.
6680	Feb., 1888	Exchange	Garnierite and chromic iron	1	Riddles, Oregon		From W. Q. Brown.
6681	Feb., 1888	Presented	Copper ore	1	Globe City, Arizona		From J. L. Vivian.
6682	Feb., 1888	Presented		1			
6683	April, 1888	Presented	Geyserite	Indef.	Lindsborg, Kans	Niagara	From J. H. Udden.
6684	April, 1888	Exchange	Pentamerus oblongus, Saw	2	Springfield, Ohio	Niagara	From W. S. Hoskinson.
6685	April, 1888	Exchange	Zaphrentis	2	Delaware Co., Ohio	Dev. Corn.	From W. S. Hoskinson.
6686	April, 1888	Exchange	Zaphrentis	2	Delaware Co., Ohio	Dev. Corn.	From W. S. Hoskinson.
6687	April, 1888	Exchange	Orthocerata	2	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.
6688	April, 1888	Exchange	Orthocerata	1	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.
6689	April, 1888	Exchange	Orthocerata	1	Miamisburg, Ohio	U.H'dn riv	From W. S. Hoskinson.
6690	April, 1888	Exchange	Cyathophylloid	3	Springfield, Ohio	Niagara	From W. S. Hoskinson.
6691	April, 1888	Exchange	Cyathophylloid	4	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.
6692	April, 1888	Exchange	Strophodonta-hemispherica	1	Delaware Co., Ohio	Dev. Corn.	From W. S. Hoskinson.
6693	April, 1888	Exchange	Strophomena-rhomboidalis	2	Waldron, Ind	Niagara	From W. S. Hoskinson.
6694	April, 1888	Exchange	Strophomena-rhomboidalis	2	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.
6695	April, 1888	Exchange	Illænus daytonensis	4	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.
6696	April, 1888	Exchange	Streptelamina	4	Miamisburg, Ohio	L. Sil	From W. S Hoskinson.
6697	April, 1888	Exchange	Favosites	2	Delaware Co., Ohio	Dev. Corn.	From W. S. Hoskinson.
6698	April, 1888	Exchange	Favistella	2	New Carlisle, Ohio	Clinton	From W. S.Hoskinson.
6699	April, 1888	Exchange		2		Dev. Corn.	From W. S. Hoskinson.
6700	April, 1888	Exchange		1	Miamisburg, Ohio	Cincin	From W. S. Hoskinson.
6701	April, 1888	Exchange	Lithostration	1	Springfield, Ohio	Niagara	From W. S. Hoskinson.
6702	April, 1888	Exchange	Eucalyptocrinus crassus	3	Springfield, Ohio	Niagara	From W. S. Hoskikson.
6703	April, 1888	Exchange	Eucalyptocrinus crassus	2	Waldron, Ind		From W. S Hoskinson.
6704	April, 1888	Exchange	Eucalyptocrinus (roots)	2	Waldron, Ind		From W. S. Hoskinson.
6705	April, 1888	Exchange	Crinoid stems	8	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.
6706	April, 1888	Exchange	Crinoid	1	Springfield, Ohio	Niagara	From W. S. Hoskinson.
6707	April, 1888	Exchange	Monticulipora dalii	2	Miamisburg, Ohio		From W. S. Hoskinson.
6708	April, 1888	Exchange	Calymene niagarensis	1	Springfield, Ohio		From W. S. Hoskinson.
6709	April, 1888	Exchange	Calymene senaria	1	Oxford, Ohio	U. Hud. riv	From W. S. Hoskinson.
6710	April, 1888	Exchange	Lichas brevipes	1	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.
6711	April, 1888	Exchange	Spirifera mucronata	1	Miamisburg, Ohio		From W. S. Hoskinson.
6712	April, 1888	Exchange	Atrypa reticularis	4	Delaware Co., Ohio	Dev. Corn.	From W. S. Hoskinson.
6713	April, 1888	Exchange	Platystoma niagarense	2	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.

Specimens Registered in the General Museum in 1887–88.—(*Concluded.*)

Serial No.	Obtained.		Name.	Number of Specimens.	Locality.	Formation.	Collector and Remarks.
	When.	Whence.					
6714	April, 1888	Exchange	Platystoma niagarense	6	Waldron, Ind		From W. S. Hoskinson
6715	April, 1888	Exchange	Eichwaldia reticulata	2	Waldron, Ind	Niagara	From W. S. Hoskinson.
6716	April, 1888	Exchange	Zygospira modesta	3	Miamisburg, O		From W. S. Hoskinson.
6717	April, 1888	Exchange	Leptæna sericea	3	Miamisburg, O	Up. Hud. R	From W. S. Hoskinson.
6718	April, 1888	Exchange	Protarea vetusta, Hall	2	Miamisburg, O		From W. S. Hoskinson.
6719	April, 1888	Exchange	Murchisonia bellicincta	2	Miamisburg, O		From W. S. Hoskinson.
6720	April, 1888	Exchange	Cyclonema bilix	1	Miamisburg, O		From W. S. Hoskinson.
6721	April, 1888	Exchange	Pleurotomaria tropidophora	2	Miamisburg, O		From W. S. Hoskinson.
6722	April, 1888	Exchange	Orthis sinuata	2	Miamisburg, O	Up. Hud. R	From W. S. Hoskinson.
6723	April, 1888	Exchange	Orthis subquadrata	9	Miamisburg, O		From W. S. Hoskinson.
6724	April, 1888	Exchange	Orthis acutilirata	4	Miamisburg, O		From W. S. Hoskinson.
6725	April, 1888	Exchange	Orthis lynx	5	Miamisburg, O		From W. S. Hoskinson.
6726	April, 1888	Exchange	Orthis faustra	1	New Carlisle, O	Clinton	From W. S. Hoskinson.
6727	April, 1888	Exchange	Streptorhynchus sulcatus	1	Miamisburg, O	Up. Hud. R	From W. S. Hoskinson.
6728	April, 1888	Exchange	Streptorhynchus planumbonus	3	Miamisburg, O		From W. S. Hoskinson.
6729	April, 1888	Exchange	Streptorhynchus nutans	3	Miamisburg, O		From W. S. Hoskinson.
6730	April, 1888	Exchange	Strophomena alternata	2	Miamisburg, O		From W. S. Hoskinson.
6731	May, 1888	Presented	Pseudomorph of magnetite and pyrite after garnet.	1	Negaunee, Mich		From N. H. Winchell.
6732	May, 1888	Presented	Rock 60 feet from surface	4	Little Falls, Minn		From N. H. Winchell, at L. F's Brew'y.
6733	May, 1888	Presented	Pyrite from blue till	1	Minnesota	Drift	From N. H. Winchell.
6734	May, 1888	Presented	Pseudomorph hematite	1	Marquette i. r., Mich.		From N. H. Winchell.
6735	May, 1888	Exchange	Tin ore	1	Pennington Co., Dak.		From Sam. Scott, Morgan's Tin Mine.
6736	May, 1888	Exchange	Greisen rock	1	Pennington Co., Dak.		From Sam. Scott, Everly Tin Mine.
6737	May, 1888	Exchange	Spodumene	1	Pennington Co., Dak.		From Sam. Scott, Etta Tin Mine.
6738	May, 1888	Exchange	Rose quartz	1	Pennington Co., Dak.		From Sam. Scott, Red Rose Mine.
6739	May, 1888	Exchange	Albite	1	Pennington Co., Dak.		From Sam. Scott, Etta Tin Mine.
6740	May, 1888	Presented	Albite	2	Amelia Co., Va		G. L. English & Co., Amelia C't House.
6741	May, 1888	Presented	Lingula acuminata	1	New York	Medina Sand.	From Rev. H. Herzer.
6770	Aug., 1888	Presented	Piece of cedar wood	1	Near Camden, Minn.	Drift	From Cyrus R. Stone.
6824	Oct., 1888	Presented	Minerals from Mt Vesuvius	12	Italy		From Mrs. M. J. Wilkin.
6825	Oct., 1888	Presented	Incrustation on gneiss	1	Near Swarthm're col, Pa.		From Miss M. L. Sanford.
6826	Oct., 1888	Presented	Meerschaum	1	Norway		Prof. J. Breda (From the edge of a glacier below Sulitind, Norway.)
6827	Oct., 1888	Presented	Lignite	1	St. Paul, Minn	Drift	Prof. N. H. Winchell.

VI.

APPENDIX.—LIST OF RECENT GEOLOGICAL PUBLICATIONS RELATING TO THE CRYSTALLINE ROCKS.

VI.

LIST OF AMERICAN PUBLICATIONS BETWEEN 1872 AND 1889 THAT HAVE SOME RELATION TO THE CRYSTALLINE ROCKS OF THE NORTHWEST.

This list of publications, while embracing most of those issued since 1872 bearing on the crystalline rocks of Minnesota, or of the Northwest, is not presumed to be complete, and it is desired that geologists who discover omissions will communicate with the writer in order that, in a future report, such additions may be made as will make the list perfect.

The list of papers and other publications prepared by Whitney & Wadsworth and published in the *Bulletin of the Museum of Comparative Zoology*, Cambridge (Geol. Series, Vol. I.), carried the record up to 1880. By the aid of that, and with the assistance of Mr. Geo. H. Barton, of the Institute of Technology, Boston, who examined some serial publications that could not be consulted at Minneapolis, the catalogue may be considered to embrace most of the publications of American geologists on the crystalline rocks of the central and eastern portions of the United States and of Canada, between 1872 and 1889. There are, however, some important serials that have not been consulted.

1873.

BELL, ROBT.

Report on the country between lake Superior and lake Winnipeg. Geol. Sur. of Can., Report of Progress. Montreal, 1872–73, pp. 87–111.

BROOKS, T. B.

Geological Survey of Michigan, with maps, 1869–73, i.; Part I., Iron-bearing Rocks, 319 pp.; Part II., Copper-bearing Rocks, R. Pumpelly and A. R. Marvine, 143 pp.; Part III., Palæozoic Rocks, Charles Rominger, 105 pp.; ii., 298 pp., contains papers by Messrs. Brooks, Julien, Wright, Jenney, and Tuttle.

DANA, J. D.

On the Quartzite, Limestone, and Associated Rocks of the vicinity of Great Barrington, Mass., Am. J. Sci., 3d Series, Vol. 5, pp. 47–53, 87–91; Vol. 6, pp. 257–278.

FOSTER, J. W.

Ancient Mining by the Mound-builders in the "Prehistoric Races of the United States." Chicago, 1873, pp. 361–374.

HITCHCOCK, C. H.

Classification of the Rocks of New Hampshire. Proc. Boston Soc. Nat. Hist., Vol. 15, pp. 304–307.

HUNT, T. STERRY.

The Geology of the North Shore of Lake Superior. (Supplementary Note.) Trans. Am. Inst. Min. Eng., 1873, ii., 58, 59.

IRVING, ROLAND D.

On some points in the Geology of Northern Wisconsin. Trans. Wisc. Acad. Sci., 1873–74, ii., 107–119.

MARVINE, A. R.

Geology of Michigan. Part II., 1873.

NICHOLSON, H. ALLEYNE.

On the Geology of the Thunder bay and Shabendowan Mining Districts on the North Shore of lake Superior. Quart. Jour. Geol. Soc., 1873, xxix., 17–24.

PUMPELLY, RAPHAEL.

The Paragenesis and Derivation of Copper and its Associates on lake Superior. Am. Jour. Sci., 1872 (3), iii., 188–198, 243–258, 347–353; Leonhard's Jahrbuch, 1872, pp. 538–540; Geol. of Michigan, Part II., 1873.

SELWYN, ALFRED R. C.

Notes of a Geological Reconnoissance from lake Superior to Fort Garry. Geol. Surv. of Canada, Report of Progress. Montreal, 1872–73, pp. 8–18.

WHITTLESEY, CHARLES.

On the cause of the Transient Fluctuations of Level in lake Superior. Proc. Am. Assoc. Adv. Sci., 1873, xxii., Part II., 42–46.

WINCHELL, ALEXANDER.

The Diagonal System in the Physical Features of Michigan. Am. Jour. Sci., 1873 (3), vi., 36–40.

WINCHELL, N. H.

Geological and Natural History Survey of Minnesota. First annual report, 113 pp.

WING, A. T.

Concerning the Spontaneous Movements and Fractures of Rock, at Quarry of W. N. Flynt, Monson, Mass. Proc. Bost. Soc. Nat. Hist., Vol. 16, pp. 41–42.

1874.

ALLEN, J. A.

Metamorphism Produced by the Burning of Lignite Beds in Dakota and Montana Territories. Proc. Boston Soc. Nat. Hist., Vol. 16, pp. 246–262.

BROWN, A. J.
The Formation of Fissures and the Origin of Their Mineral Contents. Trans. Am. Inst. Min. Eng., 1874, ii., 215–219.

DANA, JAMES D.
Manual of Geology, New York, 1st ed., 1862, 800 pp.; 2d ed., 1874, 828 pp.; 3d ed., 1880, 911 pp.

DOUGLAS, JAMES.
The Native Copper Mines of lake Superior. Quart. Jour. Sci., 1874, xi., 162–180; Canadian Nat. and Geol., 1874 (2), vii., 318–336.

IRVING, ROLAND D.
On the Age of the Copper-bearing Rocks of lake Superior; and on the Westward Continuation of the lake Superior Synclinal. Am. Jour. Sci., 1874 (3), viii., 46–56.

LE CONTE, J. L.
On Coracite, a new ore of Uranium. Am. Jour. Sci., 1874 (2), iii., 173–175.

M'KELLAR, PETER.
Mining on the North Shore of lake Superior. Toronto, 1874, 26 pp.

NEWBERRY, J. S.
The Iron Resources of the United States. International Review, 1874, ii., 754–780.

NICHOLSON, H. ALLEYNE.
On the Mining District on the North Shore of lake Superior. Trans. of North of England Inst. of Min. and Mech. Eng. Newcastle-on-Tyne, 1874–75, xxiv., 237–249, with maps.

WHITTLESEY, CHARLES.
Sudden Fluctuations of Level in Quiet Waters. Records of Observations. Proc. Am. Assoc. Adv. Sci., 1874, xxiii., 139–143.

1875.

AKERMANN, H. W.
Die Kupferführenden Schichten am lake Superior. Sitzungs-Berichte der naturwissenschaftlichen Gesellschaft Isis in Dresden, 1875, pp. 101–105.

BELL, ROBERT.
The Mineral Region of lake Superior. Canadian Nat. and Geol., 1875 (2), vii., 49–51.

BLAKE, WILLIAM P.
The Mass Copper of lake Superior Mines, and the Method of Mining it. Trans. Am. Inst. Mining Engineers, 1875, iv., 110–112.

CHAPMAN, E. J.
An Outline of the Geology of Ontario, based on a Subdivision of the Province into Six Natural Districts. Canadian Jour., 1875 (2), 580–588.

CHESTER, ALBERT H.

On the Percentage of Iron in Certain Ores. Trans. Am. Inst. Min. Eng., 1875, iv., 219.

DODGE, W. W.

Notes on the Geology of Eastern Massachusetts. Proc. Boston Soc. Nat. Hist., Vol. 17, pp. 388–419.

HUNT, T. STERRY.

The Decayed Gneiss of the Hoosac Mountains. Ibid., Vol. 18, pp. 106–108.

The Development of our Mineral Resources. Harper's Magazine, 1875, li., 82–94.

PUMPELLY, RAPHAEL.

On Pseudomorphs of Chlorite after Garnet at Spurr Mountain Iron Mine. Am. Jour. Sci., 1875 (3), x., 17–21.

SAUVAGE, E.

Notice sur les Minerais de Fer du lac Supérieur. Annales des Mines, 1875 (7), viii., 1–35.

WHITTLESEY, CHARLES.

Physical Geology of lake Superior. Proc. Am. Assoc. Adv. Sci., 1875, xxiv., 60–72.

WINCHELL, N. H.

The Geology of the Minnesota Valley. Second Report on the Geol. and Nat. Hist. Surv. of Minnesota, pp. 127–212.

1876.

BELL, ROBERT.

Report on an Exploration in 1875, between James bay and lakes Superior and Huron. Geol. Surv. of Canada, Report of Progress, 1875–76, pp. 294–342.

BRADLEY, FRANK H.

On a Geological Chart of the United States East of the Rocky Mountains and of Canada. Am. Jour. Sci., 1876 (3), xii., 286–291.

BROOKS, T. B.

On the Youngest Huronian Rocks, South of lake Superior, and the Age of the Copper-bearing Series. Am. Jour. Sci., 1876 (3), xi., 206–211.

Classified List of Rocks observed in the Huronian Series, south of lake Superior, etc. Am. Jour. Sci., 1876 (3), xii., 194–204.

BOUVÉ, T. T.

On the Origin of Porphyry. Proc. Boston Soc. Nat. Hist., Vol. 18, pp. 217–220.

CHAPMAN, E. J.

On the Leading Geological Areas of Canada. Canadian Jour., 1876 (2), xv., 92–122.

CREDNER, HERMANN.

Elemente der Geologie. 1st ed., 1872; 2nd ed., 1872; 3rd ed., 1876; 699 pp., 4th ed., 1880.

EGGLESTON, THOMAS.

Boracic Acid in lake Superior Iron Ores. Trans. Am. Inst. Min. Eng., 1876, v., 131, 132.

GEINITZ, H. B.

Alexander Winchell: über geologische Verhältnisse in Michigan. Leonhard's Jahrbuch, 1876, pp. 438–440.

HOUGHTON, JACOB, Jr.

The Ancient Copper Miners of lake Superior. Iron, 1876 (N. S.), viii., 168, 169, 199; Swineford's Copper, Iron, and other Material Interests of lake Superior. Marquette, 1876, pp. 78–89.

HUNT, T. STERRY.

On the History of the Crystalline Stratified Rocks. A. A. A. S. Vol. 25, pp. 205–208.

HYATT, ALPHEUS.

Remarks upon above paper, and upon the Geology of Marblehead Neck. Proc. Bost. Soc. Nat. Hist., pp. 220–224.

McCRACKEN, S. B.

The State of Michigan, embracing Sketches of its History, Position, Resources, and Industries. Lansing, 1876, pp. 48–69.

ROMINGER, CHARLES.

Observations on the Ontonagon Silver Mining Districts and Slate Quarries of Huron bay. Geol. Surv. of Michigan, 1876, iii., 153–166.

SWEET, E. T.

Notes on the Geology of Northern Wisconsin. Trans. Wisc. Acad., 1875–76, iii., 40–55.

SWINEFORD, A. P.

History and Review of the Copper, Iron, Silver, Slate, and other Material Interests of the South Shore of lake Superior. Marquette, Mich., 1876.

WHITTLESEY, CHARLES.

On the Origin of Mineral Veins. Proc. Am. Assoc. Adv. Sci., 1876, xxv., 213–216.

1877.

BELL, ROBERT.

Report on Geological Researches North of lake Huron and East of lake Superior. Geol. Surv. of Canada, Report of Progress, 1876–77, pp. 193–220.

COURTES, W. M.

The North Shore of lake Superior as a Mineral-bearing District. Trans. Am. Inst. Min. Eng., 1877, v., 473–487.

EGGLESTON, THOMAS.

Copper Mining on lake Superior. Trans. Am. Inst. Min. Eng., 1877, vi., 275–312.

The Conglomerates of lake Superior, and the Methods of Dressing Copper. Trans. Am. Inst. Min. Eng., 1877, v., 606–611.

IRVING, ROLAND D.

Note on the Age of Crystalline Rocks of Wisconsin. Am. Jour. Sci., 1877 (3), xiii., 307–309.

ROLKER, CHARLES M.

The Allouez Mine and Ore Dressing, as practiced in the lake Superior Copper District. Trans. Am. Inst. Min. Eng., 1877, v., 584–606.

STRENG and KLOOS.

Ueber die Krystallinischen Gesteine von Minnesota in Nord-Amerika. Neues Jahrbuch für Mineralogie, Geologie und Palæontologie, 1877, 31–56, 113–138 and 225–242. (Translation in the eleventh annual report of the Geological Survey of Minnesota.)

WADSWORTH, M. E.

Notes on the Mineralogy and Petrography of Boston and Vicinity. (Containing Bibliography of Subject.) Proc. Boston Soc. Nat. Hist., Vol. 19, pp. 217–37.

On the Granite of North Jay, Me. Ibid., pp. 237–38.

1878.

CHAMBERLIN, T. C.

Geology of Wisconsin, 1873–77, ii., 768 pp., with maps. Reports by Messrs. I. A. Lapham, O. W. Wight, T. C. Chamberlin, R. D. Irving, C. E. Wright and Moses Strong.

CLAYPOLE, E. W.

On the Pre-Glacial Geography of the Region of the Great Lakes. Canadian Nat. and Geol., 1878 (2), viii., 187–206.

DANA, JAMES D.

Manual of Mineralogy and Lithology. New York, 1878, 474 pp.

HUNT, T. STERRY.

Chemical and Geological Essays. Boston, 1874, 489 pp.; Revised Edition, Salem, 1878.

Azoic Rocks, Part I., 1878. Second Geol. Surv. of Penn., E, 253 pp.

On the Geology of the Eözoic Rocks of North America. (Abstract.) Proc. Boston Soc. Nat. History, Vol. 19, pp. 275–79.

LE CONTE, JOSEPH.

Elements of Geology; a text-book for colleges and for the general reader. New York, D. Appleton & Co., 588 pp., 8vo.

LAFLAMME, L'ABBÉ J. C.

Note sur le Contact des Formations Paleozoiques et Archéennes de la Province de Quebec. Trans. Roy. Soc. Canada, Vol. IV., Sec. IV., pp. 43–47.

MACFARLANE, JAMES.

Geologist's Traveling Hand-book, New York, 1878, 261 pp.

PUMPELLY, RAPHAEL.

Metasomatic Development of the Copper-bearing Rocks of lake Superior. Proc. Am. Acad., 1878, xiii., 253–309.

SELWYN, ALFRED R. C.

The Stratigraphy of the Quebec Group and the Older Crystalline Rocks of Canada. Geol. Surv. of Canada, Report of Progress, 1877-78, A. 15 pp. Reprinted in the Canadian Nat. and Geol., 1879 (2), ix., 17-32.

SPENCER, J. W.

Lake Superior.—On the Nipigon or Copper-bearing Rocks of lake Superior, with Notes on Copper Mining in that Region. Canadian Nat. and Geol., 1878 (2), viii., 55-81.

WADSWORTH, M. E.

Notes on the Petrography of Quincy and Rockport. Proc. Bost. Soc. Nat. Hist., xix., pp. 309-16.

WRIGHT, CHARLES E.

First Annual Report of the Commissioner of Mineral Statistics of the State of Michigan for 1877-78. Marquette, 1879, 229 pp.

WINCHELL, N H.

Notes on the Line of the Northern Pacific Railroad, and in Morrison County, Minn. Sixth Report Geol. and Nat. Hist. Surv. Minn., pp. 45-53.

1879.

BLANDY, JOHN F.

The lake Superior Copper Rocks in Pennsylvania. Trans. Am. Inst. Min. Eng., 1879, vii., 331-333, 336.

CHAMBERLIN, T. C.

Geology of Wisconsin. 1873-79, iii., 763 pp., with maps. Reports by Messrs. R. D. Irving, R. Pumpelly, A. A. Julien, C. E. Wright, E. T. Sweet, T. B. Brooks, A. Wichmann, T. C. Chamberlin, and T. S. Hunt.

CROSBY, WILLIAM O.

On a Possible Origin of Petrosiliceous Rocks. Proc. Bost. Soc. Nat. Hist., 1879, xx., 160-169.

Evidences of Compression in the Rocks of the Boston Basin. Ibid., xx., pp. 308-313.

DANA, J. D.

On the Hudson River Age of the Taconic Schists, and on the Dependent Relations of the Dutchess County and Western Conn. Limestone Belts. Am. J. Sci., 3d series. Vol. 17, 375-388; Vol. 18, pp. 61-64.

FRAZER, PERSIFOR, Jr.

The lake Superior Copper Rocks in Pennsylvania. Trans. Am. Inst. Min. Eng., 1879, vii., 336-339.

HALL, CHARLES E.

Laurentian Magnetic Iron Ore Deposits of Northern New York, accompanied by a geological map of Essex county. Report of the State Geologist of N. Y., 1884, pp. 23-34. With a supplementary note dated December, 1884.

HUNT, T. STERRY.

The lake Superior Copper Rocks in Pennsylvania. Trans. Am. Inst. Min. Eng., 1879, vii., 333–336, 339.

The History of some Pre-Cambrian Rocks in Europe and America. Am. Jour. Sci., Vol. 19, pp. 268–283; A. A. A. S., Vol. 28, pp. 279–296.

IRVING, ROLAND D.

Note on the Stratigraphy of the Huronian Series of Northern Wisconsin; and on the Equivalency of the Huronian of the Marquette and Penokee Districts. Am. Jour. Sci., 1879 (3), xvii., 393–398.

MACFARLANE, THOMAS.

Remarks on Canadian Stratigraphy. Canadian Nat. and Geol., 1879 (2), ix., 91–102.

MOSLER, CHR.

Der Kupferbergbau am Obern See in Nordamerika. Zeitschr. Berg. Hütt. Salin., 1877, Abhandlungen, xxv., 203–221; 1879, xxvii., 77–97.

SHALER, N. S.

Notes on Certain Evidences of a Gradual Passage from Sedimentary to Volcanic Rocks shown in the Brighton District of Boston. Proc. Boston Soc. Nat. Hist., Vol. 20, pp. 129–133.

WICHMANN, ARTHUR.

A Microscopical Study of some Huronian Clay Slates. Quart. Jour. Geol. Soc., 1879, xxxv., 156–164.

WINCHELL, N. H.

Seventh Annual Report on the Geol. and Nat. Hist. Sur. of Minnesota. Has a general account of the Mining Geology of the region of lake Superior in Minnesota, and a field report by C. W. Hall.

1880.

BAILEY, L. W.

On the progress of Geological Investigation in New Brunswick, 1870–1880. Proc. Am. Assoc. Ad. Sci., Vol. XXIX., pp. 415–421.

BAILEY, L. W., G. F. MATTHEW, and R. W. ELLS.

Report on Geology of Southern New Brunswick, embracing the counties of Charlotte, Sunbury, Queens, Kings, St John and Albert. Geol. Survey of Canada. Reports for 1878-79, D, pp. 1–26.

BELL, ROBERT.

Report on Explorations on the Churchill and Nelson rivers and around God's and Island lakes, 1879. Geol. Survey of Canada for 1878–79, C, pp. 1–72.

BENTON, E. R.

The Amygdaloidal Melaphyr of Brighton, Mass. Proc. Boston Soc. Nat. History, Vol. 20, pp. 416–426.

BROOKS, T. B.

Geology of the Menominee region. Geol. of Wisconsin, Vol. III., Part 7, pp. 430–599.

CHAMBERLIN, T. C.

Geology of the Upper St. Croix District; based on the notes of the late Moses Strong. Geol. of Wisc., Vol. 3, Part 6, pp. 365–428.

CROSBY, W. O.

Distorted Pebbles in Conglomerate. Proc. Bost. Soc. Nat. Hist., Vol. 20, pp. 368–378.

Contributions to the Geology of Eastern Massachusetts. Occasional Papers. Boston Soc. Nat. Hist. (3), 286 pp., with map.

Geology of Frenchman's Bay, Maine. Bost. Soc. Nat. Hist. Proc., Vol. 21, pp. 109–117.

DANA, J. D.

On the Geological Relation of the Limestone Belts of Westchester County, New York. Am. Jour. Sc., Vol. 20, pp. 26–32, 194–220, 359–375, 450–456; Vol. 21, pp. 425–443; Vol. 22, pp. 103–119, 313–315, 327–335.

List of Papers on the Taconic System. Am. Jour. Sc., Vol. 19, pp. 153–155.

DAVIS, W. M.

Banded Amygdules of the Brighton Amygdaloid. Proc. Bost. Soc. Nat. Hist., xx., pp. 426–28.

DAVIS, D. C.

Metalliferous Minerals and Mining. London. 432 pp.; copper rocks, pp. 149–164; iron ores, pp. 274–275.

DILLER, J. S.

Felsites and their Associated Rocks North of Boston. Bost. Soc. Nat. Hist. Proc., Vol. 20, pp. 355–368.

FORD, S. W.

Note on the Trilobite, Atops Trilineatus of Emmons. Am. Jour. Sci., iii., Vol. 19, p. 152.

On the Western Limits of the Taconic System. Am. Jour. Sci., iii., pp. 225–226.

GEIKIE, ARCHIBALD.

On the Archæan Rocks of the Wahsatch Mountains. Am. Jour. Sci., iii., Vol. 19, pp. 363–367.

HALL, C. W.

Report of Prof. C. W. Hall. Geol. and Nat. Hist. Survey of Minn., 8th Annual Report, for 1879, pp. 126–138.

HUNT, T. STERRY.

The History of some Pre-Cambrian Rocks in America and Europe. Am. Jour. Sci., iii., Vol. 19, pp. 268–283.

Letters and Notes on the Iron-bearing and Associated Rocks of the Marquette Region, and Comparisons with the Archæan of Canada and Eastern United States. Geol. of Wisc., Vol. 3, Part 7, pp. 657–660.

IRVING, R. D.

General Geology of the lake Superior Region. Geology of Wisc., Vol. 3, Part 7, pp. 1–24.

Geology of the Eastern lake Superior District. Geology of Wisc., Vol. 3, Part 3, pp. 53–223.

JULIEN, A. A.

Microscopial Examination of Eleven Rocks from Ashland Co., Wisc. Geol, of Wisc., Vol. 3, pp. 224–238.

MARCOU, JULES.

Sur les Colonies dans les Roches Taconiques des Bords du lac Champlain. Bull. Soc. Geol. de France, iii., Tome 9, p. 18.

NEWBERRY, J. S.

The Genesis of Our Iron Ores. School of Mines Quart., November, pp. 1–17.

PEACH and JOHN HORNE.

The Old Red Sandstone of Orkney. Roy. Phys. Soc., April.

PECKHAM, S. F., and HALL, C. W.

On Lintonite and other forms of Thomsonite: A preliminary notice of the zeolites of the vicinity of Grand Marais, Minn. Am. Jour. Sci., iii, Vol. 19, pp. 122-130. Geol. and Nat. Hist. Survey of Minn. 8th Annual Report, for 1879, pp. 166–172.

PUMPELLY, RAPHAEL.

Lithology of the Keweenawan or Copper-bearing System. Geol. of Wisc., Vol. 3, pp. 27–49.

SWEET, E. T.

Geology of Western lake Superior District. Geol. of Wisc., Vol. 3, pp. 305–362.

UPHAM, WARREN.

Preliminary report on the Geology of Central and Western Minnesota. Geol. and Nat. Hist. Survey of Minn., 8th Annual Report, for 1879, pp. 97–103.

WADSWORTH, M. E.

Notes on the Geology of the Iron and Copper Districts of lake Superior. Bulletin Mus. Comp. Zool., Vol. 7 (Geol. Series, Vol. 7), pp. 1–164.

On the Origin of the Iron Ores of the Marquette District, lake Superior. Bost. Soc. Nat. Hist. Proc., Vol. 20, pp. 470–479.

On the Filling of Amygdaloidal Cavities and Veins in the Keweenaw Point District of lake Superior. A reply to Prof. James D. Dana. Bost. Soc. Nat. Hist. Proc., Vol. 21, pp. 91–103.

On the Age of the Copper-bearing Rocks of lake Superior. (Abstract.) Am. Assoc. Adv. Sci. Proc., Vol. 29, pp. 429–430.

WHITNEY, J. D., and WADSWORTH, M. E.

Azoic System and its Proposed Sub-divisions. Bull. Mus. Comp. Zool., Vol 7 (Geol. Series, Vol. 1), pp. 331–565.

WICHMANN, Dr. ARTHUR.

Microscopical Investigations of Huronian Rocks from the Iron-region of lake Superior. Geol. of Wisc., Vol. 3, pp. 600–656.

WINCHELL, N. H.

The Cupriferous Series at Duluth. Geol. and Nat. Hist. Survey of Minn. 8th Annual Report for 1879, pp. 22–26.

The Cupriferous Series in Minnesota. Am. Assoc. Adv. Sci. Proc., Vol. 29, pp. 422–425. Geol. and Nat. Hist. Survey of Minn., Annual Report for 1880, pp. 385–387.

WRIGHT, C. E.

Huronian Series west of Penokee Gap. Geol. of Wisc., Vol. 3, pp. 241–301.

Geology of the Menominee Iron-region. (Economic resources, Lithology and Westerly and Southerly extensions.) Geol. of Wisc., Vol. III., pp. 666–734.

1881.

CROSBY, W. O.

On the absence of Joint-structure at great depths, and its relations to the forms of coarsely Crystalline Eruptive masses. Geol. Mag. Decade 11, Vol. VIII.

On the Age and Succession of the Crystalline Formations of Guiana and Brazil. Proc. Bost. Soc. Nat. Hist., Vol. XX., pp. 480–497.

DAWSON, GEO. M.

Sketch of the Geology of British Columbia. Geol. Soc. of London, Proc.

ELLS, R. W.

Report on Northern New Brunswick. Geol. Survey of Canada, Report of Progress for 1879–80, D, pp. 1–47.

FLETCHER, HUGH.

Report of Surveys in Richmond, Inverness, Guesboro and Antigonish, Nova Scotia. Geol. Survey of Canada, Report of Progress for 1879–80, F, pp. 1–125.

FORD, S. W.

Remarks on the genus Obolella. Am. Jour. Sci., iii., Vol. 21, pp. 132–134.

On Additional Embryonic Forms of Trilobites from the Primordial Rocks of Troy, N. Y., with Observations on the Genera Olenellus, Paradoxides and Hydrocephalus. Am. Jour. Sci., iii., Vol. 22, pp. 250–259.

HAWES, GEO. W.

The Albany Granite, New Hampshire, and its contact phenomena. Am. Jour. Sci., iii., Vol. 21, pp. 21–32.

HUNT, T. STERRY.

The Taconic System in Geology. Am. Nat., Vol. 15, pp. 494–496.

MARCOU, JULES.

The Taconic Rocks of the Border of lake Champlain. Geol. Soc. of France, Bulletin (3), Vol. 9, No. 1.

MERRILL, N. F.

Concerning the Lithological Collection of the Exploration of the Fortieth Parallel. Proc. Boston Soc. Nat. Hist., Vol. 21, pp. 234-242.

NEWTON, HENRY, and JENNEY, WALTER P.

Report on the Geology and Resources of the Black Hills of Dakota. U. S. Geog. and Geol. Survey of the Rocky Mountain Region, J. W. Powell, 566 pp.

ROMINGER, C.

Upper Peninsula. Geol. Survey of Mich., Vol. 4, pp. 1-241.

WADSWORTH, M. E.

On the Trachyte of Marblehead Neck, Massachusetts. Bost. Soc. Nat. Hist. Proc., Vol. 21, pp. 288-294.

A Microscopic Study of the Cumberland Iron Ore, of Rhode Island. (Abstract.) Ibid., pp. 194-197.

Some Points Relating to the Geological Exploration of the Fortieth Parallel. Ibid., pp. 243-274.

On the Relation of the Quincy Granite to the Primordial Argillite of Braintree, Massachusetts. Ibid., pp. 274-277.

WINCHELL, N. H.

Preliminary List of Rocks. Geol. and Nat. Hist. Survey of Minn. Annual Report for 1880, pp. 10-114.

Typical Thin Sections of the Rocks of the Cupriferous Series in Minnesota. Am. Assoc. Adv. Sci. Proc., Vol. 30, pp. 160-166. Geol. and Nat. Hist. Survey of Minn. 10th Annual Report for 1881, pp. 137-143.

YOUNG, A. A.

On Sandstones having the Grains in part Quartz Crystals. Am. Jour. Sci. iii., Vol. 23, p. 257.

1882.

CROSBY, W. O.

On the Classification and Origin of Joint Structures. Bos. Soc. Nat. Hist. Proc., Vol. XXIII., pp. 72-85.

DANA, J. D.

Geological Age of the Taconic System. Quart. Journal Geol. Soc., Vol. 38, p. 392. Am. Jour. Sci. iii., Vol. 24, pp. 291-293. (Abstract.)

DAVIS, WILLIAM MORRIS.

The Structural Value of the Trap Ridges of the Connecticut Valley. Proc. Boston Soc. Nat. Hist., Vol. 22, pp. 116-124.

DWIGHT, W. B.

Recent Investigations and Palæontological Discoveries in the Wappinger Limestone of Dutchess and Neighboring Counties, N. Y. A. A. A. S., Vol. 31, pp. 384-387.

FRAZER, PERSIFOR.

Mémoire sur la geologie de la partie sud-est de la Pennsylvanie. Théses présentées a la Faculté des Sciences de Lille Université de France. 179 pp.

The Horizon of the South Valley Hill Rocks in Pennsylvania. Am. Phil. Soc., Dec., pp. 510–518.

The Eozoic and Lower Paleozoic in South Wales and their Comparison with their Appalachian Analogues. Am. Inst. Min. Eng., Feb.

JACKSON, A. W.

On the General Principle of the Nomenclature of the Massive Crystalline Rocks. Am. J. Sci., 3d Series, Vol. 24, pp. 113–129.

JULIEN, A. A.

The Dunyte Beds of North Carolina. Bost. Soc. Nat. Hist. Proc., Vol. 22, pp. 141–149.

The Genesis of the Crystalline Iron Ores of North Carolina and Northern Michigan. Bost. Soc. Nat. Hist., Vol. 22.

The Genesis of the Crystalline Iron Ores. Acad. Nat. Sci. Phil. Proc., Vol. —, pp. 335–346.

MERRILL, N. F.

Concerning the Lithological Collection of the Exploration of the Fortieth Parallel. (Second Paper.) Proc. Boston Soc. Nat. Hist., Vol. 21, pp. 452–470.

SELWYN, A. R. C.

The Quebec Group in Geology. Roy. Soc. Canada, Vol. I., Sec. IV., pp. 1–15.

WADSWORTH, M. E.

The Argillite and Conglomerate of the Boston Basin. Proc. Bost. Soc. Nat. Hist., Vol. XXII., November.

On the Relations of the so-called Felsite to the Conglomerate on Central Avenue, Milton, Mass. Harv. Univ. Bul., 1882, II., pp. 431, 432.

WINCHELL, N. H.

Preliminary List of Rocks Collected in 1879. Geol. and Nat. Hist. Survey of Minn. 10th Annual Report, pp. 9–122.

The Potsdam Sandstone, *l. c.*, pp. 123–136.

Geological Notes on Minnesota, by J. H. Kloos. Translated by N. H. Winchell, *l. c.* pp. 175–200.

YOUNG, A. A.

Further Observations on the Crystallized Sands of the Potsdam Sandstone of Wisconsin. Am. Jour. Sci. iii., Vol. 24, pp. 47–49.

ZIRKEL, Dr. F.

Some Remarks upon the Petrographical Collection of the Geological Exploration of the Fortieth Parallel. Proc. Boston Soc. Nat. Hist., Vol. 22, pp. 109–116.

1883.

ADAMS, FRANK D.

Notes on the Microscopic Structure of some Rocks of the Quebec Group. Geol. Survey of Canada. Reports of Explorations and Surveys for 1880–81–82, A, pp. 8–23.

BELL, ROBERT.

On the Geology of the basin of Moose river and of the Lake of the Woods and adjacent country, 1881. Geol. Survey of Canada. Reports of Explorations and Surveys for 1880–81–82, C, pp. 1–39.

CHAMBERLIN, T. C.

The Copper-bearing Series of lake Superior. Science, Vol. 7, p. 453.

General Geology (of Wisconsin). Geol. of Wisc., Vol. 1, Part I., pp. 3–300.

COOK, GEO. H.

Archæan Rocks and Iron Ores. Geol. Survey of New Jersey. Annual Report for 1883, pp. 27–77.

DAWSON, GEO. M.

"The Quebec Group." Appendix to Notes by A. R. C. Selwyn on the life of Sir W. Logan, by B. J. Harrington.

DALE, T. NELSON.

A Contribution to the Geology of Rhode Island. (Contains a Bibliography.) Proc. Boston Soc. Nat. Hist., Vol. 22, pp. 179–201.

ELLS, R. W.

Report on Northern and Eastern New Brunswick and North Side of the Bay of Chaleurs. Geol. Survey of Canada. Reports of Explorations and Surveys, 1880–81–82, D, pp. 1–24.

Report on the Geological Formations in the Gaspé Peninsula, 1882, *l. c.*, DD., pp. 1–32.

HALL, JAMES (State Geologist).

Field Notes on the Geology of the Mohawk Valley, with a map. Fifth Report of the State Geologist, pp. 8–10. Albany.

HONEYMAN, D.

Nova Scotian Geology; Halifax and Colchester counties, 16 pp.

HUNT, T. STERRY.

The Geology of lake Superior. Science, Vol. 7, p. 218.

The Geological History of Serpentines, including Notes on Pre-Cambrian Rocks. Trans. Roy. Soc., Canada, Vol. 7, Sec. 4, pp. 165–215.

A Historical Account of the Taconic Question in Geology, with a Discussion of the Relations of the Taconian Series to the Older Crystalline, and to the Cambrian Rocks. Trans. Roy. Soc., Canada, Vol. 1, Part 4, pp. 217–270, and Vol. 2, Part 2, pp. 125–157.

IRVING, R. D.

On the Nature of the Induration in the St. Peter's and Potsdam Sandstones, and certain Archæan Quartzytes, in Wisconsin. Am. Jour. Sci., iii., Vol. 25, pp. 401–411.

The Copper-bearing Rocks of lake Superior. 3d Annual Report of the U. S. Geol. Survey, 1881-82, pp. 93-188.
The Copper-bearing Rocks of lake Superior. Science, Vol. 1, 140, 359 and 422.
On the Paramorphic Origin of the Hornblende of the Crystalline Rocks of the Northwestern States. Am. Jour. Sci., Vol. 27, pp. 27-32 and 321.
Lithology of Wisconsin. Geology of Wisc., Vol. 1, Part 2, pp. 340-361.
Copper-bearing Rocks of lake Superior. Mon. V., U. S. Geol. Surv.

LE CONTE, JOSEPH.

On the Genesis of Metalliferous Veins. Am. Jour. Sci., 1883, Vol. XXVI., July.
Mineral Vein Formation Now in Progress at Steamboat Springs, compared with the same at Sulphur bank. Am. Jour. Sci., Vol. 25, 1883, June.

MATTHEW, G. F.

Illustrations of the Fauna of the St. John Group. Trans. Roy. Soc., Canada, Vol. 1, Sect. 4, pp. 87-108 and 271-279.

SALISBURY, R. D.

Chemical Analyses Geol. Wisc., Vol. I., Part 2, pp. 303-308.

SELWYN, A. R. C.

The Quebec Group in Geology. Science, Vol. IX., p. 267.
On the Geology of lake Superior. Trans. Roy. Soc. Canada, Vol. 1, Sec. 4, pp. 117-122.
Age of the Rocks of the Northern Shore of lake Superior. Science, Vol. I, p. 11.
The Copper-bearing Rocks of lake Superior. Science, Vol. I, p. 221.
Notes on the Geology of the Southeastern Portion of the Province of Quebec. Geol. Survey of Canada, Reports of Explorations and Surveys, 1880-81-82, A, pp. 1-23.
Notes on the Life of Sir W. E. Logan by B. J. Harrington, with an Appendix on "The Quebec Group," by Principal Dawson, pp. 8.

WADSWORTH, M. E.

The Fortieth Parallel Rocks. Proc. Boston Soc. Nat. Hist., Vol. 22, pp. 412-432.

WALCOTT, C. D.

The Cambrian System in the United States and Canada. Phil. Soc. Washington, Vol. 6, pp. 98-102.

WINCHELL, N. H.

The Lake Superior Rocks. Science, Vol. I, p. 334.

1884.

BAILEY, L. W.

Report of Explorations and Surveys in portions of York and Carleton Counties, New Brunswick. Geol. Survey of Canada. Report of Progress for 1882-83-84, G, pp. 1-31.

BAUERMAN, H.

Report on the Geology of the Country near the 49th Parallel of North Latitude, west of the Rocky Mountains. Geol. Survey of Canada. Report of Progress for 1882-83-84, B, pp. 1-42.

BELL, ROBERT.

Observations on the Geology, Mineralogy, Zoology and Botany of the Labrador Coast Hudson's Strait and Bay. Geol. Survey of Canada. Report of Progress for 1882-83-84, DD, pp. 1-62.

CHAMBERLIN, T. C.

Geology of Wisconsin. Survey of 1873-1879. Vols. 1 and 2. Am. Jour., Sci., iii., Vol. 27, 146.

CHESTER, ALBERT H.

The Iron Region of Northern Minnesota. 11th Annual Report of the Geol and Nat. Hist. Survey of Minn., pp. 154-167.

CHESTER, F. D.

Preliminary Notes on the Geology of Delaware Laurentian, Palæozoic and Cretaceous Areas. Proc. Acad. Nat. Sci. Philadelphia, 1884, pp. 237-259.

COOK, GEO. H.

Archæan Rocks. Geol. Survey of New Jersey. Annual Report for 1884, pp. 57-69.

COSTE, EUGENE.

Report on the Gold Mines of the Lake of the Woods. Report of Progress of the Geol. Surv. of Canada for 1882-83-84, K, pp. 1-22.

CROSBY, W. O.

On the Relations of the Conglomerate and Slate in the Boston Basin. Boston Soc. Nat. Hist. Proc., Vol. 23, pp. 7-27.

DANA, J. D.

On the Southward Ending of a Great Synclinal in the Taconic Range. Am. Jour. Sci., iii., Vol. 28, pp. 268-275.

Professor James Hall on the "Hudson River"—Age of the Taconic Slates. Am. Jour. Sci., iii., Vol. 28, p. 311.

Note on the Cortlandt and Stony Point Hornblendic and Augitic Rocks. Am. Jour. Sci., iii., Vol. 28, pp. 384-386.

Note on the Origin of Bedding in the so-called Metamorphic Rocks. Am. Jour. Sci., iii., Vol. 28, pp. 393-396.

DICKERMAN, Q. E., and WADSWORTH, M. E.

An Olivine-bearing Diabase, from St. George, Maine. Proc. Boston Soc. Nat. Hist., Vol. 23, pp. 28, 29.

ELLS, R. W.

Report on Explorations and Surveys in the Interior of the Gaspé Peninsula, 1883. Report of Progress of the Geol. Survey of Canada, 1882-83-84, E, pp. 1-34.

FLETCHER, HUGH.

Report on the Geology of Northern Cape Breton. Report of Progress of the Geol. Surv. of Canada, 1882-83-84, H, pp. 1-98.

FORD, S. W.

Note on the Discovery of Primordial Fossils in the Town of Stuyvesant, Columbia Co., N. Y. Am. Jour. Sci., iii., Vol. 28, pp. 35–37.

On the Age of the Glazed and Contorted Slate Rocks in the Vicinity of Schodack Landing, Rensselaer Co., N. Y. Am. Jour. Sci., iii., Vol. 28, pp. 206–208.

FRAZER, PERSIFOR.

Archæan-Palæozoic Contact near Philadelphia, Pa. Am. Assoc. Adv. Sci. Proc., Vol. 33, pp. 1–5.

HITCHCOCK, C. H.

Descriptions of Geological Sections crossing New Hampshire and Vermont. 33 pp., Am. Mus. Nat. Hist. Bul. No. 5.

Identification of the Green Mountain Gneisses in New England. (Abstract.) A. A. A. S., Vol. 33, pp. 396–397.

HUNT, T. STERRY.

The Genesis of the Crystalline Rocks. Am. Nat., Vol. 18, pp. 605–607.

The Origin of Crystalline Rocks. Trans. Roy. Soc. Canada, Vol. 2, Sec. III, pp. 1–67. Am. Jour. Sci., iii., Vol. 28, pp. 72–74. (Abstract.)

IRVING, R. D.

The Copper-bearing Rocks of lake Superior. U. S. Geol. Survey, Monographs, Vol. 5, 464 pp.

Note on the Paramorphic Origin of the Hornblende of the Crystalline Rocks of the Northwest. Am. Jour. Sci., iii., Vol. 28, p. 464.

Supplement to the paper on Paramorphic Origin of the Hornblende of the Crystalline Rocks of the Northwestern States. Am. Jour. Sci., iii., Vol. 27, pp. 130–134.

IRVING, R. D., and VAN HISE, C. R.

On Secondary Enlargements of Mineral Fragments in certain rocks. U. S. Geol. Survey, Bulletin No. 8.

JULIEN, A. A.

Genesis of the Crystalline Iron Ores. Engin. and Mining Jour. Feb. 2, 1884.

KIMBALL, JAS. P.

Geological Relations and Genesis of the Specular Iron Ores of Santiago de Cuba. Am. Jour. Sci., iii., Vol. 28, pp. 416–429.

The Iron Ore Range of the Santiago District of Cuba. Trans. Am. Inst. Min. Eng., pp. 22.

LAFLAMME, ABBÉ J. C. K.

Report of Geological Observations in the Saguenay Region. Report of Progress of the Geol. Surv. of Canada, 1882–83–84, D, pp. 1–18.

On Strain in Connection with Crystallization and the Development of Perlitic Structure. Quart. Jour. Geol. Soc., Aug., 1884, p. 340.

LOW, A. P.

Report on Explorations and Surveys in the Interior of the Gaspé Peninsula, 1883. Report of Progress of the Geol. Surv. of Canada, 1882–83–84, F, pp. 1–21.

MATTHEW, G. J.

Fauna of the St. John Group, New Brunswick. Trans. Roy. Soc., Canada, Vol. 2, Sect. 4, pp. 99–124.

RUTLEY, F.

The Vitreous Rocks of Montana. Quart. Jour. Geol. Soc., Vol. XXXVII., p. 391.

SELWYN, A. R. C.

Notes on Observations, 1883, on the Geology of the North Shore of lake Superior. Trans. Roy. Soc., Canada, Vol. 2, Sect. 4, p. 245.

Report on the Geological and Natural History Survey of Canada for 1880–81–82.

STEVENSON, JOHN J.

Some Notes Respecting Metamorphism. Am. Phil. Soc., 1884, pp. 161–66.

UPHAM, WARREN.

Notes on Rock-outcrops in Central Minnesota. Annual Report of the Geol. and Nat. Hist. Surv. of Minn., 11th, pp. 86–136.

VAN HISE, C. R.

On Secondary Enlargements of Feldspar-fragments in certain Keweenawan Sandstones. Am. Jour. Sci., iii., Vol. 27, pp. 399–403.

VENNOR, H. G.

Calcium Phosphate, or Apatite, of the Canadian Rocks. Canadian Mining Review, January, 1884.

WADSWORTH, M. E.

Lithological Studies. Mem. Mus. Comp. Zool. Cambridge. Vol. IX., Part I., pp. 210, 4to. On the Relation of the "Keweenawan Series" to the Eastern Sandstone in the Vicinity of Torch Lake, Mich. Proc. Boston Soc. Nat. History, Vol. 23, pp. 172–180.

The Theories of Ore Deposits. Ibid., pp. 197–208.

On a Supposed Fossil from the Copper-bearing Rocks of lake Superior. Ibid., pp. 208–212.

WALCOTT, C. D.

Note on Paleozoic Rocks of Central Texas. Am. Jour. Sci., iii., Vol. 28, pp. 431–433, figure of section.

WHITFIELD, R. P.

Notice of some New Species of Primordial Fossils and Correction of previously described Species. Am. Mus. Nat. Hist. Bul. No. 5, p. 140.

Palæontological Similarity of the East American Acadian and Potsdam Groups. Am. Jour. Sci., iii., Vol. 27, p. 321. Am. Mus. Bulletin 5, New York.

WHITNEY, J. D., and WADSWORTH, M. E.

The Azoic System and its Proposed Sub-divisions. Mus. Comp. Zool. Bulletin XI., Vol. 7 (Geol. Series 1), pp. 331–566.

WILLIAMS, G. H.

Origin of Crystalline Schists, by J. Lehmann (Abstract.) A. A. A. S., Vol. 33, pp. 405-407.

WILLIAMS, GEO. H.

On the Paramorphosis of Pyroxene to Hornblende in Rocks. Am. Jour. Sci., iii., Vol. 28, pp. 259–268.

WINCHELL, N. H.

The Crystalline Rocks of Minnesota, by A. Streng and J. H. Kloos. Translated by N. H. Winchell. Geol. and Nat. Hist. Sur. of Minn., 11th Annual Report for 1882, pp. 30–85.

Note on the Age of the Rocks of the Mesabi and Vermilion Iron District. *l. c.*, pp. 168–170.

The Comparative Strength of Minnesota and New England Granites. Geol. and Nat. Hist. Surv. of Minn. 12th Annual Report, 1883, pp. 14–18.

The Crystalline Rocks of the Northwest. Am. Nat., October, 1884, pp. 984–1000. Am. Assoc. Adv. Sci. Proc., Vol. 33, pp. 363–379.

The Mineralogy of Minnesota. 10th Annual Report on the Geology of Minnesota, pp. 5–29.

and WARREN UPHAM.

Geological and Natural History Survey of Minnesota. Final Report, Vol. I.

WOOSTER, L. C.

Transition from the Copper-bearing Series to the Potsdam. Am. Jour. Sci., iii., Vol. 27, pp. 463–465.

1885.

BROADHEAD, G. C.

Sketch of the Geology of Missouri. Missouri Agl. Report, pp. 250–259.

CHESTER, F. D.

Results from a study of the Gabbros and Associated Amphibolites in Delaware. (Abstract.) A. A. A. S., Vol. 34, pp. 215–216.

COOK, GEO. H.

Archæan Rocks, Geol. Survey of New Jersey. Annual Report for 1885, pp. 36–55.

DANA, J. D.

On Taconic Rocks and Stratigraphy, with a geological map of the Taconic region. Am. Jour. Sci., iii., Vol. 29, pp. 205–222, 437–443; Vol. 33, pp. 270–276, 393–412.

On Displacement through Intrusion. Am. Jour. Sci., Vol. XXX., p. 374.

ELLS, R. W.

On the Geological Formations of Eastern Albert and Westmoreland Counties, New Brunswick, and of portions of Cumberland and Colchester Counties, Nova Scotia. Geol. and Nat. Hist. Survey of Canada, New Series, Vol. 1, E, pp. 1–71.

FORD, S. W.

Note on the Age of the Slaty and Arenaceous Rocks in the vicinity of Schenectady, Schenectady County, N. Y. Am. Jour. Sci., iii., Vol. 29, pp. 397–398.

Observations upon the Great Fault in the vicinity of Schodack Landing, Rensselær County, N. Y. Am. Jour. Sci., iii., Vol. 29, pp. 16–19.

FRAZER, PERSIFOR.

General Notes. Sketch on the Geology of York County, Pennsylvania. Am. Phil. Soc. Proc., December, 1885, pp. 391–410.

HITCHCOCK, C. H.

The Crystalline Rocks of Alabama. Am. J. Sci., 3d Series, Vol. 30, pp. 278–283.

IRVING, R. D.

Divisability of the Archæan in the Northwest. Am. Jour. Sci., iii., Vol. 29, pp. 237–249.

Preliminary Paper on an Investigation of the Archæan Formations of the Northwestern States. 5th Annual Report of the U. S. Geol. Surv., 1883-4, pp. 181–242.

IRVING, R. D., and CHAMBERLIN, T. C.

Observations on the Junction between the Eastern Sandstone and the Keweenaw Series on the Keweenaw Point, lake Superior. Bulletin U. S. Geol. Survey, No. 23. Reviewed in Am. Geol., Vol. 1, pp 44–57.

LAWSON, A. C.

Report on the Geology of the Lake of the Woods Region, with Special Reference to the Keewatin (Huronian?) Belt of the Archæan Rocks. Geol. and Nat. Hist. Survey of Canada, Vol. 1, n. s., CC., pp. 1–151.

MARCOU, JULES.

The Taconic System and its Position in Stratigraphical Geology. Am. Acad. Sci. Proc., Vol. 12, pp. 174–256.

MATTHEW, GEO. F.

Probable Occurrence of the Great Welsh Paradoxides, P. davidis, in America. Am. Jour. Sci., Vol. XXX., p. 72.

Recent Discoveries in the St. John Group. Can. Rec. Sci., Vol. 1, pp. 136–141.

Notice of a New Genus of Pteropods from the St. John Group (Cambrian). Am. Jour. Sci., Vol. XXX., p. 293.

PENFIELD, SAMUEL L.

Crystals of Analcite from the Phœnix Mine, lake Superior Copper Region. Am. Jour. Sci., iii., Vol. 30, pp. 112–113.

SELWYN, A. R. C.

Report of Progress of the Geological and Natural History Survey of Canada during the years 1882–83–84.

TAYLOR, W. B.

On the Crumpling of the Earth's Crust. Am. Jour. Sci., Vol. XXX., pp. 249–266.

TODD, JAMES E.

Description of some Fossil Tracks from the Potsdam Sandstone. Wis. Acad. Sciences, Arts and Letters, Vol. V., pp. 276–281.

UPHAM, WARREN.

Notes on the Geology of Minnehaha County, Dakota. 13th Annual Report of Geol. and Nat. Hist. Survey of Minn. for 1884, pp. 88–97.

VAN HISE, C. R.

Enlargements of Hornblende Fragments. Am. Jour. Sci., iii., Vol. 30, pp. 231–235.

WADSWORTH, M. E.

On the Presence of Syenite and Gabbro in Essex County, Massachusetts. Geol. Magazine, Decade III., Vol. II., p. 207.

WALCOTT, C. D.

Palæontologic Notes. Am. Jour. Sci., Vol. XXIX., February.

Palæozoic Notes. New Genus of Cambrian Trilobites. Am. Jour. Sci., Vol. XXIX., April.

Note on some Palæozoic Pteropods. Am. Jour. Sci., Vol. XXX., July.

Bulletin No. 10, U. S. Geological Survey. On the Cambrian Faunas of North America. 55 pp., 10 plates, 91 figures.

Monograph VIII., U. S. Geological Survey. Palæontology of the Eureka District. pp. 298, 24 plates, 570 figures.

WINCHELL, N. H.

The Geological and Natural History Survey of Minnesota. 13th Annual Report for the Year 1884. Contains: Notes of a Trip Across the Mesabi Range to Vermilion Lake; The Vermilion Iron Ores; Fossils from the Red Quartzyte at Pipestone; The Crystalline Rocks of the Northwest.

WINCHELL, ALEXANDER.

Sources of Trend and Crustal Surplusage in Mountain Structure. Am. Jour. Sci., Vol. XXX., p. 417. A. A. A. S. Ann Arbor Meeting, Vol. XXXIV., pp. 209–212.

1886.

BAILEY, L. W.

Explorations and Surveys in Portions of the Counties of Carleton, Victoria, York, and Northumberland, N. B. Annual Report of the Geol. Survey of Canada, Vol. 1, N. S. G., pp. 29 and map.

Geology and Geologists in New Brunswick. Canadian Rec. Sci., Vol. 2, pp. 93–96.

BELL, ROBERT.

The Mineral Resources of the Hudson Bay Territories. Am. Inst. Mining Eng. Trans., Vol. 15, p. 9.

The Mode of Occurrence of Apatite in Canada. Canadian Inst. Proc., Vol. 21, pp. 294–302.

Observations on the Geology, Zoology, and Botany of Hudson Strait and Bay. Annual Report Geol. Survey of Cauada, Vol. 1, n. s. DD, pp. 26.

BRITTAN, N. L.

Reports on the Study of the Archæan Rocks of New Jersey. Annual Report of the State Geologist of N. J. for 1885, pp. 36–55.

CHAPMAN, E. J.

On the Wallbridge Hematite Mine, as Illustrating the Stock-formed Mode of Occurrence of Certain Ore Deposits. Roy. Soc. Canada, Proc., Vol. 3, Sect. 4, pp. 23–26.

CHESTER, FRED D.

Results from a Study of the Gabbros and Associated Amphibolites in Delaware. Am. Assoc. Adv. Sci. Proc., Vol. 34, pp. 215–216.

CROSBY, W. O., and BARTON, G. H.

On the Great Dikes at Paradise, near Newport, R. I. Proc. Boston Soc. Nat. History, Vol. 23, pp. 325–330.

DANA, J. D.

On the Lower Silurian Fossils from a Limestone of the Original Taconic of Emmons. Am. Jour. Sci., iii., Vol. 31, pp. 241–248.

The History of Taconic Investigation previous to the Work of Professor Emmons. Am. Jour. Sci., iii., Vol. 31, pp. 399–400.

The Taconic Stratigraphy and Fossils. Am. Jour. Sci., iii., Vol. 32, pp. 236–239.

DARTON, N. H.

The Taconic Controversy in a Nutshell. Science, Vol. 7, pp. 78–79.

DAWSON, J. W.

Geology of the Canadian Pacific Railway. Quart. Jour. Geol. Soc., Vol. XL., p. 370.

DILLER, J. S.

Peridotite of Elliott County, Kentucky. Bul. U. S. Geological Survey, No. 38.

EMERSON, B. K.

Preliminary Note on the Succession of the Crystalline Rocks and their Various Degrees of Metamorphism in the Connecticut River Region. Proc. Am. Assoc. Adv. Sci., Vol. 35, p. 231.

FORD, S. W., and W. B. DWIGHT.

Preliminary Report upon the Fossils obtained in 1885 from Metamorphic Limestone of the Taconic Series of Emmons, at Canaan, N. Y. Am. Jour. Sci., iii., Vol. 31, pp. 248–255.

HERRICK, C. L., TIGHT, and H. L. JONES.

Geology and Lithology of Michipicoten Bay. Bul. of Denison University, Vol. II., pp. 120–144. Pls. X., XI., XII.

HUNT, T. STERRY.

Mineral Physiology and Physiography. A second series of Chemical and Geological Essays. 710 pp. Boston.

IRVING, R. D.

Origin of the Ferruginous Schists and Iron Ores of the lake Superior Region. Am. Jour. Sci., iii., Vol. 32, pp. 255–272.

LAWSON, A. C.

Some Instances of Gneissic Foliation and Schistose Cleavage in Dikes and their Bearing upon the Problem of the Origin of the Archæan Rocks. Canadian Inst. Proc., Vol. 32, pp. 115–128.

MARCOU, JULES.

On the Use of the Name Taconic. (Contains Bibliography.) Bost. Soc. Nat. Hist. Proc., Vol. XXIII., pp. 343-355.

On two Plates of Stratigraphical Sections of the Taconic Ranges, by James Hall. Science, Vol. 7, pp. 393-394.

MATTHEW, GEO. F.

Illustrations of the Fauna of the St. John Group, Continued. No. III. Descriptions of New Genera and Species. Trans. Roy. Soc. Canada, Vol. 3, Sect. 4, pp. 29-84.

PANTON, J. H.

Notes on the Geology of some Islands in lake Winnipeg. Hist. and Sci. Soc. of Manitoba, Trans. No. 20, pp. 10.

PUTNAM, B. T.

Notes on the samples of Iron Ore collected in Michigan and Northern Wisconsin. Tenth Census: Report on the Mining Industries of the U. S., pp. 412-455.

SELWYN, A. R. C.

Geological and Natural History Survey of Canada. Annual Report, n. s., Vol. 1, 1885.

SMOCK, JOHN C.

A Geological Reconnaissance, in the Crystalline Rock Region Dutchess, Putnam and Westchester Counties, N. Y. 39th Annual Report of the State Mus. Nat. Hist., pp. 166-185.

VAN HISE, C. R.

Upon the Origin of the Mica-Schists and Black Mica Slates of the Penokee Gogebic Iron-bearing Series. Am. Jour. Sci., iii., Vol. 31, pp. 453-459.

WALCOTT, CHARLES D.

Classification of the Cambrian System of North America. Am. Jour. Sci., Vol. 32, pp. 138-157.

Second Contribution to the Studies on the Cambrian Faunas of North America. U. S. Geol. Survey Bulletin, No. 30.

Description of a Pteropod from the Upper Cambrian. Bull. 30, U. S. Geological Survey, pp. 223-225, 2 plates.

Cambrian Age of the Roofing Slates of Granville, Washington County, N. Y. Pamphlet extract (one page). Proc. Amer. Assoc. Adv. Sci., Buffalo meeting, August, 1886. Salem Press, December, 1886.

WHEELER, H. A.

Temperature Observations of the lake Superior Copper Mines. Am. Jour. Sci., iii., Vol. 32, pp. 125-129.

WILLIAMS, GEO. H.

The Gabbros and Associated Hornblende Rocks Occurring in the Neighborhood of Baltimore, Md. U. S. Geol. Surv. Bulletin, No. 28.

The Peridotites of the "Cortlandt Series" on the Hudson River near Peekskill, N. Y. Am. Jour. Sci., iii., Vol. 31, pp. 26-41.

WILLIS, BAILEY.

Report of a trip on the Upper Mississippi and to Vermilion Lake, Minnesota. Tenth Census: Report on Mining Industries of the U. S.; pp. 457-467.

WINCHELL, N. H.

Geological and Natural History Survey of Minnesota. 14th Annual Report, for 1885, pp. 353.

The Taconic Controversy in a Nutshell. Science, Vol. 7, p. 34.

1887.

BAILEY, L. W.

On the Silurian System of Northern Maine, New Brunswick and Quebec. Trans. Roy. Soc. Canada, Vol. 4, Sect. 4, pp. 35-41.

BAILEY, L. W., and McINNES, W.

Report on Explorations in Portions of the Counties of Victoria, Northumberland and Restigouche, N. B. Geological Survey of Canada, Annual Report, Vol. 2, n. s. N, pp. 1-28.

BELL, ROBERT.

Report on an Exploration of Portions of the At-ta-wa-pish-kat and Albany River. Annual Report of the Geol. Survey of Canada, Vol. 2, n. s. G., pp. 1-38.

COOK, GEO. H.

Archæan Rocks. Annual Report of the Geol. Survey of N. J. for 1886, pp. 70-112.

DANA, J. D.

On Taconic Rocks and Stratigraphy, with a Geological Map of the Taconic Region. Am. Jour. Sci., iii., Vol. 33, pp. 270-276, 393-412.

Note by J. D. Dana on the Views of Prof. Emmons on the Taconic System. Am. Jour. Sci., iii., Vol. XXXIII., p. 412.

DAWSON, GEO. M.

Notes to Accompany a Geological Map of the Northern Portion of the Dominion of Canada, East of the Rocky Mountains. Annual Report, Geol. Sur. of Canada, Part R, pp. 1-72.

On Certain Borings in Manitoba and the Northern Territory. Trans. Roy. Soc. Canada, Vol 4, Sec. 4, pp. 85-99.

DAWSON, J. W.

Some Points in which American Geological Science is Indebted to Canada. Trans. Roy. Soc. Canada, Vol. 4, Sect. 4, pp. 1-8.

DWIGHT, W. B.

Palæontological Observations on the Taconic Limestones of Canaan, Columbia County, N. Y. Am. Nat. Vol. 21, pp. 270-271.

ELLS, R. W.

Report on the Geology of a portion of the Eastern Townships, relating more especially to the Counties of Compton, Stanstead, Beauce, Richmond and Wolfe. Annual Report of the Geol. Survey of Canada, Vol. 2, n. s. J, pp. 70.

A History of New Brunswick Geology. Montreal, pp. 64, 8vo.

FARIBAULT, E. R.

Report on the Lower Cambrian Rocks of Guysborough and Halifax Counties, N. S. Annual Report of the Geol. Survey of Canada, Vol. 2, n. s. P, pp. 129–163.

FLETCHER, HUGH.

Report on Geological Surveys and Explorations in the Counties of Guysborough, Antigonish and Pictou, N. S., *l. c.*, pp. 1–128.

GRATACAP, L. P.

Eozoonal Rock of Manhattan Island. Am. Jour. Sci., xxxiii., p. 374.

HOBBS, WM. H.

On the Petrographical Characters of a Dike in the Boston Basin. Bul. Mus. Comp. Zool. No. 1, Nov., 1887.

HUNT, T. STERRY.

The Taconic Question Restated. Am. Nat., Vol. 21, Feb., March and April Nos.

The Genetic History of Crystalline Rocks. Trans. Roy. Soc. Canada, Vol. 4, Sect. 3, pp. 7–37.

IDDINGS, J. P.

The Nature and Origin of Lithophysæ, and the Lamination of Acid Lava. Am. Jour. Sci., xxxiii., p. 36.

IRVING, R. D.

Is there a Huronian Group? Am. Jour. Sci., iii., Vol. 34, pp. 204–216, 249–263, 365–374. Reviewed in Am. Geol., Vol. 1, pp. 119–120.

JULIEN, A. A.

On the Geology at Great Barrington, Mass. Trans. N. Y. Acad. Sci., Oct., 1887, pp. 21–39.

LAPWORTH, CHARLES.

Preliminary report on some Graptolites from the Lower Palæozoic Rocks on the south side of the St. Lawrence from Cape Rosier to Tartigo River, from the north shore of the Island of Orleans, one mile above Cape Rouge, and from the Cove Fields, Quebec. Trans. Roy. Soc. Canada, Vol. 4, Sect. 4, pp. 167–184.

LOW, A. P.

Preliminary Report on an Exploration of Country between lake Winnipeg and Hudson Bay. Annual Report of the Geol. Survey of Canada, Vol. 2, n. s. F, pp. 23.

LAWSON, A. C.

Geology of the Rainy Lake Region, with remarks on the classification of the crystalline rocks west of Lake Superior. Preliminary note. Am. Jour. Sci., iii., Vol. 33, pp. 473–480.

MARCOU, JULES.

On the use of the name Taconic. Proc. Bos. Soc. Nat. Hist. Vol. XXIII., pp. 344–355.

The Taconic of Georgia and the Report on the Geology of Vermont. Bos. Soc. Nat. Hist. Mem.

MATTHEW, GEO. F.

On the Cambrian Faunas of Cape Breton and Newfoundland. Trans. Roy. Soc. Canada, Vol. 4, Sec. 4, pp. 147–158.

Great American Paradoxides. Am. Jour. Sci., xxxiii. 388.

Kin of Paradoxides (Olenellus?), Kierulfi. Am. Jour. Sci., xxxiii., 390.

McCONNELL, R. G.

Report on the Geological Structure of a Portion of the Rocky Mountains. Geol. Sur. of Can., Vol. II. New series, 1887. Part D, pp. 1–40.

ROMINGER, C.

Description of Primordial Fossils from Mt. Stephens, N. W. Territory of Canada. Proc. Acad. Nat. Sci., Phil., pp. 12–19.

STEVENSON, J. J.

A Geological Reconnaissance of Bland, Giles, Wythe and Portions of Pulaski and Montgomery Counties in Virginia. Am. Phil. Soc., March, 1887.

VAN HISE, C. R.

Note on the Enlargement of Hornblendes and Augites in Fragmental and Eruptive Rocks. Am. Jour. Sci., iii., Vol. 33, pp. 385–388.

WADSWORTH, M. E.

Preliminary Description of the Peridotytes, Gabbros, Diabases and Andesytes of Minnesota. Bul. No. 2, of the Geol. and Nat. Hist. Sur. of Minnesota.

WALCOTT, CHARLES D.

Discovery of Fossils in the Lower Taconic of Emmons. Proc. Am. Assoc. Adv. Sci., Vol. 36, pp. 212–213. (Abstract.)

On the use of the term Taconic. Boston Soc. Nat. Hist. Proc., Vol. 23, pp. 343–355.

Geologic Age of the Lowest Formation of Emmons' Taconic System. Am. Jour. Sci., iii., Vol. 33, pp. 153–154.

Fauna of the "Upper Taconic" of Emmons, in Washington County, N. Y. Am. Jour. Sci. (iii.), xxxiv., p. 187.

Note on the Genus Archeocyathus of Billings. (Extract, 2 pages.) Am. Jour. Sci., Vol. 34, 1887.

Section of Lower Silurian (Ordovician) and Cambrian Strata in Central New York, as Shown by a Deep Well near Utica. (Extract.) Proc. Am. Assoc. Adv. Sci., Vol. 36, 1887, p. 212.

WILLIAMS, GEO. H.

Some Examples of Dynamic Metamorphism of the Ancient Eruptive Rocks on the South Shore of lake Superior. Am. Assoc. Adv. Sci. Proc., Vol. 36, pp. 225–226. (Abstract.)

The Norites of the "Cortlandt Series" on the Hudson River Near Peekskill, N. Y. Am. Jour. Sci., iii., Vol. 33, pp. 135–144, 191–199, 243.

Note on Some Remarkable Crystals of Pyroxene from Orange Co., N. Y. Am. Jour. Sci., xxxiv., p. 275.

WINCHELL, ALEXANDER.

Unconformability Between the Animikie and the Vermilion Series. Am. Jour. Sci., iii., Vol. 34, p. 314.

Report of Geological Observations made in Northeastern Minnesota during the Season of 1886. 15th Annual Report of the Geol. Survey of Minn. for the year 1886, Part 2, pp. 5–207.

WINCHELL, H. V.

Partial Report of Observations made by H. V. Winchell. 15th Annual Report of the Geol. Survey of Minn., Part IV., pp. 401–419.

WINCHELL, N. H.

Fifteenth Annual Report of the Geological and Natural History Survey of Minnesota for the year 1886.

Notes on Classification and Nomenclature for the American Committee of the International Geological Congress, March, 1887. Am. Nat., Aug., 1887.

1888.

ADAMS, FRANK D., and LAWSON, ANDREW C.

On some Canadian Rocks Containing Scapolite, with a few Notes on some Rocks Associated with the Apatite Deposits. Can. Record of Science, pp. 185–200.

BAYLEY, W. S.

On some Peculiarly Spotted Rocks from Pigeon Point, Minnesota. Am. Jour. Sci., iii., Vol. 35, pp. 388–393.

BONNEY, T. G.

Notes on a Part of the Huronian Series in the Neighborhood of Sudbury, Canada. Quart. Jour. Geol. Soc., Feb. 1, 1888.

BOAS, FRANZ.

The Geography and Geology of Baffins Land. Trans. Roy. Soc. Can. Sec. iv, pp. 75–78.

CARPENTER, F.

Notes on the Geology of the Black Hills. Preliminary Report of the Dakota School of Mines, pp. 11–52. Reviewed in Am. Geologist, Vol. III., p. 202.

CLAYPOLE, EDWARD W.

On some Investigations Regarding the Condition of the Interior of the Earth. Am. Geol., Vol. II., p. 28.

COLLINS, J. F.

The Sudbury Copper Deposits. Quart. Jour. Geol. Soc., Vol. XLIV., p. 834.

CROSBY, W. O.

The Geology of the Black Hills, Dakota. Boston Soc. Nat. Hist. Proc., Vol. 23, p. 488. Am. Jour. Sci., iii., Vol. 36, p. 153.

Geology of the Outer Islands of Boston Harbor. Proc. Boston Soc. Nat. History, Vol. 23, pp. 450–457.

DANA, J. D.

A Brief History of Taconic Ideas. Am. Jour. Sci., iii., Vol. 36, pp. 410–427.

DAWSON, J. W.

On the Eozoic and Palæozoic Rocks of the Atlantic Coast of Canada in Comparison with those of Western Europe and the Interior of America. Quart. Jour. Geol. Soc., London, Vol. 44, p. 797. Canadian Rec. Sci., Vol. 3, pp. 182–183. (Abstract.)

DWIGHT, W. B.

Discovery of Additional Fossiliferous Potsdam and Pre-Potsdam Strata of the Olenellus Group near Poughkeepsie, N. Y. Am. Jour. Sci., iii., xxxiv., p. 27.

Fossiliferous Strata of the Paradoxides Zone at Stissing, N. Y. Am. Jour. Sci., iii., xxxviii., 139.

FRAZER, PERSIFOR.

Report of the Sub-committee on the Archæan. Am. Committee Reports, Int. Cong. Geol., pp. 1–52. Am. Geol., Vol. 2, pp. 143–192.

HAWORTH, ERASMUS.

A Contribution to the Archæan Geology of Missouri. Am. Geol., Vol. 1, pp. 280–297; 363–382. (Preliminary notice in the Johns Hopkins University Circulars, Vol. 7, No. 65, p. 70.)

HERRICK, C. L., CLARKE, E. S., and DEMING, J. L.

Some American Norytes and Gabbros. Geological Notes from the Laboratory of Denison University. Am. Geol., Vol. 1, pp. 339–346.

HITCHCOCK, C. H.

Date of the Publication of the Report upon the Geology of Vermont. Proc. Boston Soc. Nat. Hist., Vol. XXIV., pp. 33–37.

HUNT, T. STERRY.

Les Schistes Cristallins. From the Etudes sur les Schistes Cristallins. International Geol. Congress, London, 1888.

IRVING, R. D., CHAMBERLIN, T. C., and VAN HISE, C. R.

The Crystalline Schists of the lake Superior District. Intern. Geol. Congress, London, pp. 92-106.

On the Classification of the Early Cambrian and pre-Cambrian Formations. 7th Annual Report U. S. Geol. Survey, pp. 368–454.

IVES, JAMES T. B.

Iron and Other Ores of Ontario. Canadian Inst. Proc., Vol. 5, pp. 185–192.

JUDD, J. W.

Growth of Crystals in Igneous Rocks after Consolidation. Quart. Jour. Geol. Soc., Vol. XLV., p. 175.

KEMP, J. F.

Diorite Dike of Forest of Dean, Orange County, N. Y. Am. Jour. Sci., Vol. 35, p. 331.

On the Rosetown Extension of the Cortlandt Series. Am. Jour. Sci., iii., Vol. 36, pp. 247–253.

The Dikes of the Hudson River Highlands. Am. Nat., Aug., pp. 691–98.

LAWSON, A. C.

The Diabase Dykes of Rainy Lake. Canadian Inst. Proc., Vol. 5, pp. 173–185. Am. Geol., Vol. 1, pp. 199–211.

The Archæan Geology of the Region Northwest of lake Superior. Études sur les schistes cristallins: reviewed in Am. Geologist, Vol. IV., p. 59. Intern. Geol. Congress, London, pp. 66–88.

MARCOU, JULES.

American Geological Classification and Nomenclature. Cambridge, pp. 75.

On Some Dates of the "Report on the Geology of Vermont." Proc. Bos. Soc. Nat. Hist., Vol. XXIII., pp. 83–89.

Palæontologic and Stratigraphic "Principles" of the Adversaries of the Taconic. Am. Geol., Vol. II., pp. 9–43, 67–88.

Geology of the Vicinity of Quebec City. Am. Geol., Vol. II, p. 355.

MATTHEW, G. F.

On a Basal Series of Cambrian Rocks in Acadia. Canadian Rec. Sci., Vol. III., pp. 21–29.

On the Classification of the Cambrian Rocks in Acadia. *l. c.*, pp. 71–81.

On Psammichnites and the Early Tribolites of the Cambrian Rocks in Eastern Canada. Am. Geol., Vol. 2, pp. 1–9.

Illustration of the fauna of St. John group. No. iv. Part I, descriptions of a new species of Paradoxides (*Paradoxides Regina*). Part II., the smaller trilobites with eyes (*Ptychoparia Ellipsocephalidæ*). Trans. Roy. Soc. Can., Sec. iv., pp. 115–166.

McGEE, W. J.

Three Formations of the Middle Atlantic Slope. Am. Jour. Sci., iii., Vol. XXXV., pp. 120–143, 328–343, 367–388, 448–466.

McKELLAR, PETER.

The correlation of the Animike and Huronian rocks of lake Superior. Trans. Roy. Soc. Can., Sec. iv., pp, 63–73.

MERRILL, G. P.

Note on the Secondary Enlargement of Augites in a Peridotite from Little Deer Isle, Maine. Am. Jour. Sci., xxxv., p. 488.

MILLER, S. A.

The Taconic System as Established by Emmons, and the Laws of Nomenclature Applicable to the Subject. Am. Geol., Vol. 1, pp. 235–245.

PENROSE, R. A. F.

Nature and Origin of Deposits of Phosphates of Lime. Bul. U. S. Geol. Survey, No. 46.

RICHARDS, GARY F.

Lithological Notes on Contact Phenomena in South Carolina. Pl. XV. Bul. Denison University, Vol. IV., pp. 5–10.

SELWYN, A. R. C.

The Taconic at Quebec. Am. Geol., Vol. II., p. 134.

The Huronian of Canada. Am. Geol., Vol. II., pp. 61–62.

VOGDES, A. W.

Some Forgotten Taconic Literature. Am. Geol., Vol. II., p. 352.

WALCOTT, CHARLES D.

The Taconic System of Emmons, and the Use of the Name Taconic in Geological Nomenclature. Am. Jour. Sci., iii., Vol. 35, pp. 229–242, 307–327, 394–401.

Cambrian Fossils from Mount Stephens, Northwest Territory of Canada. Am. Jour. Sci., Vol. XXXVI., pp. 161–167.

The Stratigraphical Succession of the Cambrian Faunas in North America. Nature, Vol. 38, No. 988, p. 551.

WILLIAMS, G. H.

The Gabbros and Diorites of the "Cortlandt Series" on the Hudson River, near Peekskill, N. Y. Am. Jour. Sci., iii., Vol. 35, pp. 438–448.

The Contact Metamorphism Produced in the Adjoining Mica-Schists and Limestones by the Massive Rocks of the "Cortlandt Series," near Peekskill, N. Y. Am. Jour. Sci., iii., Vol. 36, pp. 254–269. Johns Hopkins Univ. Circulars, Vol. VII., p. 63.

Progress of the Work on the Archæan Geology of Maryland. Johns Hopkins University Circulars, Vol. VII., No. 65, p. 61.

Contributions to the Mineralogy of Maryland. Johns Hopkins Univ. Circulars, No. 75.

WINCHELL, ALEXANDER.

Report of a Geological Survey in Minnesota during the Season of 1887. Sixteenth Annual Report of the Geol. Survey of Minn., pp. 133–391.

The Unconformities of the Animike in Minnesota. Am. Geol., Vol. 1, pp. 14–24.

The Taconic Question. Am. Geol., Vol. 1, pp. 347–363.

Some Effects of Pressure of a Continental Glacier. Am. Geol., Vol. I., p. 139.

WINCHELL, H. V.

Report of observations made during the summer of 1887. Sixteenth Annual Report of the Geol. Survey of Minn., pp. 395–478.

WINCHELL, N. H., and UPHAM, WARREN.

Geology of Minnesota. Volume II. of the final reports.

WINCHELL, N. H.

Sixteenth Annual Report of the Geol. Survey of Minn. for the year 1887.

The Animike Black Slates and Quartzytes, and the Ogishke Conglomerate of Minnesota, the equivalent of the "Original Huronian." Am. Geol. Vol. 1, pp. 11–14.

Some objections to the term Taconic considered. *l. c.*, pp. 162–172.

A great Primordial Quartzyte. *l. c.*, pp. 173–178.

Report of the Sub-committee of the American International Committee, on the Lower Palæozoic. (Int. Cong. Geol.) Am. Geol., Vol. 2, pp. 193–224.

1889.

BAYLEY, W. S.

A Quartz-Keratophyre from Pigeon Point and Irving's Augite Syenites. Am. Jour. Sci., iii., Vol. 38, pp. 54-63.

BELL, ROBERT.

Presidential Address: The Huronian System of Canada. Trans. Roy. Soc. Can., Sec. IV., Vol. VI., pp. 3-14.

BRANNER, J. C.

The Age of the Crystalline Rocks of Arkansas. A. A. A. S., Cleveland Meeting, p. 188. (Abstract.)

The Peridotytes of Arkansas (in connection with R. N. Brackett). A. A. A. S., Cleveland Meeting, p. 188. (Abstract.)

BROADHEAD, G. C.

The Geological History of The Ozark Uplift. Am. Geol. Vol. III., p. 6.

BROWNE, D. H.

The Distribution of Phosphorus in the Luddington Mine, Iron Mountain, Michigan, with plates VIII-XIII. Am. Jour. Sci., Vol. XXXVII., pp. 299-310. Vol. XXXVIII. pp. 29-42.

HALL, C. W.

The Distribution of the Granites of the Northwestern States, and their general lithologic characters. A. A. A. S., Cleveland Meeting, p. 189. (Abstract.)

HITCHCOCK, C. H,

Conglomerates in New England Gneisses. Am. Geol., Vol. III., p. 253.

HOBBS, WM. H.

On the Rocks Occurring in the Neighborhood of Ilchester, Howard county, Maryland; being a detailed study of the area comprised in sheet No. 16 of the Johns Hopkins University map. (A preliminary notice.) Johns Hopkins University Circulars. Vol. VII., No. 65, p. 69.

HOWLEY, J. P.

The Taconic of Eastern Newfoundland. Am. Geol., Vol. IV., p. 121.

IDDINGS, JOSEPH PAXSON.

On the Crystallization of Igneous Rocks. Bull. Phil. Soc. Wash., Vol. II., pp. 71-113.

KEMP, J. F., and V. F. MARSTERS.

On certain Camptonite Dikes near Whitehall, N. Y. Am. Geologist, Vol. IV., p. 97.

LAWSON, A. C.

Foliation and Sedimentation. Am. Geol., Vol. 3, pp. 169-178.

Report on the Geology of the Rainy Lake Region. Geol. and Nat. Hist. Sur. Can., Part F. Annual report, Vol. III., 1887.

LE CONTE, JOSEPH.

The General Interior Condition of the Earth. Am. Geol., Vol. IV., p. 38.

MARCOU, JULES.

Canadian Geological Classification for the Province of Quebec. Boston Soc. Nat. Hist. Proc., Vol. 24, pp. 54-83.

Barrande and the Taconic System. Am. Geol., Vol., 3, pp. 118-137.

MATTHEW, G. F.

On the Classification of the Cambrian Rocks in Acadia. Can. Rec. Sci., p. 303.

How is the Cambrian Divided? Am. Geol., Vol. IV., p. 139.

Cambrian Organisms in Acadia. Can. Rec. of Sci., July.

McCONNELL, R. G.

Note on the Geology of Mt. Stephen, British Columbia. Am. Geol., Vol. III., p. 22.

MEADS, A. D.

The Stillwater, Minn., Deep Well. Am. Geol., Vol. III., p. 342.

MERRILL, GEO. P.

On the Ophiolite of Thurman, Warren county, N. Y., with remarks on the Eozoon Canadense. Am. Jour. Sci., Vol. XXXVII., March, pp. 189-190.

READE, T. MELLARD.

Physical Theories of the Earth in relation to mountain formation. Am. Geol., Vol. III., p. 106.

SELWYN, A. R. C.

Two Systems Confounded in the Huronian. Am. Geol., Vol. III., pp. 339-340.

SMOCK, JOHN C.

First Report on the Iron Mines and Iron Ore Districts of New York. Bul. N. Y. State Mus., No. 7. Albany.

VAN HISE, C. R.

The Iron Ores of the Penokee-Gogebic Series of Michigan and Wisconsin. Am. Jour. Sci., iii., Vol. 37, pp. 32-48.

WALCOTT, CHAS. D.

Stratigraphic Position of the Olenellus Fauna in North America and Europe. Am. Jour. Sci., Vol. XXXVII., pp. 374-392; Vol. XXXVIII., pp. 29-42.

Description of New Genera and Species of Fossils from the Middle Cambrian. Proc. U. S. National Museum, 1888, pp. 441-446, one cut. Advance sheets issued June 11, 1889.

WILLIAMS, G. H.

On the Possibility of Hemihedrism in the Monoclinic Crystal System, with especial reference to the Hemihedrism of Pyroxene.

WINCHELL, H. V.

The Diabasic Schists Containing the Jaspilyte Beds of Northeastern Minnesota. Am. Geol., Vol. 3, pp. 18-22.

WINCHELL, ALEXANDER.

Conglomerates Enclosed in Gneissic Terranes. Am. Geologist, Vol. III., pp. 153–165, 256–262.

Two Systems Confounded in the Huronian. Am. Geologist, Vol. III., pp. 212–214.

Systematic Results of a Field Study of the Archæan Rocks of the Northwest. A. A. A. S., Cleveland, p. 205. (Abstract.)

WINCHELL, N. H.

Some Thoughts on Eruptive Rocks, with Special Reference to those of Minnesota. A. A. A. S., Cleveland, pp. 212–221.

WINCHELL, N. H. and H. V.

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THE FOURTEENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1885. 354 pp.; two plates of fossils and two wood cuts. By *N. H. Winchell.* Containing summary report, notes on some deep wells in Minnesota, descriptions of four new species of fossils, a supposed natural alloy of copper and silver from the north shore of Lake Superior, and revision of the stratigraphy of the Cambrian in Minnesota, with the following papers by assistants, viz.: List of the Aphididae of Minnesota, with descriptions of some new species by *O. W. Oestlund;* Report on the Lower Siberian Bryozoa, with preliminary descriptions of some new species by *E. O. Ulrich;* Conchological notes, by *U. S. Grant;* Bibliography of the Foraminifera, recent and fossil, by *Anthony Woodward.*

THE FIFTEENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1886. 493 pp.; 8vo.; 120 diagram illustrations and sketches in the text, and two colored maps; embracing reports on observations on the crystalline rocks in the northwestern part of the state, by *Alexander Winchell, N. H. Winchell* and *H. V. Winchell;* Chemical report by *Prof. J. A. Dodge;* additional railroad elevations by *N. H. Winchell;* list of Minnesota geographical names derived from the Chippewa language, by *Rev. J. A. Gilfillan*, and notes on Illæni, describing three new species, by *Aug. F. Foerste.* Also as supplement II of the Regents' Report for 1887–1888.

THE SIXTEENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1887. 504 pp.; 8vo.; two plates and 83 other illustrations. Contains reports on the original Huronian area, the Marquette iron region, on the Gogebic and Penokee iron-bearing rocks, on the formations of Northeastern Minnesota (including the physical aspects, vegetation, quadrupeds and other vertebrates), the geology of the region northwest from Vermillion lake to Rainy lake and of the Little and Big Fork rivers; also notes on the Molluscan fauna of Minnesota.

II. FINAL REPORT.

THE GEOLOGY OF MINNESOTA. VOL. I OF THE FINAL REPORT. 1872-1882. xiv. and 697 pp., quarto; illustrated by 43 plates and 52 figures. By *N. H. Winchell*, assisted by *Warren Upham*. Containing an historical sketch of explorations and surveys in Minnesota, the general physical features of the state, the building stones, and the Geology of Houston, Winona, Fillmore, Mower, Freeborn, Pipestone, Rock and Rice counties, by *N. H. Winchell;* the Geology of Olmsted, Dodge and Steele counties, by *M. W. Harrington;* and the Geology of Waseca, Blue Earth, Faribault, Watonwan, Martin, Cottonwood, Jackson, Murray, Nobles, Brown, Redwood, Yellow Medicine, Lyon, Lincoln, Big Stone, Lac qui Parle and Le Sueur counties, by *Warren Upham*. Distributed gratuitously to all public libraries and county auditor's offices in the state, to other state libraries and state universities, and to leading geologists and scientific societies; the remainder are held for sale at the cost of publication, $3.50 per copy in cloth, or $5 in grained half roan binding upon application to Prof. N. H. Winchell, Minneapolis.

THE GEOLOGY OF MINNESOTA. VOL. II OF THE FINAL REPORT. 1882-1885. xxiv. and 695 pp., quarto; illustrated by 42 plates and 32 figures. By *N. H. Winchell*, assisted by *Warren Upham*, containing chapters on the Geology of Wabasha, Goodhue, Dakota, Hennepin, Ramsey and Washington counties, by *N. H. Winchell*, and on Carver, Scott, Sibley, Nicollet, McLeod, Renville, Swift, Chippewa, Kandiyohi, Meeker, Wright, Chisago, Isanti, Anoka, Benton, Sherburne, Stearns, Douglas, Pope, Grant, Stevens, Wilkin, Traverse, Otter Tail, Wadena, Todd, Crow Wing, Morrison, Mille Lacs, Kanabec, Pine, Becker and Clay counties, by *Warren Upham*. Distributed according to law in the same manner as Vol. I above.

III. MISCELLANEOUS PUBLICATIONS.

1 CIRCULAR No. 1. A copy of the law ordering the survey, and a note asking the co-operation of citizens and others. 1872.
2. PEAT FOR DOMESTIC FUEL. 1874. Edited by *S. F. Peckham*.
3. REPORT ON THE SALT SPRING LANDS DUE THE STATE OF MINNESOTA. A history of all official transactions relating to them, and a statement of their amount and location. 1874. By *N. H. Winchell*.
4. A CATALOGUE OF THE PLANTS OF MINNESOTA. Prepared in 1865, by *I. A. Lapham*, contributed to the Geological and Natural History Survey of Minnesota, and published by the State Horticultural Society in 1875.
5. CIRCULAR No. 2. Relating to botany, and giving general directions for collecting information on the flora of the state. 1876.
6. CIRCULAR No. 3. The establishment and organization of the Museum. 1877.
7. CIRCULAR No. 4. Relating to duplicates in the Museum and exchanges. 1878.
8. THE BUILDING STONES, CLAYS, LIMES, CEMENTS, ROOFING, FLAGGING AND PAVING STONES OF MINNESOTA. A special report by *N. H. Winchell*. 1880.
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10. CIRCULAR No. 6. To owners of mills and unimproved water-powers. Relating to the Hydrology and water powers of Minnesota. 1880.

IV. BULLETINS.

No. 1. History of Geological Surveys in Minnesota. By *N. H Winchell*.
No. 2. Preliminary Description of the Peridotytes, Gabbros, Diabases and Andesytes of Minnesota. By *M. E. Wadsworth*.
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