THE

GEOLOGICAL

AND

NATURAL HISTORY SURVEY

OF

MINNESOTA.

SIXTEENTH ANNUAL REPORT

FOR THE YEAR 1887.

Two Plates, one Map and Eighty-eight Other Illustrations.

N. H. WINCHELL, STATE GEOLOGIST.

ST. PAUL:
J. W. CUNNINGHAM & CO., PRINTERS.
1888.

THE REGENTS OF THE UNIVERSITY.

Greenleaf Clark, St. Paul	1889
Cushman K. Davis, St. Paul	1889
Knute Nelson, Alexandria	1890
John S. Pillsbury, Minneapolis	1890
Henry H. Sibley, St. Paul, *President*	1891
Gordon E. Cole, Faribault	1891
William Leggett, Benson	1891
A. R. McGill, St. Paul, *Governor*	Ex-Officio
David L. Kiehle, Minneapolis, *Supt. Pub. Inst.*	Ex-Officio
Cyrus Northrop, Minneapolis, *Pres. of the University*	Ex-Officio

---

EXECUTIVE COMMITTEE.

John S. Pillsbury, *Chairman.*

David L. Kiehle.

Cyrus Northrop, *Clerk.*

ADDRESS

THE UNIVERSITY OF MINNESOTA,
MINNEAPOLIS, March 20, 1888.

To the President of the University:

DEAR SIR: I have the honor to present herewith a report giving the results of the work of the geological and natural history survey of the state for the past year, so far as it is possible to put them into shape for publication. Investigations are being carried forward in the lithology of the crystalline rocks and in the palæontology of the fossiliferous ores, which are not as far advanced as to warrant report.

Respectfully submitted,

N. H. WINCHELL,

State Geologist and Curator of the General Museum.

CONTENTS.

Page

SUMMARY STATEMENT 9

REPORT OF N. H. WINCHELL.

1. The original Huronian.
   - Bruce. At the Wellington mines 13
   - Thessalon, Ontario 14
   - A mile northwest from Thessalon 18
   - Macbeth's bay 20
   - Little Rapids 21
   - Ansonia P. O 23
   - Otter Tail lake and Otter Tail P. O 26
   - Murray's Corners 30
   - Riddlebank P. O 31
   - Blind River 32
   - Missasaugui river 34
   - Conclusions respecting the original Huronian 36
2. The Iron-bearing rocks at Marquette
   - At Negaunee 40
   - At Cascade 43
   - Ishpeming 43
   - At the Michigamme mine 49
   - At Marquette 50
3. The Gogebic iron region.
   - The Colby mine. 54
   - At the Valley mine 55
   - The Aurora mine at Ironwood 56
   - At the Iron King mine 59
   - At the First National mine 60
4. From Grand Marais to Gunflint lake 60
5. About Gunflint lake.
   - The north shore of Gunflint lake 65
   - The syenitic gneiss on the north side of Black Fly bay 73
   - The Vermilion group at Gunflint lake 74
   - The "Black Belt" at Gunflint lake 75
   - At Iron lake 78

6. Across the country from Gunflint lake to Ogishke Muncie.......... 79
The iron location at Chub (or Akeley) lake.......... 82
Observed positions of the Gabbro.......... 87
Observed positions of the Animike.......... 87
Relation of the Pewabic quartzyte to the Animike.......... 87
7. Gabemichigama lake—The Animike.......... 89
8. Ogishke Muncie lake.......... 95
9. Saddle Bags and Frog Rock lakes.......... 98
10. Notes made between Ogishke Muncie and Kekekebic lakes.......... 99
11. Kekekebic lake.......... 100
12. Pseudomesser lake and westward to Tower.......... 109
13. Glacial directions observed in 1887.......... 113
14. Rock samples collected, list of.
From the original Huronian.......... 114
From the Marquette region.......... 117
From the Gogebic iron-range.......... 119
From Minnesota.......... 119

REPORT OF ALEXANDER WINCHELL.

§ 1. Preliminaries.
1. The regions covered by the observations of 1887.......... 133
2. Conditions of the exploration.......... 134
3. Physical aspects of the region.......... 134
4. Aspects of the vegetation.......... 135
5. Quadrupeds and other vertebrates.......... 138
6. Climate.......... 139
7. Method of operation.......... 140
8. Plan of the report.......... 140
9. Localities and rock numbers.......... 141
10. Bearings.......... 142
11. Rock identifications.......... 142
12. Earlier observations and studies.......... 142

§ 2. Observations in the typical Huronian region of Canada.
1. Observations about the Bruce Mines.......... 145
2. Observations in the valley of the Thessalon river.......... 147
3. Observations in the vicinity of the Blind and Missisagui rivers.......... 161
4 Generalization from observations made on the Huronian of Canada.. 164

§ 3. Observations in other regions outside of Minnesota.
1. The Marquette Iron region—Inferences.......... 171
2. The Gogebic Iron belt.......... 185
3. The Penokee Gap.......... 189

§ 4. Observations between Tower and Pseudomesser lake.......... 195
§ 5. Pseudomesser lake.......... 196
§ 6. Knife lake.......... 197
Fourth Arm.......... 198
Third Arm.......... 203
Body of the lake.......... 204
First Arm.......... 204
Body of the lake.......... 208

§ 7. Ottertrack and Oak lakes 210
§ 8. Lake Saganaga 211
Great southern Arms 214
Body of the lake 217
§ 9. Granite lake 226
§ 10. Pine lake 229
§ 11. Boundary river 229
§ 12. Gunflint lake 233
1. The Expansion 237
2. West, south and east shores 244
3. North side 250
4. Excursions from Gunflint lake into the interior 262
(a). Traverse north from centre of the S. W. ¼ sec. 18, 62-2 262
(b). Stacy's traverse from N. E. ¼ sec. 22, 65-3 265
(c). Stacy's traverse bet. secs. 13 and 14, 65-3 266
(d). Visit to the iron deposit west of the lake 266
5. Reflections on the Geology of Gunflint lake and vicinity 268
§ 13. North lake 270
§ 14 South lake 272
§ 15. Rat lake 274
§ 16. Rose lake 274
§ 17. Rove lake 276
§ 18. Mountain lake 279
§ 19. Moose lake 281
§ 20 North Fowl lake 283
§ 21. South Fowl lake 284
§ 22. Pigeon river 288
§ 23. Red Rock lake 292
§ 24. West Seagull lake 293
§ 25 Seagull lake 295
§ 26. Loon lake 299
§ 27. Iron or Mayhew lake 304
§ 28. Frog Rock lake 306
§ 29. Town Line lake 314
§ 30. Ogishke Muncie lake 315
§ 31. Crab lake 318
§ 32. Zeta lake 321
§ 33. Epsilon lake 321
§ 34. Garden lake 327
§ 35. General summary of facts observed 329
1. Granitoid and gneissoid rocks 330
2. Vermilion crystalline schists 334
3. Kewatin semi-crystalline schists 336
[1]. Distribution 336
[2]. General lithological characters 338
[3]. The Ogishke dolomyte 344
[4]. The hæmatite lodes of the Kewatin 344

[5]. The conglomerates of the Kewatin.................... 344
The Ogishke conglomerate 344
Lithological characters............................ 345
Relative age.. 347
The Stuntz conglomerate............................. 350
[6]. Relation of the crystalline and Kewatin schists............ 350
[7]. Are any of the chloritic and sericitic schists of the Kewatin eruptive?.. 351
4. Animike series... 352
[1]. Distribution and physiographic features.................. 352
[2]. General lithological characters......................... 353
[3]. The magnetic beds.. 354
[4]. Unconformities of the Animike........................... 357
[5]. Must the Ogishke conglomerate be assigned to the Animike? 359
5. Eruptive rocks... 360
[1]. The gabbro flood 361
[2]. Diabase, noryte and porphyry............................ 363
6. Vein rocks.. 364
§ 36. Systematic results of these Archæan studies
1. Horizons of geologic discontinuity........................ 364
2. Succession and subordination of terranes.................. 366
§ 37. Views on primitive geologic history......................... 367
Appendices:
1. Catalogue of rocks in numerical order [two seasons]............ 369
2. Catalogue of lakes and portages along the international boundary... 390
REPORT OF H. V. WINCHELL:
Region traversed.. 395
Little Fork river.. 396
Rainy Lake river.. 408
Rainy lake.. 413
Kabetogamak lake.. 426
Namekan lake.. 428
Big Fork river.. 430
Lake Winibigoshish.. 437
Mississippi river.. 437
Pokegama lake... 438
Mississippi river.. 438
Prairie river.. 439
Mississippi river.. 444
Trip to Pelican lake... 445
Elbow lake.. 446
Elbow river... 449
Pelican lake.. 450
Net lake.. 457
Trout lake.. 458
Elevations above the sea.. 462
List of specimens collected..................................... 462

Little Fork river.... 462
Rainy Lake river.... 466
Rainy lake.... 467
Kabetogamak lake.... 468
Namekan lake.... 468
Rainy lake.... 469
Big Fork river.... 471
NOTES ON THE MOLLUSCAN FAUNA OF MINNESOTA.
By Uly S. Grant.... 474
By John M. Holzinger.... 485
Index.... 493
Corrections for the reports for 1886 and 1887.... 5(0

REPORT.

I.

SUMMARY STATEMENT.

The year has been one of unusual activity and progress. Much time and labor have been given to the preparation and printing of reports. The second volume of the final report has progressed with more than its wonted speed, and now the printing has reached as far as page 632, and the county maps for the entire volume have been lithographed. So far as they were done by Messrs. Bien & Company, they have also been printed and delivered. Besides the annual report for the year 1886, there have been published three bulletins, themselves being, it is true, portions of the annual report, since they contain reports on work performed in 1886. Being of a more special character, and likely to swell the annual report beyond convenient size they are stitched, paged and covered separately.

During July, August and September the field-work on the crystalline rocks was continued. Three parties, as last year, were engaged. During July, while two of them were united in making reconnoissance of the region of the original Huronian, and the iron-bearing rocks of northern Michigan and Wisconsin, the other was engaged in the region of Rainy lake. In August but two parties were in the field, one engaged in the region of the international boundary, from Vermilion lake eastward, and the other in an examination of the valley of the Big Fork river from Fort Francis southward to the Mississippi. In September all three of the parties were engaged in field-work, one in the region between Vermilion lake and the valley of the Big Fork, and two in repeating some observations at points that had previously been visited and extending the known boundary and character of the iron-bearing strata in the region about Gunflint lake and westward to Vermilion lake.

The following law was passed by the Legislature of 1887.

AN ACT TO EXTEND THE WORK OF THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF THE STATE.

Be it enacted by the Legislature of the State of Minnesota:

SECTION 1. It shall be the duty of the state geologist, to make practical and actual tests by drilling or digging or other excavation in the earth, such as he shall deem best suited to accomplish the purpose of this bill, for the discovery of any of the hidden mineral resources of the state, such as iron, copper, silver, gold, coal, gas, coal-oil, common salt, or any other valuable material that he may deem likely to exist in any of the rock strata of the state.

SEC. 2. In determining the localities at which such testing and exploring shall be done he shall be guided by such geological facts as he may possess or may obtain, which may indicate the existence of any of the substances which it is the purpose of this act to discover. He shall also be guided by the proportionate amount of money that the owner, or owners, of the land on which such exploration may be proposed, shall contribute to pay the cost of such exploration.

SEC. 3. It shall be the duty of the state geologist to report at once to the board of regents all discoveries, either of economic or scientific interest to the state, that may be made by such testing and exploration. Such report shall be published by the board of regents in the same manner as now provided for the publication of the annual reports of the Geological and Natural History Survey of the state, and shall be paid for by the same fund; *provided*, that any important mineral discoveries, or other scientific contributions to the Geological and Natural History Survey, that the said state geologist may deem necessary for immediate publication, shall not be suppressed until the regular report of the board of regents, but shall be issued from time to time under the direction of said state geologist.

SEC. 4. That the sum of five thousand (5000) dollars for the year A. D. one thousand eight hundred and eighty-seven (1887) and the sum of five thousand (5000) dollars for the year A. D. one thousand eight hundred and eighty-eight (1888) is hereby appropriated out of any moneys not otherwise appropriated for the purpose of defraying the expense of said tests. The investigations provided for in this act shall not be conducted in the interest of any mining company or corporation.

SEC. 5. This act shall take effect and be in force from and after its passage.

Approved, March 8th, 1887.

A. R. McGILL,
Governor.

The reports of Prof. A. Winchell of Ann Arbor, Mich., and of my son Mr. H. V. Winchell, on the field-work of the season, are included in the following pages. Besides these, general assistance was rendered by Mr. U. S. Grant, Mr. F. N. Stacy, Mr. W. F. Trussell and Mr. H. W. Fairbanks.

Mr. S. W. Ford was employed three months in making maps and drawings and general office work.

Mr. Oestlund spent the summer in the western part of the state making special entomological researches, particularly in connection with the *aphididae*, and has otherwise been engaged through the year in the laboratory and museum and office. He has given his spare time to the examination of the insects of the state.

Mr. Arthur was not engaged in botanical work owing to the exactions of other professional engagements which he had to meet.

Mr. Ulrich resumed in September his work on the bryozoa of the Silurian, and has been engaged on them ever since.

In my absence from home my wife has attended to the reading of proof, both of the final and of the annual reports, and to my correspondence.

At the request of Mr. Herrick that portion of his manuscript which he had submitted was returned to him for revision and completion. He has since returned it in final readiness for publication. I have also received a statement from Dr. P. L. Hatch that his report on the birds of the state is ready and will be furnished at any time on a few days' notice. He desires to retain it for the purpose of entering the latest observations.

The specimens belonging to the museum have increased at the usual rate, and a report on the accessions is herewith submitted.

Several American and foreign societies have begun to send their proceedings and reports to the survey—indeed some have done it for several years, but recently the number has increased. These scientific works are of a strictly technical character and should be preserved to form a collection for the use of the scientific professors of the university The collection will be augmented from year to year as the publications of the survey are extended.

II.

REPORT OF N. H. WINCHELL.

In the month of July, a party was organized to make reconnoissance of the area of the original Huronian on the north shore of lake Huron, of the iron-bearing rocks of the Marquette range, in Michigan, and of the Gogebic and Penoke ranges in Wisconsin. The results of observations made during these reconnoissances will be given briefly, since they have a direct bearing on the stratigraphy of the rocks of northeastern Minnesota. Following this will be given further descriptive notes and diagrams of the geology of the crystalline rocks in the northeastern part of Minnesota.

THE ORIGINAL HURONIAN.

Bruce. At the Wellington mines, and also at the old Bruce mines about a mile further east, the country rock, so far as seen, embraces only eruptives.* The mines themselves consist of excavations in quartz veins, or in old fissures in the country rock filled and cemented by quartz and embracing many fragments of the wall-rock. These veins run in various directions, but those which were worked for the copper sulphuret run about N. 15° W. (mag.).† The aspect of these veins, and of this "dioryte," is like that of the formation seen at Silver Islet on the north side of lake Superior; the sulphide ore here being copper and there silver galena.

The rock No. 1149 represents large areas of this dioryte at this place. It is found at the village of Bruce, and in front of the old Wellington stamp-works. It has when weathered a finely specked surface, due to the whitening of the crystal grains of the plagioclase. It is heavy, dark or greenish-gray within, massive, mainly without any

* My brother, however visited an outcrop of "limestone" a little northwest from the old Wellington location, and at a mile and a quarter northeastward black slates were seen having apparently a high dip toward lake Huron,

† According to the small atlas accompanying the Canadian Geological Survey report (1863) the variation of the needle at Thessalon, on the authority of Mr. Salter, is about 4° to the west.

bedding structure but occasionally rudely sheeted like overflow eruptives, jointed in all directions, apparently identical with much rock that accompanies the black slates on Pigeon river in Minnesota. The fineness of its grain varies sometimes gradually, and sometimes suddenly. Rock 1150 which seems to be only a finer grained, even aphanitic, variety of 1149, occurs in narrow dykes and in patches in it, evidently eruptive in the coarser dioryte.

Crossing rock 1149 occurs a great dyke, running nearly N. and S. rising near the lake shore and extending onto the hills in the village. This dyke, represented by rock No. 1151, is composed apparently of the same ingredients as rock 1149, but the grains are finer, and the rock much darker and heavier.

Thessalon, Ontario. Considerable careful observation was made at this typical Huronian locality. At the mouth of the river both shores were seen to be composed of the same rock as above described at Bruce, especially in its coarser parts. It is grayish to dark, often with a greenish tint. It commonly presents a speckled weathered surface, owing to the decay of the feldspar grains which are thickly crowded among the augites, but it graduates into finer-grained rock which again passes into very fine-grained, nearly black rock. The following samples illustrate this:—

1152. Very fine-grained, sometimes aphanitic and nearly black.

1153. Coarser-grained, speckled on the weathered surface.

1154. Coarser-grained, speckled on the weathered surface.

1155. Medium-grained, and somewhat speckled with porphyritic feldspar, also with a reddish vein of granulyte.

These samples were obtained at the mouth of the Thessalon river, on the right bank. The rocks from which these samples are derived all grade into each other here in short intervals. To this point considerable observation was given. There is a confusion of strike, or what might be considered strike, the directions being seen only in short spaces, indicating either that there has been a breaking of all the structures and a recementing, or an original molten state, with considerable irregularity of flow.

On the left (eastern) bank of the river, near the lake, is a large surface exposure of similar rock, extending along the lake shore for some distance eastward, and also inland toward the northeast, its full extent not being ascertained. The rock here varies in bands and wide irregular belts, with beautiful glaciation. It changes abruptly in its direction of trend, and it rises and falls in low hillocks that are separated by swamps or by standing water. On the east side of the river, at the lake shore, much of the rock is rather fine-grained and diabasic, resembling much of that seen in 1886 on the Kawishiwi river.

Rock 1156 represents this fine-grained, dark rock from the east bank at the mouth of the Thessalon river. There is here, over the surface, a weathered green of a lighter color (1156 A) than any green seen within the rock, and in patches an abundance of epidote; also some pyrite and chalcopyrite.

Patches of "conglomerate" also appear on the glaciated surface, the pebbles being apparently of the same kind of rock, and rounded. No continuous dip can be seen, but there is occasionally a slaty disintegration which dips about 45°, but veers round so as not to be long continued and fades out. It has a prevailing direction (on the east side of the river) when seen, a little south of southwest. Sometimes this rock varies to a massive, homogeneous, firm, dark-greenish-gray, diabase-looking rock, like some seen in the railroad cut near Thompson, Minn., represented by 1157. It contains, like nearly all the rock here, very little if any free quartz. In other places are seen angular and also vein-like patches of rock apparently permeated with epidote represented by No. 1158, obtained from the east side of the river.

About half a mile east of the river, and perhaps an eighth of a mile from the lake, the surface of this eruptive rock is banded with pitted and non-pitted belts (1159). These belts undulate and vanish. Within the rock these pits are found to be filled with delessite. They are soft, give a light soapy streak though dark green when weathered. They vary from the size of pin-heads to the size of beans. In other places again these amygdaloidal pits are distributed generally and not in bands.

Instead of being chloritic these spots sometimes are filled with a harder mineral, rather siliceous, that weathers red (1160), like some of the mineral vein matter seen in 1155, and recalling the reddish substance in the felsitic dike seen near the lighthouse at Marquette. These amygdule-like forms are not due to the dissemination of pebbles in the rock from sedimentary action. They are all of the same nature, and sometimes, especially in the case of the delessite-filled cavities, they exhibit, when broken across, a radiated and fibrous structure, and a layering of concentric superposition as if they had grown up after the manner of geodic filling in pre-existing cavities. Further examination also revealed that the delessite-filled cavities become elongated downward, attaining three and a half inches in length, on the perpendicular face of the broken bluff. They rise from a common stratum which looks as if it were their source. Judging by the general appearance and the direction of these tubes where they can be measured, others must be six or eight inches in length, though visible only at their openings on the surface. They are about a quarter of an inch in diameter, varying to an eighth of an inch, presenting somewhat the appearance of *Scolithus*. Thus their forms vary from round amygdules to tubes six or eight inches in length. When elongated they must have served as ducts for escaping gas rising from some sulphureted or carbonated stratum. There is, however, now no sign of any such stratum. That from which they issue, or above which they ascend, is like all the rest of the rock, but varies in the weathering colors according to the fineness of the grain. A good photograph was obtained of this structure. (See fig. 1, pl. I).

It is apparently due to the enlargement and multiplying of the reddish felsitic amygdules, locally, and the specialization of the mineral ingredients into macroscopical crystals, that patches of red rock are produced in this greenstone. No. 1161 represents such red rock. Such patches are sometimes four, or even eight feet square, scattered capriciously about, visible on the glaciated surface of the dark rock. This red rock consists apparently of quartz and orthoclase in distinct crystals, embracing in their interstices a greenish to black, soft substance that, while finely foliated and resembling chlorite, yet does not seem to have served any other purpose than to occupy the vacancies between the other minerals as they assumed their crystalline shapes. Such nodules and veinings, if not such isolated large masses of reddish granulyte in trap rock, are not very uncommon. They occur at Taylor's Falls and at Duluth, and have been described by the writer at several places in northeastern Minnesota. Since the basic eruptives, when in their normal state, do not embrace the minerals here differentiated within them, it may be presumed that these exceptions are caused by the local and superficial mingling of small portions of the siliceous super-crust with the heated basic eruptive. On cooling and weathering the super charge of siliceous matter is rejected from the mass and is compelled to fill any convenient veins or amygdaloidal cavities that are within reach. When none such are found these crystals are formed within the greenstone and are uniformly disseminated in it, causing the well-known quartz-dioryte and orthoclase-gabbro.

These rocks are denominated "green chloritic slates" in the Canadian survey reports, and are also so designated on the geological map of the region accompanying the general atlas in 1863.* On account

* Geological survey of Canada; report of progress from its commencement to 1863. Atlas of maps and sections, 1865.

Fig. 1.—*Amygdaloidal structure in the "Green Chlorite Slates." Thessalon Pt. Ontario.*
From a photograph, by N. H. Winchell. July, 1887.

of this fact a careful inspection was made, at all places about the mouth of the Thessalon river, in order to ascertain if any part of the visible rock surface would appropriately bear that name. Besides this place the Canadian map of this region shows the same rock at but one other locality; that is about thirty miles toward the northwest, in a small area at the extreme north end of Echo lake. The only point at which any slaty structure that would warrant the use of the term "slate" was found, is on the point on the west side of the river, but near the mouth of the river. Here are some thinly parted. portions which resemble hardened crumpled black slate. That is to say, the rock parts, on the weathered exterior at least, into fissile, schisto-slaty beds about one quarter to one eighth inch in thickness, the strike and dip of which are pretty regular and uniform for about ten or twenty feet. This schistose slatiness appears on the face of a low nearly perpendicular bluff facing toward the lake, and near the lake level. The dip is north, 30° W. (mag.) and about 40° from the horizon. In the seams are minerals that result from change in diabase--chlorite and epidote —these giving a resemblance to banding and striping similar to that seen in some places in the rock already described on the east side of the river. In other places adjacent the dip is in other directions. Distinctly amygdaloidal patches are seen in this fine-grained portion, not far removed from the slaty portion, but not in the slaty. In weathered surfaces the slaty portion, under the hand-glass, exhibits no free quartz, but a gray surface of plagioclase.

Examining more broadly in the vicinity of this slaty exposure, in an area of several rods round about, on nearly all of which the surface is bare rock, it is seen that a part of the rock on the west side of the river (where it is fine-grained and also where it exhibits this slaty disintegration) is set off from the other part by an invisible dividing line, the surface being lichen-covered and hummocky. The rest is speckled with fine porphyritic feldspar crystals, as seen and described in 1153 and 1154, and is undoubtedly the equivalent of the great greenstone formation of the region seen at Bruce and on the east side of the river at Thessalon, and in the ridges that cross the river further inland. The line on the weathered surface separating these two parts is partly imaginary, and partly vanishes when sought for, since the characters of one rock are found in patches further north or south than they belong if there be genetically two rocks here, each rock transgressing the boundary that may be supposed to have limited it. These patches seem not to be easily separable from the surrounding rock by any line of demarkation in the lithology, but there is, at least in nearly all cases, a gradual change in the grain so that the full transition is effected in the space of from one to three inches. Indeed these different rocks, from one of which is produced the slaty-fissured rock mentioned, appear to be phases only of the same rock. It is hence probable that the slatiness mentioned is caused by an original flowage structure, in the laminæ of which on partial decay, were accumulated in greater amount those minerals that easily decay, in regular alternation with those that do not, and that possibly the internal grain was affected by thin sheets of finely amygdaloidal rock alternating with non-amygdaloidal. The exposed position of the little bluff would account for the conspicuous development of the slaty structure by increased decay, on the lakeward side. This slaty rock is represented by 1173.

If still this slaty phase should prove, after further study, to be due to the existence of a fragment of a once sedimentary rockmass in the midst of the eruptive, it can only be assigned to some part of the black slates of the region. It is not green within, but gray to nearly black. It is fine-grained and difficult to specifically name without microscopic and chemical examination.

About a mile northwest from the village of Thessalon, on the west side of the main road, and on the west side of the river, is a light-weathering ridge of quartzyte. It runs S. 30° west (mag.) and appears on the lake shore a few miles west of the mouth of Thessalon river. It rises at once about thirty or forty feet above the highway, and higher still at a little distance further west. This rock is represented by 1162, a gray quartzyte dipping in general N. 45° W. (mag.); but it varies to nearly white on weathered exposures, and to light red where fires have prevailed. It shows an incipient gneissic structure. It has been broken and crushed together and recemented. Its dip varies in direction in short intervals, and is even cut off squarely by a structure of a different sort, but all closely cemented together. In the vicinity of a dike forty feet wide, that runs N. 60° W. (mag.) cutting this rock, this quartzyte shows suggestive variations. Its color and texture, while principally quartzose, yet seem to manifest a felsitic or a feldspathic tendency developed in it. Compare rock No. 1163. This tendency is marked in that part of the quartzyte which is embraced between two forks where the dike separates, and close in the angle between them, where also a longitudinal close jointage is developed on weathering, resembling slatiness. The dike (1164) consists of rock like the eruptives described at the mouth of the Thessalon river. (See figure 1.)

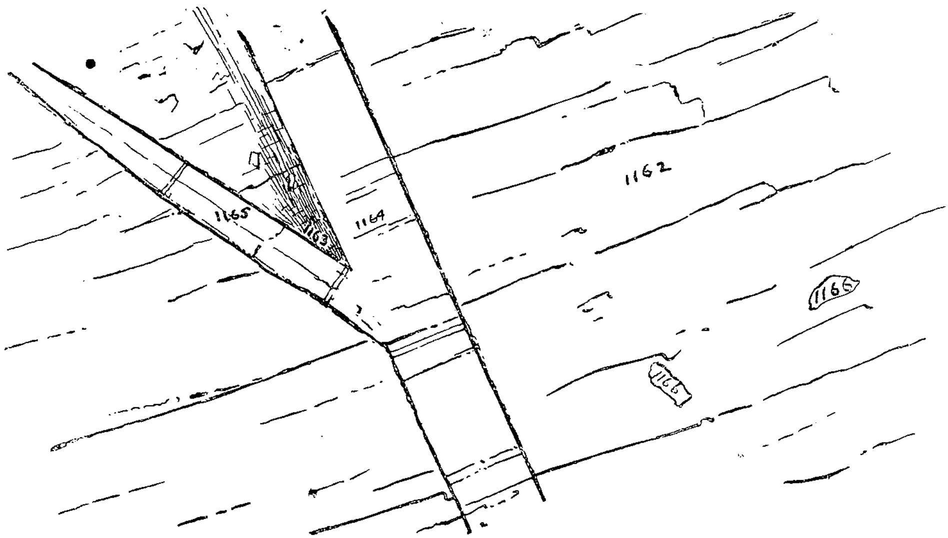


Fig 1.—*Spur of gray quartzyte enclosed between the forks of a branching dike, changed to red felsyte and gneiss.*

In the mass of the quartzyte can be seen the original banding of sedimentation, and also the "false bedding" that is common in sandstones running at different angles. There are also patches of considerable size, apparently produced by boulder masses involved in the sedimentary process at the time of accumulation, somewhat discordantly disposed in the bedding, some of which are of quartzyte similar to itself, and others are of a greenish rock, somewhat serpentinous by decay, but plainly of an eruptive nature and origin before it was embraced in the sediments of the quartzyte. Compare 1166. A photograph was made taking in a general view of this quartzyte.

The Thessalon valley is covered by a lacustrine clay which, when cleared for farming, makes a fine wide expanse for crops. The clay is gray. It was deposited when the lake level was at a beach, which is visible, about forty feet above the flat. This beach consists of coarse water-worn stones, on the rock bluff, seen on the west of the road about a mile and a half north from Thessalon on the west side of the river. On the east side of the river it is composed of gravel at some points, but it is generally coarser than gravel.

Westward from this quartzyte ridge runs similarly a conspicuous ridge of dioryte and diabase, illustrated by No. 1167, undistinguishable from the eruptive rock seen at the mouth of the river. This ridge runs toward the lake, and apparently overlies the quartzyte of 1162. It shows an igneous contact running east and west; and at a point at the roadside, where the river flows easterly, a broad uncovered surface of the quartzyte, sloping with the dip northwestwardly, is seen to pass toward the southeast directly under the trap rock of the ridge, the overlie of the trap in a sheet on the quartzyte being immediate and unquestioned. This trap bluff was photographed. (See fig. 10 p. II.)

Traveling a little further west we find the highway crosses the Canada Pacific railroad, and a rock-bluff appears facing southeast, rising about fifty feet, on which is another overlie contact of the diabase on the quartzyte. The quartzyte dips northwest at an angle of about 40° from the horizon. On the right of the exposure the quartzyte is cut off by a contact running nearly vertical, but backward so as to produce a slight overlie of the quartzyte on the diabase, as the plane of the bluff crosses the contact plane. This place is four and a half miles by the road from Thessalon village. This diabase is represented by rock 1167. See fig. 2.

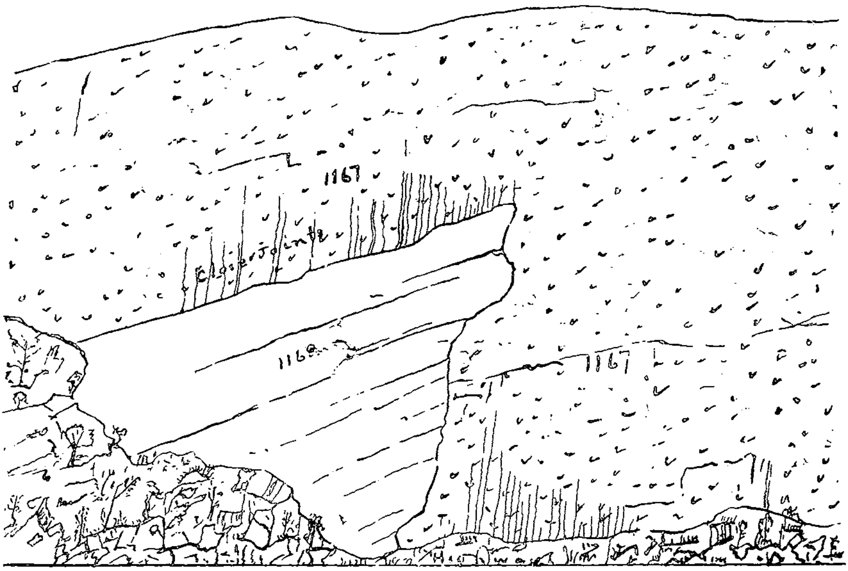


Fig. 2.—*Diabase lying unconformably on quartzyte.*

At Macbeth's bay, about five miles west of the mouth of the Thessalon river, the Canadian Pacific railroad and the highway cross the creek but little above the head of the bay. Here the quartzyte has fine exposures. On both sides of the creek it is cut by dikes of basic eruptive rock, and on the west side it is replaced entirely, over a large area, by an overflow of this rock. This is the same rock as that already mentioned, and is again represented by 1168. It is a coarse diabase, and prevails largely over the country between Macbeth's bay and Thessalon, cutting and overlying the gray quartzyte 1162. It appears as if through fissures in the quartzyte the dark diabase had issued, spreading right and left, according to the continuance of the eruption. This diabase now forms hills and ridges, the chief elevations of the region, mostly having an east and west direction; the quartzyte occupying, where seen, much lower levels.

Sometimes the quartzyte becomes conglomeritic with quartz pebbles (1169), but this is only in small rare spots; and sometimes it is slightly pinkish.

On the road running north from Thessalon on the east side of the river, at about a mile from Thessalon, a fine-grained pinkish quartzyte outcrop appears, rising in the midst of the surrounding hillocks of diabasic eruptive rock. It has an abrupt contact on the greenstone running N. 40° W. (mag.). The quartzyte is closely jointed and very hard and fine, no dip generally being visible, but in places exhibiting a sedimentary banding, which expresses a dip 30° toward the northwest.

At two miles from the mouth of the river, on the east side, the quartzyte appears again, but it is much lighter colored and very fine, almost suitable for honestones. It weathers to a kind of light pea-green color. Glaciation is abundant and fresh, showing the same kind of curving cross-fracture as seen at Thessalon, and on the quartzyte in Pipestone county, Minnesota.

At Little Rapids, three and a half miles north from Thessalon, the highlands are covered by a range of diabase (dioryte?) that runs about N. 80° W. and rises perhaps 100 feet in the vicinity on either side, on the east side having a quartz vein two or three feet wide, and somewhat amygdaloidal near the vein. But the rapids in the stream (Gas creek) are caused by a range of quartzyte that dips about 45° or 50° toward the north (mag.). Some narrow bands in this are pebbly with black jasper (rarely red) and of white quartz, but the great bulk of it consists of the same pinkish to gray quartzyte.

Gray quartzyte rises in the swamp about a mile southeast from the little rapids. This is striped with rare belts of conglomerate, one piece of white quartz being three inches in diameter. But pebbles of this size are rare. The conglomeritic belt in which this lies continues about ten feet. Its direction indicates a strike S. 30° W. (mag.). There are also here pebbles of flint and green chert, and of banded white and black jasperoid rock, also of other kinds of fine-grained rock not silica, but siliceous, which weather to a drab or light buff-color. From this place there seems to be a grand belt of quartzyte that strikes southwestwardly, running under the Thessalon and reaching the lake shore at Macbeth's bay, where it appears on the islands that lie off the coast. The dip is in all cases where it has been seen, toward the N. W.

Traveling from Little Rapids (of Gas creek) north, crossing the creek (at $\frac{1}{4}$—$\frac{1}{2}$ m.), thence west about two miles, having a range of hills on our right and the river on our left, we take the first good opportunity to examine the rocks in this ridge. They are a mingling of diabase and quartzyte, the latter being sometimes red and conglomeritic. The ridge rises about 150 feet above the road where the rock was first encountered not much above the road, it is dark-colored and diabasic, but has spots and veins of red, and even weathers red to the depth of six or eight inches. In ascending the ridge, however, this immediately gives place, upward, to a broken and confused red conglomerate or breccia-like grit, which continues to the top of the hill, the exposure being such that the observer is compelled, in ascending, to travel on the south-dipping upper surface of the stratum.

A short distance further west the southern slope of this ridge shows outcrops of southwardly dipping quartzyte. The dip is about 20° toward the southwest. The direction of the ridge crosses the dip at an angle, so that on the southern slope the strike of the different beds climbs diagonally up the hill toward the northwest, the higher layers being further toward the west. At several points the eruptive rock appears on the southern slope, sometimes near the base and sometimes well up on the hillside, but owing to the dense covering of vegetation there was no opportunity to discover, with our limited time, the relation it bears to the quartzyte, though there is no reason to suppose it is different from that already stated. It seems to have overflowed the upheaved quartzyte and to have been preserved only in the lower levels, particularly so when the accumulation was not in mountain-like hills or ridges.

There is a conspicuous outcrop of this quartzyte and conglomerate near the base of the ridge on the same side showing the same dip conclusively and generally. We examined it first in front of Mr. John Wray's house and followed it westward to opposite Mr. Wm. Ensley's house where this conspicuous outcrop occurs. It is here wholly a siliceous quartzyte, but has a few quartz pebbles running in narrow and interrupted belts through it, coincident with the bedding. It is red but varies to purple, and is vitrified and polished in the same manner as seen on the surface of the red quartzyte in Pipestone county, Minnesota. Indeed, were we not conscious of being in the area of the original Huronian we might suppose ourselves, so great is the similarity of all the geological features, to be standing on some of the red quartzyte outcrops in southwestern Minnesota.* This red quartzyte in hand samples, represented by 1171, cannot be distinguished from much of that of Pipestone and Watonwan and Cottonwood counties, Minnesota, nor from that of the ridges at Baraboo, Wisconsin. This great quartzyte, so far as can be determined by anything seen in the area of the original Huronian, or even in Wisconsin and Minnesota, whether dipping N. W., N. or S. W., whether white, pink or red, or purple, or pea-green white, whether arenaceous or pebbly, is plainly a unit. It must have a great thickness, for it extends westward from Wray's house with the same dip at least a mile. It is true that this distance is not measured here directly across the bedding, nor on the hypotenuse of a triangle perpendicular to the direction of the strike; but the thickness observed here can be fairly estimated to fall not much short of 5,000 feet, and it may be twice that amount.

At Ansonia P. O. is a place in the river known widely as "the dump." This is in the township of Le Froy. A glaciated surface outcrop of rock may here be seen at the river level, (See fig. 3) on the right bank, immediately overlain by a bank of till. The river flows over it except in time of low water. This rock seems to belong to a different formation, both on account of its different lithological characters and the different direction and amount of its dip. The bedding stands about vertical and it strikes about 30° north of west. The layers are thin, varying from slaty to two or three inches. Much of this rock, while siliceous, weathers to a light drab or even to a buff. It is finely crystalline, at the same time that it is fragmental and banded by sedimentary colors and belts of differing structure. It might be used for lithographic purposes if slabs of sufficient size could be procured. It affords a slow, fine effervescence when hydrochloric acid is applied on a fresh surface. There are here several varieties of rock related as shown in fig. 3.

*This similarity extends even to the existence of eruptive basic rock in some places among the red quartzyte. According to Prof. J. E. Todd a dioryte outcrop occurs in sec. 15, tp 102—48, about five miles S. SW. from Palisades, in southwestern Dakota. He judged from the dip at several neighboring localities that this dioryte overlies the quartzyte. "The dip of the quartzyte at Palisades is 4°—6° SW. About one and a half miles S.E. from the dioryte, another exposure of the red quartzyte dips 2°—3° N. of E. At Sioux Falls the dip is about 3° S. SW. It may be there is a fault between palisades and the locality but I had conceived the dioryte to have flowed out through and upon the red quartzyte." [*Letter dated Oct.* 22, 1885.]

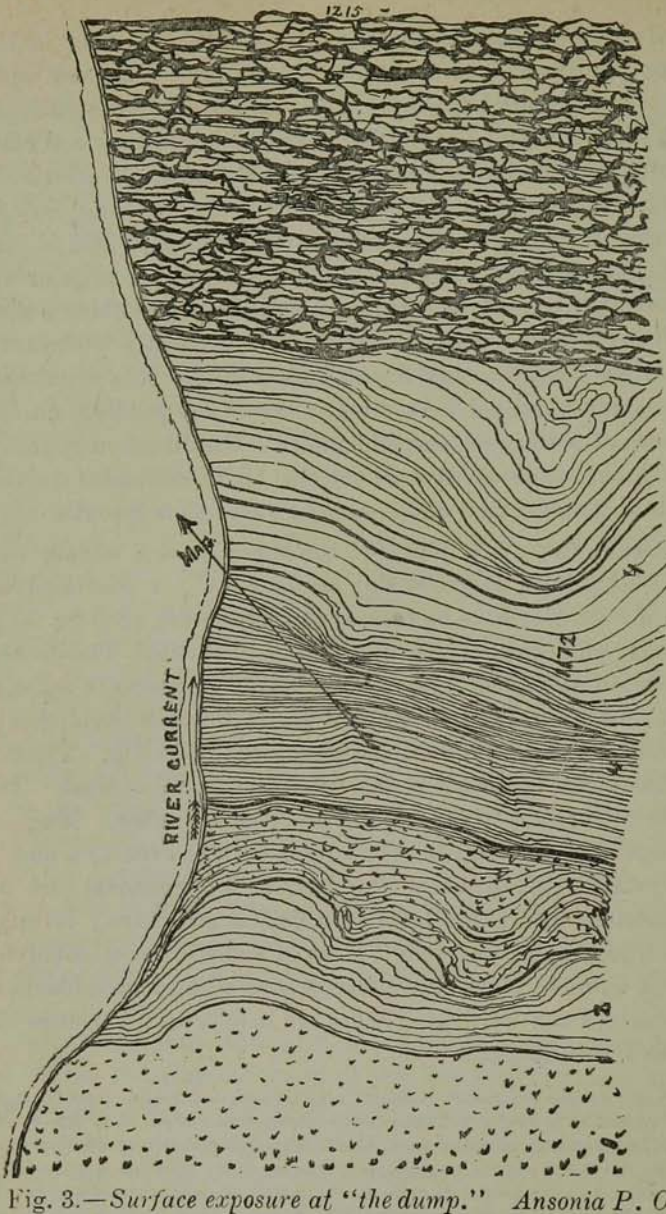


Fig. 3.—*Surface exposure at "the dump." Ansonia P. O.*

Explanation of Figure 3.

1. Fine, diabasic greenstone; width of surface exposure, seen............10 ft.

2. Fine-grained drab stone, with undulating sedimentary banding (1172); slightly calcareous gray quartzyte or lithographic stone; surface band, about........2 ft.

3. A greenish, fine-grained, apparently eruptive rock, having a very irregular width, and on the surface marked by interrupted bands and lines that seem to be

the remnant of an original fluidal structure. These fluidal lines are not conformable with those in No. 2. This member varies from....................2 to 3 ft.

4. Rock similar to No. 2, affording a very smooth hard surface, some of it very finely stratified, and some of it confused in its strike, particularly in its eastern portion ; width of belt about..20 ft.

5. This member (1215) is the most interesting. Its exterior surface is quite different from No. 4, and on first glance it would be taken for a rotted eruptive, but closer inspection shows that it is a folded, compressed and crushed condition of some of the sedimentary strata belonging in the same category with the others. It is rough and jagged, rather fine-grained, with a felsitic aspect, but darker when wet, much slickensided, has quartz veinings and is rusty with oxydized pyrite. Sometimes, on weathered angles, it appears like a fine felsyte, having a reddish tint and a pseudo-fluidal outward aspect ; and in other parts it is apparently a fine, reddish impure quartzyte. In general, it is a hardened part of the slate formation that underlies the great Huronian quartzyte. Surface exposure, width, seen, 15 ft.

Rock No. 1172 (above), seen in No. 4 seems to be allied to the chert-beds, or to some seen near the base of the Animike in northern Minnesota, but it is rather too light-colored and too coarse-grained to be called chert—though it seems to contain the same elements in about the correct proportions. It is a fine-grained, bedded, siliceous, light-gray rock, and seems to have something in it which causes it to become coated with a rust film. It resembles some pebbles seen in the great quartzyte of this region, especially some seen in the quartzyte about a mile southeast from the "little rapids" of Gas creek, already mentioned. Such source for these pebbles would indicate an unconformity between the quartzyte and this thin-bedded formation. If a horizon of rock similar to the Gunflint beds of northern Minnesota exists in this slate and quartzyte formation, nearly all the colored flint pebbles seen in the overlying great quartzyte can be referred to it; and the presence of such pebbles in the quartzyte, other relations being favorable, strongly indicates the existence of such chert and flint beds.

At a mile west of "the dump," on the right of the road, is a low hill consisting of diabase rock. Several hillocks in the immediate vicinity apparently contain the same rock. A vein of red orthoclastic granulyte runs through this rock, represented by 1193. The country about on the south side of the Thessalon is hilly, apparently with ridges and knobs of the same rock.

About sec. 8, Le Froy, south of the Thessalon river, near the highway, between it and the river, is a sloping glaciated surface of the same formation as seen at the water-level at "the dump." It dips northerly at an angle of about 40 degrees, but it is so twisted and broken that no certain statement can be made of its direction. The average strike is perhaps E. 30° N. (mag.). This rock, while belonging to the formation seen at "the dump," is yet less calcareous than that, and has a darker drab color, sometimes being bluish or greenish gray. It is intersected by many quartz veins, some of the quartz being drusy and amethystine, many of them coincident with the bedding. Mingled with the quartz are black scales of a crystalline metallic oxide, which has not yet been determined, thought to be hematite. On weathered surfaces the rock although fine, dense and hard, is coated with a rust-scale which is sometimes a quarter of an inch thick, resembling some rock seen near Gunflint lake. It is not seen to be slaty here at any place, although thin-bedded. Its outward characters resemble the silver-bearing formation seen along the international boundary north of lake Superior. This rock is represented by 1194, and 1194A.

Further northwest, about in the S. E. ¼ of sec. 31, Rose, on the north side of the Thessalon, near the road going to Otter Tail lake, the white quartzyte already mentioned again appears. The roadway passes over it. The exposure is along the crest of a hill. The dip is S. 53° W. (mag.) 23° from the horizon. The rock rises but little above the general level, but the average level is over 100 feet above the Thessalon. The rock here is blotched with purple, and also has a green tint very common. The purple spots are due to dissemination of color from hematite nodules which are embraced in the mass of the rock.

Several ridges of quartzyte were seen between this place and Otter Tail lake, but by a winding route toward the east.

At Otter Tail lake, a mountain like ridge of quartzyte runs along the northeasterly side, dipping toward the lake, while at the southeast end a second one rises abruptly, and below it the former dips conformably at an angle of about 23°. The stratification is well shown on the abrupt end of this and was photographed, the view looking west.

At the village of Otter Tail, which is on the Thessalon river near its point of departure from Otter Tail lake, a little south from the post office, is a ridge of reddish weathering rock (1195) nearly on the line between Plummer and Plummer addition, which can appropriately bear the name felsyte. (Compare also rock 1182). It is roughly bedded, though plainly with every indication of sedimentation. It dips southerly to southwesterly, about 30 deg. and is banded with finer and coarser materials. The bedding varies in thickness from less than an inch to over twelve inches. But in general the rock of this ridge, which rises perhaps 200 feet above the village, and runs northwesterly, is very uniformly constituted. Its weathered surface shows different shades of red The bedding structure is not everywhere present There are some large places where no bedded structure can be seen. Again, in one boss, or knob, of the general range, the strike is east, about 30° south; in another it is east, 30° north, with intermediate directions at intermediate points, or at points removed from both; another place shows dip S. 58° W. at an angle of 20°. The exterior surface is roughened by the removal of numerous small bits loosened by the diverse and frequent jointage. Some of the close jointed and most crumpled is coated, in the seams, with a green (chlorite?) substance, owing to more easy decay, and this also stains the rock itself to some extent, giving the appearance of some rock that has been called "trap." This rock which is here considered felsyte, has a compact uniform reddish-brown base or matrix, in which are scattered fine grains of free quartz. In other places nearly one-half of the whole seems, under the hand magnifier, to consist of quartz grains. Surfaces which show a brick-red weather-color, within are brownish-red.

Passing from this bluff across a small field in a southwesterly direction, and thus across the strike, we come to a nearly perpendicular bluff facing east, rising about twenty-five feet made up of rock similar to the last, evidently a part of the same. It here shows, in some of its parts, granular free quartz in abundance. It varies to a fine reddish quartzyte, and to a fine gray quartzyte. These varieties are shown by 1196, 1197 and 1198. No. 1196 is identical with the rock 1195. No. 1197 has a light pink-red weathered color but is brownish within. It is a fine granular felsitic quartzyte, and is separated into small angular blocks by frequent and intersecting joints. No 1198, which has a light yellowish-red, weathered surface is gray within, very hard, conchoidally fracturing, and is a sub-granulo-vitreous quartzyte, intermediate between 1172 and 1194. Although the dip is probably toward the southwest there is here a jointage system that resembles bedding that dips about 30° from the horizon, N. 20° E. (mag.). Generally, however, at this point there is no remaining trace of the original sedimentary banding. The exposed area is about sixty feet square, and it seems to have a greater extension northwest where another hill rises seventy-five feet higher, though the surface intervening does not reveal the connection with the quartzyte.

This higher hill proves on examination to consist of a congeries of pebbles and boulders compacted with and modified by a rock similar to the red felsyte first described here (1195). It seems to have been a conglomerate with a matrix of the same material as the red rock. Indeed the hill is about in the line of strike from 1195, but not continuous with it—though the surface generally ascends from it, there being, however, a low spot between covered by drift. This conglomerate contains pebbles of red granulyte (quartz and orthoclase), but the great bulk consists of the rock 1199. It is a little darker colored, but otherwise this rock is identical with No. 1195, and probably in order of stratification, belongs below 1195.

[A few miles east from this place a large boulder of coarse conglomerate was seen by the roadside. It was red externally, and dark red within. It was evidently wholly fragmental, and had sedimentary bands of fine materials crossing it. But it also embraced red granulyte boulders, six inches across, as well as some of as great a size, of greenstones. It is to be supposed it was from the unmodified beds of which this outcrop is the upheaved, pressed, heated, and metamorphic condition.]

This observation near Otter Tail postoffice is a very important one. It shows the transition from felsyte to quartzyte, from 1195 to 1196, 97 and 98, all in the same formation. It seems to be conclusive as to the origin of felsyte, such as has been described in the Minnesota reports. It is similar to that seen in "the palisades" last year, [15th report p. 342] except that it is more quartzose in some of its parts, and is generally less crystalline, and much finer-grained.

As to the relation of this red-weathering, felsitic rock to the great siliceous quartzyte described at various points in the Thessalon valley below Otter Tail lake, there is little hesitation in placing it below it. The same kind of rock was seen, later, among the black slates of the region where it could only occupy a stratigraphic position in the slates, or of a modified portion of them. As mentioned below, the strike of this quartzitic felsyte, generally gray and less changed, extends several miles to the southeast from the ridge here described, constituting what is locally known as "lithographic stone," thus showing a long belt, with a nearly uniform dip toward the southwest. How far the ridge may continue toward the northwest is unknown. It is only by a line of fault, such as has been mentioned and mapped by Logan, running approximately coincident with the Thessalon valley and passing near this place, that this rock can be brought to this position, since the white quartzyte that skirts the east side of Otter Tail lake, dipping persistently toward the southwest would otherwise naturally run under this felsyte.

Toward the southeast, across a valley, from the hill containing the above rocks, (S. 70° E. from them) about half a mile distant, and also in the line of extension of the valley of Otter Tail lake, is another knob, but much lower, of rock like 1195. The dip here seems to be about vertical; but the banded structure is not well preserved, being changed rather to an incipient gneissic and interrupted foliation.

Toward the southeast still further, on higher land, areas of red rock can be seen showing weathered surface exposures evidently in the line of strike from 1195.

In close proximity to the last mentioned felsyte knob, but a little toward the northeast from the line of strike, is a hill of gabbro, represented by 1200. This comes within about ten rods of observed contact with the felsyte, the intervening space being covered by earth and soil. Toward the north this bluff breaks off nearly perpendicularly about seventy-five feet, down to the flood-plain of Thessalon river. Only the upper part is bare, but it extends unquestionably about forty rods southeast and northwest, and perhaps thirty rods northeast and southwest. It is a curious variation in the geology of the region, but is a further instance of parallelism between the original Huronian and the Animike rocks of northeastern Minnesota. This gabbro is on the land of Mr. Day.

About a third of a mile still further southeast, on land of Mr. Day, in the bottomland of the Thessalon, is an outcrop of what Mr. Day regards as "lithographic stone." This rises about twelve feet above the surrounding land, and is on the east side of the river. It runs from eight to ten rods in the direction of strike, and subsides below the soil. It dips S. 50° W. (mag.) and 27° from the horizon. It is 1201. It is highly siliceous and does not effervesce. Some of it is reddish and purplish, but by far the greater part is of a light drab color. It is very fine-grained and very hard. Some of it is well supplied with free quartz in minute grains visible under a magnifier, and some of the coarser parts are crossed by strings and bands of chert (1202). This rock is like some seen in the Animike, particularly some of the Gunflint beds. It is also the same as seen at "the dump," and is nearly in the line of strike from 1198 and 1195. It may be considered the same rock.

Rock 1203 (like 1200), an eruptive gabbro, forms a low ridge in the midst of higher hills of red quartzyte, in the N. E. ¼ of sec. 23, Plummer, a mile and a half from Otter Tail lake northeastward; appears in the N.—S. road.

At one mile south of Murray's Corners, S. E. cor. of sec. 2, Plummer, is another exposure of red felsyte, an area of it running northwest from near the north and south road, and rising high in the hill, represented by 1204. This is about five miles nearly north from the felsyte ridge described near Otter Tail P. O., and may be supposed to be the same stratum brought to the surface again on the north side of the great fault. Some of this takes a closely sub-crystalline form (1205); indeed much of it has this character. There is no constant dip, but in some places an indistinct banding is seen which shows an inclination about 50° from the horizon, N. 10° E. (mag.); but this must be only a local irregularity. Indeed the rock here is so much changed that all its original bedding is lost. Rocks 1207 and 1208 are also obtained from this ridge of felsyte, but they are sub-crystalline, and only red superficially, the rock 1208 being gray and apparently a fine-grained quartz dioryte. This recalls some such changes seen in the bluffs of the Animike in Minnesota, particularly that examined on the south shore of Loon lake.

This felsyte ridge has an interesting and instructive relation to another ridge of a different kind which runs northwestward, parallel to it, situated across a little valley about twelve rods to the southwest. This ridge, which is a characteristic bluff of characteristic Animike slates, dips 46° S. 30° W. (mag.), and rises above the little intervening valley from fifty to seventy-five feet. It runs nearly in the direction of strike of the rock of which it is composed. Its highest portion is toward the northwestward. There is nothing in this ridge but very fine-grained gray rock which is nearly black on fractured surfaces. It frequently has a rusted weather-scale about a quarter of an inch thick. It is minutely granular, almost aphanitic. It is thin-bedded but hardly slaty, evidently of sedimentary origin. On the weathered surface it is harsh, as if a fine net-work or frame of amorphous silica consituted the base of the whole. It breaks with a flinty sub-conchoidal surface of fracture. It is closely related to, if not identical with, the rock seen at the roadside (1194) and belongs to the same formation as the rock at "the dump" and the "lithographic stone" of Mr. Day, but probably its stratigraphic place is above the "lithographic stone." It here rises into extensive ranges of hills, and forms the rock of the country.

Murray's hill is at Murray's Corners, but a short distance east, and on the north of the road—S. W. ¼ sec. 36, Coffin. This hill rises about two hundred feet above the highway. It is rough and basaltified outwardly. The sedimentation dips 78° toward the S. 20° W. (mag.), thus throwing the beds far below those seen in 1206. If there be no irregularity the felsyte No. 1204 lies between them. Here the "black slate" is a granite-conglomerate, i. e. it contains numerous boulders of red granite. The boulders are almost wholly of red granite, and the rock is but scantily slaty in the direction of the sedimentation. Close jointage sometimes produces an appearance of slatiness. Neither has it any slaty cleavage. On the top of the hill some thin veins of white quartz stand above the surface. The general weathered aspect is slightly greenish, but the color within is dark-green to gray. This is mapped by Logan as the "upper slate conglomerate." The rock is shown by 1209. This rock appears like the Ogishke conglomerate of Minnesota. Its boulders, however, do not, here, embrace any of greenstone. At the foot of Murray's hill, on the west side, is a dike, represented by 1210.

At half a mile south from Murray's Corners, on land of Hugh Matheson, is a show of hematite in a reddish sort of quartzyte—1211. It runs in strings and thin veinings, mingled with quartz and some calcite. The quartzyte is fine-grained, and seems to form a large bed, perhaps fifty feet thick. It cannot all be seen. It is brecciated, and these minerals are in the cemented fractures. There was here an accumulation of iron in crystals, as well as of quartz. This rock is like some of the brecciated Animike of Minnesota. It is a very fine-grained quartzyte, slightly reddish.

At Riddlebank P. O., which is a mile and a quarter southwest from Otter Tail P. O. on the road to "the Bruce," is an exposure, or succession of low exposures, of slate conglomerate similar to that of Murray's hill (1212). This is rather fine-grained, greatly brecciated and cemented again with hematite (in black scales unless crushed), and shows frequent changes of dip, and frequent short faults. The pebbles are principally of red and gray granite, gneiss and allied rocks, but there are a few of red jasper. There are in it gray quartzyte beds ten to twenty inches thick, which weather much lighter colored from having feldspathic grains. This quartzyte is 1213. 1214 represents pebbles from this slate. Some are of gneissic crystalline rock; some look as if they were from older graywackes but contain feldspar porphyritically disseminated, and are schistose; some are of jasper, but the most are of reddish coarse granite.

In traveling from Riddlebank to Thessalon the road goes near Bruce mines (1 m. N. E. from "the Bruce"). At the point where the road comes nearest and turns easterly, a slate conglomerate like the last is found in some low exposures. It is probably what Logan styled and mapped "lower slate conglomerate," but it seems undistinguishable from the upper. It contains here large red-jasper pebbles.

Eastwardly from this place, along the road leading to Thessalon are seen low flat areas of the same conglomerate, dipping at a high angle toward the lake; and at one place a rock like that at Bruce Mines appears by the side of the road, distant about three and a half miles from "the Bruce." But it is evident that the eruptive rock which seems to be the prevailing one at the mines, containing the vein mined for copper, is not very extensive in geographic area toward the northeast, for this road runs within a mile, or less, of the lake shore, and passes through a fine tract of farming land.

At Blind River, which is a stopping place for steamboats, the river which gives name to the village has a double débouchure into lake Huron, the principal one being the more easterly and affording water-power for a saw-mill. There is abundant exposure here of the eruptive basic diabase or "dioryte" seen further west, though somewhat coarser grained than at Thessalon (1174). Here it has occasional specks of red feldspar disseminated. It is dark-colored, rough, though glaciated, spreading generally in low knobs that rise from ten to twenty feet above the lake. On the east side of the mill are quartzytes dipping S. 10° E. (mag.) about 48° from the horizon. One bed of quartzyte, part of which is certainly in the form of a chemical vein, is about ten feet wide. It is followed on the south by dioryte, about forty feet, when quartzyte returns, varying from dark to pale red, but mainly gray, and continues to the lake shore—about fifty-five feet. On the north of the first mentioned bed of quartzyte the dioryte extends indefinitely. This quartzyte seems indistinguishable from some of that seen at Thessalon; but in general it is finer-grained and more vitrified, approaching, in a degree, the texture and color of the so-called "chalcedonic silica" of the iron-bearing rocks at Vermilion lake in northern Minnesota. The line of contact between the quartzyte bed here described, and the greenstone on either side is not straight, nor parallel with the strike of the quartzyte, but off-sets right and left, like a fracture-plane rather than a plane of sedimentary superposition or of igneous overflow; but in the main it coincides with the strike of the quartzyte.

A little further north, at the recent cuts made by the Canadian Pacific railway, the relations of these two rocks are evident. There is a continuous rock exposure from the lake to the railroad, and the cut shows the relations expressed by the subjoined diagram—figure 4, which is a view of the north side.

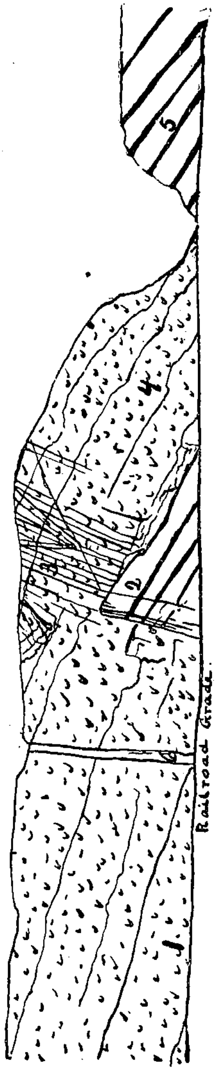


Fig. 4.—*Railroad cut showing greenstone lying on gray quartzyte. Blind River.*

Explanation of Figure 4.

2. Dioryte, showing coarse flowage-bedding often seen in overflow sheets of eruptive rock, and particularly in the great gabbro sheet of Minnesota.
2. Quartzyte, pinkish, with detached masses on the right indicating the direction of flow of the molten rock. These detached masses are pink when large, but some of them are greenish, at least superficially, with chlorite, but gray within. There is some difficulty in distinguishing them all from the enclosing igneous rock, since they come to look like the fine-grained contact parts of it.
3. Basaltic columns developed in the upper part of the igneous rock from the cooling in contact with quartzyte.
4. Dioryte not basaltic.
5. Quartzyte.
6. Quartz vein.

This ridge of quartzyte rises toward the southwest so as to coalesce with a general quartzyte area. The superficial area of the dioryte running to a point between them.

The quartzyte has patches of chloritic shaly quartzyte, some of it with less fine quartz. This is visible on the face of the perpendicular cut. The southwestward dip is exhibited plainly, but the contact of the two rocks, when sketched, is a straight plane, perpendicular to the horizon, visible specially on the south side of the cut, and continuous to the north side, where it is perpendicular or slopes a little to the northwest. Fortunately the conjunction of the railroad grade with this contact is so near the top of the ground that there is visible a continuous mass of the dioryte, spread over the surface of the quartzyte and extending again below the level of the grade and continuing till the quartzyte rises and spreads out eastwardly without interruption. There could be no more conclusive demonstration of the eruptive and later origin of the greenstone. Rocks 1175–1179 illustrate the foregoing description.

The same fine-grained gray quartzyte, varying to pinkish and dipping toward the lake at an angle of 80° from the horizon, is seen to constitute the long point that projects from the mainland southeastwardly from the westside of the westerly delta-arm of the river. It strikes W. 10° S. (mag.). It is in thin beds, and though the grain and color is much like that already described at Blind river, it is strikingly unlike that seen at Thessalon. Indeed its physical character seems to ally it with the slate formation and the rock immediately overlying the felsyte at Otter Tail P. O. rather than with the great conglomero-quartzyte described at Thessalon. Compare rocks 1197 and 1198. The point is crossed by a diabase dike (1181) forty-eight feet wide, which runs about in the direction of the strike; and by another about parallel near the lake shore a little further south.

Missasaugui river. Toward Missasaugui river, from Blind river, along the new grade of the Canadian Pacific R. R., the first outcrop is about a mile and a quarter from Blind river. It consists of glaciated domes of diabase, rising on the south side of the grade. But a short distance further west, on the same side of the grade, can be seen other similar domes, but on the north side of one of them is a lenticular area of pinkish quartzyte, the greatest length being about east and west in the direction of the strike. Toward the east it is enveloped entirely by diabase, and toward the west it is hid partly by diabase and partly runs under the soil. The northern contact plane is nearly perpendicular.

The next visible rock is at the west delta-arm of Blind river, where the new railroad crosses it. It is quartzyte, but has some dioryte associated with it. The dip is confused, but at one place it was seen to be distinctly toward the N. N. W., the reverse of that along the lake shore. But this is likely to be only a local irregularity.

At about three quarters of a mile east of the Missasaugui river is a low cut in the quartzyte, and some of it is light greenish, or pea-green, shown by 1183.

At the railroad cut at the Missasaugui, east side of the river, the igneous rock is exposed. It shows a rude flowage-structure dipping N. W., and it embraces red felsitic portions, of irregular shape and position. These are very conspicuous, and very interesting because they illustrate again the same manner of origin of felsyte as has been mentioned. These pieces (1182) can be accounted for by supposing them to have been loosened fragments from the country quartzyte enclosed in the molten rock at the time of the eruption, and in that way fused and welded to the diabase. These isolated red felsyte pieces have considerable free quartz, but it cannot easily be ascertained whether the grains have a crystalline form. The bulk of it is aphanitic, opaque and reddish, and the silica seems to have been feebly disseminated in the felsitic groundmass, chemically losing its identity in whole or in part.

Different conditions and stages of this interesting combination are here visible. One is that of the quartzyte, in association with the diabase becoming affected by heat, some of it becoming infused with what now appears like a green chloritic matter, the quartz losing some of its distinctness—1184. Another is of the same character, but darker—1185. Still further, and the change developes an orthoelastic tendency—1186. Again, without being colored by the interpenetration of any of the basic elements, the changed quartzyte becomes dense and fibrously basaltified, appearing, structurally, like the basaltic red felsyte of the "great palisades" on the north shore of lake Superior—1187. The last step in the mingling of the two rocks is seen in the formation of an orthoclase dioryte, or orthoclase gabbro, wherein the silica of the quartzyte, fused in the mass of igneous matter, apparently having sought as an acid the strongest alkaline base (potash), has combined so as to make a dioritic rock that is speckled with red orthoclase crystals—1188 and 1189. These stages are all visible within a small space at the railroad cut at the east side of the Missasaugui. When opportunity occurs a special study and presentation of these varieties of rock and their paragenesis, in connection with other similar facts that have accumulated during the past ten years, going to show the origin of felsyte from sedimentary rock, and not from a deep eruptive source, will be made in some of the publications of the survey.

At the mouth of the Missasaugui, on the west side, a dome of dioryte rises from the water's edge having the character of 1190, and on its southerly margin has an abrupt contact on a fine-grained, gray, almost flinty quartzyte which dips south at an angle of about 80° (1191). This dioryte has a different aspect and apparently a different composition from any rock seen in the area of the original Huronian. Its association is somewhat different also. The fine-grained quartzyte with which it forms an abrupt contact, while probably a part of the quartzyte series seen at Blind river, which also extends along the shore between Blind river and the mouth of the Missasaugui is darker colored, and much finer than the great Thessalon quartzyte and evidently occupies a lower stratigraphic place in the Huronian. Its granular structure is compacted, and cemented closely by secondary silica. Its coloring material gives it a suggestive alliance with the dioryte, and, owing to the greater metamorphism to which it has been subjected leads to the possibility that the adjoining dioryte is itself only a modified condition of some part of the great slate formation, the transition being similar to such as have been noted in the Animike in northern Minnesota at various places.

On the east side of the Missasaugui, at its mouth, is a beautiful expanse of this quartzyte, making the outer breakwater of the lake shore and enclosing a little bay where the river enters. The strike is persistent here and conspicuous, W. 5° N. (mag.), and the dip about 75°, toward the lake. False bedding and slaty characters coincident with the stratification, are features that appear in some of the layers. No. 1192 represents one of the greenish weathering, more slaty parts of this quartzyte. This quartzyte is cut by a greenstone dyke running S. 66° W. (mag.), showing non-conformable relations with the strike, and hence non-inter-bedding. This dike is about forty feet wide.

Between Missasaugui and Blind rivers an inspection of the shore in a row-boat revealed nothing except the quartzyte 1191, with an occasional dike or overflow-area of some greenstone eruptive. The dip of the quartzyte is regularly from 75° to 80° into the lake, and the immediate coast-line is for nine-tenths of the distance composed of it. The greenstone dikes have a direction about W. 20°—30° S. (mag.). They are represented by rock 1181, from the point off the mouth of Blind river.

CONCLUSIONS RESPECTING THE ORIGINAL HURONIAN.

This examination of the original Huronian, of which the foregoing is a brief account, leads to some important results which have a direct bearing on the classification of the rocks of Minnesota, and of the northwest.

In general, the stratigraphic grouping of the parts above noted, is about as indicated by Logan in the report and atlas of 1863, except that the "green chloritic slates," so-called, are not at all included in the terrane as constituent parts of the stratigraphy. They are a part of the eruptive basic rocks of the region, and very doubtfully ever become slaty—indeed they never exhibit the slatiness of roofing slates, and only rarely have that interrupted, wavy, thin bedding which appears on the weathering of a once molten mass indicative of an internal fluidal structure. Their macroscopic mineral characters also ally them closely with the greenstones. These slaty characters moreover are found only in the midst of areas of undoubted eruptive greenstone. Not only is this "chloritic slate," but all the "greenstones" are excluded from the Huronian. They are regarded by Logan as accidental features, except so far as they are named, and colored as "green chloritic slates." In his map, and in his table of stratigraphic parts of the Huronian (map of 1865), there is absolutely no other reference to the vast outflows of greenstone that cover many square miles in the Thessalon valley, and that constitute hill-ranges as conspicuous as those of any rock in the region.* The limestones also are quite subordinate parts, belonging in the slate number of the Huronian. They are siliceous and cherty in some cases, and very fine-grained. A limestone which is more like a gray crystalline marble appears a little northwest of the old Wellington mines, belonging in the "lower slate conglomerate," of Logan, but time was not afforded to examine into its stratigraphic relations.

It thus appears that the original Huronian can be divided into three grand divisions, viz.:

1. Red and white quartzyte, granular and sometimes conglomeritic.
2. Slates and gray quartzyte, sometimes conglomeritic.
3. Very fine-grained white or gray quartzyte.

No. 1 overlies No. 2. No. 1 includes the parts 3l, 3i, 3h, 3g, of Logan's tabular statement accompanying his map of the region, of 1865. No. 2 includes 3f, 3e, 3d, of the same table. No. 3 includes 3a and probably 3c. No observation was made that fixed without doubt the positions of his parts 3k and 3c, but from what was seen it is inferred as probable that his 3k belongs in No. 2 and his 3c in No. 3.

It seems necessary to recognize the *fault* which Logan represents running on his map northwestwardly up the Thessalon valley, by which the lower rocks are suddenly brought to the surface and made to appear, according to the prevailing dip, to lie over the upper.

No. 1, above, is divisible into at least two subordinate parts, but it is not supposed that the character on which these are based—that of color—will be found sufficiently constant to warrant the extension of this division beyond the limits of the original Huronian area, though other distinctions may be discovered which will permanently characterize these members over a broader area. 1.—Otter Tail quartzyte. 2.—Thessalon quartzyte. The highest member of the Huronian is the Otter Tail quartzyte. It is nearly white, but in limited areas it is both conglomeritic and pinkish. It also is greenish sometimes. Its greatest and characteristic exposure is in the hills along the east side

*His map is also incorrect in other respects. It represents the Laurentian as occupying the lake shore for some miles at the mouth of the Missasaugui and the Blind rivers, where the only rocks are quartzyte and greenstone.

of Otter Tail lake, and at the southeastern extremity of that lake. Its thickness is several thousand feet, but there was not time to ascertain it carefully. The underlying quartzyte is red or reddish, occasionally conglomeritic, and perhaps prevailingly somewhat finer-grained than the last. It is that member which would most probably afford catlinite, and perhaps the fossils of the catlinite in Minnesota, if similar clay beds could be discovered in it. The chief outcrop of this quartzyte which was examined occurs in the Thessalon valley forming a ridge running nearly east and west and rising to the hight of 150 feet above the adjoining low land on the south. This ridge is on the north side of the Thessalon and its composition is represented by rock 1171. The thickness of the strata here is also several thousand feet, but no exact measurement was attempted.

The subordinate parts of the other principal members are as follows: 3 —Black slate, identical in all characters with the slaty beds of the Animike in northeastern Minnesota; siliceous, carbonaecous, slaty in the direction of and incident to the sedimentation. This is supposed to embrace the limestone layer which appears near "the Bruce." This sometimes varies to a somewhat harsher grayish feldspathic quartzyte. It appears about two miles south from Murray's corners, north from Otter Tail lake, and there constitutes a series of ridges and hills that give the country a very rough contour. It contains, in some of its more quartzose strata, considerable quantities of hard black micaceous hematite distributed, along with amethystine quartz, in veins which have recemented the fragments after the strata have been brecciated. 4.—"Lithographic stone." This is found in the bottom-land of the Thessalon river a short distance below Otter Tail lake, on the south side of the great fault. It strikes from there northwestwardly and appears, in a somewhat more granular and siliceous phase, on the south side of the red felsyte hill near Otter Tail P. O. This is only a modification of the slates of No 3, by the increase of calcareous sediment, and the greater fineness of the siliceous. 5 —Red felsyte. This is found forming a ridge that rises about 200 feet, near the village of Otter Tail. It appears again, on the north side of the fault, about two miles south of Murray's corners, and again at "the dump," where it is represented in figure 4. It is roughly stratified, and is plainly only a modification of some of the beds of the formation. It is probably not a continuous layer. 6.—The Missasaugui quartzyte. This differs from the great quartzyte forming the summit of the Huronian in being always gray or white, very fine-grained, and dense. It seems to fade gradually into the more siliceous portions of the slates and to become, in some places, interbedded with slates. Its thickness is probably not less than 1000 feet. 7.—Slate conglomerate, seen at Murray's hill, near Murray's corners. This is one of the principal members of the Huronian. It is repeated in Minnesota in the Ogishke conglomerate.* Its thickness is probably at least 5,000 feet.

These are the principal masses, and they exhibit the principal aspects of the sedimentary rocks of the original Huronian. The order in which they are named above, while agreeing mainly with that given by Logan, cannot be considered established certainly by the observations we were able to make. One of the most important points to be noticed in this is the evidence of two great quartzytes, having many common features, but separated by a great body of slate and perhaps slate conglomerate.

These rocks are not crystalline, but fragmental, and show, except where they have been modified locally by contact with eruptive rock, every character that is known to indicate sedimentary origin. There are no mica schists, no sericitic schists, no hornblendic schists, no typical graywackes, though the dark slates sometimes become coarser-grained and approach the well-known wackenitic ensemble, no gneiss or gneissic rock except what is very limited in amount and is directly referable to contact with greenstone.

Among the greenstones it is not designed here to include the dioryte seen at the mouth of the Missasaugui. There are reasons which it is not necessary to mention at this place, that induce the writer to entertain a strong doubt as to the eruptive nature not only of this dioryte but of all the quartz-diorytes that are associated with these slates and quartzytes in northeastern Minnesota.† All the facts that have been observed by the Minnesota survey conspire to show they are derived from metomorphism of some of the sedimentary rocks of the group, although the preponderance of opinion of microscopic lithologists is to consider them of original eruptive origin.

The Minnesota parallels of these rocks have been indicated already in giving the local descriptions, but a brief repetition will not be out of place. It may be included in the following tabular statement:

---

*See the 15th Annual Report.

†Compare the description of the quartz-dioryte at Little Falls, on the Mississippi, by Streng and Kloos; 11th annual report, pp. 34 and 74.

Original Huronian.	*Minnesota equivalents.*
Otter Tail quartzyte. Thessalon quartzyte.	Pewabic quartzyte (?) New Ulm, Pokegama and Wauswaugoning quartzytes.
Black slate.	Animike black slate.
"Lithographic stone" and fine gray quartzyte.	Not known.
Red felsyte.	Felsytes at Duluth and probably the Great Palisades.
Missasaugui quartzyte.	Not known.
Slate conglomerate.	Ogishke conglomerate.

There is some reason to infer that there is an unconformity between the Thessalon quartzyte and the Black slate. This evidence consists in the existence of cherty and quartzyte pebbles in the quartzyte which seem to have been derived from the Black slate strata. The same kind of evidence, the existence of granite boulders in the slate conglomerate, indicates another unconformity between it and the granites of the region that lie to the east and northeast of the Thessalon river; but in the latter case the evidence is conclusive, and in the former it is but inconsiderable.

THE IRON-BEARING ROCKS AT MARQUETTE, MICHIGAN.

*At Negaunee.** Some observations were made at the new mines situated about two miles east of Negaunee. There is a singular irregularity in the rocks of the region seen in this vicinity. The Iron Cliffs and the Sam Mitchell mines are troubled by a sudden inthrust of the north wall, by which the body of iron ore is entirely cut off at an angle which, in the latter mine differs from horizontality but fifteen degrees, sloping downward toward the south. The strata carrying the ore dip northward from 65° to 80°, and this inthrust, therefore, which consists of a great quartzyte of unknown thickness, cuts the strata off nearly at a right angle. In the Iron Cliffs mine the superintendent followed the upper surface of this quartzyte, which here descends much more rapidly than in the Sam Mitchell, downward in a shaft to the depth of about seventy feet, following a two-foot layer of soft greenstone, hoping to get below the troublesome quartzyte, and then by drifting southward to find the ore again. But at about seventy feet he was intercepted by another quartzyte which seemed to be one of the beds of the iron-bearing rock, which, dipping northward at the same angle as the ore, abuts upon the intruding

*In passing from the area of the original Huronian to Marquette opportunity was afforded to note the dip of the sandstone causing the rapids at the outlet of lake Superior. It was found to be about 10° from the horizon, 10° south of west, magnetic.

quartzyte so as to leave but a space about two feet wide between them. This space was occupied by the soft greenstone he was shafting in, and, though it changed its direction so as to become perpendicular he followed downward between the quartzytes to one hundred and fifteen feet without change, and was there at work at the time of this visit. The next mine toward the west is the Buffalo, in which no such trouble has been experienced, the formation dipping regularly toward the north, or north northwest, at a high angle.

This troublesome quartyzte is represented by Nos. 1141, and 1253, the latter however from the south side of the shaft at the depth of about 115 feet. They are identically the same gray quartzyte, rather finer grained than the great overlying quartzyte of the original Huronian, and more or less mingled with a green matrix, a siliceous graywacke. The circumstances appear to indicate a synclinal folding of the gray quartzyte, the mines from which the ore has become temporarily exhausted, being in the basin of the syncline where it is shallow and runs near the surface. At the depth of 115 feet it appears that the folding was so sharp that the quartzyte was brought against itself, or was broken and thrust against itself at a higher level. This is indicated not only by the identity of the rock on the north and south sides of the shaft at 115 feet, but by the continuation of the two-foot bed of greenstone which runs down between the quartzyte beds, up to the top of the mine on the south wall of the open pit in conformity with the iron ore beds and with the main quartzyte bed on the south side.*

A similar quartzyte, but more like a siliceous graywacke (rock 1248) sometimes having a greenish aspect, appears on the northern part of the Buffalo property, (next west of the Sam Mitchell) at the railroad-cut, in such a position as to suggest the probable continuity of the rock from the Sam Mitchell mine. It here apparently dips N. and is overlain by a black slate (1249) which graduates downward into a contorted greenish slate (1250) which lies directly on the slickensided upper surface of the quartzyte. These all dip north, but this quartzyte seems to have an unconformable upper surface. It is rounded and undulating, as well as slickensided. These slates lie directly upon the quartzyte (or graywacke) at the railroad cut, but toward the westward they seem to separate, the quartzyte becoming lost, and in its place on the south side of the slates there being an old dike which runs conformably with the slates westwardly across the railroad and on to

*A similar abrupt cutting off of the ore in a mine by an inthrusting quartzyte is described by Brooks at Michigamme, the inthrust also coming from the north. *Geol. Surv. of Mich. vol. i. p.* 123.

the next knoll where these slates become somewhat iron-bearing (1252), and the selvage of the slates, the hardened and broken wall, alongside the old dike, projects above the ground conspicuously. Here the dike is hardly visible, but can be occasionally seen on the south side. This old dike is a very different rock from the slates, microscopically (1251). It is coarser but even grained, has a light green color, no free quartz, is sub-talcose to the touch, is lenticularly schistose perpendicularly, without sedimentary banding, cut by frequent quartz veins. It is probably the same greenstone which runs across the Iron Cliffs mine, and in which the superintendent shafted between the quartzyte masses.

At the Iron Cliffs (1143) and the Swan mines (which latter is a short distance west of the Buffalo) the ore is interchangeable with quartzyte, both across and in direction of the strike, large portions being rejected from the strata which, about 20 feet right or left, in the direction of the strike, were wholly reserved and shipped as ore. This irregularity is distinctly observable at the Swan mines. The sedimentary rock graduates from 1247 A, a coarse fragmental stone, mainly quartz but with glittering facets apparently of minute crystals of magnetite, through 1247 B, an impure hematite banded with light red, chalcedonic silica, to 1247 C, an earthy hematitic jasperoid rock, banded and clouded. This shows a common origin for them all rather than a chemical or eruptive source for the jaspilyte and not for the others.

Occasionally also, at the Iron Cliffs mine, the red hematite is associated with lumps of siderite, some of them being six or eight inches in diameter. There is a gradual transition from one to the other, through a yellowish limonite (1142).

Along the north side of Teal lake at Negaunee runs a range of hills made up of a nearly white granular sometimes pebbly quartzyte (1252). It is blotched with red, ripple-marked, evidently fragmental, and dips south, 18° W. about 65°. This is mapped by major T. B. Brooks as continuous with that which forms the "capping" of the ore at Ishpeming. Here it dips as it does there, *apparently* below the ore. It embraces not only pebbles of quartz but some of other kinds, among which may be mentioned a light greenish, very fine-grained serpentinous rock, and a soft red hematite. This is an immense quartzyte, visibly 200 or 300 feet thick. On the north side of the bluff it graduates downward into a thin-bedded, feldspathic fine-grained gray quartzyte (1234)* exactly duplicating the section seen north of Ishpeming.

* This seems to be the rock worked for hcnestones; *Rominger; Geol. Sur. of Mich. vol. iv., p.* 41.

Whether this is here a conformable transition is not quite certain, as there is but a slight outcrop of the thin-bedded gray quartzyte at the point examined. Next along north of this quartzyte range is a range of dioryte hills. This quartzyte is, in the opinion of the writer, the equivalent of the *Otter Tail quartzyte* of the original Huronian, and lies unconformably on the iron-bearing rocks at Negaunee.* This will be made more apparent on giving the observations made at other points.

An old, much altered, dike can be seen cutting this quartzyte near the east end of Teal lake (1255). It is somewhat serpentinous and schisto-fibrous, of a prevailingly grayish-green color but striped and blotched by different amounts of iron-oxide. This gives it, in some places, a pseudo-aspect of sedimentary banding.

At the Eldridge mine on the south side of Teal lake, which is as yet only an exploration, the shaft penetrates one hundred and fifty-three feet perpendicularly a red "soap rock," which is said to dip south as if it passed beneath dioryte hill near which it is located.

At the Hartford mine, a little further west, still on the south side of Teal lake, the situation is similar to that at the Eldridge, and a good, massive hard bluish ore is taken out.

Next west in the Cambria mine the formation also dips south. This mine has been long worked, and has sent out a large amount of ore. The mining operations exhausted a large basin-shaped pocket of ore, shut in by "jasper" on all sides, and on the bottom; the working could not be extended. Drills were run in all directions into the "jasper" and through it, but nothing more could be found of the ore. They are now exploring by following a narrow bed of ore northwestwardly, shafting and drifting.

The outbreak of the dioryte hills between Negaunee and Teal lake seems to have had no effect on the dip of the formation, since it dips southwardly on both sides of these hills.

At Cascade, which is four and a half miles south of Negaunee, the iron-bearing rock dips toward the north at all the working mines. An interesting feature here is the evident fragmental character of the ore rock. It is not only in beds that vary in thickness from less than half an inch to three or four feet, with a conformable dip 28°—40° N., but some of them contain rather coarse grains of clear quartz, about as large as mustard seeds, which are disseminated in a manner characteristic of sedimentation through some of the layers. In other places

* Compare *The American Geologist*, March 1888. *A great primordial quartzyte*. N. H. Winchell.

the ore consists almost entirely of fine magnetic octahedrons (1217). Some of the micaceous, massive hematite contains great numbers of small cinnamon colored garnets.

Lying unconformably on the edges of the ore-rock is a quartzose conglomerate, (1218 and 1219). At the bottom, this conglomerate is dark, ferruginous and pebbly, the pebbles being from the fibrous hematite of the region, jasper and white vitreous quartz, some of the latter also being purplish or smoky. *It also contains pebbles of the very fine-grained quartzyte or "chalcedonic quartz" peculiar to the iron-bearing series at Marquette and Vermilion*, and of other sorts of rock. Toward the upper part this conglomerate becomes simply a quartzyte, white or dirty white, and is seen covering several acres, and extends at least half a mile from north to south. On the summit of the hill just south of the old workings of the Watson mining company (Bagley hill) the appearance of this conglomerate is represented by the figure attached. (Figure 5.)

Here but 12 feet can be seen, dipping apparently N. N. E. about 15 deg., but it continues in knobs and hills of higher and higher strata, toward the north and northeast, showing a thickness of several hundred feet. At the recent new mines of the Pittsburg and Lake Superior Mining Company, about half a mile toward the northeast, two shafts pass through this rock, one 250 feet and one 175 feet, and nothing else, except some soft shaly material (6 to 10 feet), where they struck the iron ore formation. This conglomeritic quartzyte appears above the surface in numerous places, one knob being on the "Location" (at Palmer P. O.) It here dips 35° toward the N. 40° W., or toward the new shafts. It here contains numerous pebbles ¼ in. to 1 in. in diameter.

From the fact that pebbles of red jasper, chalcedonic silica and red hematite occur in this conglomerate it is apparent that the iron ore formation *must have been constituted in pretty nearly its present state prior to the formation of the conglomerate.* This quartzyte-conglomerate appears to be no other than the southern rim of the synclinal of which the quartzyte on the north side of Teal lake is the northern rim. While dipping in the same direction, in general terms, the two formations do not dip conformably. If the detailed structure could be known it is probable, further, that faults would be seen producing sudden upthrusts of the underlying formation, causing the apparent overlie of the lower on the upper, as at Thessalon.

Ishpeming. The basin or synclinal trough seen at Negaunee extends westward to Ishpeming; and the same general features are seen there.

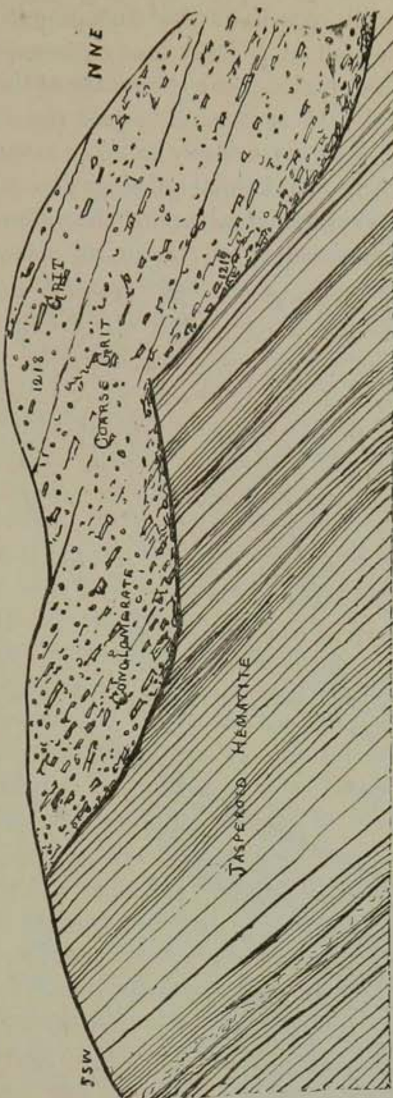


Fig. 5.—Unconformable conglomerate [Potsdam] *lying on the iron ore at Cascade, Michigan.*

There is an unconformable overlying quartzyte which on the north side is seen dipping south toward Ishpeming, and on the south side consists of a conglomerate in every respect like that at Cascade, the iron formation dipping toward the north. Intermediate between these rims lies the city of Ishpeming, and the mines (some of them) penetrate first a great thickness of the quartzyte and then come at once upon the ore. This overlying quartzyte appears in the streets of the city and is well known as the "capping" rock of the ore. It has been bored through at a great many places, and its greatest thickness, so far as discovered, is near the center of the basin, amounting to 300 or 400 feet. It is thinner toward the north and toward the south, and finally runs out entirely in those directions, the width of the trough being here about three miles, or about half as much as at Negaunee. The synclinal structure of the valley is well known, and the quartzyte is supposed by all the mine operators, and by all

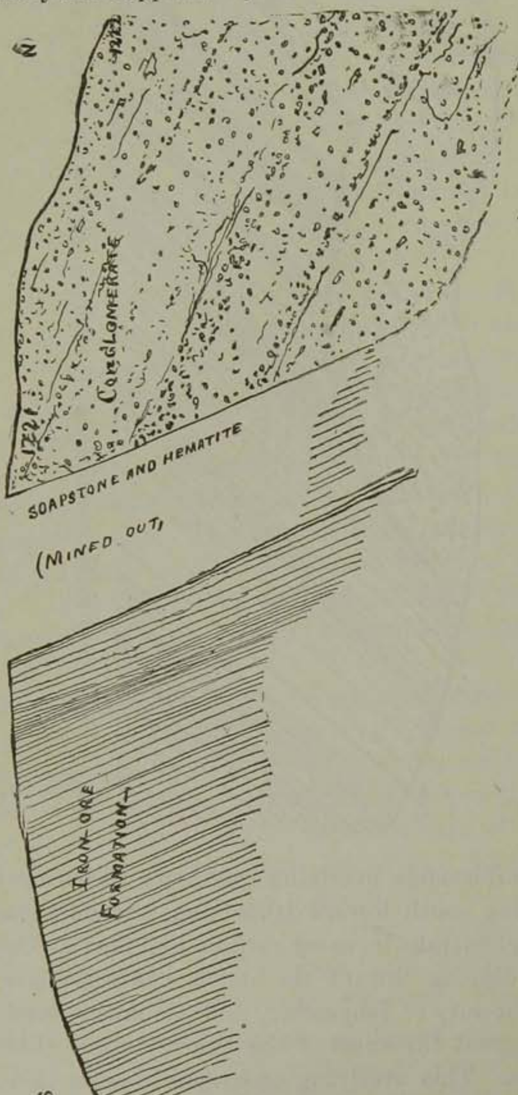


Fig. 6. The unconformable conglomerate at the Old Saginaw mine. Near Ishpeming, Mich.

geologists so far as I have learned, to be conformable with the rock carrying the ore.

The old Saginaw mine, S.W. from Ishpeming about three miles, is a repetition in all respects of the Bagley Hill works at Cascade, and the unconformable position of the conglomerate-quartzyte on the ore can be seen with even greater distinctness than at Cascade,—(rocks 1221 and 1222). Fig. 6 was sketched here. It illustrates the situation at one of the easterly small openings in this property. Further north the quartzyte rises considerably higher in rounded glaciated hills. On the northerly side of one of these knobs, in lower ground, a drill hole was made 400 feet into this quartzyte, in a sloping direction toward the south, without piercing it. *

The bed of overlying quartzyte appears again about a mile north of Ishpeming, where it causes by its outcropping edge a series of low hills that run east and west and dip toward the south. On the south side of Deer lake, where this quartzyte is cut by the grade of the railroad, it is reddish to purplish, and dips south at an angle of 50 degrees. It can here be traced almost into contact with a massive-to-schistose greenstone on which it would lie unconformably. The quartzyte here is represented by 1228, and the greenstone, which is sometimes basaltic, by 1229 and 1230. This is all on the west side of the creek just below the outlet of Deer lake. On the east side, on either side of the road to Ishpeming, the relations of these rocks are further exemplified. This massive-to-schistose greenstone becomes conglomeritic and rises abruptly in a hill at the immediate roadside, on the north of the road, to the hight of about a hundred feet, while just on the opposite side of the road appear some slightly lower layers of the quartzyte dipping at about the same angle as on the west side of the creek. These lower layers are thinner, somewhat slaty, glistening with hydro-mica scales, finer grained than the bulk of the quartzyte, and comparable to the thin layers of similar rock seen below the quartzyte on the north side of Teal lake. (1234). They dip below a quartzyte knob like 1228, conformable with it.

This hill of conglomeritic greenstone, which is situated just south from Deer lake, was carefully inspected, owing to its likeness to the schistose conglomerate seen in the Vermilion region in Minnesota. It is illustrated by rocks 1225 and 1226, and in all respects is identical with the conglomerate seen on Stuntz island in Vermilion lake, as

* Major Brooks represents this conglomerate here, and at other places, as interbedded with the iron formation; and Dr. Rominger regards it as conformable with the ore formation. Wadsworth, however, has alluded to the legitimate conclusion to be drawn from this unconformability. (Notes on the geology of the copper and iron districts of Lake Superior, p. 31).

described in the fifteenth annual report of the survey. It is soft, quartzless, or nearly so, light green, becoming darker within, especially when less changed by age and exposure, spotted (but sparingly here) with forms of boulders that are of the same stuff as the rock itself, fibro-schistose nearly vertically, cut by quartz veins, and in some places porphyritic with some feldspar. No bedding structure, such as can be attributed to sedimentation, can be seen in the rock, but along the south base, near the road, a thin-bedded, even slaty structure, standing vertical can be seen, which may be the original sedimentary bedding of the formation through which this as an eruptive may have issued. This also is a light greenish rock (1227), and were it not that it shows a markedly different structure which seems to be attributable to an original sedimentary origin it could easily be classed with the rock of the main hill and considered a part of it. But there is not a similarly abrupt change in the general mineral characters of the rocks concerned. There is what might be considered a sericitic element pervading both, giving them a slippery or "talcose" feel, and some of the schist is essentially a serpentinous schist, and fragments from it seem to be included in the agglomerate. Some of the bands that simulate sedimentary structure are finely porphyritic, and resemble the mass of the rock of the hill. The whole situation here is such as to show a non-conformity with the quartzyte across the street—whatever be the relations of the schist to the rest of the hill. This hill is a part of that which has by Dr. Rominger been classed in his "dioritic group." It seems closely connected with the "serpentine group," and indeed the writer without much hesitation regards the two as one group, the serpentinous condition prevailing whenever, locally, greater alteration has taken place in the original rock, which was an eruptive, basic one. It overflowed, and mingled with the rocks of the iron-bearing series unconformably, and where it is now in contact with them it constitutes at least in some places the "soapstone" and the "chloritic rock" of the mines. Subsequently the rocks of the Huronian were deposited unconformably on the iron-bearing and serpentine groups, these consisting of the quartzyte, the novaculitic and the black slates. These were disturbed by later eruptions and cut by other dikes.

Westward from Deer lake, traveling toward the Ropes gold mine, this pebbly greenstone continues, and appears in numerous outcrops, and in the vicinity of that mine the rocks are nearly all serpentinous. This is five miles N.W. from Ishpeming. The quartz vein (1233A) which is mined for gold is in an old, much changed eruptive, (1233) of a greenish color, hardly schistose, a part of the same formation, at least a part of the same formation as the pebbly greenstone already described (1225, 1229 and 1230). The quartz was chemically deposited. It is vitreous and white, not "chalcedonic." In the immediate vicinity of the mine the rock affords chemically deposited limestone (1231) which has been used for flux in the furnaces of the region. This limestone is associated with a considerable magnesian element, since in the cavities and veins are found nodules of pure talc (1232.) It is crystalline and of a gray color.

Recently a valuable deposit of gold has been discovered on the land of the Lake Superior Iron Mining Company about two miles southwest from the Ropes mine. This is in the same kind of silica, and very probably in the same country rock.

At the Michigamme mine, the working is in a magnetic quartz schist, the ore being represented by 1238. This graduates into jasper and hematite, the whole dipping S. and apparently lying on a dioryte which rises in a prominent range running E. from the mine. At a little further east this horizon of ore is a ferruginous laminated quartzyte, still dipping south, away from the dioryte; still further east, and a little further north, it dips in the opposite direction, indeed dips in nearly all directions, some of it being nearly horizontal, appearing as a dark micaceous and garnetiferous (?) quartzyte upheaved by the underlying dioryte which rises in isolated hills in different places. Still further north, about half way toward the granite range, are several such isolated crags of dark quartzyte, most of them dipping about 66° toward the south—1245 and 1246. This quartzyte is cut by dikes of this dioryte.

At the granite range, which lies about a mile north of Michigamme, a gray, somewhat gneissic quartzyte, comes directly in contact with the granite. This granite (1240) is red, and very siliceous. The ridge rises about 150 feet, and at the southern base a gray, coarse, fragmental quartzyte forms a crooked contact with it. It is not easy to see which overlies. A lot of conglomeritic pebbles of white quartz are stuck on the south face, which dips at an angle of about 80° south. But these may not have been conformably stratified with the quartzyte, but due to the quartzyte having abutted on the granite. At the contact there is abundance of quartz disseminated through the granite as shown by the specimen 1240 which was got 3 feet from the contact on the north side. The visible contact line is about vertical, but dips 80° north, as if the quartzyte ran under the granite. There is also some feldspathic material disseminated from the contact southward through the first six inches of the quartzyte. Compare 1241, 1242, 1243 and 1244. The quartzyte takes a gneissic structure near the contact.

At another place, a little further east, the contact is such that it appears to show that the quartzyte lies on the granite. Time was not sufficient to make further examination as to which rock here is the older.

At Marquette. Passing along Bluff street northward toward Lighthouse point, one occasionally sees outcrops of a greenish schist standing up nearly vertical and apparently forming the foundation rock of the drift-covered bluff that rises on the left. Near the extremity of the bluff, not far from the lake shore, at the saw mill, this schist appears slightly in the road (1147), and although a part of the general formation of the country at Marquette it has some exceptional features which ally it with the serpentinous rocks at Presqu'Isle and at Deer lake. These features are believed to be due to a more advanced stage of decay. It is a silky, hydromicaceous or talcose, rock, without apparent bedding but fibro-schistose about east and west. It appears, under the hand glass as if the fine grain, of which it entirely consists, might be fine "chalcedonic" silica, but on being scratched it is seen to be too soft, giving easily a white streak. The rock is slaty-schistose but not slaty, and has a pinkish tint outwardly. It is translucent, in thin scales, and is veined with chemical quartz. It passes in a short interval by insensible gradations through 1147A, which is the same as 1147 but with some felspathic aggregations, as if porphyritic, somewhat greenish, to 1147B, which is apparently a much altered, old eruptive fine agglomerate, recalling the rocks seen westward from Deer lake to the Ropes mine, a part of the serpentine group of Rominger and the equivalent of the Stuntz island agglomerate of the Vermilion region. A little further east is an outcrop of a rough-looking eruptive rock with twining coarse flowage structure, that extends to the water's edge.

Northward from this, along the lake shore and extending to the extremity of Lighthouse point, is a greenish, nondescript rock. On first view, owing to a banding and lining that somewhat resembles that of sedimentary structure, this rock might be considered as a fragmental one, and so the writer was disposed to regard it, at first, but on taking a more extended view of the general geology and also a more careful inspection of the rock itself, he is inclined to consider it, and all the rocks on Lighthouse point, as probably of eruptive origin, and a part of the "dioritic group" of Rominger, which apparently cannot be separated genetically nor geographically from the serpentine group. There are, unquestionably, diorytes, and eruptive diabasic rocks of later date than these rocks, and some of them may occur within the same areas, but these old "diorytes" that are marked by so much decay and that probably underlie the black slates and certainly underlie the great quartzytes unconformably, constituting a part of the "iron-formation" proper, are considered by the writer to belong to an older epoch of wide-spread eruption, one that seems to have preceded immediately the epoch of the Huronian. The same succession of great rock-masses seems to have taken place in northeastern Minnesota and has been alluded to in the 15th annual report of the survey, p. 381.

The strike of these schistose rocks on Lighthouse point is 10° W. of N. (mag.), and the structure stands at an angle of 80° from the horizon, dipping northerly. The whole point on which the lighthouse stands, enclosing the harbor on the south side is made up of, and caused by, a congeries of fractured parts of this greenish schist with later dikes of doleryte and belts of quartz porphyry. This later doleryte constitutes nearly one-half of the hill where the lighthouse stands, but it swells out and recedes very irregularly, forming unexpected bosses, and allowing the schist to take its place again.

This greenish schist, which in some places is very firm (1144) and only shows a fibrous grain on weathered surfaces, is heavy, dark within, free almost, or entirely, from original quartz. On its weathered surface its structure is indicated by bands of varying shades of green, and in its seams it glitters with hydro-mica. These bands of color are not continuous, but consist rather of an interrupted, narrow, striping in which the color lines become lost by running to needle-shaped points, or by fading into each other. The single, light-colored lines sometimes continue for only a few feet, or a few inches; and in some cases when narrow they rise and disappear in the space of less than an inch, bringing the darker lines into contact so as to present the aspect of a nearly homogeneous green rock. At the same time in some places they are not direct, but have, when fine, a fluidal waving toward the north or toward the south. In other places again, and particularly on the northwest extremity of the point, the striping which resembles that of sedimentation is more evident and persistent, and in some parts could be more correctly denominated a banding, some of the bands being two or three inches in width—but even then they lose their identity in ten or twelve feet, and give place to a finer, schisto-fibrous lining. The feldspathic element is gray, and evidently some plagioclase.

The reddish rock, or quartz-porphyry, No. 1146, is not common. Besides a conspicuous dike of it on the shore southeast from the light-house (whether dike or not) there is a patch of it near the water at the extremity of the point; and on the north side of the point is a nearly conformable narrow bed. This last runs thirty-five feet and

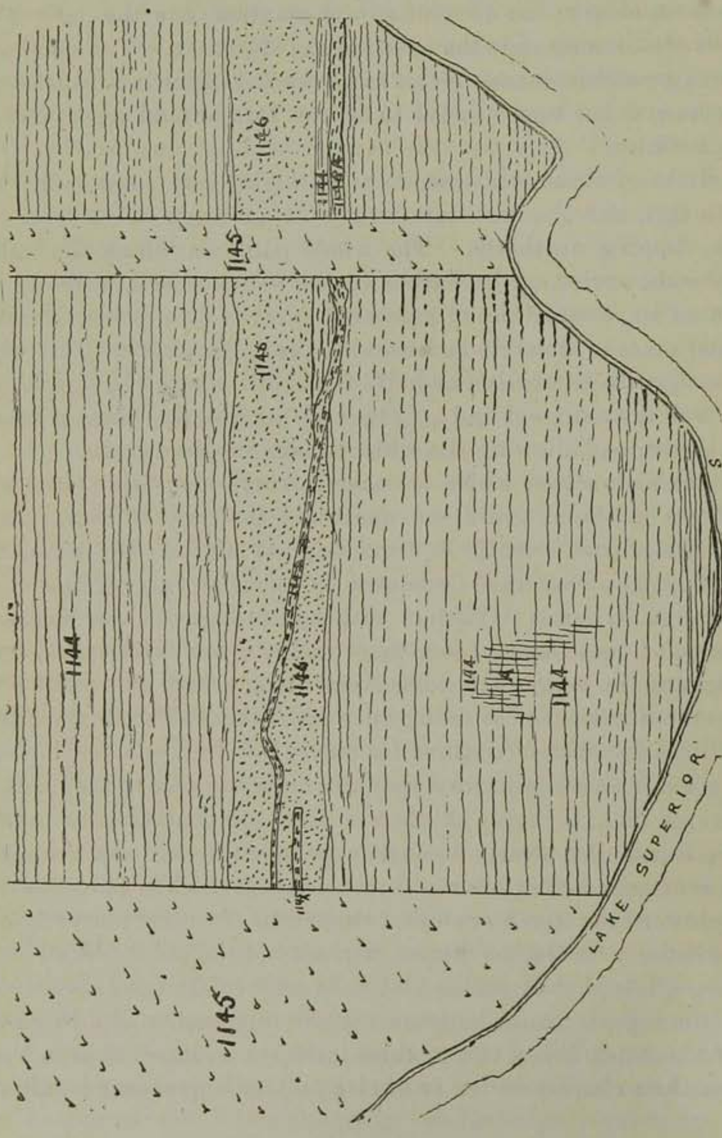


Fig. 7. Plat of the surface at Light-house Pt.

is visible all the way and at both ends. It runs out to sharp points and vanishes in the green rock in the same way that the granite, of thin beds, does in the gneiss and mica-schist at the northwest end of Vermilion lake. There is, however, here no gradual interchange of minerals between the two rocks, or successional gradation toward each other, but the porphyry appears abruptly, as an individual rock, quite different from the rock of the point, and maintains its mineral character even into the narrow points at each extremity. This bed is about a foot wide near the middle and reddish, but at the points it is more like a gray quartzose layer, (1146A). It is about 35 feet long, and appears conformable except that it swells out and again dwindles. This, however, is seen in all the beds of the schistose greenstone; see figure 7.

Explanation of Figure 7.

This sketch represents the relations of the different dikes to the rock of the country, on the south side of Lighthouse point, a little to the west of the lighthouse.

1144 is the schistose rock of the country, having a structure running nearly east and west. At the place marked A is an indistinct north and south banding or striation on the surface of the schist, due to the existence of some siliceous veinings that do not wear away as easily as the rest of the rock. This transverse fine veining is represented by 1144 A. It has no importaut significance other than that there has been exerted on the formation a force that produced an incipient fracturing and a fibrous internal arrangement nearly at right angles to that which is seen generally in the prevailing rock. At various places in 1144, especially south of the lighthouse, there appear to be minor unconformities within the rock. The fiber, running in one direction, is cut off by a compacter rock, though not distinguishable otherwise from the rest of 1144, that has its fiber perhaps finer than the other and running in a slightly different direction. Sometimes whole bands, an inch or two wide, are thus crowded out by the encroachment of others. These little irregularities are no greater than are seen sometimes in eruptive rocks, such as that figured on Stuntz island in Vermilion lake, in the report of last year, nor are they very different from that which is known as false bedding in sedimentary rock. The non-conformity of the rock 1146 (quartz porphyry) with the rock 1144 is about of this kind, though in other places it is non-conformable with 1144 more abruptly, even existing as blocks embraced in it. On the north side of the point the schist (1144) while more conspicuously banded east and west, and more persistent in all its structure, is strikingly basaltic by joints running north and south, causing a columnar aspect, resembling that seen in the eruptive rock at Taylor's Falls on the St. Croix.

1146 is a reddish-gray quartz porphyry, already mentioned. It evidently is a part of the same formation as the schists, and if not of the same origin it has very nearly the same age since it is cut by all the later dikes. North of the lighthouse this rock has its greatest development. In addition to the narrow dike already mentioned is another which intersects the point east and west, cutting off a portion which is separated from the main part of the point by a gorge caused by its more rapid disintegration. This more rapid disintegration is not because of the softer grain of this porphyry, but is caused by the close jointage which cuts it into blocks that are separated by frost and roll down to the lake. This dike is best examined NW. from the lighthouse near the water heel. The dike of 1146 shown in the sketch is cut longitudinally by a straggling dike of another sort (1145A). On the north side of the point, near where the vanishing dike of quartz porphyry occurs, is a dark dike (1145B) probably of the same age as 1145A, about a foot wide, mainly conformable but vanishing in the same way in indeterminate points. (1145A) gradually works southward, in passing through 1146, and at the east leaves it entirely and enters 1144.

1145 is the latest of the eruptives of the point. It cuts all the others and its contact is a plane running N. and S. It forms a large part of the most elevated portion of the point, and spreads irregularly and apparently occupies several fissures that run across each other.

By examining the dikes of different rock cutting this point the succession of steps that gave them origin seems to be as follows:

1. The schist is the oldest rock. (1144).
2. The quartz porphyry was introduced. (1146).
3. The dikes 1145A (and perhaps 1145B) were introduced.
4. The great north and south dikes were formed (1145). There is confusion in the direction and areas of these latest dikes. There seems to have been a tumultuous breaking of the rocks, and an outpouring of the molten matter wherever fractures occurred and allowed its escape.

THE GOGEBIC IRON REGION.

A cursory examination was made of some of the mines in the Gogebic iron region in order to be able to compare the features of the rocks and the manner of occurrence of the ore with the iron-bearing rocks of the Vermilion iron range, and some rock-samples were collected for future microscopic comparisons.

The Colby Mine. At the Colby mine the average dip is about 60° toward the north, 10° west. There is apparent no hanging wall or foot wall except the rock of the country, and that is a thin-bedded siliceous rock which itself is almost ore in some places, because of the high degree of ferruginization. This siliceous material is jasperoidal and distinctly bedded exactly like the bedding of sedimentation. The base of it all is apparently a fine "chalcedonic" silica, the same as that of the jaspilyte, though in some, or many, of the beds it is a softer material which may be earthy. When the latter is stained they call it "paint rock." But it is not the "paint rock" or "soapstone" that is derivable from the eruptives as at the Cleveland mine. Samples No. 1256 represent three of the forms of rock that alternate with each other forming the country rock that constitutes the north wall in the Colby mine. The south wall of the south Colby mine consists of a crumbling, coarsely granular, siliceous sandstone (1257), the grains being sub-angular after disintegration. In some places it is firm and correctly bears the name of quartzyte. It is stained, locally, with much or little iron, and with manganese. The "silicification" process seems here certainly to have produced fragmental silica, and subsequently, being interrupted, to have been followed by the process of ferruginization, which stained this sandstone with iron and manganese, sometimes almost constituting it an iron ore. It is not possible to say this ferruginization is a secondary, or rather a third, step, later than the general ferruginizing process, and that this quartzyte has acquired the iron by reason of the accidental contiguity since, for the quartzyte graduates into the rock of the mine, the acquired substances (iron and manganese) being the same as in the real ore. The general circumstances of the situation will not allow of such a separation.

About 250 feet further north is an opening known as the North Colby. This is a long deep pit, where the iron has been worked out superficially, and timbered shafts are being prepared for deeper mining.

On the spur-track from the Colby to the Valley mine is a short cut in siliceous, greenish and yellowish slate, now largely ferruginous. This is sometimes earthy, like some seen at the Colby mine, but it is very siliceous with "chalcedonic" silica, some of it being almost wholly white, although the prevalence of hydro-mica, and perhaps of other fine-grained mineral particles intimately disseminated through the siliceous parts gives a greenish color to even the hardest and most quartzose parts of this rock. This dips so as to conform to the rock in the Colby mine, and probably lies under the foot-wall of the South Colby. The full thickness of the bedding here involved, making allowance for the oblique direction in which the road goes across it, is about 250 feet. See rock 1258.

At the Valley mine the working is all under ground. Numerous test pits, and two shafts have been sunk, striking rock and ore similar in all respects to the rock and ore of the Colby mine, except as yet nothing is to be seen of the coarse sandstone which lies as the foot-wall of the South Colby.

In a ditch by the side of the railroad track at Bessemer is a small exposure of the bottom-conglomerate of the Cupriferous. It contains numerous pebbles of quartz and of fine porphyry like the copper-bearing conglomerate at the Calumet and Hecla mine. The dip cannot be made out as the exposure is small, and the pebbles rather evenly distributed throughout the whole. This conglomerate must lie in unconformity on the Gogebic iron-bearing rocks, and if it be the equivalent of the conglomerate at Negaunee (Cascade) as it appears to be (see p. —), it indicates the greater age of the Huronian quartzyte (the N. Y. Potsdam sandstone) than the Cupriferous formation—*i. e.*, than the greater part of the Cupriferous, since the Cupriferous strikes east and west near Bessemer, forming a conspicuous range of hills of eruptive rock but about a mile further north, the dip being such as to cause it to overlie this conglomerate.

The Aurora mine, at Ironwood, has a sandstone, or a soft quartzyte, rather coarse, identical with that on the south wall of the South Colby mine, for its south or foot-wall.

At the Aurora mine an interesting observation was made on the "granite" which forms a low hill-range a short distance south of the mine, and its manner of contact with the rocks lying just north.

The low granite range, which has been mapped as Laurentian by the Wisconsin geologists, rises about fifty feet above the mine, and lies south from the mine about six hundred feet. The section of strata intervening between the mine and the granite range is made up about as follows, in southward (and descending) order:

1. Iron ore, soft hematite. 100—150 feet.
2. Sandstone (sometimes a quartzyte), about 15 feet seen.
3. Gray and greenish slates and quartzytes, in beds from half an inch to four and six inches; distinctly sedimentary, 580 feet.
4. Gray quartzyte like that of No. 3.
5. Granite; hornblendic and massive.

The sandstone (No. 1) forms the south wall of the Aurora mine. The quartzytes and slates (No. 2) are not all exposed at the mine, but at the Colby mine a section of 250 feet, in a connected exposure, can be seen along the spur-track west of the mine. About 100 feet of similar strata are visible at the Aurora mine. Samples 1261. It is partly assumed, therefore, that the whole interval of 580 feet consists of the same rock as seen at the northern and southern limits. It seems to be a part of the Animike slates and quartzytes.

The granite (No. 5) is a hornblende-granite. Sample 1260. It rises in rounded bosses and forms three separate low bluffs or hill-ranges, each about 15 feet higher than the next one further north. The rock itself contains boulder-forms of different rock from the mass of the granite, some of them being of some dark-colored greenstone-like rock, and others of some earlier granitic rock. The great mass of the granite is mainly homogenous, and these boulder-forms appear most distinctly on the weathered surface of the bluff. When these boulder-masses were not originally of greenstone they are apparent by a blotched aspect which the granite presents, the blotches being caused by some patches, of rounded outline, much finer grained than the rest, or by a marked difference in the relative amounts of feldspar and quartz compared to the same minerals in the most of the granite. The boulder-forms are, when distinguishable, from two or three inches in diameter to twelve inches. Their longer axes lie prevailingly in the same direction, but sometimes they have lost their first shape and have been drawn out into points in one or more directions, or have been a little distorted by unequal pressure. *

This granite also has a uniform rift, or grain, brought out by the constant, or prevalent elongation of the hornblende crystals in the direction about E. & W. The boulders have their longer axes in the same position. It appears, therefore, that originally this granite was some conglomerate, which has been plastic or fluid-like.

At the most southerly of the three low bluffs of this granite, each of which faces toward the north, the granite can be seen, on the north side, to lie upon, or at least alongside of a gray quartzyte. (1261). There is an abrupt and simple contact line, and a sudden transition between them.

About 25 feet further north is the second low northward facing bluff of granite. It here looks as if the granite had been a molten rock and had flowed unconformably over the quartzyte, the dip of which cannot here be ascertained.

The third low outcrop of the granite is about ten feet lower than the last, and about 30 feet further north. In the north face of this little bluff, not more than six feet high, is observable the contact seen in "Fig. 2" of fig. 8. Here the granite is unconformable on, and embraces pieces and tongues and slabs of the gray quartzyte and quartzyte slates (1262). This quartzyte-slate is fine-grained, banded by sedimentation, and light-greenish weathering. It is greenish-gray within. Sample 1262. At one point in this little bluff is a small area of granite surrounded by crumpled and broken portions of the slate. So at least it appears on the face of the bluff, but this

*Similar changes from conglomerates to gneiss are mentioned by Dr. E. Hitchcock in Vermont, in *Am. Jour. Sci*, (2), xxxi, 372.

isolated granite area is only superficial and doubtless was, and perhaps is still, united with the main granite mass.

These three little bluffs, running, so far as they have apparent extension, in the same direction, do not conform in their trend with the direction of strike of the bedded rocks that intervene between them and the Aurora mine. They vary from it about 20 degrees, as illustrated in "Fig. 1" of fig. 8.

The interpretation of these facts, and their bearing on the strategraphic problems that relate to the horizon of the iron ore of the Gogebic range seem to warrant the following conclusions:

1st. The granite acts the role of an eruptive rock, but was originally a conglomerate. It was so far molten or plastic that it flowed over the adjoining sedimentary strata, but not so completely fused as to have rendered the resultant granite entirely homogeneous.

2nd. The accompanying beds of sedimentary rock being a perfect lithologic representative of the quartzytes and slates of the lower part

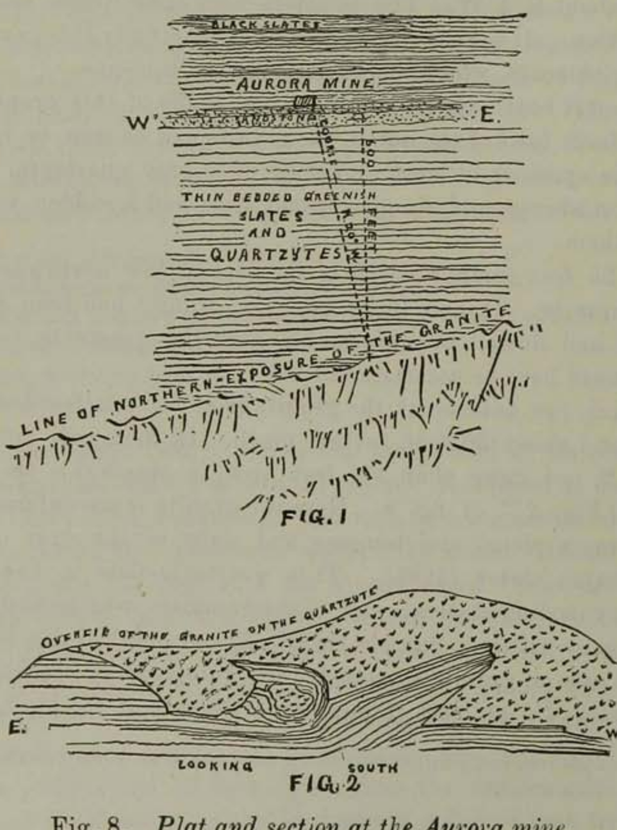


Fig. 8. *Plat and section at the Aurora mine.*

of the Animike, this conglomerate can be parallelized, stratigraphically, with the Ogishke conglomerate of Minnesota in which have been seen (Fifteenth annual report, and later in this report), similar semi-fused conditions, producing porphyries, syenite and porphyritic conglomerates.

3rd. The horizon of the ore of the Gogebic range is probably that of the Animike rocks.

4th. The granite is not of Laurentian age, but is younger in its present condition than the Animike slates, though originally a conglomerate older than those slates.

Explanation of Fig. 8.

The upper portion (Fig. 1) shows the ground plan of the rocks south from the Aurora mine.

The lower portion (Fig. 2) shows the overlie of the granite on the quartzyte—looking south, upon a low bluff facing north.

At the Iron King mine the following information was obtained of foreman Lehman. Five shafts have been sunk, two on the south "vein," and three on the north. Those in the south ore-bed are said to furnish ore that "has too much manganese;" but those on the north deposit furnish a superior soft hematite. The ore, after the shaft penetrated the "cap rock,"* widened out to eighty feet, and runs east and west. The rock intervening between the ore-beds is not exactly known, but the walls of the north deposit are, quartz on the south and "paint rock" on the north and extending north from the ore forty or fifty feet, where it becomes black slates. Between the two ore-beds is quartzyte, jasper and sandrock, mixed, judging from surface outcrops, the distance between the north and south ore deposits being about four hundred feet. The jasper is "not good red jasper, but gray to black-like, or flinty." The ore in the south bed is 80 to 100 feet wide, and "no regular hanging has been struck;" but no great development has been done there because there seemed to be some trouble with the ore. It is not known what the foot or hanging may be on the south bed of ore.

About a mile east of the Iron King mine a deep drill was being made in the "black slate" which overlies all the mines, and runs apparently in an east and west belt next north of the line of the ore deposits. This slate is shown by samples 1263.

*The imported term "cap rock," probably comes from the miners of the coal measures, and it has no definite application nor significance in the mining of iron such as found in the lake Superior region. It is used as a convenient designation for any rock that overlies, or obscures, the chief ore deposit, through which a shaft passes before reaching the ore.

At the First National mine the same general geological facts seem to exist. There are what are known as the south "vein," and the north "vein." These are simply conformable beds in the general system or series of strata which for some reason are now highly changed and charged with hematite, or hematite and manganese, and sometimes (especially further west) with magnetite, in variable proportions. There is the intervening series of strata that, while not ore, yet are so charged with iron that some portions consist of lean ore, known as jasper, quartz, sandrock, slate rock, etc. There is the quartzyte foot wall on the south side of the south ore-bed, and the soap-rock and black-slate on the north from the north ore-bed.

Visits and short examinations were made at several other Gogebic mines, especially such as are open pits without much underground mining, such as the Montreal, Kakagon, Bourne, and the Atlantic, but nothing was seen that would throw further light on the general geology or the relations of the ore to the crystalline rocks of the northwest. A trip to the *Penokee gap* was made by Prof. A. Winchell, and his report thereon will be found in another chapter.

FROM GRAND MARAIS TO GUNFLINT LAKE.

From Grand Marais to the crossing of the Devil's Track river, sec. 32, 62-1 E, not a single exposure of the underlying rock is to be seen along the usual trail running to Rove lake. The country is timbered with deciduous trees mainly, but with some scattering cedar, balsam and white pine. The whole intervening belt is fit for farming and will ultimately be occupied by farmers. The drift sheet is not superficially stony so as to impede plowing. At about a fourth of a mile north of the Little Devil's Track river was a patch of potatoes and corn. Large timothy grass grows along the roadway (Aug. 26, 1887) and is cut and stacked for hay.

At about a mile north of the crossing of the Devil's Track the red-rock of the country is crossed by a narrow belt of trap about half a mile wide, rising about 15 feet above the rest of the country and trending W. N. W. and stopping on the north side in the form of a perpendicular face. On the north of this the country is drift-covered again, but has a superabundance of red-rock boulders, verging to red granite, and an occasional one of sandstone.

The descent to Clearwater creek, on the N.E. ¼ of sec. 20, 62-1 E, is about 130 feet, and a marked topographic feature is the hill, or ridge, known as "Birch ridge," which here presents a bold face toward the north of about that hight. This ridge seems to run across sec. 20, and along the south side of Clearwater lake, which is the lake crossed by the line between secs. 19 and 20. The Clearwater creek, running from Clearwater lake, is a small affair, but has very cold water, meandering through a cedar swamp.* Elbow creek is larger. They both run over a rather smooth drift surface, about ten feet below the average level. A low trap exposure is seen about in the N.E. ¼ of sec. 9, 62-1 E, and boulders of trap and gabbro are seen in the N.E. part of sec. 17. This outcrop is rather fine-grained and somewhat porphyritic, but resembles much seen on the lake Superior shore. When weathered it assumes a brownish-green color. There is but a slight exposure, the surface being in general drift-covered, and merely undulating, with timber mostly fire-killed. About an eighth of a mile south of the town line, in the N.W. ¼ of sec. 3, 62-1 E, we crossed a little southeastwardly running creek. This is near the south foot of what is here known as Pine mountain, so named because it was formerly covered with pine. It now presents a bald, rocky outline, with only the charred remnants of the original forest.

At the place of our camp (Aug. 27) just south of the creek, a low ridge of fine-grained gabbro (or a greenstone) 1264, runs parallel with the direction of the creek forming its southern barrier, but this ridge is not continuous. It rises and falls, wholly disappearing towards the N.W. It is evidently one of the minor ranges of hills that attend mountain elevations generally, and consists of the same rock as Pine mountain.

Pine mountain is evidently only a local name for a part of an important hill-range. This range can be seen toward the west two or three miles distant, and presents the outline of eruptive dike-formed buttes in some of its individual hills. It seems to be the same that I met with on this town line not far east of here in 1879† and is in general known as the *Brule mountains.*

South from this trap ridge (mentioned) the country is red in some places with the debris of red-rock drift and chips, exactly like the red shingle on the Grand Marais beach, making it probable that, with small exceptions where the basic eruptive rock breaks through, this red rock underlies the drift to this place. But there is so much drift that the actual areal distribution of these two rocks cannot be ascertained with any degree of minuteness.

---

* The outlet of Clearwater lake is represented on the township plats as being toward the south into Devil's Track lake, but Dominick says there is no such tributary to that lake, and that its outlet is eastward and then southeastward.

†The present Rove lake road is new, only made about two years ago, and while it coincides in some places with the old road, at this place they are nearly a mile separate.

On the top, where the trail goes over this range, no rock is visible. Much drift covers it, but the trees are fire-killed. South, 25° W., can be seen a square-topped mountain which Dominick says is Cascade mountain, near the mouth of Cascade river.

After passing the main hill, from which lake Superior can be seen, but where there is no rock in outcrop, a lower, bare hill can be seen a little to the north of the main range, conical in shape (S. E. ¼, sec. 33, 63-1 E.) and having the color of the rocks of the Misquah hills (1265). Several similar hills occur near, but they are mainly drift-covered.

The Brulé mountains which seem to be largely composed of this red rock, are well named.

Such hills of red rock continue a distance northward, and the whole country is composed of such rock, which is easily disintegrated by the fires and the elements so as to cover the surface with thin gravelly soil, as far north as the southern part of sec. 4, 63-1 E. About six miles distant, in the direction toward Greenwood lake, but to the S. W. from that lake, a bare, red peak of greater hight can be seen. Beyond Greenwood lake, and rising much higher, is a long E. and W. hill covered with green timber, which Dominick calls *Greenwood mountain.* It seems to be a part of a general range of similar hills, and is probably a portion of the true (gabbro) Mesabi.

The Brulé river occupies a very deep and broad valley, running in the red rock along here, at least through T. 63-1 E. The rock itself is not frequently exposed, but the soil, and debris resulting from its disintegration, and frequent boulders, or fragments, are composed of it.

There is a marked difference in the manner of weathering of this red rock, and the ordinary gabbro. The latter never turns red, but crumbles down, maintaining its earthen gray color. Large boulders of it, seen along here, decay through and through, and pass into soil, through a pebbly condition. Where they lie on the red rock, thus crumbled, they present an appearance of little loads of gravel dumped —wheelbarrow loads, or wagon loads, according to the size of the original boulder. But the red rock, in all boulders, and all debris, is red, brick-red; and *in situ* it is superficially brick-red, and brownish-red within to any depth so far as ever observed. This brownish-red color is probably due primarily to the presence of a large amount of orthoclastic feldspar, and it prevails through all its degrees of fineness, from felsyte to red granite. When this rock is coarser crystalline it sometimes acquires a tendency toward a gray color, due to the presence of more free quartz, some hornblende, and apparently of some plagioclase, the red orthoclase crystals being disseminated more or less sparsely through it. It then seems to grade into a rock which has been designated sometimes a dioryte. Such a variation in color was noticed just before reaching the crossing of the S. Brulé.

There is a low, narrow ridge of gabbro-like rock, crossed by the trail in sec. 4, 63-1 E; but north of that the red-rock returns and and continues to the centre of sec. 19, 64-1 E. It is, however, covered with a coarse drift of large boulders consisting of gabbro, porphyry, red-rock and amygdaloidal trap; and in secs. 30 and 29, 64-1 E, this kind of drift is heaped up in morainic tumuli. These accumulations run in diverse directions, the larger number of the boulders being of the red rock. At the crossing of the N. Brulé, and south from there, are many porphyry masses, and many amygdaloidal boulders. These porphyries are sometimes stellar, in the manner of arrangement of the crystal tables, with a dark matrix; but sometimes a mass appears which is crowded with tabular crystals (1265A) from one to three inches in length, and not more than an eighth or a quarter of an inch in thickness, also with a dark (basic ?) matrix. Some masses are both porphyritic and amygdaloidal. In studying these boulders, in making the passage along the trail, one can note easily an increasing tendency toward dioritic characters—that is an increase in non-red-weathering feldspar, greater size of the individual crystals, dark hornblendic crystals mingled with schillerized surfaces, and occasionally noteworthy quantities of scattered magnetite or menaccanite.

There is north of the North Brulé much "orthoclase gabbro" among these boulders, that is a dark, coarsely crystalline rock with some red-weathering element, the conspicuous minerals being, besides the red feldspar, a white feldspar, magnetite (or menaccanite), long crystals of hornblende and some quartz. The red element here sometimes is not crystalline, but is in disseminated blotches of amorphous felsitic matter. This felsitic matter, which seems to act the part of the undifferentiated residuum of the molten mass, is disseminated through the otherwise dark gray or dark green rock. One large boulder in particular lies in N.E. ¼ of sec. 19, 64-1 E, and from this was taken samples No. 1266. This boulder is specked with red feldspar, but has also some plagioclase that does not take a red color, but rather becomes snowy white on weathering. Blotches of red felsitic matter are scattered over its outer surface, some of them being six and even ten inches in diameter, and through these blotches run strings and coarser crystals of hornblende. It also contains some quartz and magnetite. Within, this boulder does not maintain its red color, but appears like a heavy, dark (dioryte?). In the immediate vicinity are a great many boulders of the same kind, making it probable that their native place is not far away. They are curiously and coarsely specked on the weathered exterior. The red spots are non-crystalline, apparently, but are cut and crossed indiscriminately by all the crystals. The largest and most abundant are of some white-weathering feldspar, next the hornblende, then magnetite, then quartz.

But a short distance beyond (north) where these specked boulders lie, the same rock is seen in place. It occurs as an irregular dike or blotch elongated about east and west, and on the north it has the red rock in contact. 1268.

Rock 1267 represents a frequent form of amygdaloidal porphyry seen south of the North Brulé in the form of boulders.

The red rock, north of the contact above, is variously modified by different degrees of crystallization, but extends about 20 feet north and gives place to a belt of greenstone, which itself is again replaced by 1266, though the last here shows much more white-weathering feldspar, and less of the red uncrystalline matter. Rock 1266 continues about ten rods, but at the summit of the ridge, near the north side of sec. 19, 64-1E, the underlying rock is more fine-grained, though essentially the same as 1266. It is represented by 1269.

It seems possible to trace here a gradual transition from the red-rock to the eruptive rock 1269, and to 1266.

These latter are apparently forms of the dioryte that lies on the animike hills further east, and which is interbedded with the slates and quartzytes of that formation.

As we approach Crocodile lake (which is in the southern half of sec. 8, 64-1E.) on the portage from Round lake, a small outcrop of Animike rock appears near the lake, but a little further east large areas of (gabbro?) form the shore and rise in bluffs from the water.

On the portage from Bear Skin lake to Cariboo lake (N. ½ of sec 5, 64-1E.) in a small boulder of Ogishke conglomerate, which is rather far east for drift-transport from any point at which this conglomerate is known *in situ*.

The high hill just to the east and on the south side of the narrows of Rove lake, situated north from the center of sec. 28, 65-1E. was named *Mt. Reunion*, from the fact that here (i. e. at the Narrows) my party met again, according to appointment, that of my brother, after having been separated about a month.

North from the north side of North lake, nearly in a line due north from the north end of the portage from South lake to North lake, begins a trail that leads to Northern Light lake. At a little less than a mile from North lake, on this trail, a very light-colored micaceous gneiss is found, forming low hills. The weathered surface shows that there is a large ingredient of feldspar, but on a fractured surface the grains are nearly all glassy, as if it consisted of nearly all quartz. This pseudo-siliceous appearance is due to the glassy nature of the white feldspar. All the grains are fine. (1270.)

Between the lake shore and this gneiss is one outcrop of dark trap rock; and numerous fragments of the red and flinty beds of the Gunflint series indicate the rocks that intervene between the trap and the gneiss *in situ* in the intervening belt, but of the latter no actual outcrop was seen on this hasty excursion.

No. 1271 is oolitic bloodstone, or red-brown jasper, one of the forms of the Gunflint beds. This is heavy with hematite. It also was brecciated, and now holds angular fragments of rock like itself. It is also finely crystalline, appearing like No. 866A seen on the "south ridge" at Tower, where the jaspilyte appeared to have been fused and then to have taken on a sub-crystalline structure from a fragment found on the surface.

The rapids going out from North lake are caused by beds of Animike and basaltic hardened Animike 1272. The strike of the latter, looking like trap, is visible about 20 rods east of the rapids under the water of the lake, but rising nearly to the surface.

No. 1273, dense blackened trap, just west of the rapids last mentioned, north side. A short distance further west appears No. 1274, a firm mica-gneiss, similar to No. 1270. The trap must lie upon the gneiss (1274), which is in outcrop a short distance further west.

ABOUT GUNFLINT LAKE.

On the north shore of Gunflint lake, about a mile west of the entrance of the river, this trap (gabbro?) lies on a series of slates and flinty beds, the upper part of the series being changed apparently by the gabbro. No. 1275 is from the upper part of the gabbro here seen. It is made up, macroscopically, of a gray plagioclase, and a dark mineral, probably augite. These two seem to constitute the bulk of the rock, and it is with difficulty and much uncertainty that any other mineral, except a rare grain of magnetite, can be distinguished under the hand-glass. It is thus quite different from the rock

9

1266 and 1269. The underlying sedimentary beds are slaty and flinty, interstratified. Some of the strata, near the overlying trap-sheet, are plainly modified by the heat of the superincumbent mass. No. 1276 represents such a modified form of the Gunflint beds, and 1277 shows the flinty character of some of these beds. The former is from between beds of black thin sheets of horizontal slate, some of the latter adhering on each side of the specimen. It is composed essentially of pieces and granules of a dark gray, aphanitic rock varying in size from that of a pin-head to peas, or larger, closely compacted together, but cemented in the interstices by a glassy mineral that appears to be free quartz, the general aspect being that of a dark, basic, dense diabase specked with minute white spots.

About half a mile further west, on the north shore, where the bluff ceases, and a bay extends toward the north, the trap lies directly on the slates, with little flint, and with little modification of the slaty beds—Fig. 9. The trap, however, is rendered black and very fine-grained at the bottom and for some space upward—say six feet—but graduates into rock the same as 1275 at the top, making a basaltic capping over the slates, *similar to that at the east end* of South Fowl

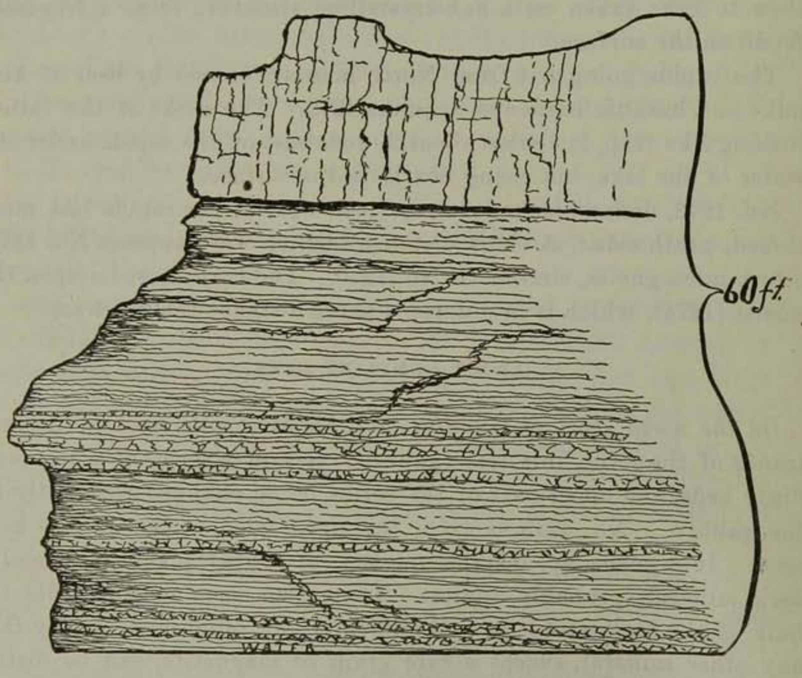


Fig. 9. *Gabbro sheet lying on Animike slate.*

lake,* but not on so magnificent a scale; and the transition seems to be as sudden. This bluff is about 60 feet high. The dip is S. E., four or five degrees. There are continuous sheets of flint, translucent like obsidian, interbedded in the slates. But this does not graduate into the trap although at first surmised to.

Near the mouth of the creek which enters Gunflint lake from the north, at the east end of the long bay, is an exposure of a dark-colored fibrous schist (1278), evidently belonging to a different formation—the Kewatin series of Mr. A. C. Lawson of the Canadian geological survey. This is nearly vertical in its general structure, or dips 85°—88° north, and the strike is E. & W. (true). This is fine and apparently hydromicaceous and softens under the weather. It embraces cubes of pyrite. In the midst of this schist appears rock 1279, somewhat like a dike, which is coarser-grained, sub-porphyritic with feldspathic grains that weather pinkish, is very siliceous, fibrous in the same direction as the schist, and runs about parallel with its prevalent structure. Intimately disseminated through this sub-porphyritic rock are fine scales of a micaceous element, appearing like muscovite but perhaps of the same nature as the finer micaceous scales of the schist. These are so arranged as to their direction as to impart a schisto-gneissic structure to the whole rock.

This exposure is interesting, being the most eastern known locality of the Kewatin rocks in Minnesota, and only about 20 rods distant from some horizontal slates of the Animike, which lie but little further south in such a position as to be necessarily unconformable over the Kewatin.

But a short distance further west gabbro appears at the lake shore in a short exposure, and rises inland.

Again, a few rods further west, appears rock 1280, a part of the Kewatin series, apparently an old eruptive. Gabbro rises high in a ridge immediately inland. This older eruptive (?) is apparently similar to the dioryte and serpentine group of Dr. C. Rominger, seen in the northern peninsula of Michigan, and perhaps is stratigraphically near the same horizon.

Next adjoining this old eruptive rock, is a larger outcrop of Kewatin strata, with gabbro lying on it. It is a gray, compact, felsitic rock, weathering reddish, 1281. It is marked east and west by very evident sedimentation bands, the strata standing about vertical, the aspect resembling that of a transition to "red-rock" seen on the Kawishiwi last year. This, however, is quite another "red rock"

* Sketched in 1878.

from that seen south from Crocodile lake last week. That was very evidently crystalline from a molten condition, but this retains its sedimentary structure, and could have been only plastic. This grayish, fine, felsitic rock, which is not sericitic, becomes hydromicaceous and glistening, or is replaced by such a rock, a little further west, and then it is laminated as if by a fluidal structure, the laminæ being curved and contorted about large quartz grains that are enclosed in the mass. Whether these quartz grains, which have the vitreous structure of chemically pure quartz and are not fragmental, are indigenous to the rock, originally porphyritically generated, or were the result of coarse sedimentation, it is difficult now to say. They are sub-angular, but are frequently elongated east and west, in concordance with a direction of the laminæ (1282).

This pebbly (or porphyritic) structure increases, further west, and the rock becomes firm and more massive, rising in vertical cliffs about 40 feet at the shore, constituting a porphyritic gneiss, the quartz grains becoming more abundant and larger and being accompanied by large crystals of white feldspar, (1283). While here the laminated structure is broken up and lost there is substituted a concordant fibrous and gneissic *rift* pervading the rock, 1283 (compare Nos. 309, 310 and 311, report for 1880). Interbedded with this gneiss is argillitic slate, 1284-5.

There is a green, fibrous rock also seen here, same as 1280, which may have resulted from change in a basic eruptive, which is interbedded with this porphyry and argillyte. It is in thick, conformable beds. It goes down deep and belongs to the same series of strata. It is not in the form of an overflow.

Making a traverse north from Gunflint lake at about half a mile west from the mouth of the river that enters from North lake, unquestionable gneiss, like that already mentioned (1270 and 1274), is met with at about a mile and a half from the lake shore, at a hight from eighty to one hundred feet above the lake. The object of the trip was to see the changes that may take place in the Kewatin toward the north, and to learn the nature and relations of the iron ore said to exist north of Gunflint lake. It proves an interesting section, which warrants the following general statements:

1. All the iron ore we find is in the Animike and near the bottom of those beds. It is not magnetic, so far as seen here, but limonitic through change, though probably hematite (with more or less magnetite) at first. The rock with which it is connected is quartzyte, even pebbly quartzyte—or a rusty, pebbly conglomerate. It lies

about three-fourths of a mile from the lake and strikes east and west. Portions of the rock are flinty and jaspery. We passed a low ridge (not more than five feet high) in the midst of the forested country, and had no favorable opportunity here to observe this ore (312, 1294, 1295).

2. This formation (the Animike) is not seen here in exact superposition on the Kewatin, but all the facts seen warrant the conclusion that has before been announced, that the two formations are discordant.* It is probable that the pebbly conglomerate, which is in some places rather a breccia than a conglomerate, separates them.

3. But a short distance further north the Kewatin appears, dipping south at an angle of about 80 degrees. It is made up of, (1), schist somewhat siliceous, but with a silvery sericitic element running all through it, 1296; (2) a coarse sericitic porphyry like No. 1281, 1297; (3) soft chloritic schist, 1298. These are all interbedded, and belong to the same system of stratification, although it is very probable that the greenish schist above called chloritic, is originally of eruptive origin among the Kewatin sediments. This is seen in some places in lenticular beds, and embraces chemical quartz veins. Generally, however, it runs great distances nearly or quite coincident with the bedding and strike of the other strata.

4. About a quarter of a mile further north a great change takes place. The bedded Kewatin is confused and twisted, and though still showing the same rocks, is largely replaced by a micaceous and hornblendic rock (1299, 1300) which itself appears also like a part of the conformable sedimentation. It is comparable to the micaceo-hornblendic portion of the Kewatin which in the report of last year was designated *Vermilion group*.‡ It lies on all sides of all the above varieties of the Kewatin proper, and also embraces some black hardened argillyte. In this dark-green belt the included "porphyry" is more nearly all crystalline. At a short distance further north the change to gneiss (1301) is complete, or so nearly complete that there appear in it only a few blackish-green, stretched or pressed, boulders and rarely a nearly white-weathering, highly siliceous fine-grained syenitic band, running east and west, uniform in direction with the general strike of all the rocks. Even in this gneiss the same "porphyritic" distribution of quartz and feldspar is observed. The feldspar weathers out in sub-angular grains on the surface, and all the minerals have an elongation east and west. This syenite-gneiss

* The Ninth Annual Report, p. 82.

‡Fifteenth annual report, p. 4.

varies, through change in the hornblende, to granitic-gneiss and chlorite-gneiss. At the point reached farthest north it is micaceous.

5. We thus have a conformable transition from the Kewatin changed graywackes and argillytes to the gneiss and syenite of the Laurentian, without any sign of eruptive origin of the latter, the whole maintaining a dip and strike in the same direction, the former being about 80° from the horizon and the latter about east and west.

A trap dike (1303) cuts these beds, running from the syenite south and passing through the Vermilion group, or the mica-hornblende belt. It is 24 feet wide. The advent of this rock is much more recent, and it maintains a massive, undecayed internal constitution.

Making a closer inspection of the rocks of the Vermilion group at this point, they are found to extend north and south about fifteen rods. There is certainly a conformable transition from the Kewatin to this, which is chiefly mica schist, at least superficially. At some depth within the rock perhaps there would be found a greater proportion of hornblende, since it seems that the mica results from the natural decay of the hornblende. The inter-bedded, light-colored rock is the gray " porphyritic " rock of the lake shore, but has some mica scales. It acts here much like the so-called "dikes" of gneiss that are interstratified with the Vermilion group or mica schists north of Vermilion lake. It fades out by very slow transitions into the mica schist, and it also is replaced abruptly by it. It runs to needle-shaped points and vanishes conformably in the darker rock. If it is, hence, eruptive, then this porphyritic rock everywhere is eruptive, and also the schist into which it graduates at the lake shore. Rock No. 1304 shows a blending of the characters of the mica schist with those of the rock that shows the porphyritic characters. The belt from which this came is about ten inches wide, and such are numerous in the schists. Indeed there can be seen almost every kind of transition and every direction of gradation between the schist, the hornblendic rock and the porphyritic and gneissic rock. They all occur as strings and as isolated portions in each of the others. There are belts of coarsely hornblendic rock that alternate several times in the mica schist, conformably with the strike, but the former are confused, lumpy and uncertain. They may have been basic eruptives in the sediments of the Kewatin at the time of their accumulation, and so spread out as sheets approximately conformable to the sediments.

The section foregoing was made on the town line extended north from the south side of the lake between towns 65–1 and 65–2, W.

At the east end of Gunflint lake Capt. Sedgwick, of Chicago, is having surveyed out a long tract of land on the north side of Gunflint lake. It is four or five miles long, and from a half mile to a mile in width, and is said to be done on account of the prospects of iron ore on the north shore of the lake. Not far west of the sand-beach, which is at the east end of the lake, but on the north shore, the Animike rises up from below the water, and from below a thin sheet of trap, and is exposed about 2½ feet above the water. It evidently was once covered entirely by gabbro, since that rock is seen immediately overlying, at the same place. Here is an interesting exhibition of the gray rock, so much resembling some gray quartzyte, of which mention has been made in earlier reports. It is very fine-grained, but while it embraces quartz it also contains a considerable percentage of feldspar, or feldspathic material; but the most of the two feet seen is blotched and variously stained gray and rusty. A film of fine rusty rock coats over much of the gray rock, such as has been the cause of much perplexity as to its origin and manner of formation ever since it was first seen in 1878.* There seems to be, however, a natural chemical round of changes which gives origin to this film, the initial point being the existence of carbon in the slates of the Animike. These gray layers are associated with thin carbonaceous slates. The two make the bulk of the Animike beds.

Given a black, shaly or carbonaceous rock.

Exposed to the air the carbon is oxidized and slowly forms carbonic acid.

This carbonic acid at once combines with some base, whatever may be present, or any oxide, such as magnetite (which is found present in the Animike here), making a carbonate. In case iron is present it forms siderite which has also been found in these beds in noticeable quantities. This carbonate may be deposited in pre-existing cavities and veins, under the guidance of percolating water, or it may be substituted, particle for particle, for magnetite in the body of the rock, and thus be found to permeate the formation in somewhat the same manner that the oxide does now.

This carbonate of iron is unstable, and immediately suffers the further attack of oxygen, making a quick transition to peroxide of iron, and even to hydrated peroxide. Hematite and limonite would be the next step, and the last, these being perfectly stable except under the operation of mechanical forces, or in the presence of some other acid. The carbonated state is least observable, both as to the time it requires and the space its product occupies. Indeed the transition

* Ninth report; p. 82.

may be so rapid that the carbonated stage is invisible, and the carbon of the shales itself may appear to act directly on the magnetite converting it to the hydrated limonite.

There are three stages, and they are all visible at numerous places, and sometimes in the same bed of the Animike.

The first stage is black and carbonaceous (see Nos. 299, 1263 and 1305).

The second stage is gray; sometimes it effervesces freely. It is compact and fine in grain and generally brittle. (See Nos. 312, and 1306, 1307 and 1310).

The third stage is rusty red with limonite. (See Nos. 312, 437, 1307).

This progressive change seems to take place in the slates, where there is probably some magnetite which partakes in the formation of a carbonate. Thus by the aid of carbonic acid magnetite is converted to hematite and limonite, and this may have affected large bodies of ore.

Iron sand appears on the beach at the east end of Gunflint lake.

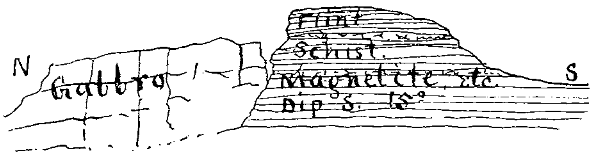


Fig. 10.

The above sketch (fig. 10) illustrates an outcrop on the north side of Gunflint lake, near the lake shore, about on sec. 13 (if the United States system of survey were extended to the Canadian shore), at the east side of a little bay which has a sandy beach. Here is one of the iron localities of the Sedgwick location. The ore here is apparently of very variable quality, some of it being a high grade magnetite (1308), but so far as seen in limited quantities. It is associated with the flinty schist of the Animike, and with a rock (1309) which resembles the olivinitic ore seen last year on the north shore of Birch lake. Fig. 10 shows a mass of gabbro lying next north of a hill of Animike slates, and rising less high than the slates. Such relative positions of these two could be repeated at various other places about Gunflint lake. The gabbro here does not seem to be interbedded in the slates and schists, but to lie on them unconformably. The top of the Animike rocks seems to have formed a zigzag line, caused either by a series of short faultings, breaking the strata so as to present perpendicular cliffs facing north,* or by erosion. Over these bluffs the gabbro flowed, and covered the country. This overflow seems to have followed immediately after the deposition of the slates of the Animike, and to have been partly cotemporary with it, since it is interbedded with them in some places.†

Along the N.W. shores of Gunflint lake are great quantities of rusty rock interbeded with flint, the two alternating in somewhat irregular and lenticular masses or sheets. This rusty rock, sometimes designated quartzyte, is evidently the same that is associated with the ore at 1308 and 1309, and is a form of the so-called "muscovado" rock. Much of this is in loose fragments, and some of it is brecciated and recemented by the rusty rock as a matrix. Compare 1310, 1311.

Some modified forms of the Animike constitute the "muscovado" rock, of the report of last year. This is seen just west of the "narrows" of Gunflint lake (1313), where the same rock is magnetited.

The trap in Animikie bay graduates into, or alternates with gabbro, and also becomes coarsely porphyritic, the large gray plagioclase crystals being embraced in a medium-grained mass, which last has acicular (feldspars ?).

The iron-bearing part of the Animikie, seen on the south side of the point south of Black Fly bay, is a quartz, and flint and jasperoid schist (1315). It is very siliceous, but still associated with the "muscovado" rock. It has a curious, fine, fluidal or streamed structure, and the white silica is chalcedonic. It is nearly horizontal, or tilted somewhat in diverse directions, fragmental, sometimes pebbly. It is fine, sometimes with bands of red jaspilyte, and sometimes with considerable magnetite.

North of this, as if underlying it, is a bluff of slaty Animike; and across the bay next north, is the Syenite range (1316), without any Kewatin intervening. This indicates either that the Kewatin is wholly changed to syenite (Laurentian ?) or that the Kewatin beds seen so conspicuous on the lake shore a few miles further east, and extending for half a mile north of it, run below the Animike as they pass toward the west. Either hypothesis would demonstrate the *non-conformity of the Animike on the Kewatin*

The syenitic gneiss on the north side of Black Fly bay (1316) is like that seen north from the Kewatin and Vermilion groups, on the traverse made northward from Gunflint lake (1301). It has here a strike E.

* As suggested in the seventh annual report, p. 15.

† See. later, the geology of Chub lake, west from Gunflint lake.

5° S. and seems to lie south from the strike of the Vermilion rocks.*

It is a very remarkable fact, however, that toward the north here there can be seen nothing of the rocks of the Vermilion group. There is almost a continuous rock exposure along the river leading toward the north, and to Saganaga lake, and nothing but syenite is seen. The mica-hornblende series is conspicuous wherever it exists, and it could not cross this river without its being observed. It is necessary to infer, therefore, either that the strike changes so as to bring the Vermilion belt in its westward extension, underneath the Animike at some point between the narrows and the place of making the traverse already described, or that the whole is converted into syenitic gneiss, with no micaceo-hornblendic stage preserved. This gneiss is like that seen to come on by a change in the Kewatin, already described. It is not perfectly crystalline, but parts are left with only an amorphous crystallization, or the feldspars and quartzes are imperfect, crowded and shapeless, but always elongated east and west, in the direction of the strike. Some of the quartzes are an inch and a half long, but no more than a quarter of an inch wide, but generally they are about half an inch long and an eighth inch wide, being rather lenticular lumps of quartz than crystals. Their forms stand out prominently on the weathered surface. The third ingredient of this syenitic gneiss, which seems to be originally and generally hornblende, becomes chloritic, hydromicaeous, or muscovite, this difference being due probably to some extent to an *a priori* difference in the sediments, but also largely to a difference in the degree of exposure and decay. The structure is vertical.

A striking fact in connection with this gneiss is the enclosure of masses of hornblendic rock, i. e. of long and lenticular patches in which the dark hornblende is much more abundant than any other mineral. This appears on the upper surfaces and on the eastward facing bluffs, showing they are of short extent, the longest not being more than eight feet east and west, and the thickest not more than eight inches from north to south. They cease by running to points and thin edges and fading out. This dark rock is the same as the rock in the Vermilion group as seen further east, and it may be the vanishing point of that group.

The Vermilion group at Gunflint lake.—Owing to the importance of the question—what becomes of the series of dark schists (the Vermil-

*According to my brother's observation the strike of the structure of the gneiss at the first falls of Boundary river, about 1½ miles north of Gunflint lake, is 10 deg. N. of E. (mag). The variation supposed not to exceed 5° E.

ion group) in its extension toward the "narrows" I sent back Mr. F. N. Stacy, with one man, to make special search for it, and for its manner of disappearance, with directions to make excursions north from the north shore of Gunflint lake across the strike of the rocks until he found what becomes of it. Two such excursions were made, one nearly on the line of extension north of the line between secs. 26 and 27, and the other nearly on the line of separation between secs. 25 and 26, if the same were to be extended across the lake into the Canadian territory. It seems from the search of Mr. Stacy that this series of strata ceases rather abruptly and is replaced by the syenitic gneiss of the region; but what are the facts of its manner of disappearance, it is not yet known.

Following is Mr. Stacy's account of this search. The specimens he obtained, to illustrate his trip and notes are numbered from 1457 to 1500, both inclusive, and are described in the appended list of rocks collected.

The "Black Belt" of Gunflint Lake.

The following is an account of two short inland excursions from the north shore of Gunflint lake, Sept. 7, 1887, by F. N. Stacy and Charles Sucker. Two days before, Sept. 5, the geological party under Prof. N. H. Winchell had discovered a conspicuous "black belt" of micaceous and hornblendic schists about three-fourths of a mile north of the lake on the north and south town line between 65-3 and 65-2, W. (Am. Surv.). The object of the excursions of Sept. 7 was to find what had become of this black belt in its westward extension.

The first landing was made just north of "Gabbro" island, about two miles west of the above mentioned landing, Sept. 5. The out-cropping rock on the shore at this point was a light gray slate of a nearly perpendicular dip, and of a nearly east and west strike. Parallel with the lake-shore for three-quarters of a mile due north, successive bluffs of slates and other perpendicular schists of the Kewatin group, sometimes cut with igneous dikes, were crossed at a gradual increase of elevation. Until at a distance of nearly a mile from the lake, and at an elevation of about 200 feet above the lake-level, the Kewatin was discovered overcapped with gabbro. North of this was a steep decline into an extensive swamp, with no further out-crops for half a mile farther north, and the search for the black belt at this point was discontinued.

Failing to find the black belt in this first inland excursion, a second landing was made about one mile further east, and mid-way between the excursion just described and that of Sept. 5. At the second landing, also, the Kewatin cropped out at the shore-line. But when first met at this point, the Kewatin was a "porphyrel" —a micaceous, sericitic schist with feldspar crystals between the laminæ. In the journey due north, next came cherty schist, then slate, followed by sericitic and micaceous schists, and, by gradual transition, the usual members of the Kewatin group; until at a distance of about three-quarters of a mile from the shore appeared the "black belt" of hornblendic and micaceous schists. These in turn were followed in the usual order by the gneissic and syenitic rocks. At a distance of about a mile and a quarter north of the lake, and at an elevation of about 250 feet above the lake-level, was found in the topmost bluffs a typical Saganaga syenite.

The "black belt" as thus discovered appeared to be in the direct strike of that found further east on Sept. 5, but was much broader in extent and higher. The narrow beds of two days before, lying in a single bluff, had widened out into a series of parallel bluffs from one hundred to two hundred feet elevation above the lake-level. These bluffs of varying micaceous and hornblendic schists rose in successive parallel terraces for over a quarter of a mile north of where first discovered, until finally merged into the syenite which formed the broad-backed summit. In its extension a half mile westward the ridges of the belt appeared to be cut off by low and swampy ground.

In the absence of definite information as to the disappearance of this "black belt," Mr. U. S. Grant was directed in July, 1888, to make further search, on the occasion of a visit to that region. His report is not rendered yet, but in a letter from the field he states that he traced it westward to within 200 feet of a range of syenite hills from which it was separated by a swamp, and the manner of contact could not be observed.

Further west, as will be stated more fully later, on the west side of the "narrows," this belt of mica-hornblendic rocks appears again and constitutes an important member of the series of the region.

As to any unconformity between the so-called "crystalline schists" and the Kewatin graywacke and the associated porphyroidal rocks, nothing is seen of it about Gunflint lake. On the contrary all that is visible indicates a conformable transition, by gradually changing proportions of minerals, aggregated in beds that are everywhere conformable, from the Kewatin to the Vermilion group. It is true, however, that the appearance of distinctly micaceous and distinctly hornblendic beds, is different from anything seen in the other portions of Mr. Lawson's Kewatin.* But with this appearance continue the same kinds of beds as in the graywacke belt, alternating with these micaceous and hornblendic beds. But when these darker constituents appear there seems to be a more complete crystallization of all the parts, the porphyritic laminations approaching nearer to crystalline gneiss, and being less sericitic. There is here a progressive crystallization from the graywacke and sericitic schist, through the schists of the Vermilion to the gneiss of the Laurentian; there seems

* It should be remembered that Mr. Lawson's definition of Kewatin makes that group embrace the Vermilion group; but frequently in this report the term Kewatin is used in a restricted sense by omitting the "black belt," and the term Vermilion is applied distinctively to the "black belt."

to be no more reason to place the Vermilion group with the Laurentian there is to place it with the Kewatin.

While there is this gradual transition, so far as can be seen, from the graywackes into the Laurentian, there is yet reason to exempt the greater part of the Vermilion group from the ordinary sedimentary methods of accumulation of clastic rock. It appears to have been introduced in some places and not in others. Its composition will allow of its having been of eruptive origin among the sediments of Kewatin time, in some such manner as the eruptive beds are seen introduced and interstratified with the Cupriferous. Indeed it is believed now to have marked one of the early, if not the earliest, general outpourings of basic eruptive rock. It was embraced into the strata of the then forming crust, and was disposed with general conformability between the underlying, older, sediments, and the later graywacke belt. It has suffered the upheavals and pressures and displacements that the other strata have experienced. It has been turned up edgewise, like them, but it has maintained its distinctive character and its general stratigraphic integrity. On the side toward the gneiss, which would naturally be the bottom of the overflow, the transition from the Vermilion group is sometimes through a series of fissures, veinings, dikes, and included masses, indicating an epoch of disturbance such as would allow the escape of molten rock, while on the side toward the Kewatin graywackes the transition is one that indicates a sedimentary mingling and interstratification of graywacke debris with debris from the eruptive rock last poured out. These alternations are sometimes very numerous, but gradually the micaceous (originally hornblendic) element fades out, and the well-known graywacke element only remains.

West from the " narrows " extends Animike bay, a spur from Gunflint lake. Ascending the point north from this on the north side of the point, thus passing from the gneiss across the strike of the Animike up to the gabbro which forms the summit of the point, an outcrop of rock is encountered such as has been seen frequently near the contact of the gabbro on the other rocks, and which has been styled, in some of its aspects, "muscovado," but here it is finer, and has a siliceous frame-work instead of siliceous grains (1319).

It passes into a siliceous (streamed?) gray rock, evidently fine-bedded and not wholly siliceous (1320).

And in immediate contact with these, sometimes one and sometimes the other, is considerable magnetite which probably here becomes valuable as merchantable ore (1321). The needle is wild; not much is visible, but it is in place, and might be in large quantity.

Passing further south, on this point, I meet with a great many large fallen masses of freshly broken (not rounded) gray, coarse quartzyte, or grit (1322), evidently derived from some portion of the bluff which here rises about 100 feet higher and faces toward the north.

At the top of the hill is gabbro (1323), but in places it is fine-grained. It is distinctly basaltic, and in some places takes the form of a coarse porphyry like 1314.

Sample 1324 is a fine black slate, nearly horizontal, from near contact with the gabbro, north of Animike bay, but slightly changed. In this black slate one can imagine, from the forms seen on the bedding surfaces, that he sees encrinites, ostracoids, climactichnites, fucoids, and mammillated or finely pitted surfaces that recall the rough plates of some large fishy reptiles. But so far as I can see these shapes are all of mechanical origin. They do not seem to warrant the unqualified statement of organic remains in this rock. Still it is very probable, judging from their carbonaceous composition, their finely slaty sedimentation, and the preservation of fine ripple-marks (1385), that life existed, probably animal life, at the time of the gathering of these sediments, and that real organic remains will be discovered in them sooner or later.

At Iron lake, at the old Mayhew location, 1287 represents the so-called changed quartzyte, on which the gabbro lies unconformably. This now seems to be the "muscovado" of last year. The gabbro is unmistakably on it unconformably. 1291 is a specimen of the iron ore at Iron lake.

Rock No. 1293 is from a boulder, north shore of Iron lake. The interesting feature in this boulder, which was rounded, and evidently far transported by drift agents, is that *it is made up of boulders*. Originally the mass measured 3 ft. by 2½ ft. by 4 ft., and by the action of fire large slabs have been made to drop off. Otherwise no samples could have been obtained with any means which we could control. This is not only made up of boulders, but it is from the mica-hornblende schist or Vermilion group, and shows that conglomerates there have been converted into crystalline rock. The small boulders are of greenstone, mica schist and changed greenstone. The matrix is granulyte or granite. Later the Vermilion group rocks have been seen and described as conglomeritic by H. V. Winchell, just east of the entrance to Black bay on Rainy lake. (See his report in this volume.)

The conglomeritic structure has therefore now been seen in the following crystalline rocks in Minnesota:

1. The Sauk Rapids "granite."

2. The porphyritic conglomerate at Ogishke Muncie lake, and the similar gneiss in Kekekebic lake.

3. In the Stuntz island porodyte.

4. In the greenstone of Twin mountain.

5. My brother reports it conspicuous in the Saganaga granite.

6. This boulder shows it in the Vermilion group. (Since this observation was recorded, an examination has been made of the gneiss quarries at Morton and Redwood Falls, in the Minnesota valley, where this structure is very common and conspicuous. This gneiss is certainly in the southwestward extension of the Vermilion group of the northern part of the state.)

7. In the "Laurentian" syenite in Michigan, south of the Aurora mine.

ACROSS THE COUNTRY FROM GUNFLINT LAKE TO OGISHKE MUNCIE.

In the report for 1881, p. 95, in reporting the observations made in the region of Gunflint lake in 1878, some reasons are given for considering the "quartzyte-slate formation" seen at Gunflint lake (the Animike) in horizontal position, the equivalent of the great quartzyte and slate formation at Ogishke Muncie lake which passes into the Ogishke conglomerate. But the matter was not settled, and has been ever since an element of uncertainty which has entered into every attempt to establish a systematic stratigraphy for the oldest rocks of the state. At that time the tilted schists and graywackes of the Kewatin series, with their contained iron ore, were considered an integral part of the same tilted series as the slates and quartzytes associated conformably with the Ogishke conglomerate; and the iron ore of the jasper ridges at Vermilion lake were considered the equivalent of the iron ore seen in the Animike. This is the view that was adopted and subsequently urged by Prof. R. D. Irving. But since the separation of the Animike from the Kewatin has been established by marked unconformities, and by constant differences in lithology (including a constant difference in the kind of iron ore associated, and their respective mineral accompaniments), it remained still to answer the question—To which series, the Animike or the Kewatin, does the quartzyte-slate-conglomerate of Ogishke Muncie lake belong? The report of last year (the 15th) leaves this question unanswered, although stating (p. 381) on the authority of some general parallelizations, that "the Ogishke conglomerate is allied closely with the Animike. It contains numerous greenstone boulders, and perhaps represents its basal portions."

In order to trace the strata from Gunflint lake westward a trip was planned through the country, leaving the Boundary waters at the west end of Gunflint lake, and reaching Ogishke Muncie lake by way of Gabemichigama lake and Fox lake.

Going west on the section line between secs. 24 and 13, 65-4 W. to the N. W. cor. of sec. 23, thence south, and a little east, a recent iron-working is found. Here is a low, northward-facing Animike bluff, not exceeding 18 feet in hight, the strata dipping southeastwardly about 12 degrees, made up of ore on the top (1325 and 1326) about 5 feet, and of alternating gray grit and sandstone, with some ore and chert, below (1327). This ore and the rock associated, resemble those of the north side of Gunflint lake, as well as those seen in the Mesabi range and reported on by Prof. Chester (11th annual report). It is but little south of the gneiss range (the Giants' range) in all three places, and appertains to the same stratigraphic plane, *i. e*, near the bottom of the Animike. No gabbro is visible here; the general slope is toward the south. This iron has been uncovered by exploring parties at several other points further east.

A little south from the face of the bluff a shaft has been sunk into this rock. It passed through the ore-belt, into the grit-stone and chert, and struck gneiss within ten feet from the surface. This gneiss is mainly gray, but some of it is reddish, having orthoclase. The shaft penetrates it about two feet. Between the Animike rocks and the gneiss is a thin layer (one or two inches) of yellowish rotted earth and rock. This ore, lying in a sheet, dipping but little to the S.E., should be taken up by the acre. On a forty-acre tract there would be many tons, but it does not go deep, like the ore at Tower, and in that respect this ore differs uniformly, so far as known, from that in the Kewatin rocks. This location was discovered by Henry Mayhew, and the working has been prosecuted by Messrs. Paulson, Barker, Boyden and Millar. Of this ore Mr. Millar gave me the following result of analysis, made by Rattle and Nye, Cleveland.

Metallic iron	55.600
Silica	10.020
Phosphorus	0 042
Manganese	4 340
Alumina	0.340
Titanium	none.

This shows a high grade ore, but very likely the sample was selected with reference to getting a good result, and that the five feet of ore seen would not average as good.

South from the place of this pit about half a mile is another range of magnetited rock, and the amount of ore there would be likely to be greater than at this place. This ore is fine-grained, compact, magnetic, indistinctly banded and everyway similar to that seen in Towns 59 and 60 on the Mesabi range, and unquestionably is in the same formation.

This unconformable position of the Animike on the gneiss is conclusive against the idea of the identity of the Animike with the Kewatin rocks, and also against their conformability, and effectually establishes the distinctness of the Kewatin from the Huronian of Canada,* the Huronian being the equivalent of the Animike and the great quartzyte that overlies it.

Further, the existence of this gneiss, which is the same as seen in the Giants' range just north of this point, at places so far south, in line of the strike of the Kewatin beds that have been described on the north side of Gunflint lake, indicates some change in the Kewatin, introducing an irregularity in the line of strike. It is possible, indeed it seems probable, in the light of facts which have been mentioned showing the variableness of the lithology of the Kewatin toward the greater crystallization of the adjoining gneiss, that there is an encroachment of the gneissic characters upon the schistose, and that the Kewatin beds seen north of Gunflint lake are changed by intensified metamorphism to the gneiss that here exists in the line of strike from there. In this gneiss occur isolated masses of a darker hornblendic rock similar to those masses already described north of Black Fly bay. A great east and west dike of greenstone seems to cut this gneiss just north of this working, but it makes only one or two slight exposures, so far as seen on section 23.

But following the trail that runs west along the north side of sec. 22, this great greenstone dike becomes visible on the north side of the trail about an eighth of a mile west of the section corner. This is in 65-4. Rock 1329 is a sample of this dike, seen on the north side of the trail. Large detached masses have fallen from the cliffs which rise precipitous along the north side of the trail. The direction of the dike, if so it may be called, is about 15° south of west. This

* This unconformity has been described by A Winchell in *The American Geologist*, January, 1888, p. 23. Compare also the paper by the writer in the same number of *The American Geologist* (p. 11) on the equivalents of the original *Huronian*.

sample is like gabbro, and does not correctly represent the nature of this greenstone. See rather 1330 and 1331.

The Giants' range, which is crossed by the section line, runs southwest at this place, and where the trail leaves it the descent seems to be about 200 feet.

Again, a little north of the quarter-post between secs. 20 and 21, 65-4, a greenstone display appears. It rises in a vertical wall facing north, and is crossed by the section line. It is somewhat weathered to a schistose rock, sometimes chloritic, on the exposed angles, but within it is a massive, fine-grained greenstone. Rises 45 feet about vertical.

Re-examining this vertical cliff, the schistose structure is seen to run W. 15° S. (mag.) which is also the general direction of strike of the rock-mass. There is no appearance of sedimentary bedding. It may be a revival of the crystalline schist belt seen on the north side of Gunflint lake, which was seen also to disappear rather abruptly by the interposition of light-colored gneissic rocks of that region. This certainly has the aspect of much of that, but it lacks, so far as can be seen, the sedimentary banding which is common in some parts of that.

Traveling south from the face of this cliff, about 200 paces, evidently all the way over the surface of the same rock, at a low crest where a descent begins toward the south, the rock 1332 is seen, plainly identical with 1330. Superficially it has a schisted aspect, but it is massive within. It does not show any sedimentary bedding—only thin seams and veins reticulating through it, of lighter minerals, in which probably is some quartz. But generally throughout this rock quartz cannot be distinguished.

South from the last is another vertical wall, about 12 feet high, just east from the trail-crossing containing the same greenstone (1333). This is after passing a swamp about 30 rods across. This ridge descends abruptly to a low east-and-west valley, after which another of the same rock rises still higher, perpendicular, about 25 feet, repeating the phenomena seen in the same kind of rock last year north of the Kawishiwi river (15th annual report, p. 346).

The iron location on Chub lake, N. E. ¼, N. E. ¼, sec. 29, 65-4. At the northeast end of the southerly of the two lakes (on the surveyor's plat wrongly included in one lake) is a recent iron exploration. This working was done by the same parties as already mentioned in connection with that on sec. 23 in the same township, and from Mr. Millar were obtained the results of assays made by Little and Nye, of Cleveland, as follows:

	Met. ir'n	Silica	Phos.	Mang.	Alum.	Titan
No. 1	58.40	8.22	.036	4.92	.52	None.
No. 2	54.01	9 37	.032	5 02	.07	None.
No. 3 (average of 6 samples)	63 98	8 90	.028	None.		Trace.

This ore is well characterized olivinitic, magnetic, granular, the yellowish waxy grains of olivine being mingled rather uniformly with the grains of magnetite (1336). It easily disintegrates and in favorable situations would give origin to iron sand.

The greenstone represented by 1330 and 1333, already described, extends southward indefinitely, occupying a tract of elevated rough country, timbered heavily with pine and spruce, and covered under foot with northern mosses. This elevated tract descends southwardly to this iron location where it is evident that the geology has changed, and the greenstone has given place to the Animike carrying magnetite. The most southern identifiable portion of the greenstone is represented by rock samples 1334. There is then a transition, in traveling south to the iron-location (what its nature was could not be ascertained owing to the vegetation, although the ground was searched over twice), to a rock represented by No. 1335. But judging from all that could be seen this rock lies upon the greenstone. It has some resemblance to the greenstone, but is blotched alternatingly with basic dark and acidic light minerals; it is hence somewhat lighter colored. It has a heavy, bedded structure which, however, does not show any evident sedimentary characters, but which is more like that of a massively bedded eruptive, or like that seen in the gneisses of the Laurentian. This bedded structure dips southward at an angle of about 45 degrees and approximately conformable with the dip of the Animike rocks carrying the iron ore, and runs under the iron bearing beds. The exact manner of contact was not seen. This rock has not the free and completely crystalline characters which indicate an original eruptive or a completely re-fused sedimentary rock. It appears rather to have been produced by a metamorphism *in situ*, of some sediments which contained a large amount of basic material, this change having taken place by hydro-thermal fusion when the sediments were yet deeply buried in the super-crust. Such a rock, so far as known, has not been seen before in Minnesota. Its geology should be further examined into before any positive statements can be made concerning its origin and relation to the greenstone on which it seems to lie, or to the Animike quartzyte under which it seems to lie. It seems to be no part of the Animike unless greatly modified. It is not slaty, nor flinty, nor evidently fragmental, but crystalline and of a medium grain. Toward the north from the iron-pit this rock rises in a hill to about 175 feet and breaks away precipitously; and another lake, elongated E. and W., lies at the foot of the bluff on the north, north of which, and about which, greenstone like 1334 only appears. Indeed the greenstone seems to come out at the top of the hill on the northern side, and the specimens No. 1334 are from there.

At the ore-pit the working was done by sledges and crow-bars, apparently without any blasting. The excavation is only about ten feet deep, and passes into the layers near the level of Chub lake, in a northward direction, and hence toward the underlying metamorphic rock No. 1335. But, what must have been a surprise to the explorers, and perhaps caused the stopping of the work, the ore beds (1336) are found, at the depth of about 10 feet, to lie on loose sand and boulders, exactly like those seen in the drift round about, the boulders being of gneiss and greenstone (1337). The sand is clean and crumbling, like lake sand. Some of the gneiss boulders are a foot in diameter, and of the greenstone at least six inches. There is on the top of this sandy and bouldery layer a kind of blackish or brownish soil-like rustiness which probably results from the rotting of the olivine in the overlying iron deposit. So far as seen the whole thickness is about twenty inches, but its depth is not shown. This gravel and sand was thought at first to be the equivalent of that seen actually between the Animike and the gneiss on sec. 23, already described, but on making further examination it was found that it more likely is a part of the prevalent drift that covers the country. It is necessary to suppose, if this hypothesis be correct, that the iron-ore beds penetrated by the excavation are only the low remnant of a cliff facing north, and that the hill which rises next north from the cliff, sloping southward under it, presented, at the time of the drift epoch, a sudden projecting jog or step behind which, and below which, this gravel and sand had accumulated, filling the depression up so as to make the hillside appear smooth. All semblance of such a jog, however, is lost, and its existence is invoked in order to explain the anomalous position of the sand and gravel.

The geology of these iron-bearing strata is quite interesting, as it reveals some new points respecting the Animike, and may be condensed as follows:

1. The beds are a part of the Animike, and dip south about 30°. They contain a considerable amount of grit. This grit is like that

seen disseminated in the Animike at Gunflint lake. It is largely quartz, but is mingled with olivine and magnetite.

2. The iron-bearing rock passes into a gray quartzyte like that seen north of Animike bay (1322).

3. North of this working is a great thickness of some changed sedimentary rock (as supposed) on which the Animike seems to lie, the hill rising 175 feet above Chub lake (1335). This changed sedimentary rock resembles somewhat that seen at the N. E. end of Gabbemichigama lake, described on pp. 379 and 380, of the report of last year, and perhaps is the equivalent of some of the so-called muscovado rock seen unconformable below the gabbro.

4. It lies to the south of a great greenstone range, the same as supposed last year to lie under the Animike, over which, by its dip, reaching sometimes 45°, it must have passed if formerly extended northward.

5. The quartzyte with which the ore is associated becomes developed, at about one-eighth mile further west, into a sharp, prominent ridge, which faces perpendicularly northward, the beds dipping 48° south, the quartzyte itself and magnetic quartz schist being from 140 to 150 feet thick, and the associated olivinitic ore beds being perhaps 50 feet thick. There is one layer of hard vitreous quartzyte (1338), very heavily bedded, which is at least 20 feet thick.

6. Inter-bedded with this quartzyte (1340) is a layer of gabbro (?), near the top of the ridge (1341) which varies from the typical gabbro of the Mesabi in being fine-grained and more like some of the muscovado beds. It is also coarsely porphyritic with a dark striated feldspar, apparently labradorite. This porphyry recalls that seen at Gunflint lake, No. 1314. The appearance of some of the thin layers of basic material seems to indicate that they were immediately followed by coarse sediments of almost pure silica (1339).

7. This inter-bedding seems to fix the age of at least the beginning of the gabbro overflow, and since the great body of the gabbro overflow is found to cover the small islands very near the north shore of Chub lake, there could not have been much interval between this beginning and the great development.

8. This rock and ore have a frequent jointage perpendicular to the dip. This causes it to break under the weather into cuboidal small blocks, the bedding being about four to six inches thick. It also gives the ore a fibrous structure under the action of which it is more easily broken across the sedimentation than in any other direction. It is this easy cuboidal disintegration that has caused it to occupy,

at the present time, the lower parts of the country, rather than the higher, the drift agents and subsequent drainage and erosion having removed it.

9. There seems to be a large amount of ore connected with this formation here, and it will probably ultimately prove valuable.

10. This great quartzyte, being near the top of the Animike (whether conformable on it or unconformable is now unknown), is a new feature in this part of the state, and is worthy of a name. In the field book it was named *Pewabic quartzyte*, from the Chippewa word meaning iron. It apparently occupies the same horizon as the quartzyte at the head of Wauswaugoning bay; which again is supposed to be the equivalent of the Thessalon and Otter Tail quartzytes of the original Huronian; which again, as the reader will have learned who has followed this report, is regarded the same as the quartzyte north of the Adirondacks in New York which has been named Potsdam.

In passing from Charley lake, in sec. 32, 65-4, to Flying Cloud lake, in sec. 25, 65-5, there being no regular route, we follow some trappers' and other dim trails. As the plat is unreliable as to the size and shape of the indicated lakes, it is impossible to identify some of them along the route we took. We travelled wholly on gabbro, and saw nothing of interest except when passing westward along an old gabbro valley, about S.W. ¼ of. sec. 30, 65-4, in which the gabbro walls rose on each side nearly vertical, though the width of the valley was about one-eighth mile. On the south side as the canoe was pushed through the brush down a little ravine that runs from one lake to another, signs of violent and copious flow of water—indeed nothing but a glacial river could have formed the pot-holes which are sculptured on the gabbro thirty or more feet above the level of the present creek.

Passing north from Flying Cloud lake, which is in the southern part of sec. 25, 65-5, on the east side of the outlet, after passing a short distance on the usual gabbro surface, a low ridge of reddish gneiss is seen (1342), near the lake shore, rising up through the gabbro. This gneiss is distinctly layered, and dips N. 30° W., at an angle of about 30 degrees. Continuing this traverse northward toward Bingoshick lake, gradually ascending, near the center of the N. E. ¼ of the S. W. ¼ of sec. 25, 65-5, the iron-bearing rocks are met again, in the appearance of the Pewabic quartzyte.

At first it is not conspicuously exposed, but is distinctly magnetic and granular. It dips 55 degrees towards the south, and strikes about east and west (E. 8° N.).

A short distance further north these quartzyte beds break off toward the north in a vertical cliff about 135 feet high (1343). It dips south as before, and probably fills the whole interval between that first exposure and this. The thickness of the bedding that can be made out thus is about 300 feet, and it may reach 500, as it can be seen also further north, and across a swamp that next supervenes. It appears as if at this place most of that quartzyte seen at Chub lake in separate ridges is gathered in one cliff.

About midway in the bluff is a bed of porphyritic gabbro (?) about 8 feet thick (1344), but in general the cliff is made up of quartzyte.

Before reaching the south shore of Bingoshick lake the same rock as seen north of the iron working at Chub lake returns (1345), but just at the lake is a greenstone (1346), or a dark, gabbroloid greenstone. These two rocks, 1345 and 1346, seem to have close and perhaps intergrading relations; and perhaps cannot be separated, but No. 1345 seems to be lighter colored and to contain some free quartz. They are both found to the north of the strike of the Pewabic quartzyte, and from north to south the belt they occupy is here half a mile wide. As compared with the schistose and micaceous greenstone seen in the W. part of sec. 23, they are more massive, more fresh, and more gabbrolike, i. e. they more nearly approach the rock that has been denominated muscovado in the fifteenth report.

Observed positions of the Gabbro.

Gabbro lies on the Animike at many places.

Gabbro lies on the Pewabic quartzyte at Chub lake, and is interbedded with it. The same is true north of Flying Cloud lake.

Gabbro lies on the Kewatin north of Gunflint lake.

Gabbro lies on the red syenitic gneiss north of Flying Cloud lake.

Observed positions of the Animike.

The Animike lies on the Kewatin unconformably, north of Gunflint lake.

The Animike lies on the gneiss in sec. 23, 65-4.

The Animike (Pewabic quartzyte) lies on the rock 1335 on the north side of Chub lake.

Relation of the Pewabic quartzyte to the Animike.

This magnetited quartzyte, which apparently is near the top of the Animike, and lies on the greenstone belt represented by 1345 and 1346, seems to extend further north than the great mass of the Animike rocks. If this relation be correctly made out, and if the greenstone be older than the Animike, it would be necessary to suppose the quartzyte was deposited during a period of increasing submergence. Thus the older sediments would be hid by the encroaching shore-line, and on upheaval might not appear at all in their proper place between the quartzyte and the greenstone. Not enough is known, at this time, concerning the stratigraphic position of this quartzyte, and the relation that rocks 1345-6 may bear to each other and to the greenstone that constitutes Twin mountain (see report of last year, p. 373) to warrant any conclusion on the exact statigraphic position of the quartzyte. Unless there be a fault running east and west through the point which is north of Animike bay, there are some thin Animike slates separating the main gabbro sheet from this quartzyte—i. e. from *some* quartzyte which is supposed to have given origin to the masses found on the north side of the point (1322).

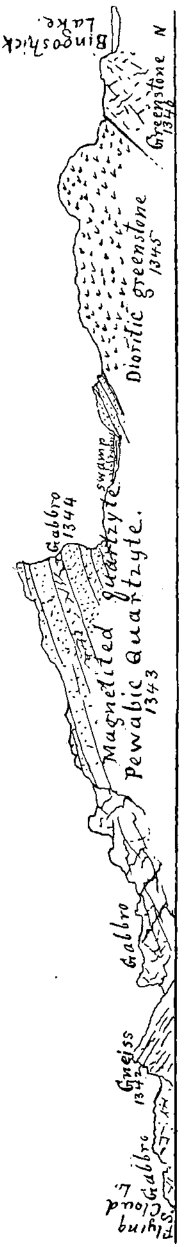


Fig. 11. Section north and south from Flying Cloud lake to Bingoshick lake.

The section represented in fig. 11 indicates the succession of rocks passed over between Flying Cloud lake and Bingoshick lake, sec. 35, 65-5, except that the gabbro area should be lengthened out and the quartzyte diminished. Probably gabbro occupies one-half of the whole distance.

In passing through *Muscovado lake*, the large lake in sec. 36, 65-5, we gave it that name because of the peculiar character of the rock which forms all its shores. It is represented by No. 1347. It is much decayed, and finely granular, having nearly the color of muscovado sugar which last year suggested the term. This color is assumed by decay, as is shown by one of the specimens, the interior color being gray, like real gabbro. This rock takes on a conspicuous bedded structure. It sometimes looks like a fragmental schist, the beds being only one or two inches in thickness, and the schistosity being fine and causing the cliffs to crumble. Indeed, except that all the rock here is fine-grained, this region exhibits the repetition, or extension of the phenomena of Wilder lake, seen last year (15th report, p. 350), where there seems to have been no transporting or eroding drift-action. It is considerably higher than Bashitanakueb lake, perhaps 75 feet.

The laboradorite rock on the south side of lake Bashitanakueb is represented by 1348. It is similar to the white-weathering gabbro of Little Saganaga lake.

There is a notable difference in the manner of decay between the greenstone and the gabbro, indicating some fundamental difference in origin and history. The former makes a chlorite, fissile schist and disintegrates (1349). The latter becomes schistose, but not chloritic. It crumbles to pieces as its constituent grains are loosened and they separately decay, making gravelly soils in many places which sustain the forests.

About Bashitanakueb lake are a few foreign boulders of gneiss, and others are on the portage northward to Kakego lake.

GABEMICHIGAMA LAKE.—THE ANIMIKE.

In passing again round the point in Gabemichigama lake (sec. 32, 65-5), which is illustrated in last year's report (p. 380), an opportunity was offered to compare some of the outcrops on the north side with some of those seen further east, and particularly with those at Chub lake. From this re-examination the conclusion was reached that the beds seen in the point are probably changed Animike. Much of this rock is fine-grained, and siliceous, and some of it is plainly fragmental, though now it is mainly crystalline. In its general aspect it very much resembles the rock 1347, and may be the same. In some of the fresher parts (1350) it shows an apparent alliance with rock No. 1345,—that on which the Pewabic quartzyte lies. At least, that it cannot belong to the vertical slates (or the *Kewatin*) is very plain. It is not magnetited, but it is tilted and broken, and was probably once covered by gabbro which exists in abundance but little further east, and rises in the hills that form the main shore of this part of the lake.

Still further toward the N. E., on the S. W. ¼ of sec 29, 65-5, just across the section line, is a vertical cliff, facing the lake, about 14 feet high. The evident sedimentary bedding dips at an angle of 45° toward the E. 40° N. This is distinctly sedimentary, because fragmental, banded and tilted like a sedimentary rock. It is very fine-grained generally (1351), and argillaceous, but on some of its weathered surfaces it has a light rusty coating about a quarter of an inch thick, covering the pale blue within, as if it were some of the Animike changed by the process noted at Gunflint lake, and further hardened and consolidated by the metamorphism due to upheaval and igneous contact. Rocks 1352, 1353 and 1354 are more coarsely fragmental portions of the same, 1353 being a gray grit, mainly feldspathic, but with evident grains of pure quartz. Near the lake level this rock is immediately overlain by a small mass of gabbro in place.

Going still further east, and northeast, about half a mile (in sec. 29, 65-5), the gabbro appears in the highland extending north nearly as far as the north end of the lake; but near the lake a bold bluff of hardened and tilted Animike, dipping as stated toward the east, runs northward. This varies from grit to blue-black, siliceous rock (in some of my earlier reports designated gray quartzyte), and is fractured and twisted so as to cause a curious mingling of fine and coarse-grained rock. This extends as far as I went north. This condition (except the much broken stratification) and this rock, can easily be recognized as a part of the Animike, and this observation confirms the doubtful inference of last year. I did not follow it far enough northward to reach the belt of greenstone which supervenes but a short distance further north. This rock differs from the Kewatin in these respects: It does not show any vertical cleavage and slatiness, but is slaty, where not too much altered, in a direction coincident to the sedimentary seructure (1355); it dips in massive beds (resulting probably from a consolidation of the original Animike slates), and in some thinner, more coarsely gritty, in a direction different from anything seen in the Kewatin; it lies to the south of the great greenstone belt; it continually changes its dip and strike, and it seems to have an insensible gradation toward the so-called muscovado rock, which itself is both in massive beds and in thin ones, and is even seen to be a part of the stratification in the Pewabic quartzyte, with which the magnetic iron ores are connected.

The hills about the N. E. extremity of Gabemichigama lake consist entirely of the Animike, fine-grained, tilted, fractured, recemented, but in general dipping northeasterly. At the lake shore these beds weather out very rough, the siliceous veins and the harder beds projecting. In some places they are about vertical, but they vary constantly in dip and strike.

In passing along the north shore westward, however, N. E. $\frac{1}{4}$ of sec. 31, 65-5, this rock becomes slaty and vertical, and strikes N. W. by compass (1355). It is bedded with rocks like 1353 and 1354.

All along the N. shore from the N. E. end of the lake to about the center of N. E. ¼ of sec. 31, 65-5, these tilted slates and quartzytes extend, having a high dip toward the N. E., and finally becoming vertical. The shore line runs across the strike, but not at a right angle. Hence in going west one passes on to lower and lower beds. At this place the Ogishke conglomerate (1356) appears on the shore, rising in a ridge about fifty feet high, at a few rods from the shore. On the beach it is disintegrated and hardly perceptible The dip of the beds of quartzyte and slate that are interbedded with it, is 88° N. E., and the strike N. W. *There is thus seen to be undeniable graduation from the Animike into the conglomerate.* This conglomerate makes also a small rock island near the shore. The greenstone hills still rise to the north of this. A little N. E. from the conglomerate are fine-grained beds which on the weathered surfaces appear like flint changed by weathering, but they are instead a very fine, siliceous, granular rock. There are different grades, about four feet of these flinty layers (1357). The strike of these beds from here would carry them, if continued, to the shores of Fox and Agamok lakes where they were described and illustrated by some figures in the report of last year (pp. 376-7-8).

Crossing the lake about south, to where the ninth "Correction line" (also the town line) intersects the shore, we found a gray feldspathic quartzyte in outcrop, in beds from four to ten inches thick, dipping about southeast at an angle of abont 40° (1358). This may be the Pewabic quartzyte, but contains much more feldspathic material than where it appears north of Flying Cloud lake. Further, it becomes converted into a biotitic gneiss (1359), in large part, similar to that seen on the Kawishiwi, and in that condition it acts like a matrix, rotting and crumbling and allowing round pieces of hard gray quartzyte to fall out and roll down to the beach. On the top of this bluff lies gabbro in place, but the contact is not visible.

On passing further along westward this rock shows some evidence of having been originally a conglomerate, i. e. that these gray "quartzyte" pieces are foreign pebbles. They hence show some kind of a non-conformity between this biotitic gneiss (or changed quartzyte) and the formation (presumably the Animike) from which they were derived. This, however, may be nothing more than the disturbed condition incident to the eruption of some of the gabbro sheets with which the period of the Pewabic quartzyte seems to have been marked.

At a point little further southwest the gabbro comes down the water, and forms the coast-line. On a vertical cliff is a conspicuous green coating (1360), evidently a weather-effect, from decay. The scale which coats the rock has the hardness of 4 to 5, and is at first white, or becomes white when thickly accumulated, although the exterior surface is continually pea-green. It does not effervesce in HCl. It may result from a change in the menaccanite of the gabbro.

About on the town line between 64-5 and 6, secs. 6 and 1, south shore of Gabemichigama lake, is a beautiful basaltic greenstone dike (1361). It is apparently not over ten feet wide, and on the side where the gabbro which it cuts has been carried away by the lake it shows the ends of the basaltic columns somewhat as represented by Norwood in his lake Superior report, handsomely piled up and fitted together. The gabbro here is apparently affected by near contact with the quartzyte, and is decaying and dissappearing, but the dike-rock is firm and fresh even to the very water.

The iron cliff on the south side of Gabemichigama lake rises about 40 feet. It consists of a muscovado-quartzose rock perfectly comparable to the beds seen at Chub lake, associated with the magnetited Pewabic quartzyte. It is filled with minerals derived from the changes effected by the gabbro overflow, as supposed. There are glittering broad surfaces, apparently of a pyroxenic mineral, which in its extentension embraces many small grains of quartz and of magnetite. Indeed, the upper part of the cliff looks much like the bottom part of the gabbro. It is all impregnated with magnetite, and the compass needle is useless. The sample obtained (1362) came from near the top of the cliff, but does not show the coarsely crystalline texture and the crumbling condition of most of the bluff toward the top. Near the bottom a recent slide has exposed some fresh regular beds of quartzyte (1364). When freshly broken these show an essentially granular, quartzose and magnetited composition, but also on some surfaces a fibrous, uniform crystalline mineral reflects a sheen of light that indicates a common matrix for all the grains. When partly decayed this matrix itself breaks up into grains, when the rock exhibits the muscovado-characters, especially if the silica and the magnetite fade out, and are replaced by some feldspathic ingredient. Mingled with the quartz grains are some of olivine. Indeed this rock makes, undoubtedly, the olivine rock, and affords the olivinitic ore which has been seen in many places near the northern border of the gabbro. The general dip, at this place is nearly east, and at the bottom, where it is distinct, in the bedded quartzyte (1364) it is 20°, but generally in the face of the crumbling cliff, and where it is heavily bedded and more coarsely crystalline in spots, it appears to be not more than ten degrees: much of this rock might be taken for rotten gabbro, or biotite gneiss.

A little N. E. of the narrows of Gabemichigama lake, on the south shore, a banded, rusty-coated, coarse, heavy quartzyte appears (1365). It has apparently olivine as well as magnetite, and is a part of the same beds as above described.

Just at the entrance of the narrows are beds of firm, quartzose muscovado rock (1366) embraced in the above quartzyte, dipping S.E, the former appearing in at least two thick beds The Pewabic quartzyte here is rather quartzose, and resembles the iron beds seen at Chub lake, and on the trip north from Flying Cloud lake.

This quartzyte strikes across the lake at the narrows, even causes the narrows, and appears on the west side, while gabbro takes its place round the southern shores of the southwestern bay.

At the near head of the southwest bay, but on the west side, is a small outcrop of coarse conglomeritic quartzyte, allied apparently to the Ogishke conglomerate, but it is overlain by a rotting, biotitic muscovado form (of gabbro?), and I could not make out any dip. It contains isolated pieces of finer rock, not argillyte, but recalling in some way the argillyte distributed in the graywacke at Tower.

From a camp which we made on the west shore of Gabemichigama lake, just south and east of the high hill that rises from the lake shore, an ascent of this hill was made, and the rock was carefully examined at numerous places, and samples were taken at ten places (1367), intended to show the average character. At the shore south of the hill (in the southwest bay, already noted), is a coarse, though greenish, conglomerate or grit. The same rock is found near the foot of the hill and at intervals all the way to near the summit, but it becomes finer and finer, and cannot be distinguished in some cases from some of the finer beds of the Animike. The whole aspect of the hill in its form, the strike of the main rock outcrops, the confused mingling of structure and texture, is that of an eruptive rock, whether from deep source or not. The color is dark, and at first glance it might be taken for a greenstone eruptive. These eruptive features are more pronounced near the top. Still, it is of a light green color, and scarcely a sample can be obtained which does not show some free rounded grains of silica. The whole rock appears somewhat siliceous. Some of it is dark-blue, and fine-grained as argillyte. There are occasional rusty, or irony, patches, like the rusty patches seen in the Animike at Gunflint lake. There are siliceous seams of the same color as the body of the rock, but much harder and finer, which on the weathered surface give a ridged reticulation like that which was photographed at the west end of Kekekebic lake last year. Re-examining all the specimens, and comparing all the facts, I am convinced this hill is made up mainly of modified beds, perhaps of the Animike, but that they have been in almost a plastic slate, and probably toward the summit were mingled with a truly eruptive greenstone without free silica, and without traces of sedimentary structure and composition.

Ten samples, 1367, are intended to show the above mentioned sedimentary characters, taken from the southern slope in ascending.

Three samples, 1368, show the nature of the summit, being a more homogeneous, darker, medium-grained, green rock, without very evident free quartz.

The position of this ambiguous hill with respect to the strike of the Pewabic quartzyte, and its general character, while comparing perfectly with that seen north of Chub lake and north of Flying Cloud lake (1345), has some evident features that ally it with the Animike, and tend to confirm the suggestion, already made, that the rocks 1345 and 1335 are in the place of the greater part of the Animike slates and quartzytes, but have been modified either by deep-seated thermal agents, or by the action of the gabbro overflow, so as to constitute now almost a completely crystalline rock. * Still these rocks (1367 and 1345) differ, in that 1345 has a tendency toward a fine-grained dioryte. It will require more examination, chemical and microscopical, to determine the nature of these rocks more exactly, and it is only after such discriminations are made that some inference can be drawn as to their genesis.

Perhaps one of the most important points to be considered in connection with this hypothetical metamorphism of the Animike slates and quartzytes into the gray-green rock of this hill, and other hills further west, is the disappearance, otherwise, of the Animike strata in their course westward from Gunflint lake. It is true that the beds seen at Chub lake, associated with the Pewabic quartzyte, have an exact agreement with some of those seen at Gunflint lake, but they are insignificant in amount, the great mass of the formation seen at Chub lake being quartzose and quite different from the most of the Animike strata. The same is true of the section observed N. from Flying Cloud lake. In both places, on the supposition that the Pewabic quartzyte overlies the Animike, there is no Animike found under it unless it be this rock. Further, at a point still farther west, at the northeast extremity of Gabemichigama lake, where the Animike formation can be

e, however, p. 95; on *Ogishke Muncie lake*.

recognized again, the strata are greatly broken, and lie in discordant and variant dip and strike. Here they can be seen, as already noted, interstratified with the Ogishke conglomerate; and in their passage toward the hills west of this lake they exhibit, about Fox and Agamok lakes, some remarkable instances of fracture and metamorphism. It remains yet to ascertain how much, if any, of the rock which here constitutes the "greenstone belt" can be referred unmistakably to a deep-seated eruptive origin. It should be noted, however, that in this statement is not included the greenstone which becomes micaceous and hornblendic, seen on the north side of Gunflint lake, and again west of that lake, which forms a terrane older than the Animike, and also older than the Kewatin, and is distinguished as the *Vermilion group*.

With intervals of non-exposure the foregoing rock (1367) extends along the N. W. shore of Gabemichigama lake as far as the portage to Agamok lake. From there to Ogishke Muncie lake is a wild mixture of graywacke, argillyte and flint, with patches of conglomerate. These are broken confusedly, dip in all directions and at all degrees of incline. It is in my opinion the Animike formation. The hill range that includes the hill last described, as well as the Twin Mts., crosses this route between Agamok and Fox lakes, and the only rock visible is this broken Animike sort.

OGISHKE MUNCIE LAKE.

But just before reaching the shore of Ogishke Muncie lake, not far east of the portage trail, a fissile, schistose light green rock is found. This embraces the marble, so-called (746) discovered in 1879, and again further east last year (1069), and belongs probably to the Kewatin series of rocks.

Making a further examination of this marble at the point near the N. E. end of Ogihske Muncie lake where was obtained last year rock 1069 (fifteenth report p. 371), I find the marble (1369) including the other schist mixed with it, is about 25 feet wide, and that it strikes N. 38° E. The argillitic slate (1370), lying next west, along the lake (No. 6, of the diagram on p. 371), and the conglomerate associated with it, strike in the same direction. The slate is vertical, and is due to the thin (sedimentary ?) lamination.

The marble is impure, apparently siliceous, and seems to blend with the chloritic slate or schist which is included with it, but many of the projecting parts, on the rusty weathered surface are angular and siliceous. The rock shows no bedded structure, nor any uniform structure except a coarse disintegrating schistosity which coincides with, and causes, the strike of the outcrop.

The marble, so-called, is in some manner allied to the rock in the hill toward the S. E., because small amounts (1371) of it are disseminated in it; but these do not extend far from the main marble ridge. There is a narrow valley between the marble ridge and the more elevated shore, in which no rock is exposed.

The shore is composed of the rock 1068 and 1372. It appears like a massive doleryte in some places and presents basaltic forms; but it embraces numerous evidences of sedimentary structure and origin for the pebbles, quartz grains and fragmental masses of strata embraced in it. It is massive, basaltically and otherwise jointed, green, roughened on the weathered surface by the projecting siliceous and feldspathic grains, and in some places has a lighter green color. There are in it small contorted areas of cherty argillyte (1373) which, weathering much lighter (a pea-green, or more nearly white), appear like siliceous veinings, but really exhibit the banding of weathered, cherty or flinty argillyte. These are shaped about rounded areas as if of boulders, but the included boulders (?) are the same as the main rock, and comprise elsewhere, the whole of it, but their forms are not evident.

In other places this conglomerate—be it igneous or changed sedimentary, that's the problem—shows patches of what appears bedded graywacke. One such is 14 inches wide and extends 4½ feet N. 35° W.; but it has a feather-edge caused by the successive branching away and disappearance in the matrix of the conglomerate, of different layers of itself, some of them weathering lighter colored, and all of them having a wavy structure.

Traveling southeastward (this is in N. ½ of sec. 24, 65-6) about a quarter of a mile away from the lake shore, we find the same greenish, massive but indistinctly conglomeritic rock continues. It disintegrates, on decay, schistosely, with a siliceous and chloritic matrix. Near the place where we turned back is an area of graywacke and slate, embraced in it. This runs diagonally across its own strike about 30 feet, but it changes its own strike in that distance from N. 10° W. to N. 45° W. This is an included mass and transported from its native place by some agency, though perhaps not far. Indeed it may be only a part of a general sedimentary formation which, becoming plastic, then compacted again, allowed this large fragment to keep nearly intact its stratiform arrangement. It is about ten feet across, and on each side of it, in the enclosing rock no structure can be seen, —simply the formless though sometimes boulder-filled green rock.

On searching further this stratiform belt, with windings and uncorformities within itself, extends northwestwardly about ten rods, and fades out. Along its westerly edge it has, in some cases at least, an abrupt and non-conformable transition to the green rock, and in other cases the green rock also exhibits a faint lining of a remnant of stratification contiguous to the line of junction, but the directions of the two are apt to disagree. Taken as a whole this banded portion turns gradually from N. 10° W. to N. 50° W. It makes this grand swing, but in some places it shows abrupt changes and discordances.

In the banded gray-wacken argillitic parts some of the pebbles seem to have a hardened shelly exterior, and sometimes two hardened cases (1374) as if concretionary.

North from this place, in the narrow spot in sec. 13, between Ogishke Muncie lake and the lake south of Townline lake, strikes a Kewatin-like rock (1375) i. e. a schistosely disintegrating light-green, or sometimes slightly reddish, apparently fragmental rock containing much free quartz, a phase of the conglomerate. It is mingled with some coarse conglomerate, and patches of argillyte and occasionally seems to have the character of the silky poroditic quartz-free rock of Stuntz island at Vermilion lake.

1376. Greenish argillyte from the conglomerate.

1377. Piece of a pebble from the conglomeritic part.

1378. Rusty carbonate appears in patches in this rock.

In general, the green rock lying adjoining the so-called marble, described above, embracing conglomeritic and brecciated parts; also the rocks extending further north (1375—1378), have their counterparts in the region of Tower, as described in the last report, and cannot consistently be considered other than parts of the same formation (Kewatin). All the structural features are also seen about Tower, and eastward from there toward Fall lake. On the other hand, this green, eruptive-looking conglomerate has such a close geographic relationship, and so strong a lithologic resemblance to the pebbly conglomerate of Twin Mt. (1077), as well as to the green rock seen in the hill west of Gabemichigama lake (1367), and to that seen about the shores of Frog Rock and Saddle Bags lakes, that they seem to be necessarily of the same terrane. They cannot, therefore, be modified portions of the Animike, because that has been shown to lie unconformably on the Kewatin. This eruptive-looking conglomerate cannot, hence, be the same as the conglomerate seen to be interbedded with Animike argillytes and quartzytes at the N. E. end of Gabemichigama lake. There seem to be, therefore, two conglomerates about Ogishke Muncie lake, viz:

1st. This old eruptive-looking, massive, schistosely weathering and decaying Ogishke conglomerate which appertains to the Kewatin, and extends from Stuntz island, in Vermilion lake, past Ely (where it was recently examined at the Iron mines) to Twin Mt. and Frog Rock lake.

2nd. The Ogishke conglomerate, of later date, which is interstratified with Animike argillytes and quartzytes, much fresher in aspect, very siliceous, evidently derived largely from the disintegration of the other, unconformable on the other, but involved with it in profound fracturing and metamorphism.

Accordingly it will not be allowable to suppose that the Animike strata, in their passage westward from Gunflint lake become converted into the rock on which the Pewabic quartzyte lies at Chub lake, and northward from Flying Cloud lake; but those ambiguous greenstone rocks (1335, 1345 and 1367) should be placed in the eastward prolongation of the similarly ambiguous greenstone seen at Tower and at Stuntz island, and perhaps that which causes the falls of Kawasachong.

SADDLE BAGS LAKE AND FROG ROCK LAKE.

The former of these names was applied to a small lake that lies south of Townline lake, between Ogishke Muncie and Frog Rock lakes, suggested by its shape. This lake was approached by a portage (without trail) from Ogishke Muncie lake, and about its shores was found a form of greenstone in which are seen occasional traces of sedimentation, appertaining, probably, to fragments, large and small, which are embraced in a once plastic matrix, in a manner similar to that evinced by the rocks 1372, 1379 and 1380.

A similar rock environs Frog Rock lake, but in some places it approaches a true greenstone (1381). Going south from Frog Rock lake to the center of sec. 19, 65-5, we crossed a wooded country with occasional low ridges of greenstone and gritty greenstone, represented by 1382. At the farthest point reached the rock 1383 appears, but it is associated with 1384 which is finer-grained, in part, and conglomeritic in part, sometimes banded, and evidently a fragmental phase in the eruptive-looking greenstone—conglomerate.

NOTES MADE BETWEEN OGISHKE MUNCIE LAKE AND KEKEKEBIC LAKE.

At the west end of Ogishke Muncie lake, on the southerly portage to Dike lake, is a dark, slaty argillyte (1385) on which are fine ripple marks. These become visible on separating the fine laminæ of the slate. This slate resembles that seen in the Animike. On the edges, when freshly broken, it is finely banded with sedimentary colors. The ripple marks are well formed and preserved.

From this point *an ascent was made, by Mr. F. N. Stacy, of East Twin Mt.*, and he reported substantially the following results. The position of the mountain was ascertained from magnetic observations, on a common compass needle, as follows:

The north side of Little Saganaga lake is E. 10° S. (mag.).

Camper's island is N. 20° E. (mag.).

Lake Saganaga (a broad expanse of water) is N. 15° E. (mag.).

The mountain which lies at the west side of lake Gabemichigama (rocks 1367 and 1368), which is near the center of sec. 1, 64-6, is about due east (mag.).

These directions place East Twin mountain not far from the center of sec. 4, 64-6, nearly a mile further south, and half a mile further west than was represented on the geological map accompanying the last report.

The summit of the mountain is made of the rock 1386, a coarse hornblendic greenstone, resembling rock 759 (10th report, p. 97), but which on deeper fracture appears to be a titaniferous gabbro.

Near the top, but on the body of the hill, on the north side, was seen a finer greenstone (1387). But further down (still on the north side), near the bottom of the hill, it is a coarser rock (1388) of the same kind as 1387, but not so gabbro-like as 1386; but at the bottom of the hill are found both coarse and fine (1389), the coarse being identical with 1386.

According to the observation made by Mr. Stacy this hill is set off abruptly, both topographically and lithologically from the following by a ravine, or series of irregular, branching valleys. The hill rises about 350 feet above this ravine. The rocks that constitute the lower hills on the north side of this ravine are in the main an ambiguous greenstone (1390), and seem to be closely associated, perhaps blended into, the prevailing sedimentary rocks that are seen about the S. W. shores of Ogishke Muncie lake. These sedimentaries consist of cherty slate, conglomerate, &c. This lower hill-range hides the Twin mountains from sight, from Ogishke Muncie lake, except at the N. E.

end of the lake, and seems to be a connecting line between the Twin mountains and the hills immediately west of Gabemichigama lake. It lies not far north of the Twin peaks. Indeed, Mr. Stacy represents that the peaks are simply higher parts of a general hill-range, cut off by ravines from the rest of the range, and that in general, the fragmental rocks cease before reaching the ravine mentioned.

Rocks 1391, 1392, 1393, 1394 and 1395 represent the broken sedimentary rocks intervening between the peaks and Ogishke Muncie lake. No. 1393 represents several small hills, or hill ranges, a gritty greenstone, a modified sedimentary. No. 1394 is chalcedonic silica, and samples closely related, all enclosed in and banded together in 1393. These are in three small ridges, successively, but the samples are all from the same ridge. The chalcedonic silica seems to indicate the horizon of the Kewatin, and the iron ore here associated with it, although magnetite, does not preclude the parallelizing of this nearly with the horizon at Tower. No. 1395, which is a widely disseminated rock, is a greenish conglomeritic one, the same as seen in many places about Ogishke Muncie lake, a part also of the Kewatin, as already mentioned. It is filled with fragmental material, but takes the forms and basaltic habit of an eruptive. It seems to be made up largely, in some places, of broken masses of older strata, as well as of individual fragmental grains, the whole compacted together by a prevailing greenish, doleritic matrix.

The hill directly east of Alpha lake is composed of hardened graywacke and slate, having a balsaltic jointage (1396). It is cut near the lake by a green dike-like belt (1397) but this may be a part of the plastic sedimentaries, as it is not a persistent direction. Macrospically it appears like a diabase, sparsely porphyritic.

KEKEKEBIC LAKE.

The gray porphyry (1094) at the S. W. cor. of sec. 29, 65-6, rises about 100 feet above the lake, and composes the whole peninsula, making a knob by itself. It is very siliceous (1398). It is massive, or coarsely jointed. The feldspar crystals are not always perfect in form, but approximate a true crystalline shape. They seem to be of orthoclase. They weather red. The long exposed (or at least the burnt) surface of the whole rock becomes reddish, but the surface scales off by fire and keeps a fresh gray color exposed. There is in some places a prevailing direction—that of the general strike—seen in the longer axes of the crystals. They are also apt to stand vertical, edgewise, in the same direction. In the rock are boulder-forms These are most frequently of greenstone, and then they are not porphyritic, but sometimes they are of some rock which weathers a pinkish red color. They are also of a siliceous gray rock resembling the matrix of the porphyry, but finer-grained, and also of other light-weathering kinds. But in the main this is a homogeneous rock. These boulder-forms are by no means a common occurence, at least at this place. Yet in other places there is a various distribution apparent in the crystals. They are either more conspicuous and more numerous, or else less frequent, in rounded spots; or they stand out at different angles, as if they had been dependent on the varying nature, position, structure or grain of the enclosing rock. This distribution and confused arrangement are so combined as to bring out to view indistinct outlines of former included boulders. From this I conclude that the whole rock is a modified condition of the sedimentaries here prevalent, and that it indicates what would become of the whole formation (conglomerate, graywacke, slate, chert, &c.) if under similar conditions the rearrangement and recrystallization had been carried to completion—a syenite or a granite, at least an acidic rock. Here there is no basic surplus to give the rock a doleritic aspect. Where this has been the case the singular, "ambiguous greenstone" has apparently been the product, a kind of fragmental basalt.

This porphyry knob lies between two hardened graywacke and slate ridges, that on the north being Mallmann's peak and its eastern extension, and that on the south being on the opposite side of the lake (here quite narrow). It is just east of the great dike that strikes across the lake here.

On the south side, immediately opposite this knob, but a little further west, this porphyry is found again. The specimen obtained (1400) is from close proximity to the greenstone dike, but the whole rock here weathers red distinctly, and also has crystalline hornblende. It seems as if the fracture which gave exit to the greenstone may also have had some agency either in the protrusion or in the production of the porphyry.

The dike which crosses Kekekebic lake (1401) * forms two islands. The rock (1402) on the west of the dike, on the southerly island, while apparently a part of the porphyry already mentioned, is also as plainly a part of the red weathering gneiss seen farther west in the islands of this lake. The porphyry on the east side, at this place, is not visible.

* Fifteenth report, pp. 368 and 153.

This gray gneiss (1403) appears on the main land a little farther west; and while weathering reddish, showing its identity with the rock of the islands, it also takes the characters of the porphyry (1400), including the boulder forms. These forms are here everywhere visible, whether the rock be gneiss or porphyry, or porphyritic gneiss.

As a gneiss it shows a schistose bedding 2-4 inches thick which, in one place at least, dips into the lake, northwardly; but this bedding is not of sedimentary origin. It is a layered manner of disintegrating. Further west it dips south, in each case about 25°.

Ascending the hill, half a mile from the lake, near the center of sec. 31, 65-6, we pass over first a low ridge of this gray red-weathering gneiss, showing boulders included, the visible ones being mostly some form of greenstone, and reach the summit of a hardened graywacke and slate, gritty, greenstone ridge, represented by rock 1404. Further south a higher hill rises, which was not visited. If the succession observed in the rocks of the Twin peaks be preserved here, this upper ridge would be likely to be of true eruptive greenstone.

The point on the N. W. ¼, S. W. ¼ sec. 31, 65-6, is composed of two rocks. One is 1405, a quartzose rock with a fine porphyritic tendency, gray inside, weathering reddish-gray and disintegrating with a coarse, schistose decomposition like the gneiss. This is a phase of the conglomerate which graduates either way, to the real porphyry or to the gneiss. The other rock is a conglomerate (1406) with a green matrix. It acquires outwardly a schisto-fibrons structure running E. 20° S., and in disintegration seems to become finely micaceous. A little further west, on the point, this rises high, and is basaltic, very pebbly, and holds many jasper pieces. On the extremity of this point which is at the narrows of the lake, is a gray porphyry (1407).

Stacy island, the easterly of the two, is made up of the conglomerate of the main land opposite, at the bottom, and a hardened graywacke, etc., overlying. But on the north side, near the water, the rock has a bedded, acquired, structure similar to that seen in the gneiss and porphyry; but the whole is greenish and not gray.

The island west of Stacy island is composed of the same gray porphyritic gneiss (1408). This has orthoclase, hornblende and (black?) mica, and an abundant quartzose base remaining.

The latter island just west of the narrows, near the north shore of the lake, is made up of chloritic schist. The sample (1409) came from near the water, south side, while that numbered 1410 came from the top of the same island. There are 15 feet of bedded (sedimentary) north-dipping chloritic schist of this kind. The schistose fiber runs (on the top) N. 45° E., and the dip is N. 30° W., about 25°. This all readily disintegrates, and as it is found extensively about the N. and W. shores of this lake it probably occupies largely the lake bottom. It seems at least to occupy it at the narrows. This soft rock extends westward from here, so as to enter the shore, and probably is the same as the chlorite schist seen adjacent to a knob of porphyry last year (15th report, pp. 367, 154). Here this green rock has a distinct sedimentary dip, as given, which precludes its being of eruptive origin. This bedded structure is visible, when freshly eroded. on the south side, but is not on weathered surfaces. It is somewhat more siliceous in some beds (1411) near the middle of the south cliff. The sample shows the sedimentary lining. It holds, near the bottom, small rounded nodules (1412) of rock like itself, somewhat simulating "boulders by disintegration," as well as some short lenticular sheets of finer rock not very different from itself (1413) the last being a part of the bedded arrangement. At the extreme S. W. corner of the island these beds are conglomeritic at the low-water line.

The smaller island, north of the last, has a similar rock, but is in places abundantly porphyritic, and dips N. 15° E. There is another small rock island just E. or N. E. of the first, in which the same rock appears, but dips southerly at an angle of about 80°.

Considerable search was made for some outcrop of the porphyry, or gneiss, which would show its exact stratigraphic position with reference to some other member of the series; but in nearly every instance the contact was hid by forest, or by drift and debris; until on coasting again westward, near the E. and W. town line, along the south side of sec. 35, 65-7, at the prominent round point of land projecting into the lake, a low bluff of the porphyry was noticed which was undermined by the more rapid disintegration of some lower and softer rock. Numerous large pieces of greenish chloritic rock, resembling the green schist seen in the small islands near the north shore in the narrows, lay here on the beach, disrupted by frost. It required but little search to find that their native place was just under the overhanging cliff of porphyry, at the water-level. Rock 1414 represents different forms of the porphyry in this little cliff, which rises about ten feet. Rock 1415 shows the underlying greenish (biotitic?) rock which rapidly wears away. This greenish rock also spreads upward irregularly, in a few patches of irregular shape (1416) in the porphyry, (the sample is rather a gneiss than porphyry).

This porphyry grades into the gneiss of the islands and into the red rock seen last year along the S. W. shore of lake Kekekebic. They are both conglomeritic.

This porphyry lies on the green biotitic schist (at least in one place) which is so common about the lake, and which itself is bedded, fragmental, and becomes a conglomerate that readily disintegrates.

This porphyry, and hence this fine, gray, red-weathering gneiss, are of more recent date than the green schist. If the porphyry holds its position as overflow through the action of eruption, it still may be a condition of the conglomerate seen about Ogishke Muncie lake which underlies the Animike.

Here seems to be an instance of a gneiss which is not Laurentian, but which has been erupted through the Kewatin, and is perhaps a result of the modification of a Kewatin conglomerate. It is in the line of strike from the coarsely crystalline syenite area further southwest, which appears on the east side of White Iron lake, and which rises still further southwest and constitutes what is called, in these reports, the Giant's range, but on which the Duluth and Iron Range railroad has a station named "Messaba Heights." This is an isolated, abrupt, granite or syenite range, and evidently is of eruptive origin in the same sense that this prophyry at Kekekebic lake is; an acid eruptive, later than the Laurentian, originally from some of the strata of the earth's super-crust, and not from a deep source. It hence may lie on any formation older than the date of the eruption. The reader is referred, in this connection, to an other part of the report where some observations at the Aurora mine, on the Gogebic iron range, are stated, in which it is also shown that a conglomeritic syenite lies on some stratified sedimentary beds, probably the Animike. He is also referred to the fifteenth report, pp. 349 and 355, where some other facts and general considerations bearing on this origin of granites will be found.

Rock 1416, a reddish porphyritic gneiss, the same as 1105, shows the intergrading of the gneissic, the porphyritic and the conglomeritic characters in the same rock.

This has been called *gneiss* this year and last, but it needs a word of qualification. It has not the real gneissic structure, or foliation supposed to be due to original sedimentary bedding. It has acquired a sheeted structure, but in general it is massive rock, showing variations due to the original conglomeritic state of its materials, as already described. Where it passes into the porphyry it is more compact and more firm than when it is not porphyritic.*

*The former state of this rock has been named *porphyrel* by my brother in the fifteenth report p. 159.

Shingwak island, (north of Animike island) is made of the red-weathering, gneissic rock (1417), but it is clouded with the variations due to the original conglomeritic nature.

Sometimes the red crystals run into a greenish biotitic rock (1418), which is associated with the red rock, the changes from one to the other being, here, in perpendicular planes.

The very small island directly south of Shingwak island is not red weathering, but the rock is fine-grained, greenish-gray, hardened gray-wacke, (1419)—with fine mica scales sparsely disseminated. Its sedimentary bedding planes are distinctly preserved.

At the west end of Animike island there is a conspicuous dip of the "acquired" bedding toward the north. While the rock here is essentially all alike, yet some of it does not take a red color in weathering (1420). I could not discern any definite order in this difference of color. Still the gray color seems to prevail in the middle beds, and the red at the N. and S. parts of the bluff. The colors are not distinctly separated. The acquired bedding, in all these islands seems to dip toward the north.

At the S. W. end of lake Kekekebic the rock is greenish and micaceous (1421), but it has all the characters of the chlorite-schist-conglomerate (1409-13) seen in the little islands near the north shore at the narrows, except that it does not here show such evident stratification. The reason seems to be that it dips away from the observer, and in general away from the lake along the west shore. It appears much like a crystalline rock, but it is of fragmental origin. At the water-level are purgatories that are wought by the water in the softer layers, roofed over by some of the former. It has harder seams and lumps that stand out on the surface.

There are two small islands south of the point in the W. part of sec. 3, 64-7, one of which consists of the same red rock as the islands further east. The other consists partly of red rock and partly of green and red (1422). They are all mingled, even the red crystals appearing sparingly in the green

The tip of the point consists of red rock (gneiss) but at the base, on the south side, are Animike slates, fine, black, closely jointed and hard, like the black slates, seen on Kekekebic last year, and being identical, apparently with the Animike slates at Gunflint lake. These slates dip east about 75 degrees, and their north-south strike continues so far as to run along the shore of the square land projection which is just north of the small point, dipping still easterly and exhibiting a high bold lakeward front, characteristic of the hardened slate group on this lake. If they continue far enough, with this dip, under the water, they must run below the reddish rock of the islands. In the same way if the dip of the gneiss in the islands (the coarse, acquired bedding) continued under the water, its western portions at least would pass below these slates. But it is certain that the dip and strike of the slates and greenish conglomerate are inconstant. This is shown by numerous observations already recorded, and it is hence probable, that although locally the gneiss (or porphyry) may overlie the exhibits through the accidents of local fusion or protrusion, the formation in general to which the red rock belongs is older than the schist and slate, and would be found lying below it when not so disturbed.

On the next, square, point the dip of the slates is N.E. at 45° angle, changing soon to 35°. But on the north side of the point, near the town line, but not at the head of the bay, the dip is again S.E.

At the head of the bay, west end of Kekekebic lake, on the town line, the green schist-conglomerate (1423) appears again, same as seen in the islands at the narrows. At the water-line the weathered surface is roughened by numerous small knot-like projections (1424). Some of them take the form of ridges. These projections make the rock look like a conglomerate. The ridges are hardened seams, and run in all directions. The general structure is vertical and in the same direction as in the islands. The rock is green. It easily wears away, i. e. more easily than the slates and greenish graywackes; yet it produces sharp, short points and islands in the teeth of the waves. At this place no certain sedimentary structure is observable, but on the north side of the little sharp point a sedimentary lining is visible in rock 1423, showing a dip E. 10° S. This structure is like that seen in the islands at the narrows.

On the shore north of this bay, and eastward, the same rock continues, and dips S.E., until it is cut by a dike (1425) on the north side of the next bay. South of this dike the green schist appears at the head of the bay, and has coarse pebbles.

Crossing this bay and coming to the point which projects S.W. toward its counterpart on the opposite side of the bay, the slates and chloritic graywackes appear again, thus *showing that in general the green pebbly beds lie below these slates.* Yet on this point there is a local dip in the slates toward the green schist beds; but the dip varies, sometimes being vertical.

Next, further east, in S. W. ¼, sec. 34, 64-7, on the shore of Kekekebic lake, near the head of the broad shallow bay, is an important variation. The graywackes vary to the green beds, but are pebbly conglomeritic. They also show a disappointed struggling ambition to become porphyritic. The color is not gray, nor green, but gray-green, and there are apparently a few fine crystals of hornblende in some parts of it. The reddish weathering siliceous portions sometimes are mingled distinctly with the softer greenish or grayish portions, the latter becoming micaceous on decay (1426). It appears as if the porphyry, the reddish gneiss, as well as the hornblende porphyry of Mallmann's peak (No. 751), were intimately associated here in embryo, in one and the same rock with the green schist conglomerate, and that by differentiation they could all be brought out, and belong genetically to the same formation. Still this commingling of characters is probably only local, such as is incident to the contact of any two formations. When it is remembered also that the porphyry and the gray gneissic rock seem to have been plastic *since the deposition of the green schist conglomerate,* and has been protruded through and overlies it, it is not only reasonable to expect that the schist would embrace materials like the original sediments of the porphyry, but also that the porphyry should enclose parts of the schist. In a common softening and metamorphism the two rocks would thus come to show approximations in mineral characters toward each other at the points of contact.

Thence to the portage going north the same green, finely conglomeritic rock continues, as noted last year.

Before leaving Kekekebic lake it would be well to group some of the recorded facts into general statements, and to give some of the inferences to which they seem to lead. These inferences are provisional, and are based on the field observations, extended now over this lake twice, but they may have to be modified when the rock samples collected have been subjected to thin-sectioning and microscopic inspection.

There are, in the main, but three formations that are to be considered.

1. The changed conglomerate, or porphyrel.
2. The green chlorite-schist-conglomerate.
3. The black slate—which resembles the Animike.

The porphyrel is plainly an extension of the same part of the Ogishke conglomerate westward. The change which converted that conglomerate into this acid eruptive rock was subsequent to the deposition of the Animike rocks and the disturbance that accompanied it involved the slates and other parts of the Animike. It was perhaps cotemporary with the formation of the last of the basic dikes. In general the conglomerate was not much moved out of its place, but was metamorphosed *in situ*, in some cases retaining some evidences of its mechanical sedimentary manner of deposition.* In others it was protruded in bosses that now rise boldly above the general level, and in still others was caused to lie upon some parts of the green schists in the manner of an overflow or laccolitic eruptive.

The green schist, which belongs apparently to a date about the same as the Kewatin portion of the Ogishke conglomerate, or is its immediate successor and conformable upon it where the contact is normal is still markedly different from it. It is apparently formed of basic erupted materials in a fragmental condition. It received its stratified arrangement through the agency of water. Volcanic vents in the immediate vicinity must have given origin to this vast supply of basic materials. It is to be considered, at present, a part of the Kewatin, because it is very likely the same as the "ambiguous greenstone" on the north flanks of Twin mountain, and in the section seen between Flying Cloud and Bingoshick lakes—and that has been excluded from the Animike (see under *Ogishke Muncie lake*, p 98).

The Animike slates, which are associated with this green-schist-conglomerate in the N. W. part of the lake seem to have been the conformable successor to the green schist so far as continued aqueous deposition was able to make conformable succession. But it is very likely that this succession would not be found conformable in the vicinity of the old volcanic vents. There was a great basic eruption that separated the Animike from the Kewatin. That is evinced not only by the actuality of this fragmental basic rock, but by the existence of mountains of truly eruptive greenstone which show the probable sources of the fragmental debris. These two greenstones are found to lie, in every case, below the Animike, when they are present; at least they intervene between the general strike of the Animike and that of the Kewatin, with the Animike dipping away from them. The fragmental sedimentary "greenstone" probably graduates upward into the Animike slates, forming their basal conglomeritic portions wherever there was no break in the sedimentation. That part of this "ambiguous greenstone" which consists of breccia, or contains masses of contorted strata, as described at Ogishke Muncie lake, must have been formed in nearer proximity to the volcanic vents, where the succession of sedimentation was interrupted by upheaval, fracture and overflow.

* Compare the 15th report, p. 353.

PSEUDO-MESSER LAKE AND WESTWARD TO TOWER.

In making the portages from Kekekebic lake toward Knife lake, the green fragmental schist, sometimes fine and sometimes pebbly, occasionally twisted and deprived of evident sedimentary structure, continues to Spoon lake. On the north side of Spoon lake, the same formation continues, but it is not green and soft—i. e. is not so green. It is rather grayish, and more firm, and mashed together so that the bedding planes appear occasionally as linings. The outward surface is rough to the touch with siliceous grains and seams, and the whole rock seems more siliceous. It is like some brecciated portions of the Animike seen along the international boundary line east of Gunflint lake. In this condition it looks as if a little more metamorphism would produce the red fine-grained gneiss.

The rock forming the point, N. E. cor. sec. 28, 65-7, in an area of Knife lake (1428), is a dark siliceous slate. But the interesting point in this rock is its compacted condition and incipient porphyrization, as well as the slightly pinkish tint which it acquires on weathered surfaces. This is not always dark within, but is grayish to black. The sample obtained last year a little further south, nearer the portage landing, was finer and black within.

We went to Pseudo-Messer lake by a route which crosses a part of Hunter's island. This is a much used trail, indeed is said to be the main route. It has long been used. I do not know why the boundary was established, on our maps, on the southern route where more portaging is necessary to reach Basswood lake. Was it because the U. S. township surveyors surveyed only to that line? If so it seems as if the United States has good claim to land, up to this old route, which seems to conform to the terms of the Webster-Ashburton treaty.

At the commencement of the first portage on Hunter's island the black siliceous slates seen last year (and again this) at the point where Knife lake is first reached from Kekekebic lake, appear, dipping southerly at an angle of 88 degrees, more or less; and at the summit of the divide the rock 1429 can be seen, which is about the same rock as at the south end of the portage, somewhat lighter colored. Slaty cleavage here runs E. 12° N. by compass, but the sedimentary dip is obscure. The slaty cleavage dips at a right angle with the direction of its strike, and the only symptom of sedimentary dip that can be found indicates a southerly direction, amounting to 88 degrees.

A little below the summit, and on the north slope, rather nearer the lake than the summit, is a dark gabbro-like dioryte (?), No. 1430. No contac with the other rock is visible, but it probably lies on it.

It forms a little ridge running S. SW., but slate recurs again just below, and continues to the lake.

The next portage to Pseudo-Messer lake is a short one, and at the west end No. 1431 appears. It is a light-green slate, rather firm, but showing a tendency to sericitic films between the laminæ. It has considerable free quartz in macroscopic grains. It resembles slate seen in the Kewatin about Long and Vermilion lakes.

The point in Pseudo-Messer lake that lies north from the portage landing, on the east side, (as extended, the U. S. survey lines would make it, on my plat, N.E ¼ sec. 19), consists of a slighty reddish-weathering, pyritiferous, fine-grained quartzyte, or gritty felsyte, firm and sharp in fracture, having no visible bedding, but looking like a changed (and now eruptive) rock (1432).

Directly across Pseudo-Messer lake from the portage landing occurs rock 1433. It is on two islands in a bay. It is a light-green schist, siliceous with chalcedonic silica, identical with some that had been described at Tower in connection with the iron-bearing rocks. This identity is further indicated by the existence here of small hematitic streaks, and jaspilyte, varying from white to red (1434 and 1435) which occurs in lumps, and in perpendicular lenticular sheets in 1433, in the same manner as at Tower This green rock is soft, schistose in the direction E. 20° N. and holds "chalcedonic" silica in nodules, also one narrow belt of jaspilitic, hematitic quartzyte about two and a half feet wide. Small pebbles of 1434, as small as a pin-head are disseminated in 1433. There is a siliceous framework also in 1433, apparently pervading it, that forms a roughness on the weathered surface, (compare the fifteenth annual report p. 229.)

It is very evident from the few observations that were made on Hunter's island, that the iron range of Vermilion lake extends across the Boundary waters and enters the British territory on the island.

Through Sucker and Carp lakes are only seen exposures of argillitic slates, graywackes and sericitic schists.

From Prairie portage to Opin Is., in Basswood lake, sec. 10, 64-10, the rock has a very uniform character. It is syenite varying to granite. It is split into sheets varying from one inch to six inches, usually about three inches, which are apt to dip north or south, but sometimes are nearly level. In addition to this bedding it has a gneissic structure, thus differing from the red, fine syenite of Kekekebic lake. It has occasionally belts of dark, quartzose, non-crystalline, or cryptocrystalline rock that show distinctly a lining due to sedimentation. These run short distances. It also holds patches and lenticular masses of granular hornblende, which is shown on the sample (1436) collected.

At the S. E. end of the portage, in S. E. ¼ sec. 6, 64-10, which leads from one part of Basswood lake to another, is a rock (1438) which seems to be simply a hardened graywacke, appearing now like a quartzose gray syenite-gneiss, with some chlorite that gives it color specks. At the N.W. end of this portage the landing is on mica schist, interlaminated with rock like 1438.

The bluff on the right bank, just below Pipestone falls, rises about 18 ft. direct from the water. It embraces three rocks, 1439, 1440 and 1441. No 1439 seems to be a dark hornblendic greenstone. It occurs on the face of the bluff, all about, and seems to graduate into rock 1440 There can be found no direct transition, nor can it be stated what the nature of the change is without microscopic examination, as the latter rock is fine grained, and seems to prevail over all the others. It seems to belong, however, with the mica schists, but is very firm and shows mica very sparingly. Rock 1441 is light-colored, somewhat reddish, coarsely granular chlorite syenite, or granulyte. This cuts both of the above rocks, running in seams and veins about five inches wide, nearly horizontal along the bluff. It also occurs in irregular bosses in the face of the bluff, alongside of which the rock 1439 stands in a vertical plane of contact.

Just above the rapids, where was obtained in 1878 rock numbered 349 from a low bluff on the right bank, there is now no rock exposed, the drift having concealed it; but large pieces that lie about are from a greenish schist, and are represented by 1442. No. 349 is styled peridotyte by Dr. Wadsworth, of the variety serpentine.

A very similar schist (1443), but more shining, lighter green, "talcose" or "sericitic," is found in abundant outcrop at the west end of the portage from Newton lake to Fall lake. It strikes toward the upper end of the rapids, at the upper landing, and apparently causes them. Its structure is about vertical, lenticular-wedged schistose, making, when weathered, a soft fissile schist. Compare 1109.

At the Cooper claim, near the head of the portage from Fall lake to Garden lake, a late stripping east and west reveals a run of jaspilyte which is six or eight rods across, at least, reaching from the west portage trail to near the river. It is more or less hematitic. At the west end of the stripping the jaspilyte is replaced by the greenstone of the region (999 and 1444).

At the place called "Silver City," north end of White Iron lake, the quartzyte containing the iron dips, on the north side of the hill, 74°N., 30°W. It is gray and similar to the Chub lake quartzyte (1445). It reverses the needle. It contains thin, irregular, green laminæ in which magnetite seems to gather most freely, but the ore is also scattered in fine rhombohedra in the quartzyte itself. The rock is certainly sedimentary in the direction stated, and thin slaty seams appear on the north side, due to that structure.

A little further west the rock dips more westerly, and the structure actually swings round so as to have an apparent dip S. W., i. e., toward White Iron lake. It is sometimes micaceous, i. e., its cleaved laminæ glitter with fine silvery scales which may be chloritic rather than micaceous, and result from a change of the green schistose substance that is interleaved with the quartz. Taken altogether, the formation is quartzyte, some of it being gray, granular, hard silica, and some of it very fine-grained and schistose. In the latter case it is darker colored, the coloring element being apparently a fine acicular mineral which lies with its longer axis parallel with the grain of the schist, and may be tremolite. Eleven samples collected (1146) show different variations and the associations of the ore.

The statigraphic position of this rock, and its geographic relations, seem to conspire to ally it with the *Vermilion series*, i. e. the mica-hornblendic rocks that are associated with the granites of the north side of Vermilion lake and north of Long lake. But the general direction of strike, from the Animike ores west of Gunflint lake and its mineral composition would allow of its being a part of the Pewabic quartzyte. It lies, however, on the other side of the Giant's range of granite from the Animike ores at Gunflint, and its age is probably that of the mica-schist. It is the only known iron-ore locality in the rocks of that age.

But a short distance below this mica-hornblende-quartzyte knob, but on the opposite (N.) side of the river, appears rock 1447 in a low outcrop. This is a fine, fibrous, greenish rock which at first glance appears like a diabase, but is in reality an extension of the tremolitic (?) quartzyte formation just described.

On the north shore of Mud lake, near the west end of the lake, but about half a mile from the lake (N. W. ¼, sec. 4, 62-14) some recent drilling has been prosecuted with a diamond drill. The rock here is the "ambiguous greenstone," with chalcedonic silica, which accompanies the ore at Tower. Nothing but this green rock (1448) can be seen at the location, and no rock at all along the road from the creek. Some samples of the drill-core which lie about, consist of the same. The place is deserted at present. No iron outcrop could be found. Samples said to have come from the place, obtained since from Mr. J. C. Clark, have been analyzed by Prof. Dodge with the following results:

	No. 1.	No. 2.
Silica	21.70	5.26
Lime	0.21	0.15
Phosphorus	0.17	0.18
Magnesia	traces	traces.
Manganese	none	none.
Titanium	none	none.
Sulphur	none	none.
Mag. oxide	77.62	92 76
	99.70	98.35
Metallic iron	56.21	67.11

At the Stone mine, at Tower, the old excavation is being filled, covering the "dike" of jaspilyte, but on re-examination very little more could be ascertained of its direction southwardly from the old mine. Yet I became more impressed with the probability of its resuming a direction about parallel with the direction of the mine at a short distance within the south wall, in the same manner as described of No. 2, last year.*

The Tower spur track cuts a light-green porodyte, 1450. This is mainly massive, except that it is basaltically close-jointed.

About five miles south-east from Tower, Mr. Hermann S. McMinn has conducted an exploration for Messrs. Andrews, Chapin & Co. This is on sec. 2, 61-15. Some samples of good magnetic ore, said to have been derived from this working, were shown at Tower, also some samples of the jaspilyte. Some of the jaspilyte is gray and white, with magnetite and pyrite (1451), interchangeable with jasper and hematite. Associated with the pyrite and magnetite is some graphite (1452). Much of it, so far as explored, is in the form of a breccia cemented by pyrite, now largely changed to limonite.

GLACIAL DIRECTIONS OBSERVED IN 1887. BY N. H. WINCHELL.

Bruce, Ontario, near the old Bruce mine, but east of it; on dioryte, at the lake level .... S. 10° W. (Mag).

Bruce, Ontario, 50 feet above the lake, on quartz vein in dioryte .... S. 10° W. (Mag).

Thessalon, left bank of the river, at the mouth, trap rock .... S. 20° W. (Mag.)

[That form of cross-fracture glaciation that has been described on the Pipestone quartzyte in Minnesota is here seen frequently on the trap rock].

* Fifteenth report, p. 235, fig. 4.

Thessalon, one mile S. E. from Little Rapids, on quartzyte.................................S. 20° W. (Mag).
Thessalon, crossing the last on the same surface....S. 30° W. (Mag).
Blind River, Ont., on quartzyte..................S. 28° W. (Mag).
Cascade, five miles south of Negaunee, Mich., on conglomerate ....S. 70° W. (Mag).
Lighthouse point, Marquette, Mich., greenstone..S. 25°-28° W. (Mag).
Bessemer, Mich., on Cupriferous conglomerate...... N. & S. (Mag).
East end of Delta lake (west of Ogishke Muncie)....S. 14° W. (Mag).
Island in Pseudo-Messer lake (1433), green schist ...S. 30° W. (Mag).

ROCK SAMPLES COLLECTED TO ILLUSTRATE THE REPORT OF N. H. WINCHELL, IN 1887.

Samples from the original Huronian.

1148. Red quartzyte from Port Finley, on the Canada side, north of St Joseph's island.

1149. Dioryte, Bruce; near the old Wellington mines.

1150. A fine diabase dike cutting 1149.

1151. From a great dike cutting 1149, running N. and S.

1152. Very fine grained, sometimes aphanitic and nearly black; near the mouth of the Thessalon river, west bank.

1153. Coarse-grained, speckled on the weathered surface; same place.

1154. Coarse-grained, speckled on the weathered surface; same place.

1155. Medium-grained and somewhat speckled with porphyritic feldspar, also with a reddish vein of granulyte; same place.

1156. Very fine grained, nearly black; east side, at the mouth of the Thessalon river.

1156A. Nodular, epidotic, veined condition of some of the rock at the mouth of the Thessalon, on the east side.

1157. Massive, dark gray, diabasic, resembling some seen in the railroad cut near Thompson, Minn.; from east side of the Thessalon.

1158. Epidotic trap rock, same place.

1159. Pitted and non-pitted and amygdaloidal rock, the amygdules being delessite; same place.

1160. The same rock, but having amygdules apparently of red felsyte; same place.

1161. Granulyte, or perhaps properly a protogine, same place.

1162. Gray quartzyte, about a mile northwest from Thessalon village.

1163. Felsitic quartzose gneiss, from a spur of 1162, embraced between two forks of a dike.

1164. From the main dike cutting 1162.

1165. From the smaller fork of the same dike.

1166. From greenish boulder-like masses included in 1162.

1167. Diabase unconformably overlying quartzyte, four and a half miles northwest from Thessalon.

1168. Coarse diabase, representative of the eruptive rock between Thessalon and Macbeth's bay.

1169. Pebbly quartzyte, 4½ miles N. W. from Thessalon.

1170. White, or slightly greenish-white, quartzyte, in the road two miles from the mouth of the Thessalon river, on the east side.

1171. Pinkish quartzyte, near Wm. Ensling's house, Thessalon valley, about two miles west of Little Rapids.

1172. Gray, fine-grained calcareous quartzyte, thin-bedded. Ansonia P. O. at "the dump."

1173. Sample of schistose slaty diabasic rock. Thessalon point, west side of the river. Logan's "green chlorite slate."

1174. Eruptive diabase, mouth of Blind river, west side.

1175. The same from the east side.

1176. Quartzyte, Blind river, east side.

1177. The same.

1178. Grayish red quartzyte, very fine-grained. Blind river, east side.

1179. So-called shaly portion of the gray quartzyte at the railroad cut. Blind river.

1180. Quartzyte, from the outer point west of the west arm. Blind river.

1181. Diabase dike, cutting No. 1180.

1182. Red felsyte, quartzose with fine, scattered grains; in patches in the diabase eruptive; somewhat affected locally by contact with the basic eruptive. R. R. cut on the east side of the Missasaugui.

1183. Light-greenish quartzyte, a phase of the quartzyte at the R. R. cut on the east side of the Missasaugui.

1184. A condition of the quartzyte at the same place in association with the diabase, the quartz losing some of its distinctness.

1185. The same, more dark.

1186. The same with an orthoclastic tendency.

1187. The same converted to red fibro-basaltified felsyte.

1188. The basic eruptive with red orthoclase crystals disseminated, same place.

1189. Same as the last, but finer-grained, same place.

1190. Dioryte, west side of the Misssasaugui, at the mouth.

1191. Fine-grained gray, flinty-quartzyte, showing an abrupt contact on 1190.

1192. Shows one of the greenish-weathering, more slaty parts of this quartzyte from the opposite side of the river.

1193. One mile west of "the dump," orthoclastic granulyte.

1194. Fine, gray, bedded "slate," broken and again cemented by many veins of quartz; sec. 8 Le Froy; hardly slaty, rust-coated.

1194A. Small bits from 1194, showing black metallic oxide, and some amethystine quartz.

1195. Red felsyte; ridge near Otter Tail P. O.

1196. Gray quartzyte, approximating the last in its felsitic aspect.

1197. Same as the last, but varies to a reddish quartzyte.

1198. Same as 1196, but varies to a gray quartzyte.

1199. From a hill in line of strike from 1195, being a portion of the same ridge toward the N. W.; a brownish, red-weathering felsitic rock, with a confused structure as if originally a conglomerate, containing much free quartz, and finely, but sparsely porphyritic with red feldspar.

1200. Gabbro, from near Otter Tail P. O.

1201. "Lithographic stone"; bottom land of Thessalon on Mr. Day's "limits," about a mile below Otter Tail lake.

1202. The same, showing free quartz in rounded grains.

1203. Gabbro, or dioryte, similar to 1200, about N. E. ¼ of sec. 23, Plummer.

1204. Red felsyte; one mile south of Murray's corners, SE. corner of sec 2, Plummer.

1205. The same, subcrystalline.

1206. Fine-grained, argillitic slate, 12 rods S.W. from 1205, forming conspicuous ridges that strike N. W.

1207. Crystalline condition of 1205, a little further N. W. from 1205, but in the same ridge as 1205; reddish seynite.

1208. Non-weathered portion of the same rock as 1207; a gray syenite, or quartz dioryte.

1209. Grayish-green "slate conglomerate," containing granite pebbles. Murray's hill, at Murray's corners.

1210. Dike-rock cutting 1209, at Murray's hill.

1211. Reddish felsitic quartzyte, one-half mile south of Murray's corners, on Hugh Matheson's land.

1212. At $1\frac{1}{4}$ miles S. W. from Otter Tail P. O., slate conglomerate similar to that at Murray's hill.

1213. Quartzyte interbedded in these slates; like 1211.

1214. Pebble from this slate.

1215. From "the dump," Ansonia P. O. the rock adjoining 1172, on the lower side, a rough, reddish felsyte.

Samples from the Marquette Region.

1216. Micaceous hematite, Cascade, five miles south of Negaunee.

1217. Hematite, showing the bedded structure, some of the layers being pebbles of quartz, Cascade.

1218. Quartz-conglomerate grit, unconformable above the ore beds at Cascade, upper portion.

1219. The coarser, lower portion of the above conglomerate, within three feet of the contact plane.

1220. "Chalcedonic silica" from Palmer (Cascade).

1221. Sample of the unconformable quartzyte-conglomerate near the contact with the ore-formation two and a half miles west of Ishpeming, at the old Saginaw mine.

1222. Same at 20 rcds north, rising 20 feet higher.

1223. Granular quartzyte, one mile west of Ishpeming.

1224. Slaty rock, interbedded, but overlying the last; slight exposure in the road.

1225. Two and a half miles N. W. from Ishpeming; a pebbly greenstone, also porphyritic, with some bits of broken schist.

1226. Sample of the main ridge, from which the last was obtained, at the southeastern side of Deer lake.

1227. Sample of the country schists, nearly adjacent to the ridge (1226) on the south side.

1228. Purplish to reddish, fine-grained quartzyte, at the railroad cut a little further west.

1229. Massive, basaltic greenstone; same railroad cut.

1230 Basaltic, conglomeritic greenstone; same place.

1231. Chemical limestone, from the serpentinous rocks at the Ropes gold mine, five miles N. W. from Ishpeming.

1232. Talc, associated intimately with 1231.

1233. The rock of the country at the Ropes gold mine, apparently the same as 1225, 1229 and 1230.

1233A. Sample of the quartz vein, Ropes mine.

1234. Fine-grained reddish quartzyte; east side of the river below Dear lake.

1235. Green "soapstone," with martite; Cleveland mine.

1236. Light, sericitic soapstone; Cleveland mine.

1237. Martite, in green "soapstone;" Cleveland mine.

1238. Magnetic quartz schist, passing to iron ore; Michigamme mine.

1239. Dioryte, from a knob near and north from the Michigamme mine.

1240. The so-called granite from the range next north of Michigamme, three feet from the contact.

1241. Contact between the quartzyte and granite, the former taking a gneissic structure.

1242. Quartzyte.

1243. Between the conglomerate and this quartzyte this rusty-green, micaceo-pyroxenic material is found, about three inches thick.

1244. From a dike 14 inches wide, cutting the granite; fine-grained, altered.

1245. South from the granite range on isolated crags of gray, fine, siliceous schist, and on the upturned edges are weathered out the forms of small, garnet-like crystals.

1246. Samples of this same gray schist, or quartzyte, with the sedimentary structure evident.

1247A Coarse, fragmental, tough.

1247B. Hematite, interbanded with impure, reddish, chalcedonic silica.

1247C. Jasper rock, banded and clouded.

These three change by innumerable gradations from one to the other. From the Swan mine, near Negaunee.

1248 Greenish quartzyte or graywacke; near the railroad cut, north side of the Buffalo property, east of Negaunee.

1249. Black slate, graduating downward into

1250. A contorted, greenish slate which lies, possibly unconformably, on the slickensided upper surface of 1248.

1251. From an old, much changed dike, north side of the Buffalo property.

1252. Iron-bearing condition of 1249, from the north side of the railroad, north of the Buffalo mine.

1253. Gray quartzyte, that cuts off the ore in the Iron Cliffs mine, near Negaunee.

1254. Nearly white, granular quartzyte, north side of Teal lake.

1255. Changed dike, cutting 1254, crossed by bands of color, due to different degrees of infiltration of iron-stain.

Samples from the Gogebic Iron Range.

1256. Alternating forms of the country rock, at the Colby mine, near Bessemer, Michigan.

1257. South wall, Colby mine.

1258. Siliceous slate; spur track from the Colby to the Valley mine.

1259. Sample of ore from the stock pile, Valley mine.

1260. Hornblende granite, south from the Aurora mine.

1261. Gray quartzyte, overlain by granite, south of the Aurora mine.

1262. Quartzyte slate, overlain by granite, south from the Aurora mine.

1263. Black slate, from a deep well drilled a short distance east of the Iron King mine.

Samples from Minnesota.

1264. Gabbro, on the Rove lake road, near the south foot of Pine mountain.

1265. Red rock, Brulé mountains, north from Pine mountain.

1266. From a boulder, N. E. ¼ of sec. 19, 64–1E.

1267. Amygdaloidal porphyry, from boulders, south from the North Brulé. [This sample seems to have been lost].

1268. Shows contact between rock 1266 and the red rock.

1269. Gabbro-like rock, north side of sec. 19, 64–1E.

1270. Gneiss, on the trail to Northern Light lake, a short distance north of North lake.

1271. Oolitic bloodstone, from a boulder near North lake.

1272. Hardened Animike, at the rapids going out from North lake.

1273. Dense trap, just west of the rapids last mentioned.

1274. Syenite, a short distance further west, north shore.

1275. Trap (gabbro), at a mile west of the entrance of the river to Gunflint lake, north shore.

1276 Modified "gunflint" beds of the Animike, north shore of Gunflint lake.

1277. Flint from the Animike, north shore of Gunflint lake.

1278. Kewatin schist, mouth of the creek, east end of the long bay, north side of Gunflint lake.

1279. Porphyritic rock, associated with No. 1278.

1280. Probably an old eruptive, belonging to the Kewatin, north shore of Gunflint lake.

1281. Changed graywacke, Kewatin; north shore of the same lake.

1282. Gray gneissoid rock, slightly porphyritic, north side of Gunflint lake.

1283. Porphyrel; bluff, north shore of Gunflint lake.

1284. Argillitic slate, interbedded with 1283.

1285. Argillyte, bedded in the rocks 1281 and 1282.

1286. Some of the changed graywacke, same rock as 1283.

1287. The gray rock on which the gabbro lies; at the Mayhew iron location, Iron lake.

1288. Magnetited gabbro, Iron lake, from points west of the Mayhew location.

1289. Drift boulder of the gray rock near the bottom of the Animike. To find the cause of the rusty coating. Iron lake.

1290. A drift piece from the same place, shows a possible change from magnetite to limonite.

1291. Sample of the Iron lake ore.

1292. Sample of the same showing olivine?

1293. From a boulder. Iron lake, showing micaceous conglomeritic gneiss.

1294. Limonitic pebbly conglomerate, and breccia, on a traverse north from Gunflint lake, on the town line (if extended) between T. 65-1 and 65-2 W.

1295. Jaspery and flinty portions of the last.

1296. Kewatin sericitic schist, same traverse.

1297. Sericitic porphyry, same traverse.

1298. Soft sericitic schist, same traverse.

1299. Micaceous rock, interbedded with the Kewatin schists, same traverse.

1300 Represents the hornblendic part of the black, best.

1301. Syenite gneiss, same traverse.

1302. Gneiss, or granite, end of the same traverse.

1303. Trap rock from a dike in this gneiss.

1304. Shows a blending of the characters of the mica schist with those of the porphyry.

1305, 1306, 1307. Three different stages in the change from the black fine-grained rock to the rusty film characteristic of some of the Animike.

1308. Iron ore, near the east end of Gunflint lake, north side.

1309. A condition of "muscovado," at the same place, near contact with the gabbro.

1310. Brecciated and angular fragments of flint and other dark rocks, north shore of Gunflint lake.

1311. Is another stage of this rusting rock; effervesces.

1312. A condition of the trap, at the narrows, black and close-jointed.

1313. Muscovado-like rock, west of the narrows.

1314. Porphyritic gabbro, or trap, Animike bay.

1315. Jasper-flint-quartz-magnetite schist; shore south of Black Fly bay.

1316. Gneiss; north side of Black Fly bay.

1317. Enclosed hornblendic rock in 1316.

1318. Darker portion of the gneiss, at the first falls north of the narrows going out from Gunflint lake. (This sample was lost.)

1319. Fine siliceous "muscovado," north side of the point that lies north of the Animike bay.

1320. Siliceous "streamed" gray rock, a condition of 1319.

1321. Magnetite, associated with 1320.

1322. Granular quartzyte, gray, in fallen masses, north side of the same point.

1323. Gabbro, at the top of the hill north of Animike bay.

1324. Black slate, from near contact with the gabbro.

1325. Ore with chert, &c. N. W. cor. of sec. 23, 65-4.

1326. Ore without chert, same place.

1327. Underlying gray sandrock or quartzyte.

1328. Gneiss, from the shaft, N. W. cor. sec 23, 65-4.

1329. From a dike, N. side of sec. 22, 65-4.

1330. Greenstone, near the quarter post between secs. 20 and 21, 65-4.

1331. Schisted conditions of this rock.

1332. Top of the slope, same rock as 1330.

1333. Similar greenstone, in a ridge about 30 rods south of the last.

1334. Most southerly exposed part of the same greenstone.

1335. Rock of the hill north of Chub lake, a rather indefinite greenish rock.

1336. Iron ore from the excavation near Chub lake.

1337. Pieces from greenstone and gneiss pebbles, below the ore. Chub lake.

1338. Gray quartzyte, associated with this ore.

1339. Hornblendic portions of the strata associated with the ore at Chub lake.

1340. Purplish-gray, vitreous quartzyte, ⅛ mile west of the ore pit. Chub lake.

1341. Porphyritic gabbro near the top of the Pewabic quartzyte. Chub lake; interbedded in the quartzyte.

1342. Reddish gneiss, but a short distance north of Flying Cloud lake.

1343. Pewabic quartzyte, sec. 25, 65-5.

1344. Gabbro interbedded in the Pewabic quartzyte; sec. 25, 65-5.

1345. Same indefinite greenstone as 1335; from the hill south of Bingoshick lake.

1346. Greenstone, at the south shore of Bingoshick lake.

1347. Muscovado, from the shore of Muscovado lake, sec. 36, 65-5.

1348. Labradorite rock from the north part of sec. 11, 64-5, south side of Bashitanekueb lake.

1349. Talcose slate, a schistose greenstone, from a fragment seen on the portage from Kakego lake to Clothespin lake.

1350. From the north side of the point, sec. 32, 65-5, Gabemichigama lake, showing apparently a finely fragmental condition of the rock that lies below the gabbro.

1351. S. W. ¼ sec. 29, 65-5; fragmental, sedimentary tilted Animike.

1352. Same as 1351, but coarser.

1353. Same as the last, but still coarser, a gray grit.

1354. Samples of Animike, obtained a little south of the centre of sec. 29, 65-5.

1355. Animike, from N. E. ¼ sec. 31, 65-5, shore of Gabemichigama lake, bedded with rock like 1354.

1356. At about the center of N. E. ¼ sec. 31, 65-5, Ogishke conglomerate.

1357. Fine-grained beds, siliceous, granular, a little N. E. from the last.

1358. Gray feldspathic rock, south shore of Gabemichigama lake, where the Ninth correction line intersects the shore.

1359. Biotitic gneiss, from the same place as the last.

1360. A little further west, gabbro.

1361. About on the town line between 64-5 and 64-6 W., secs. 6 and 1, basaltic greenstone dike.

1362. Pewabic quartzyte, magnetited, hornblendic, etc., from the iron cliff on the south side of Gabemichigama lake.

1363. From near the bottom of the same cliff.

1364. Also from near the bottom, freshly exposed by a landslide.

1365. A little northeast from the "narrows" of Gabemichigama lake; heavy, banded, olivine-bearing quartzyte.

1366. Gabbro, fine-grained, just at the entrance to the narrows, interbedded with Animike.

1367. Various samples obtained in the ascent of the hill from the shore of Gabemichigama lake, situated at the west side of the lake, intended to show the features that might be considered of sedimentary origin.

1368. Various samples from the same, which seem to be of true doleryte, from near the summit of the same hill.

1369. So-called marble, N. E. end of Ogishke Muncie lake, sec. 24, 65-6.

1370. Argillitic slate, lying next west, along the lake.

1371. Sample of the "marble," from the hill, further east, involved with the greenstone conglomerate.

1372. Samples of the greenstone conglomerate, with traces of sedimentary structures, and fragments of other strata involved, sec. 24, 65-6, shore of Ogishke Muncie lake.

1373. Small contorted masses of cherty argillyte embraced in the same conglomerate.

1374. Rounded, concretionary, or pebble-like, small masses, resembling, or suggesting shells, seen on a weathered surface of the same conglomerate.

1375. In sec. 13, adjacent to the above, in the narrow place between Ogishke Muncie lake and the lake south of Townline lake. Schistosely disintegrating, light green and siliceous condition of the same conglomerate.

1376. Greenish argillyte, from this conglomerate.

1377. Piece of a pebble from the conglomeritic part.

1378. Rusty carbonate, appears in patches in this rock.

1379. Gritty greenstone, south end of the east bag of Saddle Bags lake, on the town line between 65-5 and 6.

1380. The same from the east side of the east bag of Saddle Bags lake.

1381. Greenstone from the west side of Frog Rock lake.

1382. The same from near the center of sec. 19, 65-5, south of Frog Rock lake.

1383. Greenstone rock from the center of the same section.

1384. Associated with the last, interbanded with it, and finer-grained.

1385. Argillyte showing fine ripple-marks, west end of Ogishke Muncie lake.

1386. Rock from the summit of the East Twin mountain, a coarse greenstone.

1387. Finer greenstone, from the north slope of the same hill.

1388. Coarser greenstone again, nearer the base of the main hill, apparently eruptive rock.

1389. Both coarser and finer, at the bottom of the same hill.

1390. Greenstone from the subordinate, more northerly hill-range.

1391. Flinty quartzyte, incipiently porphyritic; from the same subordinate ridges.

1392. Imperfectly porphyritic quartzyte, or cherty-quartzyte, and black chert, same hill range.

1393. Further north; rock representing several small hills or hill-ranges; a gritty greenstone, a modified sedimentary.

1394. Chalcedonic silica, and samples closely related, all inclosed in and banded together in 1393 Same hills.

1395. Conglomeritic "greenstone," showing some sedimentary structure of itself, a widely disseminated rock, same hills.

1396. Hardened and basaltic graywacke, from the hill directly east of Alpha lake.

1397. Dike (?) cutting the same, near the lake shore.

1398. Porphyry (or porphyrel), S. W. corner of sec. 29, 65–6.

1399. Weathered surfaces of the same.

1400. The same porphyrel, from the south side of the lake, in close proximity to the great dike of Kekekebic lake.

1401. The dike which crosses Kekekebic lake. This forms two islands in the lake.

1402. The rock on west of the dike in the southerly of these islands; fine, red-weathering gneiss The sample is gray.

1403. A little further west, the same gneiss, somewhat approaching the porphyry 1400.

1404. Hardened graywacke-like greenstone, from a ridge near the center of sec. 31, 65–6.

1405. Quartzose rock with a finely porphyritic tendency. From the point N. W. ¼, S. W. ¼ sec. 31, 65–6, on the south shore of lake Kekekebic.

1406. Greenish-schist conglomerate, same place as 1405.

1407. Porphyry, south shore of lake Kekekebic, at the narrows.

1408. Porphyry, from the island west of Stacy island.

1409. Chloritic schist, from the litte island just west of the narrows, near the north shore.

1410 From the top of the same island; the same rock.

1411. From the middle of the south cliff, same island; more siliceous, and showing sedimentary banding.

1412. The same, near the water, having boulders of rock like itself.

1413. The same, with hard lenticular sheets.

1414. Near the south side of sec. 35, 65–7; different forms of porphyry in a low bluff at the shore.

1415. The same place; the greenish rock underlying 1414.

1416. Reddish porphyritic gneiss, showing the intergrading of the gneissic, the porphyritic and the conglomeritic characters of this rock.

1417. The same rock; Shingwak island (north of Animike I.) in Kekekebic lake.

1418 From the same island; the red crystals being in bands that alternate with others of a greenish biotitic rock.

1419. From a very small island directly south of Shingwak island; a fine-grained greenish graywacke.

1420. West end of Animike island.

1421. S W. end of lake Kekekebic; sec 4, 64–7. Somewhat micaçeous (biotitic) conglomeritic.

1422. From a small island south of the point, west part of sec. 3, 64–7; a greenish rock, with sparsely disseminated red crystals.

1423. Green schistose conglomerate; at the head of the bay on the town line, west end of Kekekebic lake.

1424. Pebble like forms in 1423.

1425. From a dike, north shore of the same bay.

1426. S. E. ¼ of sec 34, 64–7, near the head of the broad shallow bay, the greenish, graywacke beds seem to show a tendency toward the characters of the porphyry.

1427. Found on the portage from Spoon lake northward. A fragment showing the "red rock" in veins cutting the biotitic gneiss.

1428. The rock forming the point in Knife lake N. E. cor. sec. 28, 65-7, a dark siliceous slate.

1429. At the summit of the divide, on the first portage from Knife to Pseudo-Messer lake, siliceous slate.

1430. Gabbro, a little below the summit and on the north slope, same portage.

1431. At the portage-landing, south side of Pseudo-Messer lake. Argillitic slate.

1432. From the point north from the portage-landing, on the east side, in Pseudo-Messer lake. Reddish-weathering, pyritiferous gritty felsyte, firm and sharp in fracture.

1433. Directly across the Pseudo-Messer lake, from the portage-landing, soft schistose greenstone, with "chalcedonic silica" and jaspilyte.

1434. Chalcedonic silica, so-called, embraced in lumps in 1433.

1435. Hematitic jaspilyte, embraced in the same.

1436. Micaceo-syenitic gneiss; sec. 10, 64–10, Bassi-menan (or Basswood) lake.

1437. Mica schist, from S. W. ¼, sec. 5, 64–10, long peninsula in Bassi-menan lake.

1438. Changed graywacke, from the S. E. end of the portage, S. E. ¼, sec. 6, 64–10.

1439. Bluff on the right bank, just below the Pipestone rapids, greenstone.

1440. Fine mica schist, same bluff.

1441. Light-colored, reddish, chloritic granite. Cuts 1439 and 1440.

1442 Just above the rapids, right bank, from large pieces apparently derived from the bluff, the rock *in situ* being hid.

1443. Shining sericitic schist, from the portage from Newton lake to Fall lake.

1444. Greenstone that replaces abruptly the jaspilyte, at the head of the portage from Fall lake to Garden lake.

1445. Quartzyte, at the place known as Silver city, at the rapids between Garden and White Iron lakes.

1446. Eleven samples showing the variations in this rock, and the associations of the ore.

1447. N. E. ¼, S. E. ¼ sec. 28, 63–12 on the north shore, not far east of Silver city. A firm dark rock, in some places schistose by decay.

1448. Greenstone, N. W. ¼ sec. 4, 62–14. Recent drilling for iron has been done here.

1449 White schist, (talc?) from the Stone mine, Tower.

1450. Light-colored, green siliceous rock, mainly massive; cut by the Tower spur track from the mines.

1451. A form of the jaspilyte that is gray and white, with pyrite and magnetite, sec. 2, 61–15, interchangeable with jasper and hematite.

1452. Graphite, associated with the same.

1453. Asbestine ore, Black River Falls, Wis., associated with the magnetic ore of the York opening.

1454. Asbestine with a fold in the fiber, Black River Falls, Wis., at the York opening.

1455. Granite, near the furnace of the York Iron company, Black River Falls.

1456. Gray jaspilyte, a form from Black River Falls, Wis., just southwest from "Mound No. 1," near the river, and nearest the granite. The bedding is about vertical but curiously twisted and curled, strike nearly east and west. This is the most southerly point at which (here) the magnetic quartz-schist can be seen.

[*Note.*—The "soap rock" here is the sericitic schist, and is apparently a rock with a sedimentary comformability with the magnetic schist. The magnetic schist varies to a hematitic schist. It is magnetic at the York opening, and hematitic at the Dubuque. The latter underlies the former, and they both seem to run below the granite in the river adjacent at an angle which is generally 15°, but at the York opening, near the river, is no more than 2°. A dike of rotted greenstone runs about E. and W. across the mound. It is seen at the opening near the river, at the west end, and again at the opening further east, in a similar ore, cutting diagonally across the sedimentary structure.

The sedimentary bedding in all the "ridges" containing iron ore in the vicinity of Black River Falls, has a dip toward the south, i. e. toward the granite and not toward the north away from the granite. The latter was reported by the Wisconsin geologists.]

The following is a list of the specimens taken and described by Mr. Stacy to illustrate his excursions on the north shore of Gunflint lake. The order in which they are numbered is that in which they were discovered in the excursion from the lake shore, northward.

EXCURSION I.

1457. Outcrop at water's edge—fine-grained light-gray slate—strike E. 18° N. (This is the true meridian.)

1458. 30 feet north of shore—coarse-grained oolitic slate, resembling siliceous graywacke.

1459. 40 feet north of shore—dark oolitic slate—strike E. 12° N.

1460. 400 feet north of shore—dark siliceous slate—strike E. 12° N. —occurs in bluff 60 feet high and 80 feet broad at summit.

1461. 600 feet north of shore—gray compact granular schist, somewhat massive and finely oolitic—occurs interbedded with same slate as 1460.

1462. 1200 feet north of shore—in bluff 100 feet high, black fine-grained slate.

1463. Same location—same slate more siliceous and oolitic with specimen of trap in contact.

1464. Same location—similar to 1461, but coarser, pebbly, a porphyrel with graywacke-like base: two samples.

1465. Same location—trap-like schist, greenish-gray, somewhat sericitic—occurs irregularly interbedded with 1462-3, and often appearing to intersect more as a dike.

1466. Same location—a form of 1465 more distinctly laminated and schistose resembling sericitic schist, a weathered condition of 1465.

1467. Same location—a dark, tough, trap-like rock occurring in dikes with 1462–3, and resembling a fine-grained gabbro.

1468. Same location—same as last, finer-grained, more weathered, the weathered surface exhibited.

1469. 1600 feet north of shore—gray, compact, flinty argillaceous rock, schistose but unlaminated.

1470. Same location—micaceous porphyrel interbedded with 1469: two specimens.

1471. 1800 feet north of shore—dark-gray hydro-mica schist, similar to lustrous graywacke, like 1470 but not porphyritic—occurs interbedded with chert and slate, resembling 1462 and 1469.

1472. 2700 feet north of shore—black siliceous slate—occurs in successive bluffs interbedded with a more massive slate.

1473. A porphyrel which occurs with the slate.

1474. Same location—massive, lustrous, siliceous slate in thick laminæ interbedded with 1472—abounds in many bluffs for a quarter of a mile northward.

1475–6-7–8. 3500 to 4000 feet north of shore—different conditions of apparently the same rock in varying stages of decomposition: 1478 being trap-like, compact and dark; and 1475 being light greenish gray, thinly laminated, and apparently a hydro-mica schist.

The last specimens occur in an immense bluff of from 150 to 200 feet elevation and are irregularly interbedded with the dark slates 1472–4, and much contorted in places. The bluff at the highest point of elevation is capped with gabbro. A swamp lies immediately north of the bluff at a descent of nearly 200 feet

EXCURSION II.

Specimen 1479. 50 feet from shore—sericitic micaceous porphyrel.

1480. Same location—cherty schist.

1481. Same location—slate—strike varies from E. 12° N. to E. 18° N.—Note: 1479–80–1 occur interbedded for 500 feet northward.

1482–3. 550 feet north of shore—micaceous sericitic schist—occurs with 1481 and extends northward 400 feet, graduating into 1484, &c.

1484–5–6–7. 800 to 2000 feet north of shore—chloritic, micaceous and hornblendic schists, varying from massive to schistose according to weathering, and occurring in numerous ridges and knolls.

1488. Same location—flint-like and massive—occurs in ridge in swamp.

1489. 2500 to 3000 feet north of shore—lustrous, dark gray, micaceous and sericitic schist—occurs interbedded with slate and chert.

1490. Same location—hornblendic, trap-like micaceous schist, pebbly and granular—interbedded in slate and chert.

1491. 3500 to 5000 feet north of shore—syenitic porphyrel, appears to contain hornblende and feldspar crystals in a sericitic base—[This is the beginning of the black belt formation].

1492. Same location—same as 1491, but more sericitic and schistose.

1493. Same location—hornblendic and feldspar schist.

1494. Same more micaceous.

1495. Black lustrous mica and hornblende, fine-grained schist like that found a mile east—[This is the black belt sought].

1496. Same as 1495—showing contact with the syenitic porphyrel.

1497. Hornblendic, sericitic schist.

1398. Hornblendic gneiss, containing large black crystals.

1499. Gneiss.

1500. Syenite—mile and a quarter, or about, from lake.

Specimens 1491–1499 are of one formation and lie in successive terraces and ridges for over a quarter of a mile until 1500 is reached.

REPORT OF A. WINCHELL.

REPORT OF A GEOLOGICAL SURVEY IN MINNESOTA DURING THE SEASON OF 1887.

EMBRACING COMPARATIVE OBSERVATIONS IN SOME OTHER REGIONS.

BY ALEXANDER WINCHELL.

---

§ 1.—PRELIMINARIES.

1.—*The Regions covered by the observations of* 1887. The first part of the season was devoted to comparative observations in the region of the typical Huronian formations north of lake Huron; to a review of portions of the Marquette iron-bearing region, a brief visit to the Gogebic range, and a study of the geology of the Penokee Gap. These studies upon territory already worked up, to a considerable extent, by American and Canadian geologists, seemed indispensable to a proper correlation of the rocks of northeastern Minnesota with the facts existing in other parts of the continent, and the interpretations which had been placed upon them by preceding investigators.

With this preparation, work was resumed in northeastern Minnesota, and, before the end of the season, was carried to the extreme limit of the state. In reaching the meridian at which the operations of last season were interrupted by the advent of inclement weather, I embraced the opportunity to supplement and complete observations on some portions of the territory covered by my report of 1886—especially in Burntside, Basswood and Sucker lakes. Parts of Garden lake were also subsequently reviewed The territory new to my own studies extends from Range 7 west to Range 5 east, and from Town 64 north to Town 67 north, and beyond, into Canadian territory; or from the western extremity of Knife lake to Grand Portage on the east, and the northern shores of Saganaga lake, on the north. The actual observations extended into eighteen different townships. The following are the lakes whose shores were geologically investigated:—Burntside, Basswood, Sucker and Garden, supplementarily; Pseudomesser, Knife, Ottertrack, Oak, Saganaga, Red-Rock, West Seagull, Seagull, Granite, Pine, Gunflint, Loon, Iron, North, South, Rose or Mud, Rove, Mountain, Moose, North Fowl, South Fowl, Frog-Rock, Townline, Ogishke-muncie, Crab, and Epsilon lakes. The vicinity of the streams connecting these lakes was also studied. Of these, the Boundary river, flowing west, and Pigeon river, flowing east, are the most important.

2.—*Conditions of the exploration.* The mode of travel, as last season, has been by birch bark canoes, over the numerous lakes and navigable streams, and intervening portages. To accomplish the geological work of the season, ninety-six portages had to be made, aggregating thirty-eight miles. When the time and labor necessitated by the portages are considered, with the time and labor occupied in affairs about camp and in protection against bad weather, together also, with the time required for paddling several hundred miles, it becomes apparent that the net time and strength left for actual scientific work are comparatively meagre. When it is further considered that the actual work has to be carried on, many times, under most difficult circumstances—over mountain precipices, in deep, slippery gorges, along high and almost inaccessible cliffs, under the intense heat of a summer sun, or the chilling effects of a drizzling rain, with the haste sometimes necessitated by an impending storm or an approaching sunset, and all in the midst of an incessant and bloody conflict with the northern hordes of merciless insects, it must become apparent that geological fieldwork in a region like this is difficult and fatiguing—far from the summer pastime which is sometimes pictured. But though such statements seem required for a just appreciation of the labors of the geologist, it must be understood that his work is prosecuted with a cheerfulness and zeal inspired by a love of nature, even under her rudest aspects, and a thirst for knowledge which knows no discouragement in the pursuit of its gratification. Of peculiar interest has been the work in northeastern Minnesota, since, in addition to being a field little known, it promised to supply the facts which would point to a final solution of long pending geological problems.

3.—*Physical aspects of the region.* No conspicuous features of mountain relief traverse the country, though a low, interrupted swell, called the Giant's range, trends east and west through the sixty-fifth tier of townships, becoming most conspicuous in range 4 west, and continuing eastward into Canada; and another series of still higher reliefs, stretching through the south part of tier 65, and westward into the north part of tier 64, is known as the Mesabi range. This is not the Mesabi range of the vicinity of Tower.*

* On these ranges, see N. H. Winchell, Thirteenth Ann. Rep., 1884, pp. 20-24.

The Giant's range is formed by an uplift of syenite, which in breadth stretches northward to the north part of Saganaga lake and southward to near Gunflint lake, and, with a southwestward continuation, which will be considered in due connection. The east-west ranges which culminate in the so-called Mesabi range are formed of gabbro, resting chiefly on cliffs of Animike slate, and their geology will also be considered in the proper connection. The gabbro-crowned hills occur in the eastern portion of the district examined, and impart to it an exceedingly rugged character. The ranges present, generally, an abrupt descent along the northern aspect and a gentle descent toward the south. The northern slope consists mostly of a vertical precipice of rudely columnar gabbro at the summit, with a vertical wall of slate beneath, and a long talus of fragments sloping to the water level. The gabbro precipice is sometimes fifty to one hundred feet high. This measures the thickness of the gabbro covering the country. The slate cliff has generally an equal thickness; and the vertical hight of the talus is even greater. Between the east-west ranges the little lakes are lodged which supply the chief means of communication across the country. A sparse growth of jack pines once covered these gabbro ranges, but at present they are almost completely denuded. A little soil is accumulated along the southward slopes of the ranges and the northern lake borders; but, as a general statement, the surface is rugged and uncultivable. The regions of syenitic outcrop are even more rocky and sterile than the gabbro district. It is impossible to conceive a country of more desolate aspect than that along the rapid Boundary river between Granite and Gunflint lakes. The entire region bordering Seagull, West Seagull and Saganaga lakes is, with the exception of occasional small tracts, a continuous, undulating floor of shattered syenite. The region of Knife lake, with its long arms, lies north and west of the syenite of the Giant's range; but the schists weather in beetling cliffs and rugged contours, affording but contracted space for forest growths, and supporting little soil adapted to cultivation. Still further west, the physical features become more subdued, especially in the parts underlaid by schists; but the granite borders of Basswood lake, like the northern border of Burntside, still further west, present a forbidding aspect to the agriculturist; while along the Boundary river, northwest of Basswood lake, the granite region presents its characteristic barrenness fully developed.

4.—*Aspects of the vegetation.* The region between Fall lake and Grand Portage, and north of Grand Marais, is a literal wilderness without inhabitant, without mails, without roads, and with only an occasional party of Indians or explorers, following the ancient and overgrown trails of two centuries ago. Fires have denuded the region of its primitive forest; but the older burnings are becoming overgrown chiefly by dense thickets of the trembling aspen (*Populus tremuloides*), and in places, by the white paper birch (*Betula papyracea*), with occasional cherries (*Prunus pennsylvanica*). Remnants of the original forest consist of white, Norway and Jack pines, balsams, spruces and cedars, with intermixtures of white birch, aspen and balsam poplar (*Populus balsamifera*). In very limited areas, the white and Norway pines have attained noble dimensions—especially along the Pigeon river. On the portage between Rose and Rove lakes, I measured a white pine three feet in diameter. Other large examples of white and Norway pines were scattered about. In the more strictly granitic regions, the Jack pine (*Pinus banksiana*) slender and mast-like, forty to sixty feet high, is, or has been, almost the exclusive occupant, maintaining its hold in situations where neither soil nor moisture would seen accessible. In some districts, especially the syenitic regions along the Giant's range, where fires have swept over the surface, the skelton forms of the slender Jack pines still stand like huge bristles along the crests and slopes of the rugged ridges.

In the soil-covered tracts. an undergrowth of striped maple (*Acer spicatum*) frequently exists, which thrives with amazing luxuriance, while in the openings, and over many burned areas, the red raspberry flourishes and fruits in great productiveness, regardless of the stony nature of the soil; and the welcome, unpretentious blueberry holds possession of granitic and schistic knobs, even when deserted by all other forms of woody vegetation. The raspberries, during August and September, supply an abundant and very welcome article of food. The former are found at the same time, especially during September, in all stages of development, from the green fruit, just out of flower, to the ripe fruit on the same stem. This ever-bearing variety would seem to be worthy the attention of horticulturists.

The blueberry (*Vaccinium canadense*) flourishes with luxuriance in inverse ratio to the amount of soil. On the most rocky hills it fruits in such abundance as to impart a blue aspect to a distant slope. At Blueberry rapids, in the Giant's range, I cut one stem with four elongated clusters of large berries, and in one cluster were seventy-two berries. On a granite hill near the Pigeon river, I observed a distinct form of blueberry growing side by side with the ordinary form. Its hight was only about two inches, and very uniform, but it bore abundant large pear-shaped berries, somewhat less sweet and meaty than those of the ordinary form. If this is the dwarf blueberry (*Vaccinium pennsylvanicum*), the shape of the fruit ought to be mentioned as a characteristic feature. I never saw it in any other situation.

Most of the low grounds are occupied by the common alder (*Alnus viridis*), and this hardy shrub frequently overhangs the borders of the lakes and streams. But a more frequent fringe of the waters is formed by a luxuriant growth of the fragrant-leaved bayberry (apparently *Myrica gale*), which weaves a barrier almost impassable. With the alders, but more generally grouped by themselves, are species of willow not exceeding the alders in hight. Four species of cherries have been noticed, of which the wild red cherry (*Prunus pensylvanica*)—a sort of choke cherry, is most generally distributed. The racemed black cherry (*P. virginiana*) having also a choking quality, and apparently the well known red choke cherry, is found frequently on rocky taluses; and the fine large-fruited, black dwarf cherry (*P. pumila*) is occasionally met along the borders of lakes, keeping company with *Myrica* and *Azalea.* The sweet black cherry (*P. serotina*) is occasionally seen. The fire-red fruit of the mountain ash (*Pyrus arbutifolia*) frequently gleams through the prevailing green and brown of the lakeside foliage; and in the far east and along the Pigeon river, the high cranberry (*Viburnum opulus*) in its fruiting season is similarly conspicuous.

Among the low herbs, the dwarf, scarlet fruited cornel (*Cornus canadensis*) is generally abundant, growing both in dry and moist situations. With this, but rather preferring the low grounds, is the purple-fruited orchid (probably *Platanthera obtusata*). A species of blue-flowering aster is very wide-spread, often covering the ground, and the bristly sarsaparilla (*Aralia hispida*) is quite frequently encountered. Sedges and grasses hold uplands sparsely, but appropriate somewhat exclusively the situations deficient in drainage; while rushes—especially *Juncus balticus*, flags (*Typha latifolia* and *Acorus calamus*), and wild rice (*Zizania aquatica*) encroach widely on the areas covered by standing water.

Many small tracts of deep and productive soil intervene between almost universal rocky, or thinly covered, exposures. At the south end of the portage from South Fowl lake, I measured, at the end of August, a Balm of Gilead shoot of the season's growth, forty-nine inches in length. A similar shoot north of Gunflint lake, measured six feet and three inches. The white pines already mentioned supply similar indications. A large tract of pasture land and arable soil lies on the Pigeon river, in township 64, ranges 4 and 5 east; but the greater part of this falls within the Indian Reservation.

5 —*Quadrupeds and other vertebrates.* Among the quadrupeds of the region, the common northern hare (*Lepus americanus*) is one of the most abundant; and, to the skilled methods of trapping known to the Indian, yields a considerable supply of savory food, while the white winter pelage is esteemed as material for handsome robes. The porcupine (*Erethizon dorsatus*) is not unfrequently met, and yields also a coveted article of food. The black bear (*Ursus americanus*) is an inhabitant of the region, and is sought, at the suitable season, both for fur and meat. The moose (*Alce americana*) is, however, the large game most pursued, as every part of the animal is converted by the Indian to some special purpose of utility. The caribou (*Rangifer caribou*) ranks probably next in esteem of the hunter and Indian. Besides these, the sly fox (*Vulpes vulgaris*) sometimes fails to elude observation; while the fisher (*Mustela pennantii*), the beaver (*Castor fiber*), the otter (*Lutra canadensis*) and the mink (*Putorius vison*) supply evidences of their occupation of the country, though seldom seen. The muskrat (*Fiber zibethicus*), on the contrary, is everywhere present, and does not always take alarm with such promptness as to escape observation. By far the most abundant of all the quadrupeds, and most accessible to approach, is the squirrel of the country (*Sciurus hudsonius*, but broadly white underneath), whose peculiar and very characteristic chattering is heard everywhere, as he sits on a limb or a log, dissecting the cone of the pine or white cedar for the extraction of the nuts. But the chipmuck (*Tamias striatus*) is also somewhat abundant, and often ventures rashly into the midst of the camp to gather up the crumbs from the explorer's repast. Equally unconscious of danger, a little field-mouse sometimes ventures near, to share with the chipmuck the waste of the camp. A jumping mouse is also rarely seen. The wolf (*Canis lupus*) and the weasel or ermine (*Putorius erminius*) complete the list of quadrupeds which have fallen under the observation of members of our party. The former is excessively shy, but the soft-furred and handsome brown weasel intrudes sometimes into the camp, and roguishly steals and bears away such bits of meat as suit its palate, if left exposed to the plunderer. The writer has seen a bat occasionally, having the size and appearance of the New York bat (*Atalapha noveboracensis*).

The partridge is quite abundant, and supplies to the hunter a most delicate and savory article of food. Wild ducks, in the season, are equally abundant and equally sought. Hawks and eagles often scream from their high flights overhead; and loons, as they float past, rend the air with their unearthly vocalization. Crows and gulls are few. The robin is common, but lacks the strong utterance of the southern representative of the species. The blue-jay scolds fiercely from his dried tree trunk, and the interesting Canada jay practices the tricks of a thief about the camp. The flicker screams from his high hole, and smaller woodpeckers enlarge the representation of their family. The white-throated sparrow sings mournfully and with monotonous sweetness during July, and loses his voice in August. Some creepers and sparrows diversify somewhat the avifauna of the region. But, on the whole, the birds are not numerous. Reptiles are still more infrequent. I have seen a small turtle (apparently a *Chrysemys*), and an occasional garter snake (*Eutænia*). Once I saw for an instant a livid-dark salamander, with red-striped tail, which immediately disappeared among stones; but among Amphibians, the green frog (*Rana fontinalis*) and shad-frog (*Rana halecina*) are common representatives. I once met on a hill, seventy-five feet above the Pigeon river and a quarter of a mile back, a frog acting like the land frog, but marked like the common shad-frog of the pools.

Fishes appear to exist in moderate abundance, but the pickerel and black bass are the only ones which our trolling-hooks have brought to the surface. Small fry are occasionally seen, but their scarcity would imply the lack of any abundance of other species than those named.

6 —*Climate.* Of the winter climate I know nothing from observation. The summer climate is agreeable. During two seasons, sunny days have been the rule. In the former season, violent thunder showers occured frequently, and, for the greater part, during the night. In the latter season, very few showers fell, and the weather became dry. I noticed in both seasons, a little tendency in August and September, to settled cloudiness and drizzling rains. Two or three times during the past season, the weather displayed truly alpine characters: and this I attribute to the considerable elevation attained in the region between the sources of the Boundary and the Pigeon rivers. The clouds floated near the earth and enveloped us in a chilling mist. Sometimes this experience lasted for half a day; but sometimes, only during the passage of a stray cloud. During days at a time, squalls of fine rain could be seen between us and distant hills, almost continually.

The hours of sunlight, in July and August, are intensely hot—especially in the sun's rays; but the declining sun is accompanied by a marked change in the temperature of the atmosphere; and the nights are always cool—generally cold. In such a temperature, the surface of the warm lake steams, and often saturates the air with a morning fog. The frosts, of course, appear early in the autumn; and signs of snow may be seen in the middle of September. With frosty nights and some hard freezing, the weather continues fine till late in October. On the whole, the summer climate is decidedly agreeable.

7.—*Method of operation.* The observations have been restricted chiefly to the lake shores; but the intention has been to identify, and if necessary, study, the rock at every outcrop. In most cases, a landing was made; but sometimes an inspection and hammer-test from the canoe has been sufficient. Rarely, in a region of uniform character, an examination at every eight of a mile has been deemed sufficient. Many times, of course, excursions were made inland from a quarter of a mile to two miles. This has been done especially where the geology of some eminence seemed to be an important object of research. Thus, in connection with the necessary portages, a considerable knowledge of the country intervening between the lakes has been obtained.

All notes of facts observed were made in the field and on the spot; but frequently, generalizations were written out in camp, when a particular section of work had been completed, and while the facts remained in memory, even in greater detail than could be recorded in the notes.

8.—*Plan of the report.* The general plan is similar to that of last year. The first part, after an abbreviated statement of the most important observations and results obtained outside of the state, consists chiefly of a somewhat full detail of facts observed in Minnesota, with particular designations of localities. This, it needs not be said, results in a presentation of little interest to the general reader; but it forms a repository of precise facts for the student and investigator, and serves to place him, as far as possible, in the position of an original observer, with the means of putting his own interpretation upon the geology of the region. The other course—I may say the usual course, supplies the reader with a connected readable account; but it is simply the writer's individual conception of the facts and their meaning, and furnishes the reader with little means of judging for himself of the soundness of the writer's conclusions. It is a method which places the judgment of the reader at the disposal of the author until the latter's opportunity for work in the same field, or for access to an exact statement of facts, enables him to exercise an independent judgment. It is a method which, for a time, forestalls criticism and establishes the writer's conclusions in the opinions of his contemporaries; and this may by some be considered an advantage. There are many occasions where the writer's interpretation of the facts is all that is expected or proper; but I think the geologist or the citizen who well considers the question, will admit that the whole body of facts accumulated by the State at considerable expense, and already on record in note-books, ought to be made accessible to every citizen interested; and that the annual report of work done is the proper receptacle for such facts.

But the writer would regard it as extremely unwise to leave an annual report restricted to an undigested statement of details. The general reader requires a digested and systematized account of the meaning of the facts; and the person who accumulated them stands in a more favorable position than any mere reader to supply such account. Accordingly, the second part of the present report is a statement of the observer's own conception of the meaning of the facts observed. This part *only* is addressed to the general reader. Perhaps this part should have been placed first, and the details on which it is based, afterward. But I see no adequate reason for disregarding the logical order, which ranges facts first and their interpretation later.

The work of the past season has completed a careful reconnoissance of the northeastern part of the state by the present writer. He is now in position to join the facts collected in 1886 with those collected in 1887, and attain to a somewhat complete view of the geology of that most interesting region. He has, therefore, permitted himself to conclude the present report with a presentation of those general and taxonomic conclusions which have been suggested by the writer's personal investigations.

9.—*Localities and rock numbers.* As heretofore, the writer has endeavored to ascertain the precise locality of every observation recorded; and this of necessity has been indicated in the report. It would obviate the chippy and perhaps unpleasant appearance of the first part of the report to omit citation of precise localities or to weave them into paragraphs, and give this part more the appearance of a narrative. This has been well considered. But I feel confident that the specifications of facts in detail would be less accessible than under the arrangement which puts foremost, and in a uniform position, the definition of locality, and follows that by the statement of fact. In this part utility should take precedence of style.

The rock numbers are in continuation of the series begun last year. As these numbers have not been reported in complete consecutive order, a table is appended to this report, presenting in serial arrangement, the localities for both seasons, with references to the pages of the two reports on which they are described.

The order of succession of the work in this report, as in the last, is geographical. All the facts are clustered around the several lakes and the more considerable rivers. As it often happened that one shore of a lake was surveyed on an outward trip and the opposite shore on the return, it results that the consecutiveness of the rock numbers is broken between the two trips.

10.—*Bearings.* Magnetic bearings, for convenience, were taken in the field; but these are here corrected for the true meridian by the use of data recorded on the Government township plats.

11.—*Rock identifications.* These were preliminarily made in the field, but often under difficult circumstances, and always without adequate means for investigation. A few of the identifications for the present year have been revised in the laboratory, partly by microscopical and chemical methods, and a few laboratory notes have been appended to the field notes. But, manifestly, no thorough petrographical investigation could be accomplished in the time allowed for an annual report; nor indeed would such work be appropriate. It yet remains to subject the entire series of rock specimens to careful study, with a view to rectifying the nomenclature and establishing true correlations between the petrography and geognosy of northern Minnesota and other well investigated regions. This will be a work of no little magnitude.

In the use of terms I have followed nearly the same practice as in the report for 1886. This conforms substantially to the usage of German petrographers, and especially of Rosenbusch in the new edition of his "Massige Gesteine." So far as my practice diverges from the German standard, it is chiefly in the use of a few words, and this circumstance will not in the least embarrass the intelligent reader.

12.—*Earlier observations and studies.* The belt of country along the international boundary was traversed by Dr. Douglas Houghton, in 1831, while travelling as physician and botanist to the Schoolcraft Expedition to the sources of the Mississippi river. Subsequently, while acting as geologist for the State of Michigan, he recalled the observations made and left a brief record in the introduction to one of his annual reports. "The route of the fur trade to the northwest," he says, "by way of Rainy Lakes, Lake of the Woods and Lake Winnepic was formerly carried on by passing over these hills [north of lake Superior] from a point a few miles west of the mouth of Pigeon river [Grand Portage settlement]. The trail or portage path passes over a low portion of the range and finally falls upon Pigeon river,* which is ascended to its source, from which, by a series of portages, the sources of the streams flowing northwesterly are reached. The hilly portion of the country, though of exceeding interest in a geological point of view, is the most desolate that could be conceived."†

During the progress of the geological survey of the Northwest, under the direction of Dr. D. D. Owen, a rapid reconnoissance was made by Dr. Norwood, from Pigeon point and the locality now known as Grand Marais, to Gunflint and Saganaga lakes. Beyond the latter point, no observations along the boundary are recorded.‡ Dr. Norwood's notes are lacking in precision and intelligibility. It is often impossible to identify his localities or his facts.

A rapid reconnoissance along the international boundary was made in 1872 by Mr. Robert Bell, under instructions from the Geological Survey of Canada.§ The facts recorded, however, are few, as the chief object of the expedition seemed to be an exploration of the country further northwest.

In 1878, professor N. H. Winchell, in a survey of the mining geology of the northwestern part of Minnesota, visited numerous localities near the boundary, both in Minnesota and Canada, and traversed the boundary from Pigeon point to Basswood lake, proceeding thence to Vermilion lake.||

A more extended reconnoissance was made by N. H. Winchell, in 1880,¶ stretching from Grand Portage along the international boundary, and diverging to Vermilion lake, and thence to Squagamaw bridge on sec. 5, T. 58-15. This was part of a very extensive examination of the general geology of the northeastern part of the state. The report presents a broad and masterly, though condensed, grasp of the geologic structure of a vast region long acknowledged difficult of access, complicated and obscure; and the later developments have confirmed its general accuracy.

---

* For quite a full description of the physical and geological features of this trail, see N. W. Winchell, *Eighth Annual Report, Geology of Minnesota*, 1880, pp. 71-73.

† Houghton, *Fourth Annual Report, Geology of Michigan*, 1841, p. 13.

‡ Norwood, in Owen's *Geological Survey of Wisconsin, Iowa and Minnesota*, Philadelphia, 1852, 405-493.

§ R. Bell, in *Geological Survey of Canada*. Report of Progress, 1872-3, Montreal, 8vo, pp. 92-94.

|| *Seventh Annual Report, Geology of Minnesota*, pp. 9-25. This report contains also, *some observations* by C. W. Hall, under instructions from the state geologist, pp. 26-29,

¶ *Ninth Annual Report, Geology of Minnesota*, pp. 71-107. This contains a general descriptive list of rocks collected in 1878 as well as 1880, extending over pages 11-114.

Explorations of the geology of northeastern Minnesota were further extended by N. H. Winchell, in 1881. They were carried over the Grand Marais trail, and along the boundary westward, but more extensively across the country wholly unknown to geology, west of the Grand Marais trail, between the boundary and lake Superior* and as far west as Ogiskhe-muncie lake.

In the operation of the United States Geological Survey, the study and discussion of the Archæan rocks of the Northwest having been assigned to professor R. D. Irving, geological observations made by himself and under his direction, have been extended from Nipigon and Thunder bay of lake Superior, into Minnesota, as far as Gunflint and Ogishke-muncie lakes. The particulars of these explorations have not yet been published; but some of the general and most important results have been made public from time to time, in memoirs and papers by professor Irving.† Professor Irving's investigations, sustained by the great resources of the national survey, and carried on with the aid of much experience and excellent preparations, may be expected to bring to light a vast multitude of facts, and to go far toward settling the difficult and fundamental questions now outstanding in reference to the geological character and history of our oldest terranes.‡

The State survey of Minnesota resumed, in 1886, the investigation of the rocks northwest of lake Superior, and made this a principal effort during the year. The region of Vermilion lake was minutely studied. The country eastward was explored as far as Ogishke-muncie lake, and the geology along the boundary belt was examined from Iron lake to Knife lake. The volume of results exceeded all previously published.§

---

* *Tenth Annual Report, Geology of Minnesota*, 1881, pp. 64-106. Geological notes from Duluth to Silver islet and return, are contained on pp 34-64.

† See *Third annual Report, U. S Geol. Surv.*, 1881-82 (dated 1883), pp. 157-165. *Monograph. U S. Geol. Surv.*, vol. v. (1883) pp. 367-386, 395; *Preliminary Paper on an Investigation of the Archæan Formations of the Northwestern States*, March, 1886. extracted from Vth Ann. Rep., U. S. Geol. Surv., 175-242 (especially pp. 203-208): *Amer. Jour. Sci.*, III, xxxiv, 259-363.

‡ While the manuscript of this report is still in hand, tidings come of professor Irving's death. I feel moved to embrace the opportunity to record both my personal sorrow, and the loss, seemingly irreparable, which has been sustained by the national survey, and by the interests of geological science at large. Professor Irving's work revealed a most conscientious, painstaking and intelligent treatment of the difficult problems assigned to him for discussion. His achievements in a few years, alas too few, have contributed permanent lustre to the annals of American science.

§ *Fifteenth Annual Report. Geol. Surv Minn.*, 1885, pp. 7-207 by A. Winchell; pp. 209-382 (embodying observations by Dr. M. E. Wadsworth) by N. H. Winchell; and pp. 401-419 by H. V. Winchell. This report contains the first colored geological map of northeastern Minnesota made from original observations, and a detailed geological map of the vicinity of Vermilion lake.

§ 2 —OBSERVATIONS IN THE TYPICAL HURONIAN REGION OF CANADA.

A portion of the rocks of northeastern Minnesota have been provisionally referred by recent geologists, to the Huronian system. The most recent writer on the assemblage of oldest formations in the Northwest, expressed the conviction that the entire series of strata in Minnesota, from the top of the crystalline schists up to the top of the Animike slates, belonged properly in that system which, a quarter of a century ago, the geologists of the Canadian survey described and named as Huronian. The region reported to contain the rocks thus assembled in a system, lies on the north of lake Huron. Being somewhat remote, if not difficult of access, American, and even Canadian, geologists, have been in disagreement as to the lithological character of the original so-called Huronian rocks, and as to the position which they actually hold in the bedded structure of the earth's crust. An ulterior purpose of the Minnesota survey must be. First—To ascertain whether any proper Huronian rocks occur in the state; Second—To determine what portion of them is to be regarded as Huronian, and in what particulars they agree, and in what those distinguished from them disagree; Third—To determine the relative geological age, both of the rocks ascertained to be Huronian, and of those to be excluded from the Huronian. But precisely what was meant by Huronian was a point in dispute; and any settlement of the question in time for the purposes of the Minnesota survey, required a personal visit to the typical Huronian region. In conformity with this necessity, my brother and I made a personal investigation of most of the important points and districts within the region referred to. The following pages contain an abstract of observations made by the writer, with such occasional interpretations as, to his judgment, seemed justified by what we saw.

The quartzytes exposed along the north shore of the channel, between the Sault and the old Bruce mines, were hastily passed; and no careful studies were undertaken until "the Bruce" was reached.

1. *Observations about the Bruce mines.* At the old Bruce mines the rock near the shore (384)* is a mass of diabase, intersected in various directions by joints, but without discoverable signs of bedding. It is a compact mixture of a dark, augite-looking mineral with a reddish feldspar. The dark mineral constitutes a sort of groundmass; but the feldspar is very abundant. In places, the red feldspar occurs in crystalline masses an inch or two in diameter.

* The numbers in this section refer to the rocks collected.

Near the gravel bank made from the crushing mill on the east side, the diabase (385) is a little coarser, and the feldspathic constituent is nearly white. In the midst of the rock are masses of a fine-grained material which, at a glance, appears slaty, but, on inspection, seems to be a very similar thing in constitution. These fine masses are partly vein-like, and partly like regular fragments of a schistose rock.

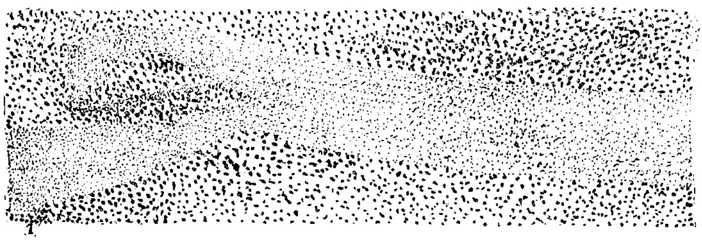


Fig. 1.—*Vein-like mass in diabase at Bruce mines, Ontario*

Whatever the nature of these forms, the whole mass of rock, seems to be a dike in the other diabase. If these different diabases are not dikes successive in origin, they show abrupt limitations dike-like. To me the whole mass looks like a vast dike or overflow; but the different parts are supplied from somewhat different sources, and cooled under circumstances a little different.

In one place I find diabase with disseminated globules of serpentine.

At the Glanville shaft of the Wellington mine, the vein is seen running N. 82° W. It is of quartz with dissiminated chalcopyrite. The country rock resembles the diabase with red feldspar; but near the quartzyte it becomes slaty-chloritic.

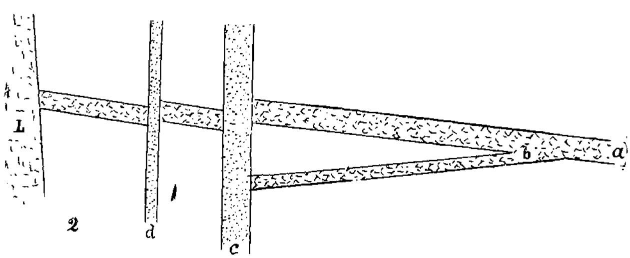


Fig. 2.—*Plan of cupriferous veins at old Wellington mines, Ontario.*

The main vein *a*, branched in *b*, was cut by a dike at *c*, and ran into a limestone at *L*.

Mining was carried on 35 years and has been suspended 10—in consequence of ore running poor and copper cheap.

About a quarter of a mile west of this is an outcrop of limestone in a ledge trending N. 4° W. and dipping a little south of west, but much contorted, and with interbeddings of trap isolated from the general mass of trap. This outcrop in a straight line, is about a mile from the west landing.

From the little cove immediately east of the old Bruce mines rises toward the west, a hill on which lie an enormous quantity of "greenstone" fragments. Where the greenstone outcrops, it is a compact diorite or diabase. In this is a quartz vein striking N. 6° E. and two feet wide. The entire mass of the hill is of the same sort of rock, and on the summit and the western slope are large quartz veins which ramify in a complicated fashion. In one place, a quartz vein intersecting the country diabase, itself incloses a large fragment of diabase, as shown below:

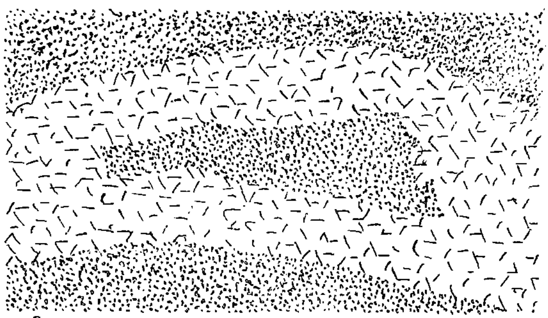

3

Fig. 3.—*Fragment of diabase included in a quartz vein intersecting a field of diabase near the old Bruce mines, Ontario.*

Among the bowlders of this vicinity I recognized bedded and conglomeritic quartzyte and jaspery conglomerate; also a conglomerate resembling that of Ogishke-muncie—a dark, diabasic groundmass with red granite pebbles.*

The diabase surfaces are glacially smoothed, and show grooves trending S. 20° W.

2. *Observations in the Valley of Thessalon river.*—At Thessalon, on the west side of the river, the rock (389–391) which is put down by Logan as "chlorite slate," has superficially an eruptive look. Occasionally one sees evidences of bedding, though obscure. The dip appears to be 37°, in the direction N. 41° W. The rock is fine-grained,

* A list of the rock-collections will be included in proper numerical order in the Table at the end of this report.

dark, hard, having the aspect of a metamorphic argillyte; but on close inspection with a lens, thin scales possess a waxy, greenish translucency. So far it might be a highly metamorphic felsitic argillyte.

A few rods to the east of this, however, the formation passes into a diabasic rock similar to that carrying the copper vein at Bruce. As no probability exists that this is of an eruptive character, and the other rock sedimentary, I examined the transition carefully. The strong impression made by the study was that the case is simply one of greater or less metamorphism.

This diabasic or d oritic condition is seen coarser and finer exactly as at Bruce. Here also, are numerous ramifying quartz veins. If this formation is an altered sediment, so is that at Bruce.

Several times subsequently I revisited this locality—on the west of the river—after having made quite an extended study of the surrounding country. I repeated my attempts to ascertain the nature of the bedded structure. I could not easily divest myself of the impression that a true sedimentary arrangement had originally existed, on which, in the course of metamorphism, a conformable slatiness had been induced. The evidence, unquestionably, is ambiguous, but I retained two small specimens showing distinct marks of sedimentary character. This structure prevails in patches over an area of forty square rods. The dip, according to renewed measurements, is 32°, in a direction N. 48° W. Naturally, it varies in both respects within short distances; but though the bedding is undulating, it is not crumpled.

In the midst of the most slaty patches occur more diabasic portions; and generally in proximity to small veined streaks—as if greater heat and more complete fluidity had been the condition of the more diabasic rock.

There are indeed, places a square rod in extent, in which the rock is strictly diabasic; and it here appears that the coarser condition of the diabase is most remote from the slaty rock.

This particular spot is a fair representation of the whole of Logan's "green chlorite slate." While no demonstrative evidence exists of the nature of its genesis, there seems to be room for the supposition that the entire formation was once a marine sediment; but if so, it has been subjected to powerful alteration—in places, to actual fusion and recompounding of the chemical elements.

On the east side of the river, the same formation (392) prevails extensively. The bedded condition is more unmistakable than on the west side. The strike of the beds is nearly coincident with the direction of the glacial striation, which is S. 20° W. There is difficulty in deciding what are the bedding structures and what schistosity or veins. Near the water the bedding appears most unmistakable.

But another phenomenon here is important. Along some of the vein-like appearances are rounded pebbles imbedded in a mass similar to the neighboring rock, but darker and distinguishable in texture. The rounded pebbles are of rock similar to the prevailing formation; and on close inspection, lines can be traced across them—fine, like flowage lines or thin laminæ. The appearance is precisely like some conditions of the Ogishke formation—not the characteristic conglomerate.

At the north end of the village near the head of the bay east of the saw mill, the same formation (393) contains large angular masses of epidote, mixed with a black mineral. These masses are up to three feet in length, with a width of two. Here are also, veins of quartz, some containing chalcopyrite, and some having a selvage of fine, dark chloritic mineral.

Quite at the head of the bay east of Thessalon, the following observations were made: 1. Regions containing many little blackish lumps, giving the rock an amygdaloidal appearance (394). The lumps look like amorphous chlorite externally. When scratched they are bluish, slaty-white. 2. These quasi-amygdules are in places arranged in courses. Sometimes the courses are rectilinear, and sometimes curvilinear; and in both cases, several ranges are parallel with each other. But in immediate contiguity, the curved bands are seen in a different positition. This phenomenon reminds me of what I have figured from the east end of Snowbank lake, Minnesota*; but in that case the amygdular cavities are in single series, and the apertures are sharply circular. 3. In some places, larger lumps of this chlorite-like mineral are remotely disseminated, Also, some of these larger cavities are filled with epidote—either finely crystalline or mixed with another mineral. 4. The formation is also intersected by veins of calcite or dolomite. 5. Also by veins of a red color, composed of a transparent mineral like calcite, and a pale reddish mineral, having, like the other, the hardness of calcite. 6 Bands also, of small epidotic amygdules—some in belts one and a half inches wide and separated by a condition of the country rock—a soft chloritic argillyte, itself filled with very small elongated amygdules of amorphous chlorite—the longer axes parallel with the axis of the band. 7. In the vicinity, some of the chloritic amygdules are elongated downward, from one

* *Fifteenth Ann. Rep Geol. Surv. Minn.*, p 129.

diameter to three and a half inches—in section of the rock looking like rootlets of *Stigmaria*.

At the head of the bay east of Thessalon, near the new barn are seen two sets of glacial striæ in unusual relation to each other The main set trends S. 20° W. and the other S. 48° W. The former are grooved; the latter smoother. The main system terminates abruptly along the line *ab*. fig. 4., and that line is like the ridge of a low roof.

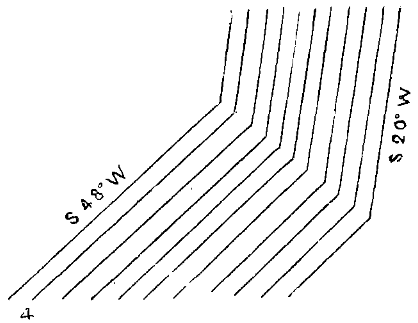


Fig. 4.—*Unusual feature of glacial striation, Thessalon, Ontario.*

Further along is a similar crest without change in direction of striæ

After quite an extensive and careful field investigation of the formation about Thessalon, I failed to find any sufficient reason for distinguishing it from that about Bruce; though Sir William Logan has laid it down as "green chlorite slate" while the Bruce formation is mapped as "lower slate conglomerate." It is more slaty on the east side of the Thessalon river than on the west. Still it can hardly be said that the evidence is clear. The resemblance to the Bruce formation is general; but only on the west side does it seem complete. Here the diabase is fully developed, and we trace it by gradation into the slates. But on the other hand, quartz veins are common on both sides of the river, and they contain chalcopyrite. On the east side of the bay a vein is said to be four feet thick, and to have been worked to a limited extent. In all salient characters, the Bruce and Thessalon formations are the same. I must leave for future study to ascertain whether in origin it is rather sedimentary or eruptive.

About one and a half miles from Thessalon landing, on the Government road west of the river, is an outcrop of quartzyte (395). It rises in a range west of the the highway. Near the road it is light gray and pretty fine, with distinct bedding and a northward dip of about 35°, but somewhat contorted. Farther from the road it becomes darker and more granular (396). A few rods still farther west, the formation rises in a succession of short parallel swells trending east and west, and exposing a general dip northward. The appearance is shown in fig. 5, on plate 2.

We find dark angular masses (397), included in the quartzyte; and inspection shows them to be essentially identical with the Thessalon slate; but even more baked.

Still farther on, occurs a dike three rods wide, running nearly north and south, and appearing to be a compact diabase (398). In contiguity with this, the quartzyte is red blotchy, and on the west, prevailingly red (399). Included in the dike is a wedge of quartzyte, two rods long and fifteen feet wide, which is very red. Here the dike along its western margin, is divided vertically by jointage, into a succession of thin slabs. Close by, the quartzyte retains its proper bedding.

Sometimes too, the bedding of the quartzyte is interrupted by dike-like masses of its own substance, which, with loss of stratification on their part, cut off and terminate the beds of the main quartzyte.

About two and a half miles from Thessalon, along the same road, on the northwest of the quartzyte, is seen rising a huge diabasic mass (400), resembling the diabasic portions seen on the west side of the river at Thessalon. From the summit, I can trace the ridge to the quartzyte last seen, and beyond, along the west side of it toward Thessalon point. Possibly the point has this diabase for a foundation.

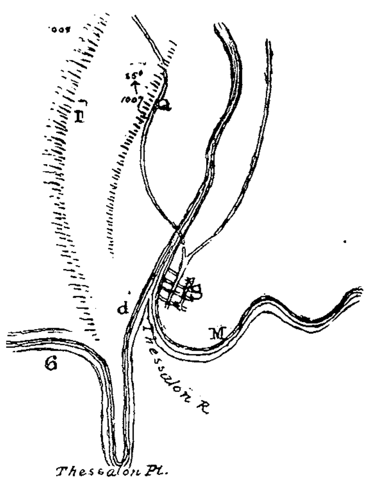


Fig. 6.—*Geology about Thessalon, Ontario.*

D, the diabase here referred to. *Q*, the quartzyte 395. *P*, Thessalon point. *M*, the sawmill near the landing. *d*, diabase west side of river, *s*, Thessalon slate (or slaty diabase).

Queries. Is there a fault along the river? Does *D* underlie and form the point? Are *D* and ***d*** the same as *s*?

About three miles from Thessalon, on the same road, a bold promontory strikes the highway. Of this all the upper portion is of diabase (402), and the lower, near the road, is of quartzyte (401).

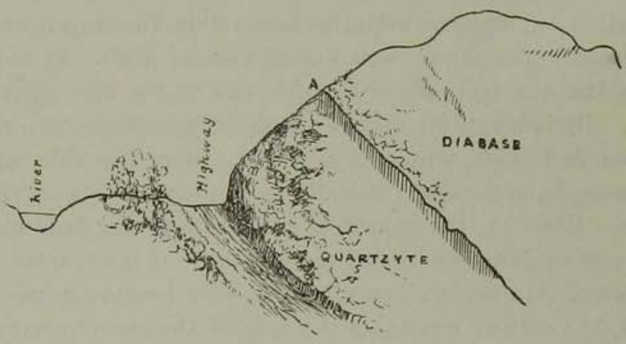


Fig. 7.—*Junction of quartzyte and diabase three miles northwest of Thessalon, Ontario.*

The line *AB* shows the junction of the two, and its direction is east and west. But the plane of junction descends almost vertically into the hill, so that it is not possible to say the diabase overlies the quartzyte. The diabase is in continuity with the last seen.

At about five and a half miles from Thessalon, another promontory is found abutting on the road from the right. Here the great mass is diabase (403), well characterized and moderately coarse-grained; but quartzyte is in contact in an unintelligible way. The face of the exposure is shown below:

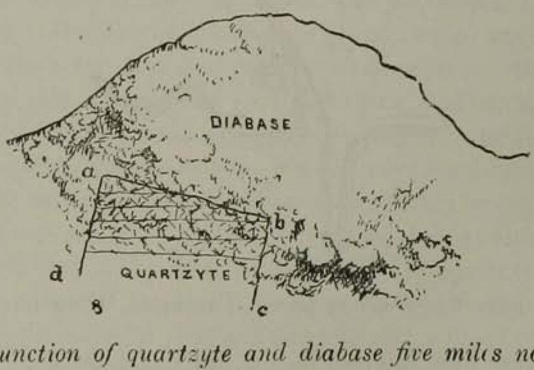


Fig. 8.—*Junction of quartzyte and diabase five miles northwest of Thessalon.*

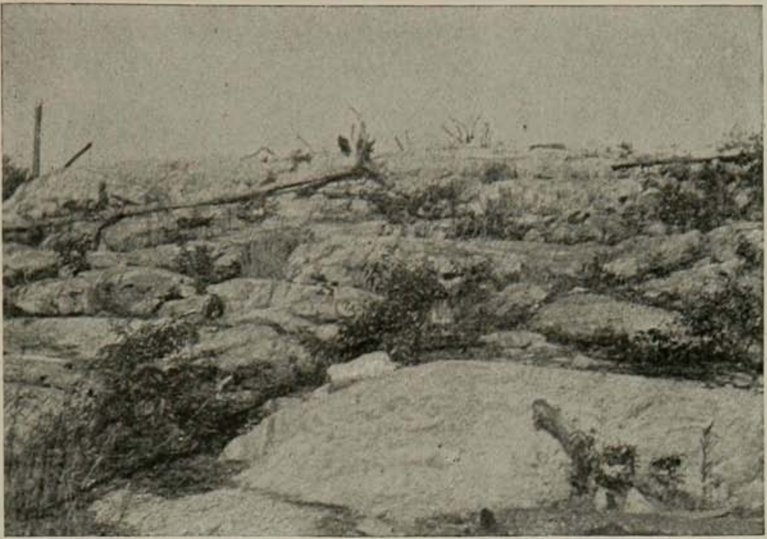


Fig. 5.—*General view of white quartzyte, two miles northwest of Thessalon, Ontario.*

The dip is away from the observer.

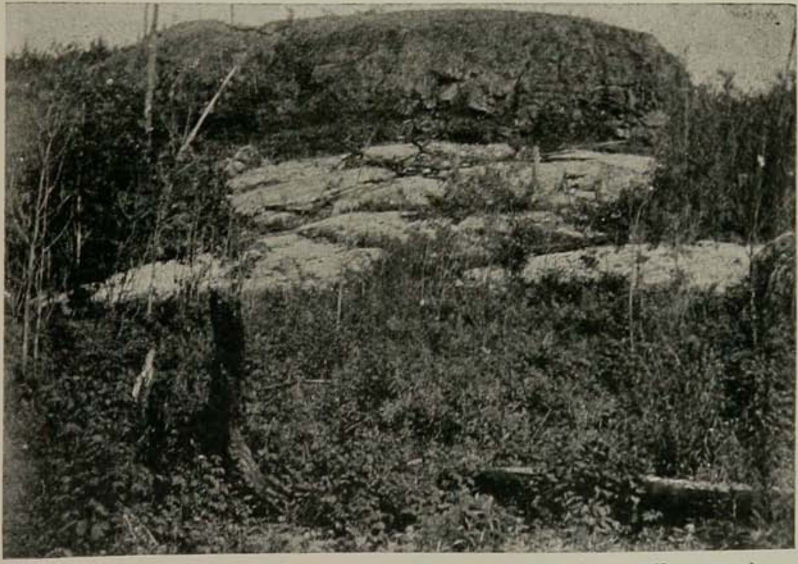


Fig. 10.—*A knob of diabase overlying quartzyte four miles northwest of Thessalon.*

The quartzyte incloses angular masses of Thessalon slate.

From *a* to *b*, the quartzyte dips toward the diabase, and seems to go under it northward. From *b* to *c*, the diabase cuts off the quartzyte like a dike. Hence it does not appear what is the relation between the two. The quartzyte is cut off also from *a* to *d*.

The diabase is quite characteristic, consisting of a mass of crystalline, black, augitic mineral, with short linear crystals of plagioclase imbedded in it.

Six miles from Thessalon, where McBeth's creek is crossed by the Canada Pacific railway, in view of the lake, quartzyte and diabase are seen in contact again. The junction is sharp and runs N. 60° W. The quartzyte is light gray, and resembles 401—not so reddish as that at the base of 403. Some of the diabase is rather coarse and characeristic. The junction with the quartzyte is vertical again—neither is superimposed.

Across the creek from this point, and on the north of the Canada Pacific railroad, is a hill composed of quartzyte (404) and diabase; but a portion of the quartzyte becomes conglomeritic with glassy quartz. One of the dikes of diabase pursues an irregular course, as shown below, and varies greatly in width—from thirty feet to zero. Unusual collocations of quartzyte and diabase are further illustrated below:

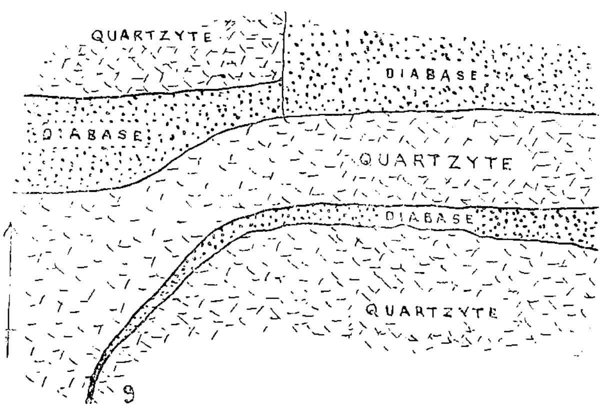


Fig. 9.—*Map of alternations of quartzyte and diabase on hillside at McBeth's creek, at crossing of Canada Pacific railroad, northwest of Thessalon.*

At about four miles from Thessalon, a high boss overlooks the road from the south, in which we find diabase distinctly resting on quartzyte. The external aspect of this exposure is shown in fig. 10, plate 2.

At the distance of one mile from Thessalon on the east side of the river, is another nearly vertical junction of diabase and quartzyte, striking N. 40° E. The junction is sharp. No dip of the quartzyte is ascertainable. Its color is pale pinkish. Near here the quartzyte dips 30° toward N. 40° W. and its color is still pinkish. At another point the color is white.

At two miles from Thessalon on the east side of the river, is an outcrop of quartzyte (405), weathering pistachio greenish, fine-grained and saccharoidal. It includes masses of coarse pinkish quartzyte containing quartz pebbles. Apparently, this quartzyte would make good hones.

Quartzyte knobs rise above the alluvial plain at frequent intervals.

At Little Rapids of the Little Thessalon, three and a half miles from Thessalon, is a coarse diabase with veins of quartz. It rises in a knob which continues in a range eastward. It appears also on the west of the road. Near by here, is a vitreous quartzyte with pebbles of black jasper arranged in courses. The direction of the dip is N. 10° E. and amount apparently about 45°. This spot is one-fouth mile from the hotel, and in stratigraphical order ought to overlie the rock at Little Rapids.

At about four miles north-northeast from Thessalon, is a boss of well striated quartzyte, having one set S. 20° W. and the other S. 30° W. The quartzyte is granular, pale gray, homogeneous, and would make excellent hones—much resembling that of 405 In places it consists of clear glassy grains imbedded in a groundmass.

A knob of very fine diabase forms a ridge extending north and south, at a distance of about three miles northeast of Thessalon.

Extending examinations to remoter points, we find, a quarter of a mile north of Little Rapids, a knoll of horizontally-bedded, very fine sand—evidently alluvial.

On the west side of the Little Thessalon, and about three-fourths of a mile from Ansonia—familiarly known as "The Dump," on the north of the road, is a ridge, exposing much red rock (406), which proves to be a red quartzyte, with pebbles of clear quartz, and some small red jasper pebbles. It is virtually a conglomerate. This ridge ranges N. 70° W. and attains an elevation of about 150 feet. With much labor I traversed the whole length of this forest and brush-covered ridge, and noted a succession of formations like the following. Passing from the condition just mentioned, we come to conglomerate. Then comes a dike of diabase (407), 100 feet wide, extending from top to bottom of the hill. Next recurs conglomerate, coarser than the first, with white quartz pebbles. This is followed by another dike of diabase, 40 feet wide, cutting the hill, like the other, from north to south. Next follows for 30 rods, a conglomeritic quartzyte This is a bold outcrop. The bedding is distinctly shown by great slabs two feet thick, and by courses of pebbles. The dip is 30°, and direction S. 48° W. This continues to another bold outcrop of quartzyte. which is fundamentally very red and vitreous, with small pebbles. The bedding is shown by slabby structure and by dark streaks—almost black, as if of magnetite or plumbago. Oblique lamination is also present, and the strata are a little bent.

This entire ridge is a little over half a mile long. Diabase appears at the base, and can be seen on the summit; and the appearance is that a dike runs along the crest, and this has tilted the quartzytes to their present position.

The quartzyte beds dip 42° in a direction making an angle of 20° with the axis of the ridge. As the ridge was traced for a distance of about two and a quarter miles, we thus attain the data for calculating trigonometrically, the vertical thickness of the whole quartzyte formation. I thus find it to be 4,542 feet As the horizontal distance was merely estimated, no great exactitude can be ascribed to this result. As further, I have no evidence that this traverse crossed the whole width of the formation, it would be quite within the bounds of probability to set down the red quartzyte as having a thickness of 5,000 feet.

At Ansonia Post-office (411), are rapids in the Thessalon river, and here the saw-logs from the surrounding country are "dumped" to be rafted to Thessalon. The rapids are caused by a mass of bluish, fine, compact diabase, but the geology of the place is obscure. After visiting the spot three times during the progress of our survey of the Huronian, the following is the best account I can give of it. Beginning up the stream, we have first, a mass of fine blue diabase (448); then alongside of this, some vertical standing, ashes-of-roses colored, cherty-calcitic beds (449), running up from the water. This formation weathers ochreous-yellow. Within, some parts are fine, compact, chalcedonic-looking, opaque; other parts are pinkish, very finely granular (450), and closely resembling the rock 447, to which refer. Still another part is less homogeneous, with iron-oxide veins, and a little coarser texture. Still below this occurs a diabasic slate (451) in a thoroughly brecciated condition. A bowlder from the ochreous mass was found by me at Bruce. It seems to correspond to Logan's "chert and limestone." It is a cherty limestone (452), and effervesces feebly with acid, but its stratigraphical position is not made apparent from the concomitant facts.

Half a mile south from Ansonia, the ridge studied at 408, but at a point a mile further south, presents characters similar to those already described. Some of the pebbles here are like the ochreous rock 409; and this would imply that this rock underlies the quartzyte—the red quartzyte.

On a later occasion these examinations were carried still farther into the interior. One mile beyond Ansonia, on the south side of the Thessalon (428-429), a knob on the right of the road is composed of speckled diabase. A vein of red feldspar runs through it, and many patches of the same occur.

Two miles west of Ansonia, on the north side of the road, in the field and on the hillsides, are large detached masses of reddish quartzyte, with bands of pebbles as south of Ansonia. Also of red jaspery conglomerate.

Some two and a half miles west of Ansonia, in the S. W. ¼ sec. 8 Lefroy, on the right of the road, is a low smooth outcrop of fine-grained rock (430), appearing like schist standing nearly on edge, and traversed by many rough, irregular quartz veins. The rock on weathering peroxidizes a considerable amount of iron, forming a rusty crust. The rock is excessively tough, and thin scales are pale, yellowish-green translucent.

The strike of the structure referred to is N. 75° E. and the dip 30° to 40°. The formation is intersected by metalliferous veins. The contained matter is crystalline, black, with red streak.

Two and a half miles east of Ottertail lake, about S. E. ¼ sec. 31 Rose, is a white vitreous quartzyte, having a dip S. 53° W. amounting to 23°. Within limited areas it is purple; but the purple portions are chiefly related to a vein and jointed system trending S. 80° E. There are also spots purple-colored, consisting of hematite in the ntre.

Near the southeast end of Ottertail lake, is a lofty ledge of quartzyte of a gray color, and dipping southwesterly. This is on the left of the road leading from the village of Ottertail north to Duff's valley.

Ottertail village is at the southern corner of Ottertail lake, in the township of Plummer and on the south side of the stream. Twenty rods south of the four corners is a prominent outcrop of a reddish rock (435), which on inspection is seen to have a southwesterly dip, and is therefore conformable with the prevailing quartzyte of the region. It is not however, a proper quartzyte. It undergoes change on exposure to the weather. It has not the lustre of quartzyte. It is compact and has a large feldspathic constituent. It seems to be a real felsyte, but clearly not an erupted felsyte. Much of the formation is thin-layered, and it may properly be designated a felsitic schist.

On the east side these beds can be seen dipping S. 58° W. at an angle of 20°. Here also is a dark, slaty, fissile, somewhat soft trap-slate in an irregular seam striking across the bedding of the formation.

Twenty rods west and at a higher altitude, the felsyte again outcrops: but the dip here is only 12°, and in a direction N. 10° E.

The prevailing dips in this region have been found toward the southwest. From this point, a ridge of white quartzyte can be seen on the northeast at the distance of half or three-quarters of a mile, on the north side of the river, in which the dip is directly toward this felsyte. Unless some great disturbance in the order of stratification exists, the place of the felsyte is above the quartzyte. This ridge of quartzyte is shining white and though it attains an altitude of one or two hundred feet, a dip of twenty degrees would carry the top of it quite below the felsyte.

Thirty rods still further west, and about half a mile in a straight line from Ottertail four corners, rises a conspicuous bluff twenty feet high, composed essentially of felsyte of red color (434). It has a dip of 30°, in a direction N. 20° E. Here can be seen convincing evidence of transition between quartzyte and this felsyte. Not only is the sedimentary bedding everywhere observable, but here the red felsyte visibly passes into a dark gray flint rock just perceptibly tinged with ashes-of-roses color where unweathered, and red rusty as far as the weather has penetrated. Under the lens, the fresh rock seems to be about all fine amorphous quartz, with numerous glistening points, which really look like thin scales. There are also disseminated small grains of quartz. The rusted portion is a skeleton of quartz draped with limonitic oxide.

On the highest knob facing the village and 125 feet above it, the rock is an altered slaty conglomerate. The main mass is dark greenish earthy material, similar to the vein in 435, though not here in a vein—having obscure but unmistakable bedding, appearing brecciated in places, inclosing some well-defined angular pieces of the same; but specially noticeable for containing many worn masses of granulyte composed of white quartz and a larger proportion of white feldspar. This whole formation is therefore conglomeritic; and its position, in connection with the prevailing dips in the neighborhood, indicates that it is higher than the felsyte 435. But of this one cannot feel sure, since some of the dips in this vicinity lie in opposite directions.

In general, however, we may say that in the hill south of Ottertail, we have a mass of highly altered schists, which range from felsitic to quartzose and conglomeritic, with fine earthy slate for groundmass. Their vertical relations to each other and to the quartzytes of the vicinity cannot be absolutely determined from evidences supplied by the neighborhood.

About half a mile from the place of 434 in a direction S. 70° E, rises another boss of felsitic slate with bedded structure about vertical, trending toward 434, but of the lithological character of the rock 435.

Twenty rods northwest of here, and about in a line parallel with the axis of Ottertail lake, and on the south of it, occurs an erupted mass of rock (437), weathering light gray with a tinge of green, and composed of pale greenish augite and lamellar labradorite. There are occasional rusty spots, but no iron constituent is conspicuous. The rock approaches a compact gabbro. Its position is also above the great white quartzyte of the Ottertail range, and perhaps below the slaty felsyte already described. It may however exist in the form of a dike and not of an overflow. The outburst traced northward a few rods is found terminating in a cliff 75 feet in perpendicular hight. Here the rock has a more diabasic aspect.

Down the Thessalon river, half a mile below the bridge at Ottertail, is found an outcrop of fine grained, well-bedded, somewhat fissile, cherty limestone (439), gray within, but weathering cream-colored. It dips S. 58° W. at an angle of 20°. It contains bands of pale reddish color, and bands of chert. It is a cherty limestone, and is reputed a lithographic stone. This, like the cherty limestone seen in the bed of the river at Ansonia, may represent Sir William Logan's "chert and limestone." This I will designate the Ottertail limestone.

This range of limestone trends conformably with the Ottertail quartzyte, and holds position above it, unless brought up from below by a fault. That its original position is below the quartzyte is indicated, as already stated, by the discovery in the quartzyte of pebbles which seem to have been derived from a rock of the kind.

Leaving this neigborhood and penetrating farther into the interior, we find that at two miles north from Ottertail, we have crossed a white quartzyte ridge about a mile wide, and also a mass of underlying red quartzyte about three-fourths of a mile and strike here a mass of noryte (440).

Four miles north of Ottertail, we pass another sharp hill formed of noryte-looking material which would perhaps pass for gabbro.

In the town of Plummer, two miles south of Murray's Corner, one and a half miles north of Orange Hall, and somewhat more than four miles north of Ottertail, on the west side of the road, is a high outcrop of metamorphic slates (441), mostly compact, with slatiness moderately well developed, but to a large extent a well characterized slaty argillyte, siliceous in places and inclosing bands of siliceous schist. It is impossible to possess any information respecting the Animike series, without recognizing that formation here. The dip is S. 30° W. at angle of 46°.

This formation clearly passes under both of the quartzytes—the white and the red.

It is now apparent that the rock 441 is also Animike slate.

Twelve rods northeast of this, and separated from it by a little valley, is an isolated outcrop whis is largely red felsyte (442), but is also largely an incipient granulyte—the red feldspar appearing in progress of separation from the quartzose constituent. This is fine-grained, and the quartz appears in small round globules. This transitional state between felsyte and granulyte has a petrographic significance analogous to that between felsyte and quartzyte as seen in 434.

It is worthy of note that the stratigraphical position of this felsyte, as will presently appear is a short distance below the summit of the Plummer argillyte—just as the felsyte at Ottertail appears to be superimposed by a similar slaty argillyte at the summit of the knob south of Ottertail.

Eight rods beyond, and close by the north and south road, a ridge of noryte (443), comes down from the west. It appears to contain magnetite, and may probably be regarded as a proper gabbro.

At Murray's Corner, 23½ miles from Thessalon, on the town line, one mile west of the northeast corner of Plummer, rises an enormous promontory of argillyte (444, 445), the greater mass of which extends over into the town of Coffin, sec. 36. It has the same character as 441; but the dip is much steeper—being southward 78°. It contains pebbles of red granulyte, of all sizes up to two feet in diameter It recalls somewhat the peripheral portions of the Oghiske conglomerate, but is somewhat more earthy.

From the top of the hill, which is probably 175 feet high, above the road, is revealed a wide outlook over the surrounding country. Close by is Rock lake, on the west. Beyond, rise high hills, with wavy outlined tops; and in the horizon, the country looks mountainous. In all directions, the region is hilly, broken and rough. The rock formation on the summit is hard and slaty, and contains red granulyte pebbles. The direction of the dip is S. 20° W.

The formation in the vicinity includes a bed of quartzyte in which occurs crystallized hæmatite in small branched veins.

On the "Soo" road, two miles southeast of Ottertail, is another outcrop of Plummer slates, very similar to 430 and 431. The slate is bluish-black, weathering greenish. The stratification is horizontal—an attitude which may indicate the passage to the opposite dip—that is, toward the northwest. The shale is fissile and intersected by many joints, which are frequently filled with brillant iron oxide. It includes a bed of red quartzyte, the faulting of which is illustrated below:

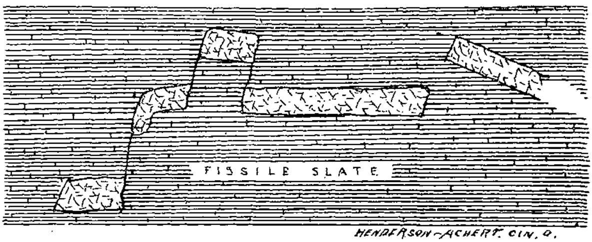


Fig. 11.—*Faulting of a red quartzyte bed, two miles southeast of Ottertail, Ontario.* In Huronian slates.

The slates have been faulted the same as the quartzyte; but that does not show.

The movements of this formation have opened chasms 6 to 12 inches wide, which have been filled mostly with a breccia of the country rock. It also contains rounded pebbles of red granulyte.

Within a distance of twelve rods of this place, on the east, is another outcrop of the same (446). It contains rounded pebbles of syenite with red feldspar, also great angular masses intersecting the formation but limited; having apparently a siliceous constitution, but without any quartzose lustre. On closest inspection with a lens, I can distinguish apparent particles of reddish feldspar, and many specks appearing like hæmatite or magnetite.

The quartzyte (447), seems to be very finely porous, and resembles that containing iron ore at Matherson's, near Murray's Corner. It serves to identify the lower division of the Plummer slate-conglomerate.

At about one and half miles north of Bruce, on the "Soo" road the slate conglomerate outcrops again. It contains red jasper pebbles and graywacke, and the formation is rather harder than at the last two points

From here eastward the slate conglomerate outcrops frequently—even as far eastward as McEwen's cross roads and school-house

3. *Observations in the vicinity of the Blind and Missisagui rivers.*—This investigation was also pursued in the vicinity of Blind and Missisagui rivers. At Blind river landing, the rock (413), first seen and widely distributed in the vicinity, is massive, well glaciated, dark colored, apparently composed of augite in a crystalline groundmass, with many interbedded grains of reddish feldspar (oligoclase) and fewer grains of a pale greenish feldspar. It is therefore a diabase like that at Thessalon, but with the individuals larger. No quartz can be discovered.

On the east side of the bay, near the upper sawmill at Blind river, is a red, vitreous quartzyte (414). very obscurely bedded. Close by, on the south, is a diabasic formation. Next follows another mass of quartzyte, more distinctly bedded, having a dip of 48° in a direction S. 12° E. The intervening diabase is also bedded.

In the cut of the Canada Pacific Railroad are irregular alternations of vitreous quartzyte and diabasic rock, but the two are not seen to be interbedded. Their relation is one of unintelligible confusion. The diabase is often quite slaty, but is in isolated and fragmentary masses, lying in all positions in reference to the structure. There seems to have been a junction here between the quartzyte and the diabase, but both are broken into fragments, and the two are mixed in great confusion. The quartzyte, however, can generally be seen to have a tendency to a southeasterly dip, and to strike northeast. The diabase sometimes shows bedding coincident, but the bedded character is not persistent, and we cannot find the diabase anywhere passing under the quartzyte. In some places it terminates by a vertical joint against the quartzyte. The quartzyte, in approaching the diabase, sometimes becomes darker, without ceasing to be strictly a quartzyte. Some of the slaty patches of the so-called diabase become distinctly siliceous, without the presence of isolated grains; and the rock thus acquires the character of a siliceous argillyte (418) in its exterior aspect. I did not discover the evidence that these siliceous slates constitute any part of the quartzyte formation rather than of the so-called diabase slate. They are intermediate between the two.

North of the cut of the railroad at Blind river is a wide area occupied by rocks of the same general character, that is, quartzytes and diabases, but chiefly here, diabases. Of these, one variety contains only a pale greenish feldspar (415); another contains also a pink feldspar (416). The greenish feldspar, in both varieties, tends to become confluent with the dark mineral, and form a feldspathic ground mass In other specimens, the dark mineral remains well isolated, and in places tends to a lamellar crystallization (417).

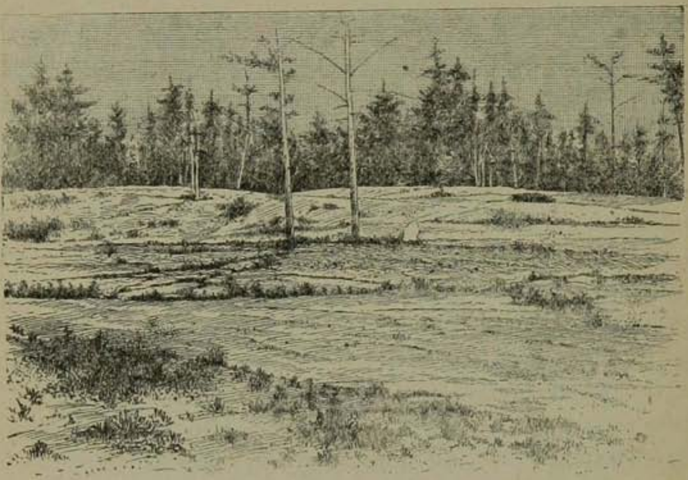


Fig. 12.—*A field of diabase, Blind river, Ontario.*

Similar alternations of quartzyte and diabase are found in all the surrounding regions, and upon the islands contiguous to the mouth of the river.

On the railroad track, one mile west of Blind river, we find diabase apparently identical with that at the sawmill.

About one and a quarter miles west of Blind river, south side of the railroad, is a large outcrop, mostly diabase; but there is a mass of bedded quartzyte in it, twenty-five feet wide, and striking N. 70° E. It is a white, compactly granular rock, distinctly bedded, with a dip of 75° toward the higher mass of diabase. The latter appears both sides of the quartzyte, but it is not revealed whether the quartzyte is interbedded. The upper junction with the diabase is nearly vertical as far as indicated, but dips southward about 85° apparently, so that the beds of quartzyte are intersected by the diabase. On the north junction, the contact is also about vertical, but dips rather northward than southward. The quartzyte traced eastward a few rods, is seen to terminate, the diabase connecting from the south to the north side. On the west, the quartzyte passes under low ground and disappears.

This case is very similar to one in the Thessalon valley illustrated in fig. 8. The general relations of the quartzyte and diabase may also be compared with those seen at localities about the mouth of McBeth's creek and in the Thessalon valley.

At about two miles from Blind river, on the west side of the west mouth of the river, occurs a quartzyte, dipping about N. N. W. This is soon succeeded by diabase of the familar sort.

At two and a half miles from Blind river, is an outcropping of much quartzyte, having generally a dip toward the northwest, with reddish color, varying to dark gray, and a vitreo-granular texture. Some patches are of a greenish color, but still completely siliceous.

At the Missisagui river, is a rock-cut on the railroad, one and a half miles from the mouth of the river. Here is a distinctly bedded structure dipping west about 45°. Of course, this may all belong to an erupted rock It may also be the remains of an originally sedimentary arrangement.

Some of the rock (419) is bluish black, with an augitic groundmass, in which are imbedded individuals of red feldspar. These are sometimes pretty sharply outlined grains, a sixteenth of an inch in diameter or less (421). Sometimes the red feldspar is in minute blended grains and strings, as if just emerging into existence (420). Mixed with this rock, are angular masses of red quartzyte (424), tending to a disposition structurally similar to the last, but certainly without evidence of true interbedding. Portions have a petrosiliceous look (425).

In some of the joints between the two kinds of rock, are sheets of dark slaty chloritic rock (422) which, of course, may have resulted from friction, and probably have, though also, possibly remnants of an originally sedimentary structure.

Most of the rock is a bluish black mass, apparently consisting of augite and feldspar—thin edges being translucent.

At the mouth of the Missisagui river, on the west side, is a large boss of diabase (426). The great mass appears to be augitic; but feldspar is present in white branching nuclei. In contact is a bed of vitreous quartzyte—real gray or smoky flint (427).

On the east side, at the extremity of the promontory, is a great mass of flinty quartzyte, striking N. 74° E, with a dip south of 74°. The stratification is but little undulate, but diagonal bedding is frequent. Bands of the rock present the character of siliceous slate. This flint is at least 180 feet thick. It is succeeded on the north by compact diabase. The junction between the two seems to be vertical; but its bearing is N. 66° E. and therefore intersects the bedding of the quartzyte. Still beyond, the quartzyte reappears.

In proceeding eastward from the point at the mouth of the river, it is seen that the quartzyte of the point, after reaching a total thickness of 225 feet, is succeeded by dark diabase.

At the mouth of Little Bear creek, one mile east of Missisagui, diabasic knobs appear, which continue along the coast eastward. Occasionally, a section of bedded quartzyte appears alongside. In one instance, the junction could be traced 60 feet under water. Then, on the east side, the quartzyte terminated in a perpendicular section, descending into Black river.

This coast, between Missisagui and Blind rivers, is mostly quarzyte of a vitreous variety and steep dip. About one-fifth is diabase. Vast quartzose masses, with the angles due to bedding and jointing, can be seen passing, in many places, into twenty or thirty feet of water.

In a comparision of the geology of the Missisagui and Blind rivers with that of the Thessalon near the mouth, we find this difference observable. The quartzyte is more vitreous, and has a higher dip than that north of Thessalon, and is entirely destitute of pebbles and fragments. The diabase is mostly finer textured than that about Thessalon and Bruce; but on the contrary, portions of it are coarser textured, and take on the aspect of hyposyenite, or syenite of the Germans. That supposes, however, that the pink feldspar so generally present is orthoclase; but the augitic appearance of the dark mineral would render that supposition improbable. The mode of crystallization moreover, is little like that of syenitic rocks.

4. *Generalization from observations made on the Huronian of Ontario.*—The observations thus reported are deemed sufficient to convey a just conception of the meaning of the Canadian geologists in proposing the Huronian system. It only remains to correlate them, and ascertain what state of facts gives rise to the phenomena observed.

It is very evident that a large volume of eruptive rocks, mostly diabases and norytes, is present with a great thickness of rocks of undoubted sedimentary origin; while an equal volume of obscurely slaty character, without quartz, presents an ambiguous aspect. The latter appear to constitute the "green chlorite schist" of Logan. At Bruce and Thessalon, they occupy the general surface; and, as far as external appearances go, might be either an ancient and much altered overflow of erupted matter, or a highly altered deposit of sedimentary origin. In several instances noted, the quartzytes contain large angular fragments of such character that they seem derived from the "green chlorite schist," or diabase schist, as I have sometimes styled it; and this circumstance would give countenance to the theory that the latter are older, and probably sedimentary in origin. The uniformity, in the trend of the obscure slatiness observed, points also to a sedimentary origin. On the other hand, the microscope reveals in the minute structure, a multitude of small, highly refractive crystals, imbedded in a large volume of amorphous matter. From some localities, rock-sections contain many amygdular forms, refractive, and not pleochroic in white light, but bluish-green crystalline in polarized light, without change on rotation. While I do not consider a subcrystalline structure demonstrative of a non-sedimentary origin, but only of a non-sedimentary present character, I am led to assume, for the present, that the slaty sheets covering the surface about Bruce and Thessalon, and generally about the Blind and Missisagui rivers, in the regions examined, are really ancient overflows of erupted material. Strongly corroborative of the correctness of this assumption, are the minute amygdular structures just mentioned, and the macroscopic amygdular forms described near the head of the bay at Thessalon; since, on the accepted explanation of the origin of such features, the vicissitudes of a metamorphic sediment supply conditions less suited to their production than do the conditions of an erupted or intrusive mass.

Whatever may be the origin of the so-called diabasic slates of the coast, undoubted diabases, norytes and gabbros exist in frequent occurrence and great abundance in the interior; and especially along the valley of the Thessalon. But these masses do not occur in the condition of wide overflows. I found them nowhere occupying extensive surface areas, or interbedded between sheets of clastic formations, nor even underlying them. They generally appear as dikes with nearly vertical walls, holding various positions in reference to the lines of sedimentation of the rocks which they pierce. Only in one instance did I observe a diabasic mass resting on the sedimentary rocks. But I could not affirm that they nowhere in the interior exist as interbedded formations.

Passing by all these intrusive and quasi-eruptive formations, the characteristic features of the Huronian are to be sought in its clastic rocks. Of these, we find conspicuously, two great quartzyte formations—the Ottertail and Thessalon quartzytes—pretty closely approximated in vertical relations, and two great argillitic slate formations, also closely approximated in a vertical sense—the upper and lower Plummer argillytes. Whatever uncertainty may exist in reference to the stratigraphical positions of subordinate beds, there is no doubt that the relative situations of these is correctly shown below:

Ottertail (white) Quartzyte.
Thessalon (red and gray) Quartzyte.
Plummer (conglomeritic) Argillyte { Upper. / Lower.

These constitute the principal part of the mass of Huronian strata. The Ottertail or white quartzyte attains a vertical thickness which I would estimate at four thousand feet. This estimate is based on the distance traversed across the formation in proceeding north a mile and a half from Ottertail. The Thessalon or red quartzyte is estimated to have a vertical thickness of five thousand feet. The method of forming this estimate has been explained in the preceding pages. The Plummer or conglomeritic argillyte has also a great thickness. In the region north of Ottertail and Rock lakes where the northern outcrop occurs, we travelled across the trend of the formation for a distance of over two miles, and the northern limit, apparently, was not reached. At Murray's Corner the dip is 78°, and at the southern margin, it is 48°. If we assume the average dip at 50°, and the horizontal distance across the formation, at two miles, we calculate the vertical thickness of the Plummer argillyte (upper and lower), as a little over 8,000 feet. There would be little risk in setting down the aggregate thickness of these three terranes as 17,000 feet.

The Ottertail quartzyte is mostly white, subvitreous and massively bedded. It contains few pebbles. The Thessalon quartzyte is less massive, and generally contains ferruginous and argillaceous impurities. The upper portion especially—but all parts to some extent—embraces dispersed pebbles of a siliceous character, often ranged in courses, and among them pebbles of red and black jasper. As boulders of a red jaspery conglomerate are seen on the south, there is reason to suppose the upper portion of the Thessalon quartzyte locally assumes this character; and would thus answer to Logan's "red jasper conglomerate," which he places between the "red" and "white" quartzytes. In my estimate of thickness, I include the conglomeritic portion Some of the pebbles of the red quartzyte are glassy vitreous. It also contains great angular masses of itself.

That which I have designated the Plummer argillyte seems to be divided into two portions, as I shall point out; but both contain, generally, disseminated pebbles. These are mostly reddish, and of the character of granulyte, or granulitic gneiss, up to two feet in diameter. Others are of red jasper, white quartz, graywacke greenstone, syenite and mica-bearing granite. It may therefore, be designated as conglomeritic. It would be misleading, however, to style it a conglomerate, even a "slate conglomerate." Conglomeritic slate, however, is admissible. The greater part of the mass is a slate.

This slate is quite uniformly dark argillyte. Generally, also, it is permeated by a siliceous constituent. In many places it assumes the condition of a siliceous argillyte, and not unfrequently, of a siliceous schist, more or less darkened, but occasionally vitreous. It conveys, however, an erroneous conception to describe the formation, or any portion of it, as a "quartzyte," or even a quartz schist. Some portions may be denominated siliceous schist or flint schist. Aside from the disseminated pebbles the formation is the exact prototype of the dark schists of Gunflint lake of Minnesota, and of the Animike formation of Thunder bay.

These great formations present two series of outcrops. The one is on the southwest of the Thessalon river, with dips in a northerly and northwesterly direction; the other series is on the northeast of the river, with dips southwesterly. Owing to great dislocations, these two series do not precisely face each other. Thus the Thessalon valley marks the location of a synclinal, as announced by the geologists of Canada.

Besides these great type masses of the Huronian, we find some relatively unimportant terranes, whose stratigraphical positions provoke discussion. On the north of Bruce, at the distance of a mile, is an impure limestone, which I will call the Bruce limestone, somewhat earthy, crystalline and thin-bedded. but not attaining, as far as I observed, a thickness exceeding one hundred feet. In the bed of the stream at Ansonia, is an obscure, siliceous limestone appearing to stand vertically: and near Ottertail, is a very similar cherty limestone, dipping conformably with the neighboring quartzyte This I will designate the Ottertail limestone. There can be no risk in identifying these two outcrops, since the rock is very similar in the two, and is peculiar. But on these grounds, the Bruce limestone must be distinguished. Its stratigraphical position also, seems removed.

In addition to the limestones, we find three separated outcrops of reddish felsyte—passing into quartzyte and granulyte. Petrographically, they must be identified but the mode of showing how this is structurally possible affords ground for debate.

Thirdly, we find, especially about the mouth of the Missisagui, a peculiar vitreous, often reddish, quartzyte—along the line of the Canada Pacific railroad surprisingly broken and intermingled with diabasic masses. Its aspect is notably different from that of the Thessalon and Ottertail quartzytes; it contains no pebbles; it is not granular; and it has also, a steeper dip. In constitution it is quite purely siliceous, and about the mouth of the Missisagui assumes the character of genuine flint. I do not feel inclined to regard it as resting in continuity with either of the other quartzytes—still less, as the deep-sea representative of the Plummer slate. Petrogrphically, the latter conclusion is reasonable. Structurally, the dip being in the opposite direction from that of the Plummer slate, an anticlinal must separate the two. Still, this is not a fatal objection to the view. A real petrographic objection, however seems to lie against it in the necessity of supposing the Plummer slate has undergone so great a change within the distance of 25 miles toward the southeast, while in the opposite direction, it has retained persistent characters as far as Thunder bay and Gunflint lake—a distance in a straight line, at least seven times as great. I shall therefore set the Missisagui quartzyte down as a distinct formation; and this is what I think Logan has intended to do. Travelling over it four miles, from the Missisagui to Blind river, we pass partly in the direction of the strike. That is, the strike is N. 74° E. and the line of coast is S. 80° E. The four miles of coast, therefore, go at right angles, one and a half miles across the formation; and, as the dip at the Missisagui river is 74°, the resulting vertical thickness of the formation, supposing half the distance diabase, is over 3,750 feet. This all depends, however, on the continuance if a dip of 74° all the way between the Missisagui and Blind rivers. No formation of such volume exists between the top of the white quartzyte and the bottom of the Plummer argillyte; and I shall therefore, put it down below the Plummer argillyte.

It remains to ascertain the positions of the limestones and the felsyte. If the Bruce limestone is distinct, as I believe, from the Ottertail limestone, there seems to be no possible position for it but below the Plummer argillyte; and, as the Missisagui quartzyte, assuredly, is not above this limestone, it must lie above that quartzyte.

The Ottertail limestone and the felsyte remain. At Ottertail, the limestone lies constructively above the white quartzyte; but the red (or lower) quartzyte contains pebbles of this limestone; and the latter must hold position, therefore, below both quartzytes. Moreover, at Ansonia, its topographic and constructive position is below the red quartzyte. Its regular stratigraphical place, therefore, at Ottertail, is 9,000 feet below the top of the white quartzyte; but we find it only 250 feet below topographically; and if the neighboring quartzyte were produced to the outcrop of the Ottertail limestone, the latter would appear even above the top of the former. This limestone must, therefore, be raised at least 9,000 feet above its original position; and a fault of this magnitude must run along the valley of the river in this vicinity. This would assign the Ottertail buff and cherty limetone to a position between the red quartzyte and the Plummer argillyte. Sir Wiliam Logan has posited "yellow chert and limestone" between a "white quartzyte chert and limestone" above, and a "white quartzyte" below—apparently within the mass which I have denominated white or Ottertail quartzyte.

Now as to the felsyte, I find it exposed in three localities visited; and in each place I find a small amount of Plummer argillyte at a higher level. North of Ottertail, the super-jacent argillyte has a vertical thickness of about a hundred and fifty or two hundred feet. South of Ottertail, it is not over sixty feet to the summit of the hill which it caps. But both felsyte and argillyte are stratigraphically out of place in the outcrop south of Ottertail. They are far above their normal stratigraphic position. They are also, within three-quarters of a mile of the Ottertail limestone, which I have just now concluded to be raised 9,000 feet by a fault. But in the next place, the felsyte at Ottertail, is topographically 75 feet above the limestone, while, as I reason, its normal place is at least 150 feet below it. The felsyte then, has been raised 225 feet more than the limestone. Another fault of this amount, must therefore, intervene in the 240 rods of surface between the limestone and the felsyte.

Recapitulating and tabulating these conclusions, we should have the Huronian of Canada, as far as observed, constituted, in descending order, as follows:

8. Ottertail (white) Quartzyte.......................... 4,000 feet
    "l. White Quartzyte, chert and Limestone" and "i White Quartzyte" of Logan.
7. Thessalon (red and gray) Quartzyte.................. 5,000 "
    "h. Red Jasper Conglomerate" and "g. Red Quartzyte of Logan.
    (I think Logan's "c. White Quartzyte" must belong here also.)
6. Ottertail Cherty Limestone say...................... 100 "
    "k. Yellow Chert and Limestone" of Logan.
5. Upper Plummer (conglomeritic and siliceous) Argillyte 500 "
    "f. Upper Slate Conglomerate" of Logan, in part.

4. Red Felsyte, granulyte and quatzyte.................. 100 feet
   Not mentioned by Logan. The "e. Limestone" of
   Logan is lower, and not noticed by me.
3. Lower (conglomeritic and siliceous) Argillyte....... 7,400 "
   "d. Lower Slate Conglomerate" of Logan.
2. Bruce Limestone.. 100 "
   This seems to be placed elsewhere by Logan.
   (Logan's "Green Chloritic Slate" is in this interval.)
1. Missisagui (vitreous) Quartzyte........................ 3,750 "
   "a. Gray Quartzyte" of Logan.

It will be observed that neither the lower nor the upper limit of the Huronian is embraced in the observations above reported. It may be added, therefore, that the white quartzyte is seen occupying the north shore of the Channel as far as the St. Mary's river, and it appears, also, along part of the north shore of St. Joseph's island. Here I found it immediately overlaid by a siliceous and fossiliferous limestone—apparently the Chazy. The same was observed years ago, at Campement d'Ours and at Sulphur island, six miles south-southwest of Thessalon point The same superposition is reported at all the islands ranged along parallel with the north shore of the Channel. It thus appears that the Huronian is a system following downward immediately below the Lower Silurian, in this part of the continent. If no intervening terranes are wanting, it follows that it occupies the position of the Taconic of Emmons and the Lower Cambrian of Sedgwick.

At its lower limit, it must be succeeded by formations of vitreous quartz, red jasper and graywacke, besides greenstones, red granulytes, red gneiss and mica-bearing granite; since fragments of all these occur in the Plummer argillyte. It may be admitted that the quartzyte pebbles of the argillyte were derived from the Missisagui quartzyte; but the red jasper and graywacke must have been derived from a terrane older than the Huronian, and evidently newer than the crystalline masses of the Laurentian. The character of this underlying system will appear in the records of my subsequent observation.*

I should not do justice to my sentiments nor to the labors of the

* A condensed synopsis of the foregoing observations and inferences was presented at the New York Meeting of the American Association for the Advancement of Science, under the title of "The Huronian System of Canada." Nothing, however, has appeared in print from my pen. Other communications were similarly presented by professor N. H. Winchell, under the folowing titles: "The Slate Conglomerate of the original Huronian the Parallel of the Ogishke Conglomerate of Minnesota," and "The Animike Black Slate and Quartzyte and the Ogishke Conglomerate of Minnesota the Equivalent of the original Huronian."

Canadian pioneers in the Huronian field, if I should fail to acknowledge explicitly the general accuracy of their reports, as far as my own observations have gone. When we consider the great intricacy of the geology, and the extreme difficulty of travel through the region when settlement was in its infancy, the great amount accomplished with such accuracy of detail, may well command our admiration.

I wish to record an observation supplementarily, respecting the surface geology of the district about Thessalon. The region generally is covered by an alluvial deposit. This has given the usual argillaceous soil and subsoil, accompanied by much standing water. But at the same time, this soil when well cleared and drained, makes very fine farms, and is already much improved. Crops of timothy grass and clover are especially rank. I saw also, good spring wheat, oats and peas. Still, so far as I observed, proper drainage is generally neglected.

Over the alluvial clay, I observed extensive regions occupied by fine sand, and here is a truly warm and productive soil. I saw Indian corn growing in some gardens; and it was nearly as rank as that in southern Michigan. But I saw none in the fields; and I presume the autumnal frosts are too early for field corn.

I observed numerous ancient beaches at elevations within 100 feet of the present lake level. Indeed I should suppose an ancient beach would surround each of the rocky knobs which must have projected as islands from the former lake—as many still project above the actual surface of the North Channel. I crossed one old beach which had low land on both sides, and must have been a point, perhaps submerged, at the time of the former extension of the lake—just as Thessalon point at present, projects miles into the modern lake. That Thessalon point is an ancient beach or reef I have ascertained—but still, there may be a foundation of erupted rock.

§ 3.—OBSERVATIONS IN OTHER REGIONS OUTSIDE OF MINNESOTA.

1.—*The Marquette Iron Region.* The geological position of the iron ores of this region has been generally, though not universally, regarded as within the Huronian system. The observation of the true character of the typical Huronian rocks of Canada rendered it necessary to ascertain how far the iron-bearing rocks of Marquette agree with them, and, in case of difference, to determine whether any portion so agrees, and in what respect the other portions disagree. It was also necessary to determine whether the iron-bearing rocks of the Marquette range can be identified with those of the Vermilion range, a lithological assemblage which was supposed to stretch to the northeastern limit of Minnesota.

My studies in this region were directed only to certain points, and with reference to information desired on particular questions. The research began at Ishpeming, and a few memoranda of facts are here recorded.

I am much indebted to Mr. Hall, the superintendent of the Lake Superior mining properties, for the use of means of conveyance, and for his company and many details of information. In the office I was shown a very extensive series of drawings of the mining property, including numerous vertical sections across the iron-bearing lodes, and along their axis. Mr. Sturtevant, the engineer, had the goodness to prepare for me two sections across the soft hæmatite deposit, and one along its axis. These are presented below on a reduced scale.

The accompanying diagrams show that the great iron-bearing lodes of the Marquette region do not occur in isolated lenticular forms, as has been sometimes supposed; but are really interstratified in the formation, as at Tower. Here however, all the stratification is much disturbed and wrinkled. Besides what these diagrams illustrate, Mr. Hall pointed out on the ground, the evidences that the deposit in transverse section was originally bent into the form of an S, giving thus at differents points in its breadth synclinal and anticlinal attitudes.

Mr. Hall showed me, also, many samples of the gold taken from the Ropes gold mine, and other samples of gold-bearing quartz from a new find recently made on the property of the Lake Superior Company. These localities are both within three or four miles of Ishpeming, on the north.

In an old opening of the Lake Superior Company, Sec. 19, T. 47-27 (rocks 453, 454), the deposit of iron is seen to run east and west, with a dip N. 63°. The hanging wall is a quartzose conglomerate. This, however, sometimes continues through the iron deposit in modified character.

Twenty rods north of this place, immediately east of the Saginaw mine, is a boss of a curious conglomerate (455), consisting largely of iron—a sort of imperfectly bedded groundmass of a hæmatitic character—in which are imbedded rounded and partly angular pebbles and fragments of red jasper, white quartz, flint, glassy quartz, and less important fragments. This has been bored into, and, according to Mr. Hall's recollection, it is at least 400 feet thick. Here the Lake Superior Company did a good amount of mining; and the Saginaw

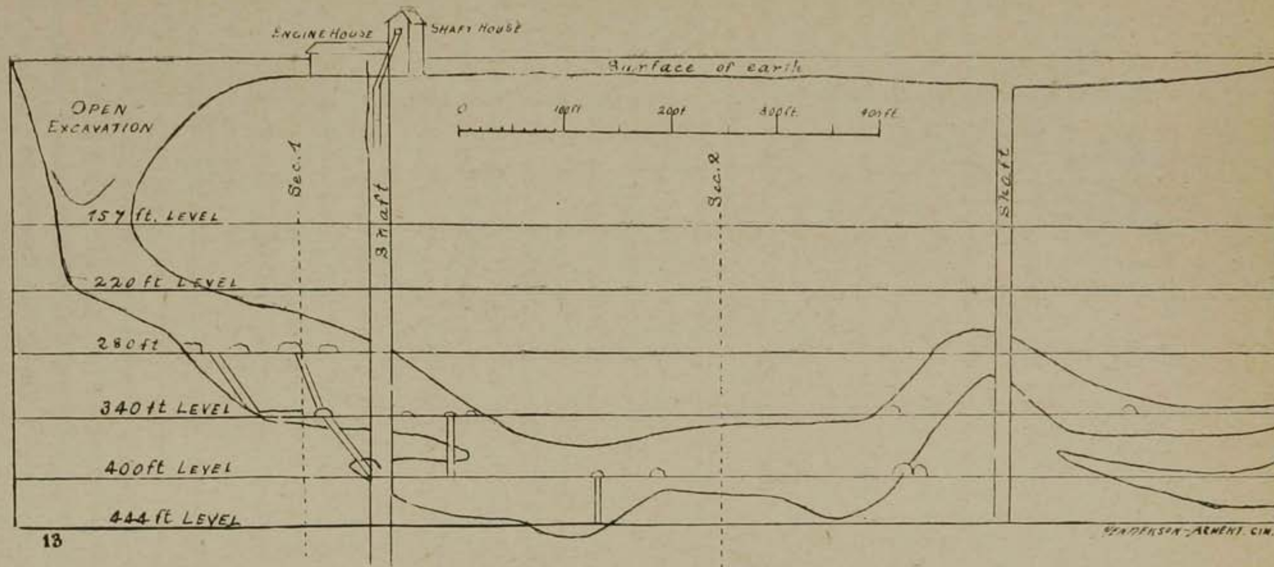


Fig. 13. *Vertical east and west section along the axis of the soft hæmatite deposit of the Lake Superior Iron Company.*

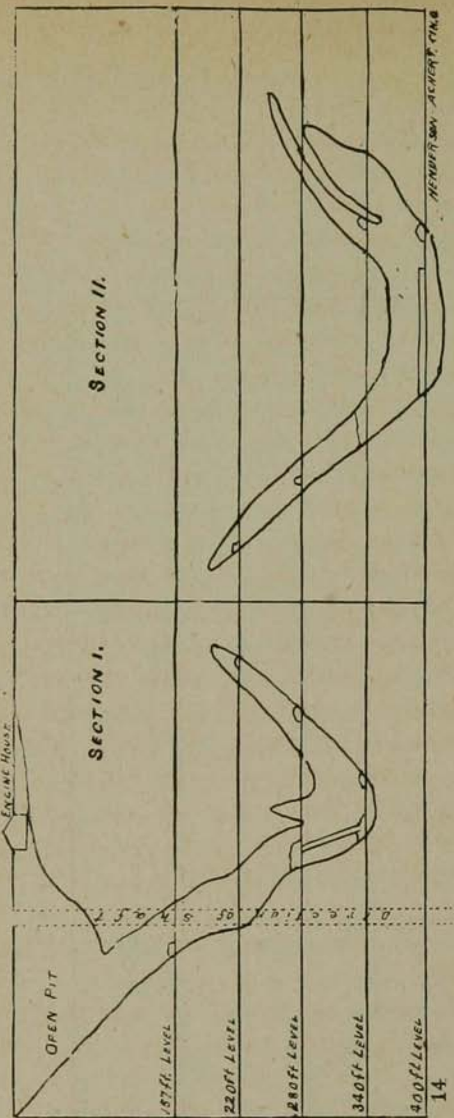


Fig. 14. Vertical north-south sections across the same deposit, at points marked in fig. 13.

Company did much on the westward continuation of the deposit. But all work is now abandoned.

About one and a half miles west of Ishpeming is an outcrop of a dark, argillitic, sericitic slate (456). It dips N. 10° E. at an angle of 70°. Conformable with this is a bed of gray, rusty-speckled, granular quartzyte (457) underlying the other.

From information gathered at Ishpeming from Mr. Taft, the chemist of the Cleveland Iron Mining Company, from Mr. J. R. Wood, and others, it appears that a synclinal exists in this vicinity, with a southern outcrop, on which the town is located, and another three or four miles to the north. The downward succession of the beds in this synclinal is as follows: 1. Red slate; 2. Black slate and mixed ore; 3. Ore; 5. Talcose rock, so-called; 6. Dioryte The red slates are banded hæmatite and jasper—pretty hard. The black slates are magnetic jasper, and the mixed ore is similar to the red slate bed, but contains more ore. The talc is essentially argillitic. This is also true of the "chlorite rock," so-called—a rock also styled by some, "talc," and by the miners, "soap rock."

One and a half miles north of Ishpeming, on the Deer lake road, is an outcrop of quartzyte, having a dip quite steep—about 70°. It contains beds of quartz pebbles.

About two and a half miles from Ishpeming, on the road to Deer lake, and one-third of a mile south of the saw-mill at Deer lake, is a high knob on the right of the road. It consists of nearly vertical slates (458), which would formerly have been called talcose. In some portions, however, are developed multitudes of feldspar crystals. It is, therefore, in the condition which I have styled "porphyrel" (459).

Climbing to the top of the hill, we find an obscure conglomeritic structure, like that at Stuntz's island, in Vermilion lake. The resemblance is confirmed by the presence of isolated portions looking serpentinous or talcose, and by the existence of many obscure, intersecting quartzose veins. The obscurely outlined pebbles, it should be recorded, are essentially identical with the country rock, as at Stuntz's island.

All this confirms the parallelism of the Marquette and Vermilion iron-bearing groups, and the non-Huronian character of both.

In the highway by the bridge at Deer lake, and about in the strike of the ridge last mentioned, is an outcrop of rock (460, 461), which to me appears sedimentary; but assuredly it is much altered, and presents a quasi-eruptive aspect. It is admittedly the equivalent of the Stuntz island rock; and they who regard that as eruptive will pronounce this eruptive also. The rock here contains foreign pebbles; and I regard that as conclusive evidence of a fragmental origin. The schistosity, also, is completely conformable with that of the neighboring sericitic slate.

On the west side of the bridge at Deer lake the rock (462) is highly and distinctly conglomeritic; but having a slaty structure, with beds standing vertical. It might by some be regarded as having a basaltic structure. In places it passes to a still more eruptive-looking rock. The resemblance to Stuntz island is maintained. Still, I think the formation was sedimentary originally, and that it retains distinct traces of its original condition.

The conglomeritic aspect comes out chiefly on the weathered surfaces. Some of the fragments are angular, some rounded, and many elongated in the direction of the structure, i. e. vertically.

Twenty rods south of the last point, along the railroad west side of Deer lake, occurs a quartzyte (463) dark gray and red in bands. This dips S. 25° E. at an angle of 55°. The rock is rather vitreous. The lower part of it is darkened by the presence of hæmatitic material apparently, and contains thin bands of hæmatite. The higher part becomes almost uniform in color, of pinkish gray. Still higher it is whitish. The quartzyte and the slate are not seen in juxtaposition. An interval of four rods separates their nearest outcrops. The vertical structure of the slate, however, is strikingly unconformable with the dip of the quartzyte; and favors, perhaps the theory of the eruptive origin of the slate.

At a point about two and a half miles east of the Ropes gold mine, (1069), near the charcoal pits, we observed a large pile of rock-fragments said to have been brought from the gold mine to use as a flux. The fragments indeed contain a large percentage of calcium carbonate; but there is present also so large a quantity of talc that the material is said to have proved unservicable. Yet we obtained fine specimens of amorphous (464) and crystalline (465) talc. Noticing that the rock on weathering acquires a deep stain of iron rust, we judged that it probably has the composition of ankerite.

At the Ropes Gold mine, it was observed that the gold-bearing quartz vein occurs in a rock appearing like a chlorite slate (466)—though probably a compact argillyte—appearing to be the same formation as that seen at the knob east of Deer lake, and on both sides of the bridge at the lake. The shaft at this mine was stated to be about 360 feet deep with seven levels. In the mill twenty stamps are in operation.

On the return to Ishpeming, we examined a spot on the opposite side of the road from the knob before mentioned, 458. Here is a formation consisting of thin-bedded quartz with laminated, sericitic schist (468) more or less siliceous, intervening. Dip S. 15° E. amounting to 64°. The formation occupies the interval noticed on the opposite side of the lake, between the nearest outcrops of the quartzyte and slate. The gap is evidently due to the easier disintegration of the thin-laminated rock.

In company with Mr. Taft, chemist, we visited the Cleveland mine, and made a careful examination of the "dump." At our request Mr. Taft took a sample of the green argillyte, Rock 469a, and a sample of the ashen argillyte, 470a, to subject to careful analysis. The result, as subsequently communicated to me, and which will probably be elsewhere published in full, establishes what was before stated, that the rock variously known as talcose slate, chlorite slate, or soap rock is essentially an argillyte.*

At this mine were found martite crystals (471); and Mr. Taft showed a specimen of an iron breccia, very similar to the conglomerate seen at the Saginaw mine, 455. This, he says, is terminated abruptly by the overlying quartzyte.

At the Michigamme mine, we found the rock immediately over the ore to be a quartzose chlorite schist (472). Above this is a thin-bedded quartzyte, similar to that seen under the quartzyte east side of Deer lake.

The first knob north of Michigamme mine is formed of dioryte, so-called (473). The higher knob, farther north is formed of "granite" (474). Immediately in contact with this is a greenish quartzyte, which passes by transition into the granite. Professor Irving, who accompanied us, represented this as the usual character of the contact. It might also signify that the "granite" was originally a sedimentary rock, but containing more feldspar-making elements than the quartzyte, metamorphism changed it to a rock of the granite series, but could not make anything but a quartzyte of the overlying beds.

* The samples bear the numbers of the series of N. H. Winchell. The analyses done by Mr. Taft were omitted accidentally in the proper place, and are appended here.

	No. 1235. (469a)	No. 1236 (470a)
SiO_2	27.13	28.35
FeO	21.50	2.38
Fe_2O_3	9.80	11.30
Al_2O_3	24.23	36 54
CaO	trace	.36
MgO	4.21	13.21
H_2O	7.10	2.89
Total	93.97	95.03

Mr. Taft remarks: "They are both short about five per cent and I fail to account for it, except that they may contain soda and potassa. I have not means for determining these elements properly, and have used all of one of my samples." [N. H. W.]

I proceeded to the summit of this range and worked eastward in search of a gneissic structure in the granite, but the surface was generally concealed. Descending at the distance of about twelve rods, I found the quartzyte (475) again in contact with the granite; but the contact here is abrupt. I found the granite intersected by a diabase dike (476).

A short distance southeast of here is a small, sharp, high cliff of quartzyte, thin-bedded and with interlaminations of sericitic sheets (477). These contain multitudes of garnet-like minerals. A short distance south of this is a ledge, unquestionably in place, dipping southward 66°. The dip in the sharp knob is 63° toward N. 28° W.

At the east end of the marsh is a precipitous exposure of dark gray, distinctly bedded quartzyte (478), with a diabase dike through it. The dip is various in direction and amount. The great mass, however, is nearly horizontal, or slightly eastward-dipping.

In visiting the Swan mine, east of Negaunee, I observed on the dump heap interlaminated fine sandstone and hæmatite (479), and, in contiguity, chalcedonic silica and hæmatite (480); and finally, jasperoid laminæ (481) and hæmatitic. All these were necessarily formed in continuity by the same kind of action in the same spot. But it is incredible that all these should be the product of eruptive action.

At the lower shaft of the Buffalo mine I saw the same material taken out as at the Swan mine. As these materials are above the ore, it would follow that ore probably underlies them at the Swan mine. The ore is soft and earthy. The open excavation near the upper shaft shows the ore and country rock in great confusion; but, in general, with a northerly and steep dip.

One-fourth mile north of the Buffalo mine, on the railroad, is an outcrop of quartzose schist and slate. The so-called quartzyte (482) is not quartzyte. It is greenish chloritic and quartzose.

Across the railroad is a black argillyte (484), thin-laminated, dipping northerly, but at a much lower angle than the "quartzyte," so-called. *It is unconformable with the quartzyte.* The slate (483), interbedded with the "quartzyte," is decidedly another formation, unlike the argillyte of black color.

It is worthy of particular remark that this black slate *resembles the Animike black slate;* and its unconformability with an underlying formation is also very suggestive. The dip of the black slate is 40° toward N. 51° W. The greenish slate, or the so-called "quartzyte," on the opposite side of the railway, dips 47° toward S. 62° W; at another place, S. 82° W.

Near by I find a contact between the slate and the sandstone (quartzyte) like the following:

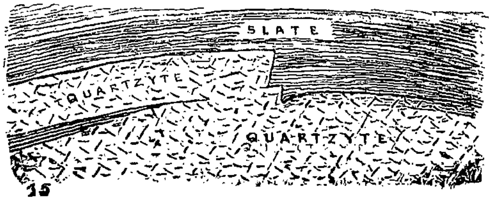


Fig. 15. *Contact of slate and quartzose sandstone, one-fourth mile north of Buffalo mine, near Negaunee.*

This slate is further mixed with the sandstone by imbedding of flakes.

The unconformability of the two slates is further illustrated and established by observations on the neighboring hill-slope a little further northwest. The argillitic slate (485) is here largely developed. It possesses a vertical slaty structure; but it has an unmistakable sedimentary dip everywhere toward N. 51° W., conformably with that of 484. This, therefore, is a higher stratigraphical position than that of 484; but it is unmistakably the same formation. Is it Animike?

The opening of the Iron Cliffs Company is adjacent to the "Sam. Mitchell mine." The work here is arrested by an anomalous disposition of formations. The ore deposit is cut off by a quartzyte. This quartzyte is south-dipping, and a shaft was carried down along the south side of it, when it was intercepted by a north-dipping quarzyte (486). The two quarzytes seemed now to fold together and inclose a selvage of green rock. Along this selvage the shaft is continued almost vertically. The quartzytes are both greenish, and do not differ except that a few ferruginous patches occur in the southward dipping one. This is not the place to offer any reasoning as to the probability of recovering the ore deposit. Still, it may be said that the bedding of the formation in general is northward, and the southward-dipping quartzyte should be of the nature of a vein with the ore body under it, more or less displaced. This view is favored by what is seen in the brush one-eighth of a mile north of the mine, to which superintendent Sodergren accompanied me. Here is an outcrop of quartzyte (487), dark gray but granular siliceous, thought by him to be the southward-dipping quartzyte. A few rods farther north, also, are some test-pits and one shaft planked up. From the bottom of the latter was thrown out a quantity of quartzyte fragments of dark gray color, resembling the southward-dipping quartzyte, but, still, not of grains so uniform in size and constitution. In a cliff west of these localities is a large outcrop of quartzyte, so-called, dipping north; but this is a different quartzyte.

It looks on the whole, therefore, as if the prevailing dip of the formation hereabouts were northward, and the southward-dipping quartz a mere vein, of probably no great thickness; and the ore ought to be under it.

Some observations were made in the district north of Negaunee and Teal lake. North of the east end of Teal lake is a massive range of quartzyte (488). It is gray, granular, vitreous, blotched with red, thick-bedded, with various joints, and an appearance of sedimentary structure dipping south at an angle of 65°. This quartzyte, in its physical characters, is unlike that (487) in the ridge visited with Supt. Sodergren. It is much more compact and vitreous; that is granular, with intergranular cement; still, the grains of this are distinctly defined, though glassy. The formation has some thin seams of black crystalline hæmatite.

At the west limit of this quartzyte knob we find a deposit of sericitic schist, argillitic and ferruginous. Its relation to the quartzyte is ambiguous. It looks like a vein or dike, but is exceedingly schistose, and its schistosity is not conformable with the bedding of the quartzyte. The knob next west of this is all of the same quartzyte. The range seems to be a continuation of that north of Ishpeming.

On the northern border of the city of Negaunee, and not far removed from the south side of Teal lake, is a high dioryte knob or ridge. On the north side of this is the Eldridge mine. The ore body is not reached. The surface rock was "soap rock;" and this was continuing at the depth of 153 feet. The dip is southward about 60°. For a hundred feet a good deal of iron had been mixed with the "soap."

At the Hartford Mining Co.'s mine, also on the south of Teal lake, and half a mile north of the Eldridge, a shaft was sunk sixty feet deep. There they struck ore and are now drifting east and west—the ore having a southerly dip. The overlying rock was banded, siliceous hæmatitic schist. The ore is a soft rich hæmatite.

At the Cambria mine south of the west end of Teal lake, we ascertain that the general dip of all the rock in this neighborhood is steeply southward. There is a large main deposit of ore, on which are located the Hartford, Cambria, Lily, and another mine. The Hartford and Lily are still working, but the Cambria has ceased to be productive. The working ended with jasper on all sides. They have drilled into the jasper in various directions. North, they come into banded, siliceous hæmatite, similar to the overlying rocks. On the south they claim to have found ore.

Since the loss of the main deposit the management have sunk a new shaft 350 feet, and have drifted in various directions at the 2d, 3d, 4th and 5th levels, and found thin, irregular beds of ore, one of which trends northwest, but is only one or two feet thick. On the sixth level they found no ore.

The general conclusion geologically is, that the stratification is extremely irregular, and ore deposits not to be long depended on.

A few studies were made at Marquette. At the end of Bluff street, on the peninsula by the saw-mill, is an outcrop of sericitic schist (489) with vertical schistosity, and crumbling to chips. It is drab, pervaded by dashes of a dull pink color. The bedding is wavy, inclosing lenticules of quartz (490). The sedimentary bedding planes are visible, dipping N. 8° E. at an angle of about 15°.

Twenty rods farther northeast, are rounded glaciated bosses (491) of an ambiguous character, but reminding one of rocks at Thessalon; yet nowhere plainly diabasic. Over the surface are seen streams looking like fluid currents, with many oblong and lenticular pieces of the country rock—such as occur at Thessalon, and many localities in the Vermilion region. At the same time, there are places which reveal a structure dipping northward, and looking sedimentary. The rock varies much within short distances, in texture, hardness and composition.

Near the light house, but not at the point, rises a rounded smooth boss (492), as before, but with very distinct banding on the surface, which dips N. 1° E. at an angle of 71°. Careful examination with a lens reveals no free quartz, but the rock is rather hard, and rings under the hammer. Silica is probably present; though scratched on the fresh or weathered surface, there is no indication of a free quartzose constituent. It has scarcely the hardness of feldspar on the fresh surface; and the whole rock, as far as I can make out in the field, is a felsitic schist, though the feldspathic ingredient does not appear to be orthoclase. This is the best conclusion I can reach from the data supplied at this spot.

This formation strikes a few rods to the north of the last two localities. The same sort of rock continues toward the light house; but the exposure there is further north, and stratigraphically above. A dike of diabase is seen cutting it.

At the Light House point, Marquette, the formation presents a banded structure, and a striking appearance of steeply dipping sedimentary rock. Here also, is the felsitic rock weathering red, and in places becoming a porphyry (493). The banded schist weathers dark, and on fracture, is dark. It appears to be an intimate mixture of feldspar and hornblende; containing many glistening points. Thin scales have a dark greenish translucency; and the weathered surface has a fibrous, sericitic aspect (494).

This formation is intersected by dikes nearly parallel with the bedding, and by another great dike making an angle of 60° with the first set. Further research reveals the fact that the felsitic and porphyritic mass is in the nature of a broad dike nearly conformable with the dark-banded schist; but really bounded on both sides by a slightly discernible unconformity. The porphyry and schist are intersected by small diabase dikes parallel with the schistic bedding; and that gives the appearance of bedding to the porphyry. Then, also, the whole formation is cut by two great dikes running nearly north and south.

In one place, I saw a banding transverse to that of the schists; and that awoke the suspicion that the main banding may have been caused in a similar way. But after careful study I concluded that the transverse banding is in the nature of veins. Sometimes, in the porphyry, —which in many places is simply felsytic—the transverse veins give the appearance of a woven fabric.

Proceeding toward the extremity of Light House point, I find a similar schist continuing; but opposite the Light House, it is crossed by an enormous dike of greenstone, at least a hundred feet wide, and divided longitudinally by joints about fifteen feet apart; and these being unequally eroded, leave great gaps, as if each section were itself a dike.

Some portions of the schist become exceedingly hard and diabasic, and I find again the cross banding noticed above.

On the north side of the point is another great dike, about thirty feet wide, belonging to still another system; for it trends exactly east and west, and dips north at an angle of 77°. It is granular and glistening, but there is no free quartz. The powder is bluish-white, and the glistening seems to be due to faces of labradorite. I made a search to find the intersection of this dike with the great north-south dike immediately east of the light house. This dike continues beyond the place of intersection, and runs north of the light house; but at the place where the intersection should be, neither dike is certainly identifiable. I judge, however, that the east-west dike cuts the other. If so, the east-west dike is next to the last geological phenomenon in the history recorded in the structure of the rocks forming this point. The granulitic veins which I have found intersecting all the other dike structures, undoubtedly intersect this also. We should have therefore, the successive epochs of the geological history of the point marked off as indicated in the following diagram:

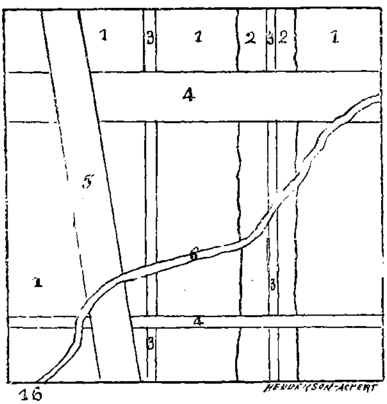


Fig. 16. *Diagram illustrating geological epochs evidenced at Light House point, Marquette, Michigan.*

1. Epoch of the fundamental dark schist.
2. Epoch of the porphyry.
3. Epoch of the little dikes, nearly conformable with the schist, but not entirely so.
4. Epoch of the great north-south dikes.
5. Epoch of the great east-west dikes.
6. Epoch of the granulitic veins, which cut the great dikes.

This is a new and instructive example to illustrate well known principles in structural geology.

The few statements made in reference to the mode of occurrence and the associations of ore deposits in the Marquette district, will, it is hoped, possess some interest for citizens of Minnesota connected with the iron developments of the "Vermilion Range." The facts noted of a purely geological character reflect important light on the geological parallelism of the Marquette and Vermilion ranges; and indirectly, on the economic questions concerned in Minnesota mining. It is only the geologic outcome of the comparison, however, with which, in this place, we are concerned; and it may be stated as I understand it, in the following propositions:

(1.) *The Marquette iron-bearing rocks are of the same age as those of the Vermilion Range.* Their geological position is immediately above the crystaline schists and gneisses; and there are indications, as will be shown, of a position, as in Minnesota, beneath other slates, in unconformable relations. The fundamental sediments generally, are but little crystalline, but are highly altered, often almost to the point of fusion, and sometimes, to the point of true crystallization. They consist largely of argillytes, ranging in nature, from proper to chloritic, sericitic, hydromicaceous, siliceous and hæmatitic; and, in condition, from earthy to graywackenitic, felsitic, porphyritic and diabasic. The ore bodies are true bedded constituents of the system, subject to all the usual accidents of stratification; the most important of which are liability to expand and contract and even to pinch out, in the direction of the axis of the lithologic folds. The occurence of an obscure conglomeritic structure in both regions, is a point of resemblanee which is almost demonstrative. The inclusion of masses of serpentinous or parophitic character, has the same significance. A g eat abundance of red jaspilyte and jaspilitic iron schists is a common feature of the Marquette and Vermilion districts. In both, the jasper and jaspilitic ore are disposed in layers conformable with the bedding of the hæmatite and of the inclosing schists; and in both, similar indications exist of a sedimentary and aqueous history The observations made at the Swan and Buffalo mines may be here again referred to. Of clastic rocks, the quartzytes of the Marquette region are little known in the Vermilion region. Rocks of eruptive origin are common in both, but in the Marquette region occur both as dikes and intruded beds—though a question remains as to the real origin of the dioryte beds. While the Vermilion rocks have been subjected to one grand system of disturbance, which has left them almost universally in a vertical attitude, the Marquette rocks have been thrown into several folds, within each of which the constituent strata may be found in all attitudes.

(2.) *The Marquette iron-bearing rocks are not of Huronian age.* While the opinion is not new that they antedate the Huronian, it has been generally admitted that they fall within that system. That they are older than Huronian is shown by a four-fold line of evidence. (*a*). *The rocks are different.* In the original Huronian, the argillytes are almost exclusively black and carbonaceous or magnetitic, instead of bluish or ashen and hæmatitic. They are more prevalently siliceous or flinty. The quartzytes attain a more enormous development, are much purer, especially the upper, and hold position entirely above the argillitic member. (*b.*) *The Canadian Huronian succeeds immediately beneath the Palæozoic System.* The Marquette strata do not. The Marquette strata are succeeded immediately downward by crystalline schists. The Huronian strata are not. (*c.*) *Some evidences exist of an unconformable, overlying, sub-palæozoic system in the Marquette region.* I refer here, both to the unconformability described in the foregoing notes in the vicinity of the Buffalo mine, and to major Brooks' brief notices of highly carbonaceous black slates occupying a position higher than the Marquette argillytes. (*d.*) *Proof is to be adduced in this report, of the unconformable subterposition of the Vermilion iron schists relatively to the Animike slates.* If the Marquette and Vermilion rocks are mutual equivalents, the former must hold position beneath the same system—that is, beneath the Huronian.

(3.) *The Marquette iron-bearing rocks belong to a system not yet defined.* If they underlie the Huronian, they equally overlie the Laurentian. They are not separated from the Laurentian by a structural unconformability; but by the evidences of a long intervening lapse of time, and a most important change in the action of the geologic forces. Strata fully crystalline and strata essentially earthy, though found in conformable juxtaposition, must necessarily belong to two different ages and modes of geologic activity. This subject will be more fully treated in the final generalization from my studies in Minnesota.

2. *The Gogebic iron belt.* I shall confine selections from my notes almost wholly to facts illustrating the geology of the range, and supplying a basis for comparisons with the Vermilion Range. At the "south vein" of the Colby mine the ore is an incoherent earthy mass which, for the greater part, is worked out with pick and shovel. It is, however, imperfectly cemented together in irregular patches; and some blasting is required to remove the whole. The general color, before weathering, is dark brown. This deposit is about eighty feet

wide, in a sheet dipping north 50° to 70°, with an average of about 60°. But on the north side the same material extends at this place, to a greater distance. The limiting wall on the south (foot wall) is a compact, hæmatitic slate. Here we notice through a part of the excavation, the continuance of the earthy mass; but beyond this, westward, a broken ferruginous slate sueceeds it; and at the western end of the excavation, it approaches the opposite wall, and all the ore is pinched out. Forty or fifty feet of the rock on the south side are broken and in confusion; yet one can trace bedding courses in the lower twenty feet of this. There are no indications whatever of eruptive action.

On the south side the regularity is much interrupted. When the hæmatitic slaty wall is removed, one sees behind it a jumble of rock, masses perfectly promiscuous in position, but mostly hæmatitic. Still, some portions are greenish, amorphous, chloritic, passing down in shapeless masses, bent and arched in a promiscuous way. Some are light colored, sandstone-like masses, simply stained with iron. The iron which pervades all these conditions of rock seems to be simply forced out like fat; and to have accumulated where the action was most intense or where the condition of the rock most favored.

South of the Colby mine, in the cut of the railroad is an outcrop of siliceous argillytes (500), reddish and drab, with dip N. 10° W., and amount 65°. These are interbedded with quartzyte schist. The thickness exposed is 250 feet.

By the railroad near Bessemer, coming from the Valley mine, is an outcrop of conglomerate, with slight dip north. It is a small exposure, but in place, composed mostly of pebbles of dark red sandstone, hæmatite, granulyte and diabase. It appears like a conglomerate at the base of the Kewenian.

At the East Norrie mine, southeast of Ironwood, the open excavation shows simply a confused mass to the depth of a hundred feet. Soft ore is raised from underground workings.

At the Aurora mine the open work shows a general dip north at the usual steep angle. On the south side is a quartzyte which, in decayed situations, resembles the sandrock in the Colby mine. Much excellent soft ore is coming out of the ground here.

By means of observations at the Aurora mine and thence to the hill one fourth mile south, we were able to determine the following sequence, in descending order:

Broken and mixed ore.

Main deposit of ore dipping north at an angle of about 65°.

Quartzyte forming the foot wall in the Colby and Aurora mines.

Siliceous argillyte south of Colby mine—seen 250 feet. This perhaps occupies part of the concealed space south of the Aurora.

Quartzyte and syenite gneiss interbedded, in the hill 633 feet south of the north face of the quartzyte in the Aurora. Thickness, 595 feet.

Syenite gneiss (502) on the hill south of the Aurora.

This syenite is a heavy outcrop. It contains some fragments, mostly of greenstone, and only partly rounded. It reminds me of the Seagull and Saganaga regions, Minnesota. The rock weathers light colored. It is granular and porous, varying to compact. The feldspar is very pale pinkish, and the hornblende is grayish-greenish. It presents all the characters of true syenite, showing no trace of bedding within the area subject to observation. But it is evidently a fragmental rock, since it contains many rolled fragments. It furnishes us ocular evidence that real syenite, with all its proper crystalline characters, may be a rock of sedimentary origin.

Looking around, we discover other evidence of its close affinity with products of sedimentary action. Close by, it overlies a true, fine-grained quartzyte (503). The contact is apparent in several places. Four rods south of this syenite, a considerable mass of quartzyte is imbedded in syenite. Down the hill a few rods further, we find a vertical ledge of gneiss including warped and broken sheets of a siliceous schist. Some conception of the relations may be gained from the following diagram:

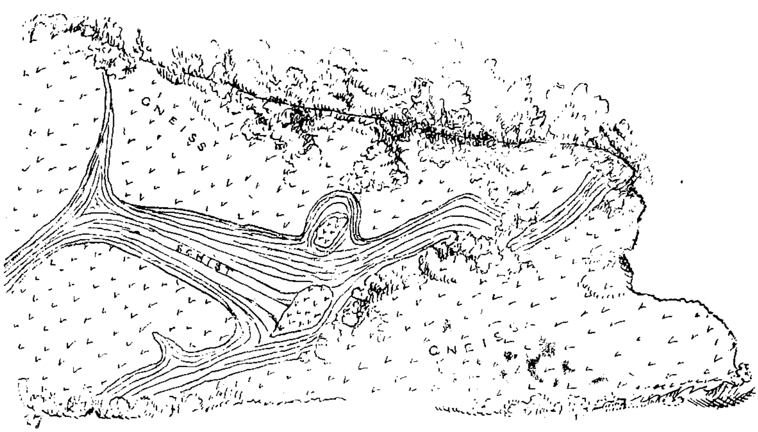


Fig. 17. *Relations of quartz schist and syenite gneiss, Gogebic Range, Michigan.*

This siliceous schist resembles some portion of the slates seen west of Colby mine; and this and the quartzyte spoken of as in contact with the syenite, may easily be the lower portion of that very series of slates.

In the above diagram, the isolated areas of syenite shown in the midst of the quartzyte may be the summits of bosses protruding through from the principal mass of syenite, and not as they appear, small masses wholly detached, and belonging, therefore, to the incidents of a fragmental process.

At the Iron King mine, it is said there is neither any well defined hanging or foot wall. The south country, where explored, is quartzyte, but the hanging wall is "paint rock." We find here two ore deposits. Between the north and south deposits are jasper and quartz and sand rock. The jasper is not red, but "gray-black." The distance between the two deposits is about 400 feet. The south deposit is also about 80 or 90 feet wide; but they have struck no regular hanging wall.

At the First National mine, the distance between the two deposits is 200 to 800 feet, and there is no good footwall on the north deposit

I noticed, about half a mile east of the Iron King mine (1104), close by the road, on the north, that exploring parties had thrown out a quantity of black slate (504) quite unlike any hitherto seen in the region by myself. It has the aspect of the Huronian black slate of Canada; but is strikingly distinct from any seen by me in connection with the iron deposits either of the Gogebic or Marquette region. It would be exceedingly interesting to learn whether this black slate is conformable with the ordinary ore-bearing schists of this range.

The foregoing detached statements from my note-book, must suffice. The evidence renders it probable that the rocks of the Gogebic Range are the geological equivalents of those of the Marquette region. Lithologically, the resemblances are close, and need not be here repeated. Their low position, removed but a few hundred feet from the crystalline rocks, is analogous. They have been subjected, however, to less disturbance; and hence occur in a continuous "range," with dip and order of stratification somewhat uniform. In respect to disturbance, they hold a position intermediate between the rocks of the Marquette and the Vermilion districts; but more resembling the latter. We find here, also, intimations of an overlying system, of contrasted character, and recalling, as at Marquette, the slates of the Huronian.

3. *The Penokee Gap.*—The railway from Hurley to Mellen makes sundry cuts through argillytes of dark and brown color, dipping north ward at an angle of 75° or 80°. One signal instance is less than a mile east of Hoyt. Toward Mellen, we see heavy, blue-black slates dipping N. 56° W at an angle of 80°.

After the classical study of the Penokee Gap which was completed by professor Irving in 1876, I had no expectation of making any additions to knowledge during my short sojourn there; but I deemed it important to become personal witness of the phenomena which he had described, with a special view to exercising an independent judgment on the question of the equivalency of the Penokee and Gogebic ranges. This question, in view of observations recently made by me in the original Huronian, and in the Marquette and Gogebic districts, had acquired for me a new and special interest. I wished to make a few examinations in entire freedom from prepossessions; and I therefore, dismissed from my mind completely, all recollection of conclusions enounced by the Wisconsin geologists. My notes were recorded exactly as if no other geologist had ever written of the Gap; and what I introduce here will be strictly a few excerpts from my field-book.

Arriving at Penokee station, I proceeded at once to the outcrop about three-fourths of a mile south, and carefully studied northward along the railroad. At the point where I began is a bedded formation dipping S. 22° E. at an angle of 88° to 90°. It consists of interstratifications of pale-reddish and blackish-gray bands. The dark bands (505) range in thickness from one-fourth inch to two feet. The pinkish (504a) are similarly variable, but constitute a large majority of the formation. Where the pinkish attain a thickness over one or two inches, they are intersected by sheets of the darker, and where the darker are of similar thickness, they are laminated by sheets of the pinkish. The darker, besides, are striped by paper-thick sheets of the pinkish; and, in the extreme of attenuation, the latter become resolved into separate grains disposed in planes through the dark bed.

When the dark beds are examined under the lens, they appear composed of a fibrous, almost scale-like, hornblendic mineral, which in places seems passing to mica, or an argillaceous scaly mineral—and with this, generally, more or less reddish orthoclase. So, it is neither hornblende schist nor syenite gneiss; but rather a hyposyenite gneiss.

When the pink bands are examined, they are seen to contain reddish grains of orthoclase and grains of glassy quartz. So they are essentially granulitic gneiss. But the pink rock varies in constitution, first, by admitting a sparse dissemination of the black mineral, then, so much of it as to constitute continuous films; second, by fusion between the quartz and feldspar, so as to form a petrosilex; and third, a fusion of the grains of feldspar by themselves, or nearly by themselves, forming a felsite (506–507).

The alternating bands of pink and dark rock are not entirely persistent, especially, when less than two or three inches thick.

The amount exposed at this outcrop is 30 feet.

Twenty rods north of this place, are beds having the same steep dip —almost vertical—consisting of pinkish, blackish and grayish alternating. The blackish (508) appears to consist of "nascent" mica and quartz grains, with a little orthoclase. It appears like hornblende schist passing to mica schist. This sort predominates. The blackest layers only, contain less feldspar and quartz. The pinkish are about the same as at the previous locality. The gray are the same as the pinkish, except that the orthoclase is white.

In this exposure are some beds very solid, under the lens containing a sort of groundmass apparently of orthoclase and hornblende, and in this, disseminated grains and crystals of some feldspar (508a). It is not a porphyry, nor even truly porphyroid; nor a complete porphyrel; but it approaches the last.

About twenty feet of this exposure are seen. Then the formation is concealed 60 feet; then an outcrop of the same, 10 feet; then concealed 50 feet.

About 125 feet from the last locality, toward the north, the formation dips 79° toward S. 7° E. having beds of alternating porphyrelloid and hornblende schist (509), with also thin beds of muscovite schist. The last contain some hornblende, and the other a little muscovite. Some of the pinkish rock continues in diminished amount. The thickness exposed here is about 180 feet, but the proportion of pinkish beds is in places increased, and the bedding is also in places thinner. The dip diminishes to 71°. For the next 12 rods north the rocks are concealed.

Twenty-three rods still farther north, occurs another outcrop (510) very similar to the last, dipping in about the same direction at an angle of 74°. The formation, however, though dark and dark-gray, contains less of distinguishable hornblende, and much more quartz;

and some heavy beds, though so dark colored, are essentially quartzyte (511). But others approach hornblende schist, and some contain many disseminated grains of reddish feldspar. The breadth of this outcrop is 200 feet. Then the rocks are concealed for 80 feet, to the bridge over the Bad river. This is the red truss bridge, and the second bridge south of the station.

Under the bridge, 300 feet from rock 510, is seen a vitreous quartzyte (512), dipping N. 22° W., amount 62°. The vitreous variety is under the north end. That under the south end is porphyritic (513). Here is a marked unconformity; but the exact junction of the northward-dipping with the southward-dipping rocks is concealed. The situation is shown in the following cut:

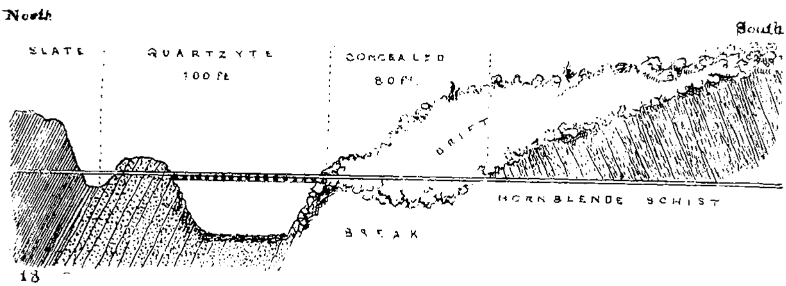


Fig. 18. *The unconformity in the Penokee Gap, Wisconsin. Looking east.*

The last rock seen going north, is at *a*, and it is so massive that no bedding can be detected; yet, in immediate contact, south, the dip is south.

Professor Irving reports limestone under the south end of the bridge, but I did not observe it. A thin bed may occur there.

Three hundred and eighty-three feet from the southern limit of this quartzyte is an outcrop of dark siliceous slates (515), thin bedded, and much jointed, dipping N. 25° W., amount 64°. They are highly siliceous toward the bottom, and more argillaceous above (516-518). In places, they are in compact beds four or five inches thick; in places, they become thin-laminated, and occasionally crumbling. They are an exact representation of portions of the Animike slates. The bedding on the whole, is very true, but there are occasional kinks and changes in dip. These slates are seen for 42 paces—126 feet—; then comes a concealed place, for 75 paces—225 feet.

The next outcrop (519), ten rods north of the bridge nearest the station on the south, is decidedly flinty or jaspery, and the beds contain a large percentage of iron. Though distinctly stratified, this outcrop is as hard and slippery on the polished surface, as a boss of steel. The outcrop is seen for fifty feet. In a position stratigraphically 100 feet above this, on the hill-side, is an exploratory shaft. It is carried down on the dip, and a large amount of rock (520) has been thrown out which is heavy with magnetite. But obviously, the experiment was made without knowledge. We have therefore, so far, 150 feet of magnetitic schists. The same formation, with diminished amount of magnetite, is traceable 200 feet from the locality by the river bank.

At a point five rods north of the railroad tank at the station, the iron formation is succeeded by black argillytes (521), also a perfect reproduction of the Animike. They are thin-bedded, little siliceous and strictly undisturbed. They are traceable 34 paces—102 feet—then comes a concealed interval of 168 paces—504 feet—to the first bridge north of the station. About half a mile beyond this is the next outcrop.

This outcrop is ten rods north of the third bridge north of the Penokee station. It consists of black carbonaceous argillytes (522) similar to 521, but a little more siliceous, and containing a multitude of small dark spots or specks of about the hardness of the slate. The specks weather out, leaving little cavities. The dip is here 64°, toward N. 23° E. The length of the exposure is 158 paces, equal to 474 feet. This is along the railroad, which runs N. 25° W. Hence the distance across vertically would be by trigonometrical calculation, 363 feet.

If the thickness this side of the bridge is 363 feet, and the same slate continues under the half mile interval north of the bridge at same angle of dip—giving, say, 1,760 feet, then the whole thickness of the slates would be

Magnetitic slates, (519)		200
Black argillytes exposed	102	
Black argillytes concealed, to first bridge	504	
Black argillytes concealed north of bridge	1,760	
Black argillytes, (522)	363	
		2,729
Magnetitic slates		100
Total		3,029

The 100 feet of magnetitic shists indicated above are the last part of the outcrop 522. Here numerous test pits have also been opened, but also without success, as might have been expected.

Beyond this outcrop I examined along the railroad about a thousand feet, and found no other exposure. The needle, of course, becomes very unreliable in this cut—varying to the extent of 50° one way and the other.

In this large cut north of the station there is much more physical disturbance revealed than in the one south of the station. In one place, the continuity of the strata is completely interrupted for a space of six feet on the east side; and on the west side, a disturbance such as indicated below has taken place.

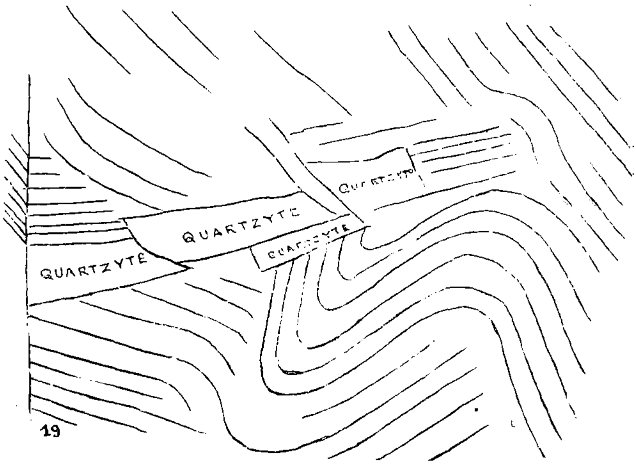


Fig. 19. *Contortions in the magnetitic schists at Penokee Gap, north of the station.*

Bringing the various observations into correlation and aggregating, it appears that we find in Penokee Gap 988 feet of strata dipping south and 3,480 feet dipping north. These figures, of course, do not indicate total thicknesses of formations.*

* The results of professor Irving's work in the vicinity of Penokee Gap may be found in the *Geology of Wisconsin*, vol. iii, pp. 94-5, especially. Atlas sheet xxiii. Plate xiii is a view of the second bridge south of the station. Particular descriptions of the rocks follow.

The firmly accepted conclusion of the Wisconsin geologists in reference to the equivalency of the magnetitic and carbonaceous slates of the Penokee Gap makes them a continuation of the hæmatitic schists of the Gogebic range. That is, they hold the formation in both regions to be Huronian. That the Gogebic iron-bearing strata are not Huronian, I feel prepared to affirm. And I cannot resist serious doubts of their equivalence with the Penokee strata, which strongly impress me as holding characters strikingly similar to those of the Huronian slates of lake Huron and the Animike slates of Gunflint lake and Thunder bay. This resemblance impressed me from the beginning; but I feel reluctant to controvert the judgment of the Wisconsin geologists.

But while I hold the decision in abeyance, I take the liberty to offer a few points for consideration:

(1). We discover the strong lithological resemblance referred to.

(2). The lithological characters are unlike those of the ore-bearing strata of the Gogebic, Marquette and Vermilion regions.

(3). The ore also is magnetic instead of hæmatitic.

(4). It is diffused through the laminated sheets of the formation, as at Gunflint lake, and not segregated in lodes, as in the other regions mentioned.

(5). A higher system of black slates, apparently unconformable on the hæmatitic schists, appears to exist in the Gogebic and Marquette regions, as it certainly does, in the eastward prolongation of the Vermilion schists.

(6). At the distance of 15 to 18 miles in a direct line S. S. E. of the Gogebic range, is a well known line of magnetic attractions, such as are exerted by the magnetitic schists of Penokee Gap.

(7). These lines of attraction, though as far as I know, they lie too far south, may nevertheless, when more accurately located, be found in the strike of the Penokee schists, especially if the great exposure a mile north of Penokee station affords a reliable indication of the strike; for that is S. 67° E. But this is probably disturbed somewhat by the great fault.

Should the Penokee slates be identified with the Animike (true Huronian), then the Marquette or Kewatin system, will be found underlying, and the juxtaposition of the Penokee slates with the (supposed) Laurentian schists on the south, may be due to an overslide accompanying the formation of the great fault. If the dislocation resulted from a horizontal movement, instead of an upthrow, then the strata on the east side must have slipped southward over 900 feet; and, if the movement was confined to the Penokee slates, they may thus have concealed a thin representation of the Kewatin which, on the identification assumed, is at present, wanting at this point.

§ 4.—OBSERVATIONS BETWEEN TOWER AND PSEUDO-MESSER LAKE.

On the portage from Mud lake to Burntside lake a fine-grained graywacke appears on the hill (523).

This formerly very bad portage, referred to in my report for 1886, has been improved by laying timbers lengthwise along the path through the long swamp. But the execrable portage on Mud creek has received no improvement whatever.

I embraced the present opportunity to complete my line of observations on the northwest shore of Burntside lake. (See Rep. 1886 pp. 37 and 206.)

N. W. ¼, S. W. ¼, sec 30, T. 63-13. Burntside lake. Graywacke schist continues, but here much intersected by veins of granite.

Island, N. E ¼, S. E. ¼, sec. 30, T. 63-13. Mica schist and gneiss interbedded. The schist also is much veined with gneiss.

N. W. ¼, N. E. ¼, sec. 30, T. 63-13. Main land north side. Gneiss and mica schist, but mostly gneiss. The schist is exceedingly fine-grained.

North point of small island, S. E. ¼, S. W. ¼, sec. 20, T. 63-13. Good muscovite schist.

North end of long island, N W. ¼, S. W. ¼, sec. 21, T. 63-13. Nascent mica schist. No mica distinctly formed, to the naked eye; but under the lens it comes out unmistakably.

The general tenor of the rock formation from here all around the north side of Burntside lake is indicated in the preceding observations. Most of the islands in the lake are of the same character. The outlet of the lake only, at the west end, and its immediate vicinity lies to the south of the great crystalline masses.

Proceeding eastward we find the portage from Long lake to Fall lake presenting near its eastern end, a remarkably bad condition. The last twelve rods are literally under water except at low stage.

At north end of portage from Newton to Fall lake the previaling character of the rock is as stated below; but this is quite different from that before seen in this vicinity. It is the old "talcose slate." (979.)

At Pipestone rapids at the entrance to Basswood lake (*Report*, 1886, p. 104) the quartz mass exposed last year in the middle of the stream was now found completely submerged and the water covered the br ad beach on the east side below the falls, quite up to the high bank. The volume of water appeared to be twice as great this year as it was last year in the same month.

Rock 524. Chlorite rock—"pipestone" from Pipestone rapids.

N. E. ¼, S. E. ¼, sec. 6, T. 64-10. At end of portage from Arm IV to Arm II, Basswood lake. The syenitic gneiss here contains many half rounded grains of nearly white feldspar; but the rock has a dark gray feldspathic groundmass disposed in a bedded manner. This itself apparently consists of finer particles of the same feldspar, with a decaying chlorite-like mineral. There is no hornblende present here. The rock is chlorite gneiss.

Proceeded over portage from Arm II to Arm III and by north side of the large islands in Basswood lake.

S. W. ¼, S. W. ¼, sec. 32, T. 65-8, as of Minnesota. North side of Sucker lake. The rock is a felsitic argillyte (525), hard and ringing, tending to split into thin laminæ. Thin scales are waxy-translucent. Many joints cross the vertical bedding.

The temperature of the air at 7 A. M. (Aug. 8) was 50° Fah. The lake was steaming, with a temperature of 57° near shore and 68° remote from shore.

The slate at portage out of Sucker lake is a dark argillyte. On Melon lake, the rock is also translucent on thin edges.

§ 5 —PSEUDO-MESSER LAKE.

Pseudo-Messer lake lies mostly north of the accepted boundary; though the canoe route commonly pursued passes through most of its longitudinal extent, and by the terms of the treaty fixing the international boundary, nearly half of the lake would seem to fall on the American side. The southwestern end of the lake rests on the boundary as recognized, and connects with Sucker lake on the west, and with a series of three small lakes on the east which lead into Knife lake (*Rep.* 1886, p. 142). The usual portage approach from Knife lake starts from the north shore at N. E. ¼, N. E. ¼, sec. 30. T. 65-7, (as of Minn.) and proceeding over a hill reaches a Canadian lake about a mile in length. A portage of twenty-five rods leads from this to Pseudo-Messer. The shores of the last mentioned are mostly surrounded by cliffs of slates presenting the usual appearance of the neighborhood of mica and hornblende schists; but the schists do not touch the shore even at the most northern point. The shore line is very irregular, rendering canoeing difficult, and toward the southern extremity are narrows located close to the east main shore.

S. E ¼, S. E. ¼, sec. 19, T. 65-7, (as of Minn.) On the portage north from Knife lake. Slates of dark color several times outcrop. The structure is nearly vertical and strikes N. 78° E. I looked carefully for bedding planes unconformable with this structure and found none.

N. W. ¼, S. E. ¼, sec. 19, T. 65-7, (as of Minn.). Near north end of portage. Gabbro occurs in a low exposure of 4 feet (974) and about 20 feet above the Canadian lake.

N. E. ¼, N. E. ¼, sec. 24, T 65-8, (as of Minn.). At end of portage from Canadian lake to Pseudo-Messer. Here are signs of approach to mica schist (975).

Believing the boundary of the crystalline schists to exist in the near vicinity, I made an excursion to the northern extremity of the lake.

S W. ¼, sec. 13, T. 65-8, (as of Minn.). North part of Pseudo-Messer lake, west side. The rock here (976) is a rough-weathering slate having the appearance and approximately the constitution of the chloritic rock at Kawasachong Falls (*Rep.* 1886, pp. 58, 60)—by some supposed eruptive

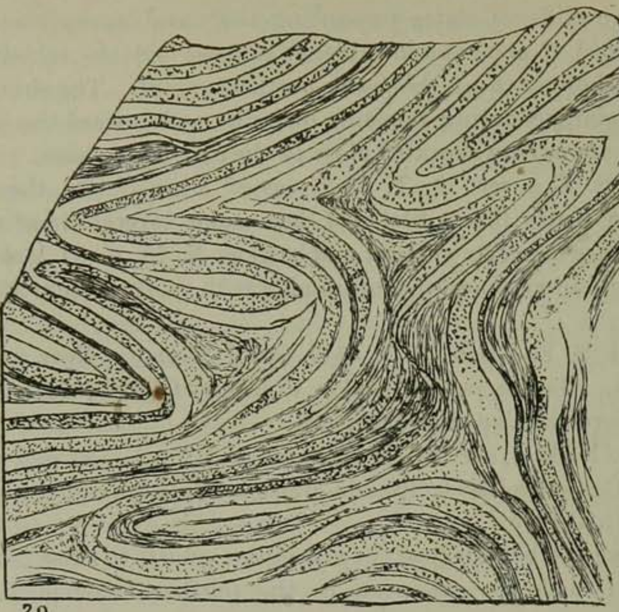
N. W. ¼, sec. 13, T. 65-8, (as of Minn.). Extreme north bay of Pseudo-Messer lake. The rock here preserves a similar aspect to the last. On islands near, it contains iron. Here is a cascade falling into the lake.

Rock 977. A sort of porphyrel.

Rock 978. Micaceous green rock, passing into the red rock of Kekequabic lake. Found on portage, not in place.

§ 6.—KNIFE LAKE (See *Rep.* 1886, pp. 142-4.)

Revisited eastern end of portage from Potato to Knife lake. Dark vertical slates (526) are here seen, varying from carbonaceous argillyte to siliceous and red jaspery schists excessively convoluted with bands of hæmatitic schist sometimes quite rich.



20

Fig 20. *Convoluted, jaspery and argillitic slates, west end of Knife lake.*

Similar slates continue eastward to Mokoman island, where they stand on edge and strike N. 72° W. They split into very thin leaves —even a sixty-fourth of an inch thick.

Arm IV (Knife lake).

N. W. ¼, N. W. ¼, sec. 27, T. 65-7, Knife lake, Arm IV. Very siliceous slate (527), not splitting readily. This is not felsitic. In color it is blackish-gray.

N. W. ¼, N. W. ¼, sec. 26, T. 65-7. Siliceous slate near the shore, compact and ringing, weathering white. Farther back, less hard, more slaty, composed of interstratifications of slate-colored bands and greenish bands. The latter are in places much bent and folded. The lighter bands weather poroditic in aspect, but they are really slaty within.

Rock 528. Flinty argillyte.

Rock 529. Siliceous argillyte.

Rock 530. Greenish bands in last.

Rock 531. From a bowlder.

N. W. ¼, S. W. ¼ sec. 24, T. 65-7, Arm IV, Knife lake. An outburst of diabase trending east and west, and forming a broad promontory on the south side of the Arm. The opposite shore appears to be slate.

S. W. ¼, S. E. ¼, sec. 24, T. 65-7. Siliceous slate.

S. W. ¼, S. E. ¼, sec. 24, T. 65-7. Large outcrop similar to that of rocks 528-530. The lighter-weathering beds, however, assume a conglomeritic structure—lumps of hornblende impacted in an argillo-feldspathic groundmass and weathering conglomeritic and very rough (533). But this is not the character of the Ogishke conglomerate. (Compare Rep. 1886, p. 412.) Rock 532. From the more compact and diabasic part.

S. W. ¼, S. W. ¼, sec. 19, T. 65-6. The same formation continues.

S. W. ¼, S. E. ¼, sec. 19, T. 65-6. Felsitic siliceous schist (534), hard and compact, pale greenish.

S. W. cor. sec. 20, T. 65-6. Felsitic siliceous schist.

N. W. ¼, S. W. ¼. sec. 20, T. 65-6. Mixture of diabasic slate and argillyte (535).

The rapids from Epsilon lake on the south can be seen descending a slope apparently 75 feet.

American Giessbach, N. E. ¼, S. E. ¼, sec. 20, T. 65-6. The formation here is a true argillyte. Crossed the portage here and looked into Epsilon lake (see § 33, Epsilon lake). Its surface is but ten feet below the crest of the dividing ridge at this point.

S. W. ¼, N. W. ¼, sec 21, T. 65-6. The rock approaches the character of the Stuntz island conglomerate in Vermilion lake.

This south bay or bifurcation of the IV Arm of Knife lake is surrounded by wavy topped and barren hills, reaching altitudes of 100 to 150 feet and over. They present precipitous faces toward the lake, often assuming a rude columnar aspect.

N. W. ¼, N. W. ¼, sec. 22, T. 65-6. Stuntz conglomerate. It contains no foreign pebbles, but only pebbly forms, especially on weathered surfaces, which seem to be little different from the general mass, and beneath the surface are merged undistinguishably in it.

N. W. cor. sec. 22, T. 65-6. Good dark argillyte (536) exactly like that at east end of Sucker lake.

N. E. ¼, N. E. ¼, sec. 21, T. 65-6. Felsitic argillyte (537), but approaching Stuntz conglomerate.

Memorandum. The Tower iron-mine blasts are audible here, a distance of 58½ miles in an air line, but nearly along the strike of the rocks. After many observations on these sounds during two seasons, I am convinced that the crust of the earth is the medium of transmission of the vibrations which at this distance produce the sensation of sound. But I have never noticed any second report transmitted through the air. I have remarked, however, that the sounds are transmitted to a greater distance *in the direction of the strike* than in a direction across it. This fact accords with observations on the transmission of seismic disturbances.

N. E. ¼, N. E. ¼, sec 20, T. 65-6. Stuntz conglomerate (538)—the constituent pebbles giving a faint porphyritic appearance.

S. E. ¼, S. E. ¼, sec. 17, T. 65-6. Rock (934) quite argillitic but the sedimentation lines are distinctly conformable with the schistic.

N. E ¼, N. E ¼, sec. 17, T. 65-6. Finely porphyritic schist (935).

N. E. ¼, S E. ¼, sec. 17, T. 65-6 A low entirely massive exposure of a rock (936) of porphyrelloid aspect, containing striated feldspar.

N. E. ¼, S. W. ¼, sec. 16, T. 65-6. Noryte, same as "Pulpit rock" noryte. Rocks 926-9.

Rock 937. Pulpit Rock noryte.

A few feet north of this appears a gray felsitic slate (938), having the aspect of the Vermilion slates, but the dip of Animike. The dip is southward 53° in a direction S. 20° E.

Searching to the top of the hill for vertical schistosity I found it, but the rocks are argillytes—black and gray interlaminated (939 Kewatin series?).

N. E. ¼, S W. ¼, sec. 16, T. 65-6. Gray feldspathic rock (940), similar to 938, but it contains angular fragments of black siliceous argillyte.

N. W. ¼, S. W. ¼, sec. 16, T. 65–6. Near the point.

Slate. Banded argillyte (941), with dip of 71° toward the S. 35° E. —the sedimentary structure corresponding with the schistosity. Supposed of the Kewatin series.

N. E. ¼, S. W. ¼, sec. 16, T. 65–6. In the narrows, south side.

Here a rock-mass apparently schistose vertically, but in quite a brecciated state, stands between two masses without discoverable schistosity. The one at the point shows structure-lines running but little east of north, with vein-like forms, but no true veins, and these faulted. This mass is only less brecciated in structure than the middle one; and I find some pebble-like portions isolated from the general mass. On the whole I shall set the rock down as Stuntz conglomerate. The formation weathers exceedingly rough. Rock 942.

S. W. ¼, N. E. ¼, sec. 16, T. 65–6. Flinty argillyte, dipping about south at an angle of 25°. There is no schistosity separate from the sedimentation (943). Query, is this Animike?

S. W. ¼, N. E. ¼, sec. 16, T. 65–6. Stuntz conglomerate forms the whole point.

N. E. ¼, N. E. ¼, sec. 16, T. 65–6. A mass of porphyritic character, having a granular feldspathic base and feldspar crystals. It is similar to Rock 936.

N. W. ¼, S. W. ¼, sec. 15, T. 65–6. In the southward bay, west side. Same sort of porphyritic rock. The cliffs rise majestically around the shores of this bay.

N. E. ¼, S. E. ¼, sec. 16, T. 65–6. A perpendicular bluff fifty feet high, broken in sub-columnar forms. It is still the porphyrelloid rock, closely related to Stuntz conglomerate.

The same formation uprises at the extremity of the bay, and walls in nearly all the southeast side.

S. W. ¼, S. W. ¼, sec, 15, T. 65–6. Inland, south of head of bay.

A lofty hill which at shore, is quite conglomeritic, but back from shore is scarcely more than the porphyrelloid rock so abundant. No certain schistic or bedding structure can be seen, but there is an ambiguous structure running N. 20° E. From such observations it appears that the Stuntz conglomerate, porphyrel, porphyrellyte and porodyte sustain close relations of structure, composition and genesis; and actually graduate into each other. The schistic condition of the porphyrellyte and the fragmental character of the conglomerate, appear as reminiscences of a sedimentary origin; while the massive porodyte and generally unbedded porphyrel reveal the nature of the changes to which all have been exposed.

Rock 944. Groundmass of Stuntz conglomerate.

S. W. ¼, N. W. ¼, sec. 15, T. 65–6. Mouth of little bay, east side.

The porphyrel is cut by a dike of diabase (945) 30 feet wide, dipping 85° northward, and trending N. 42° E.

Porphyrel continues to the eastern end of this northern bifurcation of Arm IV, Knife lake I do not make out any distinct system of bedding or schistosity. The rock-masses are rough, rugged, lofty and structureless; obscurely, however, there exists a series of vertical, but very irregular divisional planes, giving rise to rough and rude columnar and pyramidal forms; but every feature is irregular.

N. E. ¼, N. W. ¼, sec. 15, T. 65–6. A great boss of the same rock indenting the head of this Arm.

N. W. ¼, N. W. ¼, sec. 15, T. 65–6. A perpendicular bluff 100 feet high, which, from the fragments thrown down, appears to be irregularly bedded slate, some of which is bluish and some blackish.

N. E. ¼, N. E. ¼, sec. 16, T. 65–6. Porphyrel appears densely and neatly porphyritic.

The high range of bluffs along the north shore of the north bifurcation of Arm IV, as far as the narrows, is all formed by porphyrel, varying little in external aspect or internal structure. No schistosity is disclosed. Some of the bluffs present a wild and picturesque appearance.

S. E. ¼, N. W. ¼, sec. 16, T. 65-6. A high vertical bluff, a little different (945 bis). It is finely porphyritic, with a feldspathic groundmass, and inclosing slivers of dark argillyte.

S. E. ¼, N. W. ¼, sec. 16, T. 65-6. Slaty argillyte (946), mostly dark color, with schistosity and sedimentation planes dipping 73° toward S. 70° E.

S. E. ¼, N. W. ¼, sec. 16, T. 65-6. An enormous vertical mass of slaty material dipping 57° S. S. W. The sedimentary banding coincides. The slate is mostly dark, roughish argillyte interbedded with granular, grayish argillyte. Some portions have the hardness and fracture-look of diabase; but they are not truly diabasic.

Memorandum. I saw here a strawberry flower, and a ripe Alpine strawberry on the same stem—Sept 16.

S E. ¼, N. W. ¼, sec. 16, T. 65-6. A mass of slate dipping 55° toward S. 25° W., and intersected by a diabasic dike 15 inches thick, dipping 30° toward N. 25° E., and therefore, almost exactly at right angles with the slate.

Rock 947. Diabase from dike.

Rock 948. Slate in immediate contact.

Rock 949. General character of the slate.

Rock 950. Coarse material interbedded.

Rock 951. Fine dark diabase-looking rock.

Rock 952. Conglomeritic or brecciated portion of formation with many grains of glassy quartz.

The highest rock is 951.

Similar rocks form the entire promontory which faces the little bay on the north shore. On the north side of the bay the dip is about 80° south. For the next third of a mile, the shore is lined by large hills having the same aspect as these.

N. E. ¼, S. E ¼, sec. 17, T. 65-6. Chloritic argillyte (953), very irregular in structure and rough in weathering.

S. E. ¼, S E. ¼, sec. 17, T. 65-6. Black siliceous argillyte (539). The banding is conformable with the schistosity.

Glacial striæ S. 19° W.

There is no sign of a human being along these shores. The forest is primeval; the ancient moss clothes the ground.

Sleeping all night within sound of the roaring falls from Epsilon lake, I determined to visit them and obtain a photograph if practicable. I find the falls the finest that I have yet seen in northeastern Minnesota. There is a descent of at least 75 feet, down one continuous but broken slope, at an average angle of about 45°. I took three negatives under considerable difficulties, all of one scene about two-thirds the way down. A view of twice the length of cascade is glimpsed higher up, but a clump of ceders forms too serious an obstruction to chop away. The falls are visible from the lake, and present so much the aspect of the falls of the Giessbach from the lake of Brienz in Switzerland, that I propose to name these the American Giessbach. This bifurcation of the IV Arm is also of nearly the dimensions of the lake of Brienz, and is surrounded by a similar rampart of ancient rocks.

S. W. ¼, N. E. ¼, sec. 20, T. 65-6. Island near north side in front of the Giessbach. The slate hills on the north, with their steep fronts present from here a very impressive view, and I took a photograph.

S. E. ¼, S. E. ¼, sec. 17, T. 65-6. Stuntz conglomerate. The course now passes along the north shore of the IV Arm.

S. E. ¼, S. E. ¼, sec. 18, T. 65-6. A high and massive bluff of the nondescript sort of rock (540), which has heretofore been denominated Graywacke.

S. W. ¼, S. E. ¼, sec. 18, T. 65-6. An enormous talus fallen from a high bluff. Fine, bluish, dark rock (541), without conspicuous quartz, and looking somewhat like very fine diabase; but I think it a phase of the graywacke last seen.

N. W. ¼, S. W. ¼, sec. 24, T. 65-7. Graywackenitic rock (542), but a little more slaty in aspect than the rock 541.

Arm III (Knife Lake).

S E. ¼, N. E. ¼, sec. 23, T. 65-7. Portage from Arm IV to Arm III, Knife lake. The two arms are separated here by about forty paces, and we portaged over, with a view to working eastward toward Saganaga lake. No rock is in place on the portage, but I saw large bowlders of Stuntz conglomerate (543) and of graywacke. The conglomerate is obscurely porphyritic.

S. E. ¼, N. W. ¼, sec. 23, T. 65-7. Mouth of Arm III, Knife lake. Island Rock with a sub-slaty structure, breaking into cuboidal fragments, hard, with a slightly graywackenitic aspect, but on close inspection, proving to be a compact, siliceous slate. The sedimentary structure coincides with the slatiness.

Body of Knife lake.

S. W. ¼, S. W. ¼, sec. 14, T. 65-7. Flinty argillyte; but while the beds seem fixed and rigid in direction, *there are convoluted bandings*, indicating an original sedimentation-structure *unconformable with the schistosity*. The films limiting the bands are nearly black, while the bands are grayish-black and weather dark gray, with the aspect of a compact quartzyte. In thin section, under the microscope we find a very fine granular quartz base with many minute disseminated grains of a black opaque substance appearing anthracitic. In all these features it approximates the flinty schists of Gunflint lake, to be described hereafter. This very dark siliceous schist is represented by rock 544.

S. W. ¼, S. W. ¼, sec. 14, T. 65-7. This is only an eighth of a mile north of the last, but the rock (545) presents much the appearance of the Stuntz conglomerate.

S. W. ¼, N. W. ¼, sec. 14, T. 65-7. Island opposite mouth of Arm II, Knife lake. Sericitic felsitic schist (546) rising 75 feet above the lake.

N. W. ¼, N. E. ¼, sec. 14, T. 65-7. Mouth of Arm II, north side. Porphyritic Stuntz conglomerate; rock 547.

Arm I (Knife lake).

S. W. ¼, S. W. ¼, sec 12, T. 65-7. Bear Narrows, entrance to Arm I, Knife lake. Siliceous argillyte.

S. W. ¼, S. W. ¼, sec. 12, T. 65–7. Siliceous argillyte (548), massive, dark. Strike N. 72° W.

The strait into Arm I of Knife lake is two rods wide, swelling in the middle, and a perceptible current flows out.

N. W. ¼, S. E ¼, sec. 12, T. 65–7. On my first visit to this locality the rock was set down as "poroditic" and obscurely porphyritic.

Rock 549. Poroditic porphyrellitic rock.

On my second visit to the locality, I made the following observations: This rock, which is the same as I have seen in many places, especially around Knife lake, is closely related to porphyrel. (For use of term see Report for 1886, p. 159). It not only consists mainly of the groundmass of porphyrel, as I have seen it in Arm IV of Knife lake, but there are clear evidences of the incipient emergence of feldspar crystals from the mass. Thin scales possess a waxy translucency, and the whole base looks felsitic, but it is not hard enough for this, though what I have called felsitic schist, from Sucker lake eastward, is sometimes closely similar. I am unable to form in the field, a final opinion respecting its nature. It requires investigation. From macroscopic study I should say it is composed of argillaceous matter, feldspar and silica in varying proportions, with indications of a magnesian mineral. Perhaps it is parophitic. It seems to form essentially the groundmass of what I have called porphyrel, and for the sake of understanding myself, I will hereafter call this *porphyrellyte.*

This rock I think generally nearly destitute of free quartz, but sometimes I am sure quartz grains are present. When they give a marked hardness to the rock, or when a fine siliceous constituent causes the rock to abrade steel, it may be qualified as *siliceous porphyrellyte.* If argillaceous matter is also present, resulting in a moderate hardness, though free quartz be present, the rock may be characterized as a *graywackenitic porphyrellyte.*

Rock 954. Porphyrellyte from N. W. ¼, S. E. ¼, sec. 12, 65-7.

Rock 955. Slaty porphyrellyte. (Slatiness not much seen in this specimen.)

S. W. ¼, N. W. ¼, sec. 7, T. 65-6. A stupendous vertical cliff (956) at the lake front of a hill composed of what I have designated siliceous porphyrellyte.

N. W. ¼, N. W. ¼, sec. 7, T. 65-6. This point is composed of rock very similar to rock 954; but with somewhat the aspect also of the porodyte of Vermilion lake.

Rock 550. Poroditic porphyrellyte (provisionally).

N. W. ¼, N. W. ¼, sec. 7, T. 65-6. A good typical outcrop of the so-called porphyrellyte. Rock 957.

At this place I find fragments left by some other person, of a conglomerate possessing interest. The groundmass is a siliceous porphyrel, but the rock holds also rounded pebbles of a very dark color, apparently amorphous hornblende, and also pebbles of dark fine diabase. Yet the rock is not Stuntz conglomerate as seen in this region. It is, however, similar to Stuntz conglomerate seen on islands in Vermilion lake.

Rock 958. Conglomeritic porphyrel.

N. E. ¼, N. W. ¼, sec. 7, T. 65-6. On the northeastern shore of a small bay setting from Knife lake, First Arm. The land rises steeply to the hight of seventy-five and one hundred feet, and presents near the summit, as seen from the water two or three abrupt precipices. At the base of the hill, the formation is porphyrellyte (Rock 959). After an ascent of about 40 feet, gabbro is seen, quite characteristic, in places carrying magnetic iron ore. It has a vertical thickness of at least 50 feet. At the summit I was able to trace an abrupt break between the gabbro and the porphyrellyte. The line of junction traced on the surface, is shown on the following diagram:

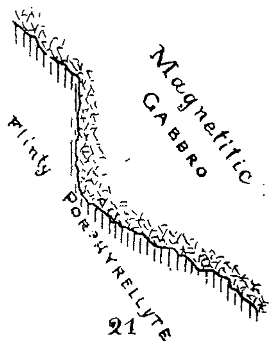


Fig. 21. *Junction between gabbro and porphyrellyte, Knife lake.*

The gabbro along the line of junction is magnetic; the porphyrellyte, flinty.

The relations here existing seem to indicate that the gabbro is an overflow over an old, already denuded surface.

Rock 959. Porphyrellyte from base of hill.

Rock 960. Gabbro with magnetite.

Rock 961. Flinty porphyrellyte, in contact with gabbro.

Rock 962. Magnetitic gabbro in contact with porphyrellyte.

Rock 963. Gabbro of prevailing character.

About twelve feet north of this line of junction, I find another. The porphyrellyte is the same mass as the other. The line trends differently; but this depends undoubtedly on the configuration of the porphyrellyte surface.

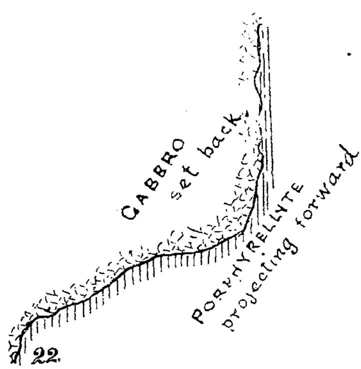


Fig. 22. *Another junction between gabbro and porphyrellyte, Knife lake.*

I find other lines of junction in exploring the summit of the hill northward. All the junctions are irregular whether traced vertically or horizontally. No appearance of a dike-form is seen. It is as if there had been a rough and irregularly rounded surface over which the gabbro had flowed. My conception of the relative positions of the gabbro and slate is represented by the following diagram:

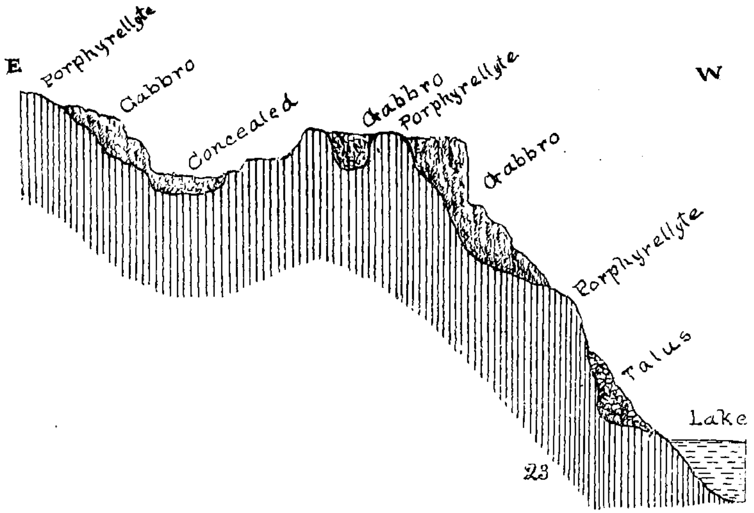


Fig. 23. *Relation of the gabbro and strata at* N. W. ¼, sec 7, T. 65-6 W., Knife lake. Section east and west.

Continued my observations in the contiguous hill still farther northward, and found the two formations alternating with a kind of irregularity entirely suggestive of the explanation embodied in the above diagram.

Extended the examination to the northern and highest hill. This mass is all porphyrellyte, in most parts somewhat slaty. It presents on the westward facing cliff, a rude columnar appearance.

It is not apparent why the gabbro should remain just here, and not be known on other parts of Knife lake so far examined—for I have seen nearly all the Minnesota shores of the lake. Of course, this apparent absence may result from insufficient investigation. It is also, an interesting question, why here, the highest summit is not covered, while the two lower ones are partially covered. Has the gabbro been denuded? or was this latitude above the level of the flow?

N. E. ¼, S. W. ¼, sec 6, T. 65-6. Porphyrellyte like 550 and 957-8, somewhat poroditic in aspect. Rock 551.

Portage eastward out of Knife lake. N. E. ¼, S. W. ¼, sec. 32, T. 66-6. Porphyrellyte—552.

S. E. cor. sec. 31, as of Minn., Canada. Siliceous slate, standing vertically, *with sedimentary structure corresponding.*

Coursed along the entire Canadian shore of this (First) arm of Knife lake.

S. E. part of sec. 1, T. 65-7, as of Minnesota. Porphyrellyte. Found along this Canadian shore nothing but siliceous slate and porphyrellyte in conditions more or less slaty.

At Bear narrows, the western entrance to Arm I, a line of rounded detached rock-masses extends across the strait. Geologically speaking it is not long since there existed here a continuous rock barrier, with only a cut for the drainage. Arm I was then a separate lake, and may have stood at a higher level. There were rapids then, connecting with the main lake.

Body of Knife lake.

From Bear narrows pursued the windings of the north or Canadian shore of the main lake, and laid them on a township plat. I thought perhaps this shore would extend to the crystalline schists; but it does not.

At the most northern point of Knife lake, Canada, the formation is gray, semi-argillaceous slate (964), distinctly but irregularly bedded

Slates varying from gray to dark, extend along the whole Canadian shore of the body of Knife lake. They rise in rounded hills from 100 to 200 feet in hight, presenting some deep intervening gorges and percipitous escarpments facing the lake. They are partly covered by small spruce and Norway pines, which have generally escaped the destructive burnings of the Minnesota side. The shore line is deeply and irregulary indented by bays, and cut by lofty and massive headlands and promontories stretching from a third to half a mile into the body of the lake.

S. E. ¼, S. E. ½, sec. 21, T. 65-7. Knife lake promontory, west end. This is a bold and conspicuous head-land, as seen from the western part of the lake in sections 21, 28 and 29. It is narrowly connected with main-land at the eastern extremity where we made a portage from the Fourth to the Third Arm. Its main mass is 150 to 200 feet high and has been denuded by fire.

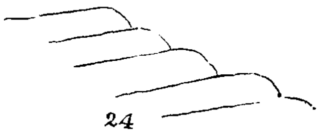
I first examined the second point from the north on the weathered face of the promontory. To my surprise, the rock found here is gabbro (963). It rises up from beneath the water-level, and continues uninterruptedly to the summit.

North of this rises a higher hill, with an escarpment also facing west. Between the two is a depression. I walked across to the high hill. At the commencement of the slope I found a greenish gabbro-slate (966) with grains of quartz-like hardness (olivine?)

To this succeeds a highly olivinitic (?) granular rock 967, consisting of rounded glassy olivine (?) grains imbedded in a gray-feldspathic matrix, breaking irregularly, and presenting on the fresh surface, many reflecting surfaces, and only partially a gabbrolitic aspect.

Quite at the summit of this northern hill, the rock is a coarse-grained greenstone (968). In tracing it eastward, however, along the promontory, it soon passes to gabbro again.

I find the surface presenting a succession of imbricating beds, about twenty inches thick, dipping northward at a low angle as shown below:



24

Fig. 24 *Imbricating beds of gabbro, summit of Knife lake promontory. Dipping northward.*

This feature suggests a succession of overflows from the south. The phenomenon is identical with that seen on the summit of a high head-land in lake Gabimichigama. See Halt 840, p. 171, Rep. 1886.

Within half a mile, I find gabbro with considerable magnetite. The rock also changes to a variety with a large proportion of white feldspar.

Rock 969. Magnetitic gabbro, Knife lake promontory.

Rock 970. Gabbro with white feldspar, Knife lake promontory. Here is a bluff of gabbro facing east, and a lower level of the promontory. I *presume* this is the place where the gabbro ends eastward; but I did not go down to the brush-covered level below.

Gabbro continues from the summit of the highest bluff down to the water's slope and below.

Rock 971. Gabbro from base of north bluff.

Rock 972. Purplish gabbro with much glassy olivine.

Took photograph of this promontory from a spot on the Canadian shore.

At the portage out of Knife lake, northward is a siliceous schist of dark color, almost pure flint. Rock 973. See further under Pseudomesser.

§ 7.—OTTERTRACK AND OAK LAKES.

Ottertrack lake lies wholly in T. 66, R. 6, W. It stretches from the southwest quarter of sec. 32 to the western boundary of sec. 24, with an average width of a quarter of a mile. The timber has been completely burned on the Minnesota side, but remains flourishing on the Canadian side. Both shores are walled in by massive hills of argillitic and graywackenitic slates intersected by numerous dikes of diabase. These hills attain elevations up to 200 feet and on the north shore present in places lofty vertical precipices, especially at the eastern extremity. Oak lake, so named from a few small oak trees at the eastern extremity, is about half a mile in length and lies wholly in sec. 24, T. 66–6. The soil-covered and arable areas near the shores of these lakes are very limited in extent, and in the absence of timber the region presents few inducements to settlement.

N. E. ¼, sec. 30, T. 66-6, (as of Minn.). North shore Ottertrack lake. Graywacke—a grand cliff fifty feet perpendicular, with a talus slope of thirty feet.

Rock 553. Fine textured graywacke.

N. E. ¼, N. E. ¼, sec. 32, T. 66–6, (as of Minn.). A mass of diabase (554).

Same sixteenth as the last. Graywacke again (555), but with a slightly slaty aspect.

S. W. ¼, S. W. ¼, sec. 28, (as of Minnesota). Canadian shore.

Rock with the aspect of graywacke, but when broken, feldspar crystals and grains are seen emerging from a feldspathic, chloritic groundmass, and glassy crystals of quartz are scattered here and there.

Rock 556. Chlorite gneiss, Ottertrack lake.

N. W. ¼, sec. 33, T. 66–6, Minnesota. Graywacke with clear small grains of glassy quartz disseminated.

Rock 557. Graywacke, Ottertrack lake.

S. E. ¼, sec. 28, T. 66–6, Minnesota. Tough, slaty argillyte (558), in places graywackenitic.

Near centre sec. 27, T. 66–7. Lofty cliff of dark, fine graywacke—rock 559.

N. E. ¼, sec. 27, T. 66–6. A presq'ile formed by a hill about 100 feet high. The rock is still graywacke.

S. W. ¼, sec. 23, as of Minnesota. Graywacke (560), with heavy beds dipping N. about 40°; but these do not appear sedimentary, and I do not find indications of sedimentary structure over any part of the cliff.

Much of the rock in this vicinity is massive slaty, and the hills rise 125 to 150 feet above the lake.

S. E. ¼ sec. 23, T. 66-6. Siliceous argillyte (561). These exposures are so lichen-covered that bedding features are concealed. Opposite this point is an imposing precipice 150 feet high.

N. W. ¼, sec. 24, T. 66-6, as of Minnesota. Siliceous argillyte like last, but sedimentary bedding is distinct (562), standing vertical and much warped.

On portage from Ottertrack to Oak lake. A ridge formed of rock with weathered surfaces strewn with white grains which prove to be crystals and fragments of feldspar, and some grains of flinty quartz. The groundmass is graywackenitic, with traces of slaty structure.

Rock 563. Porphyroid graywacke.

The portage is a third of a mile long and rough, ending in a swamp.

N. E. ¼, sec. 24, T. 66-6. Oak lake. Graywacke, fine and gray.

N. E. ¼, sec. 24, T. 66-6. East end of Oak lake.

Compact mass of grains of feldspar and glassy quartz in an imperfect groundmass of feldspathic character. In places a vertical bedding is visible.

Rock 564. Compact granulyte.

The route from Ottertrack to Saganaga lakes illustrates well a passage from argillyte and graywacke to gniess and syenite. We pass no transition from distinctly bedded to distinctly massive rocks. The bedding becomes obscure in the graywacke and the rock soon reveals itself as a groundmass in which emerge into view first obscurely and then distinctly, crystals and crystal fragments of feldspar. The rock is porphyritic, but the bedded structure is so evident that I distinguish it as porphyrel. Almost simultaneously individuals of quartz rise into view and we have a quartzitic porphyrel, or, with little groundmass, a granulyte. A little further on in this series of changes a chloritic constituent becomes apparent; and still further this is seen to be but an altered hornblende, and the quartzitic porphyrel has become a real syenitic gneiss. The bedding of the gneiss is demonstrably the prolongation of the porphyrel, the graywacke and the argillyte.

§ 8. LAKE SAGANAGA.

Lake Saganaga is in many ways interesting. It carries the boundary of the state farther north than at any other point east of the thirteenth range west—the boundary passing through the southern part of T. 67-4. The lake itself reaches into T. 68-4—if we extend into Canadian territory the United States system of geographical descriptions. With this understanding we may say the body of the lake stretches from the middle of T. 66 into the southern tier of sections of T. 68. But there are three southward stretching Arms of which the small westerly Arm reaches sec. 24, T. 66-6, the long middle Arm reaches Red Rock lake in sec 28, T. 66-5, and the easterly Arm reaches sec. 31, T. 66-4. In dimension from east to west this lake extends from sec. 24, T. 66-6 into sec. 23, T. 67-4, as nearly as I could estimate. This makes the extreme length of the lake from north to south of about twelve miles, and an extreme breadth from east to west of about eleven miles.

It must be explained, however, that locations extending into Canadian territory can only be regarded as rough estimates. As the Canadian territory has not been surveyed and platted, as far I am informed, the distances and configurations of the Canadian shores were laid down from the canoe by estimation while coasting along A good pocket compass was always in hand, and bearings were taken of salient points from each other. Such methods are of course, undesirable; but it seemed important to obtain as good a map as possible of certain parts of the lake.

Another interesting feature of this lake is its labyrinth of granitic islands and the intricacies of its deep winding bays and channels. A rough measurement of the shore-lines bordering Minnesota gives 48 miles. A similar measurement of Canadian shores traversed and platted gives 33 miles. Through T. 67-5 and 66-5, the Canadian shore not meandered, would amount to perhaps 15 miles. This would give a total shore line of nearly 100 miles, without reaching the island shores.

The country bordering the shores presents a succession of rounded hills rising to hights of 100 to 200 and 300 feet. The timber on the Minnesota side is mostly burned. What remains consists of spruce and Jack pines, with patches of poplar and white birch. Tamarack is also found in the swamps. The features of the country are carved out on a broad, bold scale The landscape is striking and abundant in scenic interest; but it is dreary and inhospitable.

The lake rests mainly in the indentatations and undulations of a syenitic surface. The Minnesota shores are all syenitic, except the most southern prolongations of the great central and eastern Arms, which attain the region of schists bordering the great syenitic mass. On the southwest is found a noteworthy conglomerate; and on a Canadian island near the eastern shore, a similar conglomerate. My exploration shows that most of the north shore borders on an area of earthy schists apparently of the same age and nature as those near Vermilion lake. The indications point to a continuation of these schists along the northwest shore, through Towns 67–5 and 66–5. Professor Irving reports schists also on the eastern side; but though I saw most of the eastern side I did not observe them.

The course of the observations through lake Saganaga begins at the southwestern extremity on the boundary, and proceeds eastward along the windings of the three southward bays to the portages or rapids into the adjacent lakes—Red Rock and Sea Gull, including Sea Gull river (so-called) and continues to the rapids out of Granite lake. From here, the whole Canadian shore is meandered through T. 67–4 (as of Minnesota) into T. 68–4, as I estimate, and thence about as far as sec. 10, T. 67–5 (as of Minnesota). The Canadian shore from here to the place of beginning was not visited.

The most intricate and interesting portion of the body of the lake is mapped on the following page, and the halt numbers within that limit are expressed on the map.

The formation at the entrance of Saganaga lake is similar to that near Oak lake, but here it weathers red. It is essentially a compact granulyte (565).

S. E. ¼, sec. 24, T. 66–6. In the small southward Arm.

Here the formation is mostly argillyte, striking in the unusual direction of N. 34° W., standing vertical, and alternating with beds of graywacke, very fine, sometimes aphanitic, and everywhere feldspathic. This is evidently a prolongation of the rock on Oak lake at sec. 24, 66-6.

Rock 566. Argillyte, quite characteristic.

Rock 567. Graywacke, interstratified with 566.

S. E. ¼, sec. 24. Extremity of bay. Porphyroid graywacke (568) like No. 563, on Oak lake.

Along the shore southeast of this bay, the rocks are very distinctly slaty, standing nearly vertical.

N. E. ¼, sec. 24, T. 66–6, on town line. Blueberry island. This is a quarter of a mile east of the termination of the portage. The granulyte of Oak lake (Nos. 564 and 565) assumes a very quartzose condition (569)—the grains of quartz at least two-thirds of the whole mass.

It will be interesting to note that from the region as far as the

Saganaga syenite is traced, large grains of quartz constitute a distinctive character.

N. W. ¼, S. W. ¼, sec. 19, T. 66-5. Chlorite syenite (570). The grains of quartz are large, angular and numerous, and on weathered surfaces stand out prominently. The feldspar exists in sub-angular patches, imbedded with the quartz in a groundmass which is mostly chloritic, and in places develops chlorite spots, while in other places, hornblende forms emerge into visibility. So, apparently, a syenite either appears or disappears. These characters I have learned to recognize as the borderland between schistic and gneissic areas.

Centre of sec. 19, T. 66-5. Chlorite syenite like the last. This rock here differs from the chlorite gneiss of Pipestone rapids, in having the quartz gathered in crystalline aggregates.

S. W. ¼, S. E. ¼, sec. 18, T. 66-5. Chlorite syenite, but with quartz crystals still larger (571). Here also are associated hornblende appearances.

S. E. ¼, S. E. ¼, sec. 18, T. 66-5. Chlorite syenite, with quartz weathering very conspicuous.

N. E. ¼, S. E. ¼, sec. 18, T. 66-5 Here the rock presents a fairly well developed hornblende (572). The isolated individuals of quartz are about one-third of the mass; and there are two varieties of feldspar—a pale, lemon-colored and a more abundant pinkish—the latter not well isolated.

Centre of sec. 17, T. 66-5. Syenite like last.

For the space of a mile along the direct coast from here no outcrops are observed.

N. W. ¼, S. E. ¼, sec. 9, T. 66-5. Syenite, the individual minerals all handsomely isolated—the quartz grains glassy and much the largest. Rock 573.

Great Middle Arm, Saganaga lake.

Centre of sec. 10, T. 66-5. This position faces the greatest body of the water. Here is an expanse of water looking northeastward, estimated at six miles in breadth. This is at the mouth of the great middle Arm of the lake, which from here has a general direction southward and southwestward. The formation is syenite, mostly porphyritically quartzose as before; but I find some portions with all the constituents fine.

Rock 574. Fine grained syenite as above.

S. E. ¼, N. E ¼, sec. 15, T 66-5. Syenite, still porphyritically quartzose. Blotches two or three inches in diameter have undergone a ferruginization.

This point is over a mile from 1177, the centre of sec. 10, 66–5, but several examinations of the rocks have been made, to find a continuous shore-line of syenite. Near this locality the sound of a cascade is heard in the stream coming in from the small lake in secs. 20 and 21.

S. W. ¼, S. E ¼, sec. 15, T. 66–5. Syenite with large angular grains of quartz

S. W. ¼, N E. ¼, sec. 22, T. 66–5. Syenite exactly as heretofore.

Centre S. W. ¼, sec. 22, T. 66–5. Syenite as before. It does not present a red appearance along the shores because lichen-covered.

Rock 575. Saganaga syenite.

N. E. ¼, N. E. ¼, sec. 28, T. 66–5. Syenite as before.

This Arm is indented by constantly occurring deep and sinuous bays and is studded with low syenite islands.

S E. ¼, N. W. ¼, sec. 14, T. 66–5. Island near mouth of middle Arm. A singular rock in an unexpected situation. From the water, on the east side of the island, white quartz is seen in considerable abundance. On examination I find some veins one or two inches in diameter; but most of the quartz results from the excessive abundance of the usual quartz grains. These are very unevenly disseminated—sometimes aggregated, and in places, nearly wanting. The rock itself is not, of course, a characteristic syenite. All hornblende has disappeared. A feldspathic matrix remains, with some green specks and spots, and the quartz is imbedded in it. Some of the broken surfaces of the rock have a sericitic lustre. The formation, on the whole, appears roughly bedded, with a dip of 63° toward S. 70° W. But this dip is not persistent. In places, the rough beds stand on edge —yet even here I suspect these are jointed prisms, since the southwest bedding can still, in some cases, be detected. The edges of the outcropping layers are a mass of small, lenticular parts packed closely together, and weathering exceedingly rough. This sort of rock extends along the east side of the island for eight or ten rods.

Rock 835. Quartz from island as above.

Rock 836. Samples of the formation.

Rock 837. Samples eight rods further north.

North end of the island. I considered it necessary to trace this peculiar formation further. At the north end of the island, the appearance is similar. The surface has a peculiarly brecciated aspect.

Rock 838. Sample from north end of the island.

Rock 839. Sample showing the weathered surface.

Rock 840. A rounded mass included in the rock.

By degrees, in approaching the northwest angle of the island, we find a condition of the rock (841) in which the feldspar weathers reddish.

To some extent now the formation is a granulyte. There is no other exposure on this island.

Little island one quarter mile southwest of last. The rock is ordinary syenite.

Point of main land east side. N. W. ¼, S E. ¼, sec. 14, T. 66-5.

Looks like ordinary syenite of the region. The quartz grains are rather large. The principal feldspar is reddish, and there is also a little whitish. The dark mineral is a dark greenish viridite with light green streak.

Rock 842. Viriditic syenite.

S. W. ¼, S. W. ¼, sec. 31, T. 66-4. North end of portage from Seagull to Saganaga lake. Syenite, unlike that at the south end of the portage. (See Seagull lake, rock 608). It contains small hornblende individuals.

S. W. ¼, sec. 30, T. 66-4. Island in so-called Seagull river.

The syenite here contains a predominance of small quartz grains, and somewhat sparsely scattered kernels of very large size—up to five-sixteenths, and rarely, half an inch in diameter.

N. W. ¼, sec. 19, T. 66-4. Saganaga syenite—609.

This so-called river is little other than a long irregular narrow bay setting southward from Saganaga lake. Still, it is somewhat more than that since a gentle flow of water sets southward and at the narrows a quarter of a mile further south, we find gentle rapids. The shores are very continuously hemmed in by rounded hills of Saganaga syenite.

S. W. ¼, N. W. ¼, sec. 17. T. 66-4. At the termination of so-called Seagull river. The last narrows half a mile south of here are set down as "Caribou narrows." Saganaga syenite (610) continues, but here with an increase of hornblende. The red feldspar is well isolated.

Near centre of sec. 8, T. 66-4 Syenite without coarse quartz, though the prevailing character along this shore is otherwise. This formation contains rounded pebbles of another variety of syenite composed mostly of hornblende (perhaps augite) and small disseminated quartz grains and little feldspar.

Rock 611. Syenite with pebbles.

Body of the lake (Saganaga).

S. E. ¼. sec. 5, T. 66-4. Saganaga syenite (coarse quartz) and also containing rounded pebbles of dark hornblende syenite as before.

Rock 612. Syenite with pebbles, as above.

N. E. ¼, sec. 4, T. 66-4. Island. Saganaga syenite, still with dark rounded pebbles.

In reference to the occurrence of water-worn pebbles in the syenite, compare especially Rocks 599-607 in Seagull lake, and Rocks 615-624 in Saganaga lake.

Syenite hills rise on every hand in all this region. The island in T. 67-4, Minnesota, consists of low syenite protuberances mostly not over 30 to 50 feet high, but others reach 150 feet.

Rapids out of Granite lake, Saganaga syenite (613). The quartz kernels are up to half an inch and more in diameter.

The rapids *seem* to be incorrectly located on the plat. They come in at the south extremity of the little bay, and *not* on the east of the bay. They form a pleasing view, and I took a successful negative of the scene.

Determined to make an examination of the Canadian shore, I sketched in as well as I could the configuration of the land on the same scale as the American township plats.

NOTE.—The localities at which rock samples were collected, indicated on the map of Saganaga lake by the original "halt" numbers, correspond to the rock numbers as follows:

1218	is the locality for rock	613.	1231	is the locality for rock	633.
1219	"	614.	1234	"	634-638.
1220	"	615-624.	1235	"	639.
1222	"	625-626.	1239	"	640.
1224	"	627.	1240	"	641.
1225	"	628.	1241	"	642.
1226	"	629.	1242	"	643-4.
1228	"	630-632.			

[N. H. W.]

Near centre of sec. 34, T. 67-4, (as of Minn.). A little island which from the surprising character of its geology I named *Wonder Island.* It is northwest of a smaller island, and northeast of an island rock.

Saganaga syenite. Rock 614. Kernels of quartz up to half an inch in diameter. Hornblende greenish-black, well isolated. Feldspar reddish and abundant. The formation contains occasional

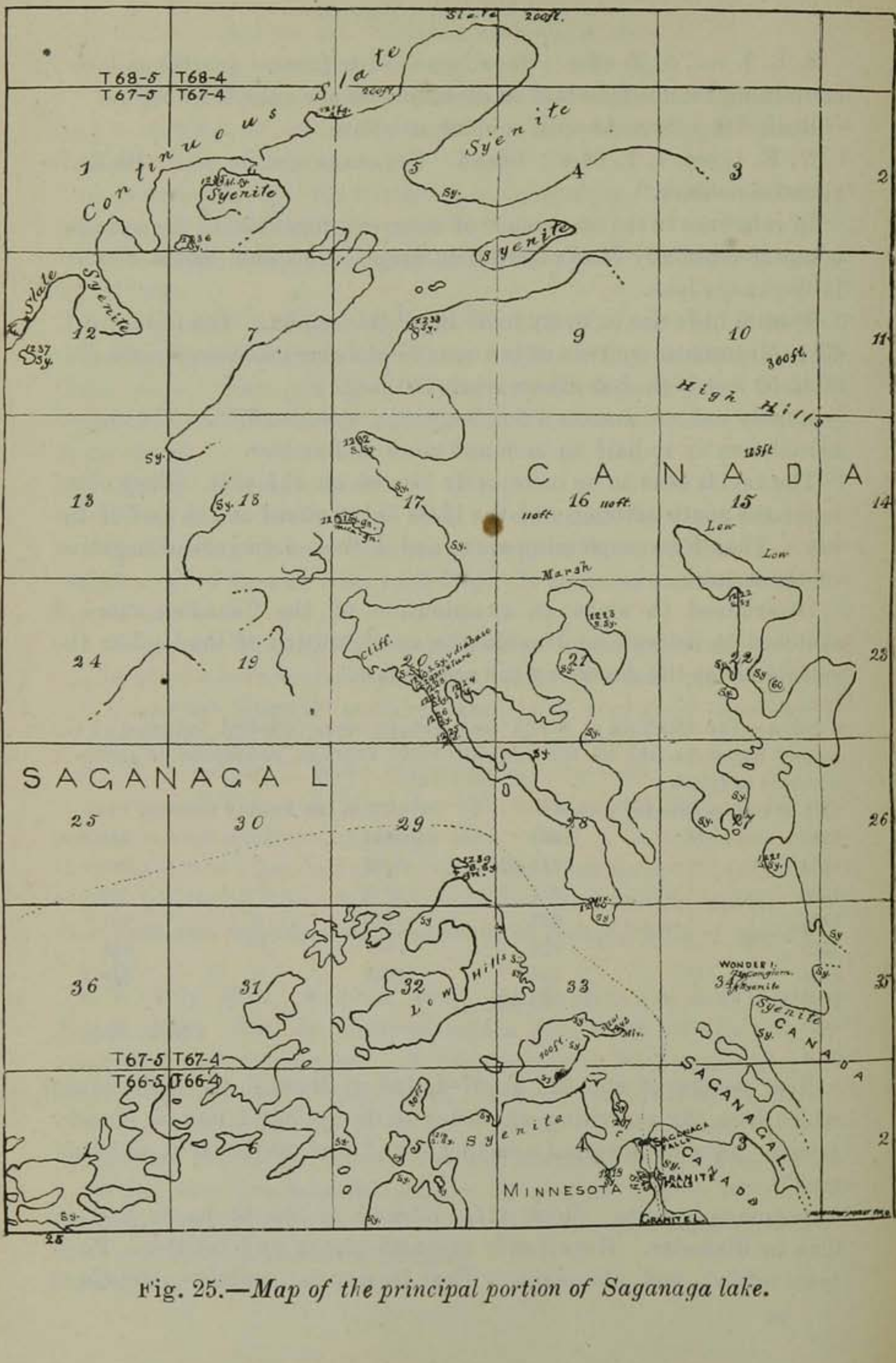


Fig. 25.—*Map of the principal portion of Saganaga lake.*

dark rounded pebbles, as before. This is at the south end of the island.

North end of Wonder I. near centre of sec. 34, T. 67-4, (as of Minn.). Here is a real conglomerate. Well rounded pebbles are crowded together as in the Ogishke conglomerate, and the general appearance is entirely like that of the Ogishke. But there is an important difference. The groundmass of the Ogishke is fragmental, though often highly altered. That of this conglomerate is regular syenite. A real conglomerate of rounded pebbles imbedded in a groundmass of typical syenite is certainly an extraordinary occurrence. I have never seen it before. I have never read of it. But if the thing is a fact, probably this is not the only place where it has been observed.

I copy here the suggestions made to my mind, and written down on the spot:—The inferences from the occurrence are important. A puddingstone like this is universally regarded as of fragmental origin. Not only that, but of origin through aqueous agency. The conglomerates associated with eruptive sheets on Keweenaw Point, once suggested to be of igneous production, are now regarded as due to aqueous agency. So, if this conglomerate is sedimentary in nature, the syenite groundmass must, at the time of the deposition of the pebbles, have been also, in a state of semi-fluidity under the influence of water. It may have been subjected simultaneously to energetic thermal action; but it was not in that state of fluidity which accompanies, and results from, recent eruption as molten matter from some deep source. This view of the origin of granitic rocks, I have heretofore maintained; and this remarkable observation is a gratifying confirmation of the correctness of the opinion.

The conglomerate is seen on the shore in two patches separated by a few feet of syenite, and with syenite on the other two sides. These patches emerge from beneath the water, and in the space of six feet, pass under the soil of the island. In one case, the conglomerate presents a thin edge landward, overlying syenite, as if it had been a sheet dipping northward at a low angle. But I do not consider this incident important; since I imagine that beds of pebbles may have been placed in any position whatever, in the progress of these movements which brought water-worn pebbles and real syenite in such extraordinary juxtaposition.

The following is a general plan of the phenomenon:

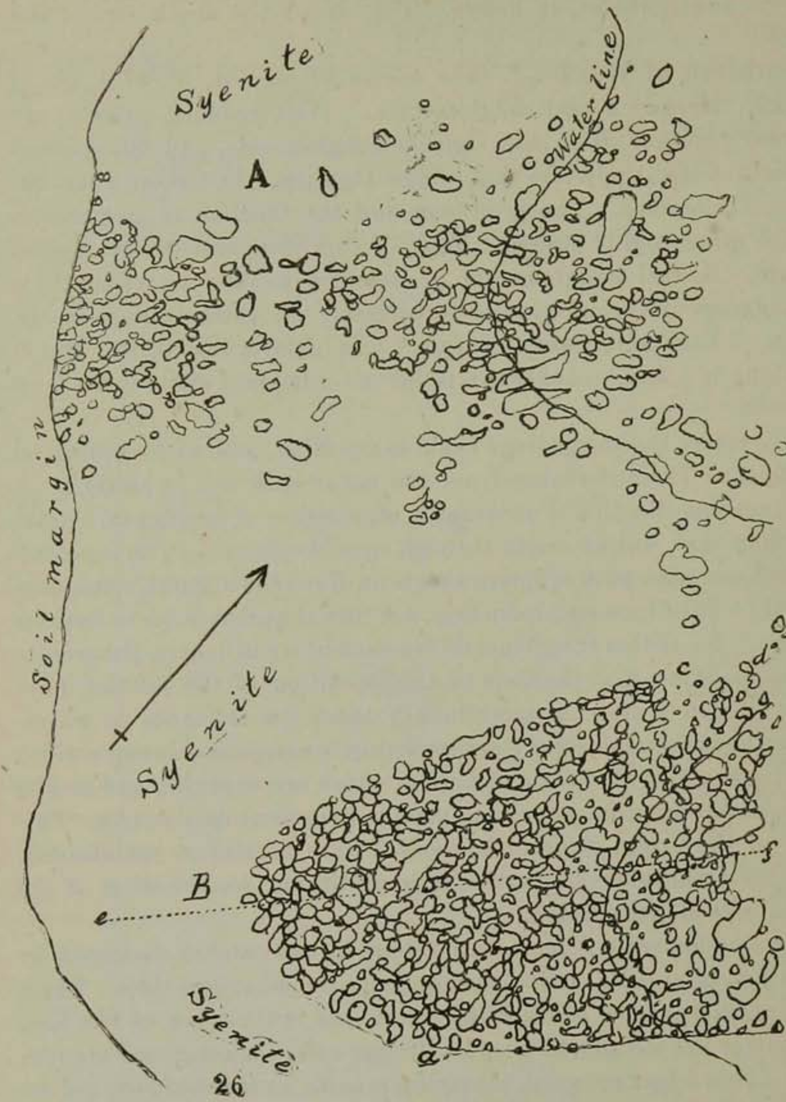


Fig. 26.—*Relations of conglomerate and syenite at Wonder island, east shore of lake Saganaga.*

Here are two patches of conglomerate, A and B. The first is about four feet wide, and the other, three feet. The separating syenite is ten feet—here shown reduced. The patch A graduates into the syenite on both sides; B is sharply limited, especially along the line *a b*, where a distinct joint appears between it and the syenite. From *c* to *d* this patch may be seen overlying the syenite, for the thin edge is broken away. Around the remainder of the border of B, the conglomerate appears to terminate with a thin edge, but it is so closely united with the syenite that it is difficult to say whether clean syenite underlies, as along *c d* or not. The appearance of B is as if a vertical section along *e f* would present the relations following:

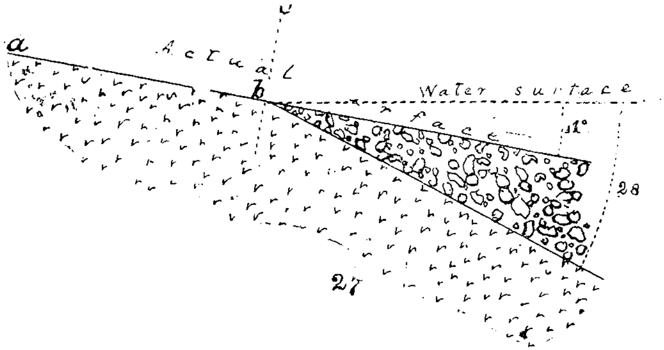


Fig. 27.—*Theoretical vertical section of the conglomerate, fig.* 26 *along the line e f in the mass B.*

These appearances may, however, be illusory. The lower limit of the conglomerate may not be as abrupt generally as it appears when the thin edge is broken away. Still, if it graduated downward into the syenite, some pebbles should exist to the landward of the termination at *b*, that is along the interval *a b*. But they do not exist. However, as before said, I base no important inferences on this appearance.

A single pebble *g*, appears beyond the joint *a b*, which separates the principal mass of conglomerate from the syenite.

As the diagram shows, the pebbles are more closely arranged in the patch B, than in A. It might at first be supposed that B was a bed of pebbles over which the syenite had been poured in a liquid state. But certainly, the other patch could not be so conceived. Here the pebbles are not supported by each other Evidently, they have been deposited in a paste dense enough to prevent their falling together. The epoch of the paste and that of the deposition were the same. The conglomerate and the syenite were put in place simultaneously. The syenite was not "erupted" after the conglomerate existed. The conglomerate was not laid down on the solidified syenite. I have seen on an island in Gabimichigama lake, a pile of angular fragments of "muscovado," over which gabbro had been poured in a state fluid enough to permit it to fill all the interstices among the fragments of muscovado. (Report 1886, p. 172,) But the pile of fragments was self-supporting. It was like a talus at the foot of a cliff over which water had been poured, and had congealed in all the cavities. This case is entirely different. Even though the mass B is more compact than A, it will be seen that it, even, could not have been originally a self-supporting mass of pebbles.

The pebbles are quite uniform in lithological aspect. They are uniformly dark colored, and in a rough way, would be called greenstones. I have endeavored, however, to make some field discriminations, with the following result:

Rock 615. Lamellar augite, in coarse agglomerations.

Rock 616. Lamellar augite in fine agglomerations, with a minute quantity of light feldspar disseminated in strings and grains.

Rock 617. Lamellar augite with conspicuous grains of feldspar.

Rock 618. Augite, feldspar and epidote.

Rock 619. A lamellar mineral, soft as talc or chlorite.

Rock 620. Pale green augite inclosing lamellar augite.

Rock 621. Augite hyposyenite.

Rock 622. Greenish, transparent augite in slender prisms.

Rock 623. Lamellar augite like 615, but of a pale green color.

Rock 624. Saganaga syenite inclosing above pebbles.

A majority of the pebbles are like 615, 616 and 617. There is no syenite, no quartzyte, no jasper, no sedimentary fragment. In one instance, I saw two or three large grains of quartz imbedded in a large pebble of 617.

This differs, therefore, from the Ogishke conglomerate both in the mineral character of the pebbles and the nature of the groudmass.

This is the only locality at which I have observed pebbles of this nature or any other, in such abundance in a matrix of syenite. Scattered pebbles seen heretofore in the syenite of this lake, but more especially in that of Seagull lake (as will be shown) are of a similar nature to these, and in my opinion have had a similar origin and similar history. However, in the E. ½ of sec. 7, T. 65–5, near the northwestern shore of Seagull lake a conglomerate has been reported to me by Mr. Frank Stacy as the Ogishke conglomerate; but it seems more probably of the nature of the conglomerate on Wonder island. The region referred to by Mr. Stacy is within the limits of the mass of Saganaga syenite.

I visited sundry other islands in the vicinity of Wonder island, but found no more conglomerate. Single black pebbles, however, are of frequent occurrence.

Proceeded to follow up the east shore of Saganaga lake, but after paddling two or three miles found ourselves at the head of a deep narrow bay. Returning from this we entered another deep sinuous bay reaching nearly as far north. From the head of this we returned nearly to Wonder island, and at length struck into a channel which proved to be the main passage to the north shore.

Sec. 27, T. 67–4, as of Minnesota. Main land east side. Saganaga syenite. The syenite is continuous along this shore.

Northern part of sec. 22, T. 67–4, as of Minn. Saganaga syenite (625). A few pebbles. A dyke of another syenite (626) three feet wide, striking N. 40 °W. and dipping N. 80°, contains much hornblende and little quartz.

The formation contains numerous rather angular pieces of dark rock which proves to be simply another syenite similar to that of the dike. The subject could not be investigated on the spot sufficiently to determine whether they are wholly identical with the dike-syenite. Their identification would create a problem of some difficulty, and the presumption is that the two syenites are not identical.

Sec. 21, T. 67–4, as of Minn.; near head of second winding bay. Saganaga syenite unchanged.

Sec. 20, T. 67–4, as of Minn. Saganaga syenite (627). The feldspar is mostly light colored. Contains some pebbles of diabase.

South part of sec. 20, T. 67–4, as of Minn. Rock very unhomogeneous. The greater part is a dark chlorite-hornblende, mostly with small grains of red feldspar disseminated through it (628) Much however, consists of red feldspar disposed in irregular strings, bands and vein-like forms. A good deal of epidote also, is gathered in the fissures. The rock presents a very ragged exterior, and easily chips to pieces.

A few rods further north. A ragged-weathering syenite, entirely different from the Saganaga variety. Composed largely of brilliant black hornblende with some feldspar disseminated through it, and occasional grains of quartz.

Rock 629. Black syenite.

Sec. 20, T. 67-4, as of Minn., Saganaga syenite. Near the last Saganaga syenite, with dikes and irregular prolongations of diabase (630), having shining, slender rods of hornblende and a little feldspar. This syenite weathers very rough.

Rock 631. Thin lamellar augite resembling the pebbles 615.

Rock 632. Red feldspar and chloritic hornblende, like 628. Near the last, centre of sec. 20, T. 67-4, as of Minn. This is a mixture similar to that of rock 628.

Centre of sec. 20, T. 67-4, as of Minn. Saganaga syenite and diabase, like rocks 630-32.

S. W. ¼, sec. 17, T. 67-4, as of Minnesota. Island. Mostly Saganaga syenite; but some of the formation is a micaceous gneiss (633), with minerals arranged in parallel beds. First mica seen on this lake.

Sec. 17, T. 67-4, as of Minn. Point of cape. Saganaga syenite. Breaks into huge cuboidal fragments.

Sec. 8. T. 67-4, as of Minn. Saganaga syenite.

Main-land of extreme north shore. Supposed near the northern line of T. 67-4. To the east of this a broad bay extends half a mile farther north. Here is a hill attaining an elevation of about two hundred feet. A range somewhat continuous extends east and west for four or five miles, having an aspect different from that of the isolated domes of the syenite, and differing also, in its dark color when seen from a distance. At this point it is a dark, semi-slaty rock. Climbing to the summit which is here about 200 hundred feet above the lake, the slatiness is in places quite marked, though tending to split in coarse fibrous forms, and not altogether in laminæ or sheets. It has marked cleavage in planes mostly S. S. W. at an angle of 75°. and hence approximately at right angles with the bedding, the dip of which is N. N. E It is intersected by veins of quartz.

Rock 634. Showing the slatiness.

Rock 635. More solid portions.

Rock 636. Showing the cleavage.

Rock 637. Showing warped, parallel lamination.

Rock 638. Quartz from a vein.

From this summit I see a range of hills about fifteen miles distant, following the horizon from a point S. 30° W. to a point S 10° E.—and less elevated, to a point S. 30° E. This is probably the "Giant's Range" showing the culmination of the syenitic mass separating the Kewatin slates of the north from the Kewatin and Animike slates of Gunflint lake.

An island in about sec. 6, T. 67-4, lying less than a quarter of a mile from the north main shore. This island is mostly syenite; but here, near the western end it is syenite mixed with chlorite syenite (639).

Another but smaller island southwest of the last judged to be within the same sec. 6, and lying but an eighth of a mile from the slaty main land. This is ordinary syenite.

A little further southwest a promontory half a mile long projects into the lake, and the main mass of this is syenite. But the main land continues slaty.

A small island supposed to lie in the western part of sec. 12, T. 67–5, as of Minnesota. This is good Saganaga syenite, with rude horizontal bedding, like some of the syenite seen on Basswood lake and elsewhere. (Compare Halts 440, 443, p. 99, Report, 1886.)

Supposed to be in sec. 11, T. 67–5, as of Minnesota. About a mile farther southwest. Slate continues, having about the same characters and same dip as described at the north extremity of the lake. It is intersected here by a dike of diabase and a vein of quartz.

There is good reason to believe that the same argillitic slate continues along the west shore of Saganaga lake as far as the national boundary where my observations began. The north and northwest shores mark the division line between the syenite on the south and the earthy schists on the north. I did not discover the existence of the usually intervening crystalline schists, but as the belt of these is in other parts of the region somewhat narrow, it cannot be affirmed that the earthy schists occur in immediate contact with the syenite. The chlorite syenite and chlorite gneiss seen at several points hold the usual intervening position. The micaceous gneiss seen on the island in sec. 17, lies very probably in the vicinity of mica—or hornblende schist. It is just as likely, however, to be a detached mass, since the ordinary Saganaga syenite lies between it and the north shore slates.

Thinking the north shore had been examined as far as my time would permit, I determined to strike directly across Saganaga lake for Saganaga falls, out of Granite lake. In passing among the labyrinth of islands in the southern part of the lake, I found to my annoyance several erroneous records of the land surveyors. For instance the blazes on the trees between secs. 31 and 32 read 32 and 33 in several places. But the meander corners between secs. 29 and 32 set things right. It is worthy of note that after traveling so sinuous a course from Wonder Island, without sight of a known landmark, with distances all estimated by the eye, and directions determined by a good pocket compass, the course ended at a point but little more than a mile distant from the calculated position.

Island 20 rods north of most northerly angle of Big island platted on

T. 67–4, Minn. Saganaga syenite and biotite gneiss (640)—the former prevailing.

Land on east of north side of Big island. Sec. 33, T. 67-4. The formation is mostly syenite, as on the contiguous island; but for the space of a quarter of a mile occurs the formation which I have recorded as "mixed." It is mostly a chlorite-augitic groundmass with a small quantity of light feldspar and a greenish mineral disseminated; in many places minute specks of a red feldspar, and some veins of this. Rock tough, seamed, not hard.

Rock 641. Chlorite-augitic rock.

East extremity of island southeast of Big island. Sec. 33, T. 67–4. Very ragged-weathering formation, consisting mostly of lamellar augite like 615, with grains of red feldspar sparsely disseminated, and numerous nodules from an inch to three inches in diameter of syenite composed of white feldspar, transparent granules of quartz and jet black crystals of hornblende. This, apparently, *is the rock which has yielded pebbles to the prevailing syenite*

Rock 642. Mostly lamellar augite in coarse agglomerations.

Near extreme point of same island, a few rods east of the last. A dike of white weathering feldspar with disseminated grains of quartz. Three feet wide, vertical. The feldspar is livid pinkish, not striated. This intersects a formation substantially like that described in connection with rock 642, but the disseminated red feldspar is in coarser grains.

Rock 643. Feldspar and quartz from dike.

Rock 644. Formation containing the dike 643.

Farther along and at the extreme point, the syenite is seen alternating and mixed with, the augitic rock.

§ 9.—GRANITE LAKE.

Granite lake, so-called, undoubtedly from the high conspicuous and rugged hills which environ it, lies in the midst of the Giant's range, and presents a physical aspect even more forbidding than Saganaga. The hills are not lofty, rising only fifty to one hundred feet above the lake; but they are mostly bare, with a massive, sterile expression as if the world had but recently been finished and vegetation had not yet taken root. But they bear nevertheless the evidences of vast denudation and reflection presents them to us as relics of a remote antiquity. The entire township in which the lake rests is a surface of rolling hills and domes with narrow marshes or clear lakelets between. It is distant only about two miles east from the eastern long arm of Saganaga; and Gull lake extends its head to within two miles of the principal bay of Granite lake. This lake lies wholly in township 66 of range 4 west, having a length of little more than six miles. Its average width is about three fourths of a mile, but in places it widens on the Canadian side to about two miles, and south of this, narrows to a simple stream interrupted by numerous rapids which will be described. In the midst of a long series of rapids leading out of Pine lake is a small expansion a third of a mile long which is named Basin lake. These features will be more particularly described.

From Saganaga lake the lower or Saganaga falls are passed by a short portage on the west side.

Portage at the upper, or Granite lake falls, S. E. ¼, sec. 4, T. 66-4. The portage is on the east side of the stream and about 28 rods in length. Parts of it are quite difficult, in consequence of rocky slopes. The landing and embarkation are also difficult. The rock is regular Saganaga syenite.

N. E. ¼, N. E. ¼, sec. 16, T. 66-4. Saganaga syenite, with quartz individuals a quarter of an inch in diameter. The western shore of the lake to here is quite direct and trends south. Syenite presents itself almost uninterruptedly. A few poplars and Jack pines are seen, and, on the low ground at this point, tamaracks and birch.

S. E. ¼, S. E. ¼, sec. 16, T. 66-4. Saganaga syenite continuously.

S. E. ¼, S. E. ¼, sec. 16, T. 66-4. Saganaga syenite in a much shattered bluff. The syenite along the shore weathers pale red.

S. E. ¼, S. E. ¼, sec 21, T. 66-4. Saganaga syenite. Occasional greenstone pebbles. The country becomes diversified with high rounded hills from fifty to one hundred and fifty feet in altitude above the lake.

N. E ¼, N. E. ¼, sec. 28, T. 66-4. Saganaga syenite.

S E. ¼, N. E. ¼, sec. 28, T. 66-4. A massive exposure of Saganaga syenite.

Near centre of sec. 27, T. 66-4. Saganaga syenite; rock 645.

The stream connecting the two portions of Granite lake is a broad, deep river, widening in the middle. By an abrupt bend in the stream the current sets south. The shores are lined with massive syenite containing coarse quartz.

S. E. ¼, S. E. ¼, sec. 22, T. 66-4. Near outlet of southern section of Granite lake. Saganaga syenite.

A fragment of slate lies on the shore which is identical with that north of Saganaga.

The syenite in this region is but very faintly red.

The surveyor's plat becomes again very treacherous. This lobe of Granite lake is represented as having a broad southern portion; and no rapids are laid down until we reach the southern extremity, in the northern part of sec. 36. Now, as a fact, the Canadian shore approaches the American in the southern part of sec. 26, and here are rapids an eighth of a mile long, flowing north. There we navigate. A distinct current flows also through the narrows on the line between secs. 23 and 26. Beyond, or south of, the rapids, we come into a broad stream, with a quite perceptible current, widening to an eighth of a mile; and in the midst of this we discover a meander stake to help us out. We examine one bearing tree and cannot make out whether it is 35 or 36. Very well, the other tree should decide. Alas, the other reads 25 or 26, and no one can tell which—such is the fidelity of the government surveyors. After studying the hieroglyphics of the first tree again and again, I conclude they read 35. Then those on the north tree must stand for 26. But the line between 36 and 25 is platted as passing along rapids—though east and west rapids. The configuration of the shores shows it impossible that we have reached these rapids. There are then long rapids not platted and in a place where the Canadian shore is represented two-thirds of a mile distant. Such facts, while they are not geology are some of the geologist's experiences.

S. W. ¼, S. E. ¼, sec. 26, T. 66–4. Near meander stake. Saganaga syenite.

N. W. ¼, N. E. ¼, sec. 35, T. 66–4. At rapids which also, are not on the plat—which shows Canadian shore half a mile distant. Saganaga syenite. Quartz exceedingly coarse.

These rapids are in two sections, altogether a quarter of a mile. The canoes were pulled up with considerable effort.

Rapids S. E ¼, N. E ¼, sec. 35, T. 66–4. These rapids also are not on the plat and they require to be portaged, though in going down stream, they may be "shot" in an empty canoe. The portage lies south of the rapids and crosses a point of land. It ends on a little lake, which from its form I named Basin lake. The syenite is the regular Saganaga variety which prevails throughout this region. The syenite generally about here, weathers white.

Basin lake is half a mile long and a quarter of a mile broad lying in the N. W. ¼, sec. 36, T. 66–4. At the end of this are other rapids not on the plat. These appear to be the lower of a series of four rapids—the others platted—which occur in a northward bow of the stream. We manage to flank all these. From a little bay at the southeast corner of Basin lake we pursue an indistinct trail southeastward and along a difficult route, shunting a big syenite hill on the right, and in about a quarter of a mile, reach a little lily-bearing bay opening southeastwardly into a small lake in the southeast part of sec. 36, which proves to be the northern extremity of Pine lake. So we escape four portages, but lose fully a mile of coast line.

§ 10.—PINE LAKE.

Pine lake lies in the southeastern part of T. 66-4, W. and the northeastern part of T. 65-4, W. Its length is about two and a half miles, with an average width of a third of a mile, with narrows and rapids at about mid-length. Its entire shores are bound by massive syenite not greatly elevated above lake level. The vegetation possesses no importance.

N. E. ¼, S. W. ¼, sec. 36, T. 66-4. Twin-Bay portage from Pine lake to Granite. High cliffs of the Saganaga syenite (646). Most of the feldspar is white, but some is pale pink. Generally, it is not well isolated. There are greenstone pebbles in the syenite.

The high hill south of this portage and crowding upon it was ascended, on a second visit. I found the usual east-west structure. The quartz individuals, however, were not generally elongated.

N. W. ¼, N. E. ¼, sec. 1, T. 65-4. Near foot of narrows and rapids of Pine lake. The Saganaga syenite has here a jointage structure running east and west, and it seems to be dependent on a system of foliation. This jointage, then, is conformable with the prevailing bedding system of the schists of the country.

N. W. ¼, N. E. ¼, sec. 1, T. 65-4. Near the rapids, on the upper or southerly side. Saganaga syenite (647)—the quartz coarse and conspicuous—the feldspar a groundmass.

These rapids are not on the plat, and it is difficult to ford them.

About half a mile from the southwestern extremity of Pine lake, the sound of a roaring rapid is heard; and here the Boundary river comes in from the east. The portage out of Pine lake is about an eighth of mile south of the stream, and leads in the space of a third of a mile to the southern extremity of a bend in the river.

§ 11.—BOUNDARY RIVER.

The entire chain of small lakes and connecting streams lying along the international boundary may be viewed as simply a stream serving for drainage of the region; but on the nearly horizontal general surface expanding at frequent intervals, to fill the basin-shaped depressions which dot the surface of the crystalline and schistic rocks. There are two of these rivers. One flows eastward and southeastward into lake Superior; and the other flows westward and northwestward into Rainy lake. The dividing ridge between the headwaters of these two streams lies between North and South lakes at an elevation of 1,097 feet above lake Superior, as barometrically determined by Prof. N. H. Winchell.* It is the westerly stream which I have designated the Boundary river. The other is the Pigeon river. The international boundary does not in all cases correspond with the position of these rivers. It follows, in accordance with treaty, the usually traveled canoe route, and this makes several short cuts.

The length of the Boundary river from Gunflint lake to Pine lake, is less than three miles by its windings, and in a straight line it is not over two; but its course is zigzag and the stream is interrupted by half a dozen rapids. It flows through the most desolate and rugged portion of the Giant's Range. Bald syenitic summits rise fifty to one hundred feet above the stream, and in many regions the surface is studded with the blackened erect trunks of the recently burned Jack pine forest. Frost has broken down the ancient precipices, and the ruin of the mountains contributes its weird effect to the impression made by the ruin of the forest.

N. E. $\frac{1}{4}$, N. W. $\frac{1}{4}$, sec. 12. T. 65-4. Disappearance of Boundary river. This point is shown in figure 28.

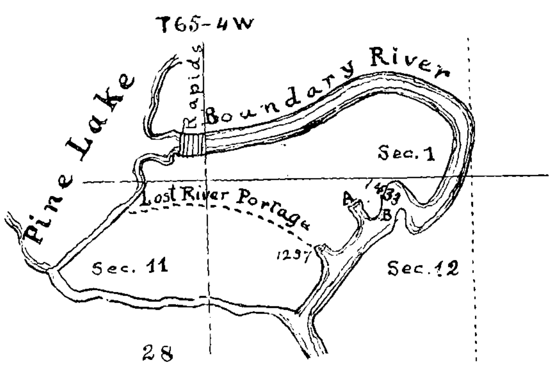


Fig. 28.—*Map of Boundary River showing point of Disappearance.*

* Ninth Annual Report, Minn. Sur. p. 89.

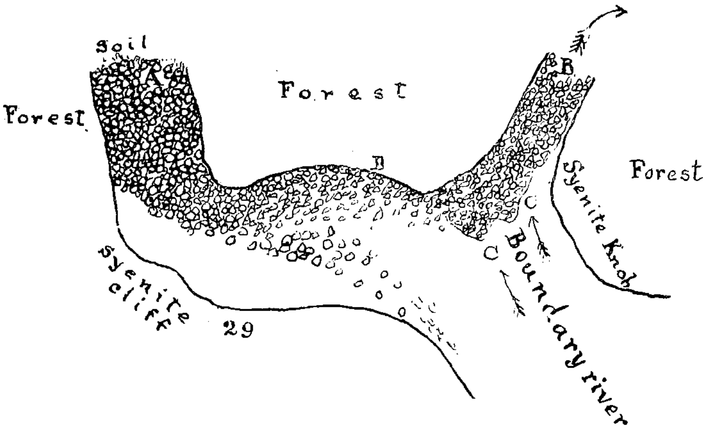


Fig. 29.—*Bowlder-filled ancient channel of Boundary river.*

At the place indicated a singular accumulation of bowlders is seen (A. fig. 29) rising apparently in a cobble stone wall to a hight of about fifteen feet above the water.

This is the appearance as seen in perspective at the distance of about twelve rods toward the south. On approaching nearer the surface exposed to view is seen to be not a wall but a slope of about 20°, and the curious effect is discovered to be simply that of a mass of bowlders filling what is probably an ancient bed of the stream. The bowlders are quite uniformly about ten inches in diameter. The right and left borders of the bowlder-filled bed are abruptly limited by vegetable growths, and a well developed forest surrounds. The farther limit is also sharply determined by a fringe of sedges and a forest covering, as shown in figure 29. Standing water approaches the foot of this slope, but no current whatever sets toward this old channel.

On the contrary, a channel, B., filled with bowlders through which the stream actually flows goes out toward the northeast. The water here entirely disappears. I obtained good photographs of both channels.

I imagine that this is the place of the old preglacial channel, and that through the agency which transported the bowlders, it became filled. I imagine that for ages, the spaces between the bowlders remained sufficiently open for the water to flow through. By degrees, however, accumulating *debris* choked the spaces, and a soil formed at the top, which became overgrown with the forest. The mass of bowlders now seen is what remains uncovered by the soil. Vegetation has encroached upon it from the sides, as fast as the soil could find resting place.

Hence the sharp lateral limits of the bowlder-filled space, as indicated at the surface. On each side where the forest stood before the burning, the bowlders are seen to be exceedingly numerous wherever the soil is removed; and hence I infer that the ancient channel was broader than the space now remaining uncovered by a soil.

The channel B must have been filled in a similar way; and this also must have been preglacial. Supposing the two channels contemporaneous, it was an island which lay between them. The existence of alternate channels rendered it easier for the first to become choked; since, as soon as a hindrance was experienced by the water passing through it, the other may have remained available for the passage of an enlarged flow.

It appears inevitable, however, that the second channel should in time become choked; and then, as no alternative channel remains, the stream will flow over the surface of the bowlders in channel B. In fact, the absence of soil over that surface indicates that already, at times of flood, a portion of the water is carried off by a surface flow.

N. W. ¼, N. W. ¼ sec. 12, T. 65-4. East end of portage from Pine lake. Saganaga syenite (648) in full character. Much of the feldspar is pale red, and forms a crystalline mass in which the hornblende and quartz are imbedded. Some of the hornblende is partially chloritized, and crumbles under the finger nail.

Blueberry cascade and Portage, N. E. ¼, S. W. ¼ sec. 12, T. 65-4. Here is a small U-shaped bend in the river, opening south-southwest, and a portage of 20 rods passes across the opening. Here a long cascade comes roaring and foaming tumultuously down over the straggling fragments of the shattered contiguous syenitic slopes. Of this I obtained a good photographic view. The ruined hillslopes appear in every direction, and the black trunks of the sparse dead forest stand bristling along the hill-crests and lie in impassable tangles across the stream. I obtained also a good view of one of these shattered slopes.

Sterile as the region seems, it sustains an amazing growth of blueberries. One single stem bore hundreds of large and savory berries, and of this I also prepared a photograph. This crop appeared to be in full maturity when we camped here on the seventeenth of August; but it was apparently undiminished and unimpaired when we returned on the eighth of September.

Immediately above this bend in the river we encounter other rapids. These we ascend with difficulty. Syenite lines all the shores. Now follows a quiet lake-like stretch of three-fourths of a mile, and then we come to falls.

N. E. ¼, N. E. ¼, sec. 13, T. 65–4. Gunflint falls, upper (south) end of portage. The falls are wide and quite precipitous. The portage lies on the east side. Took a photographic view. The formation is Saganaga syenite. The dark mineral however, is *arranged in courses*, and the rock is truly gneissic (649). The hornblende too, is a little chloritized. The quartz grains are large but not enormous. The strike of the gneissic structure at this place is N. 80° E. The strike of the Kewatin slates where seen at sec. 22, 65–3, (as of Minn.), is N. 72° E.

The syenite here is intersected by a dike of rather peculiar diabase (822) crossing the strike.

A few rods further up the stream other rapids intercept our course, but with labor and risks we pole the canoes past them. And now the stream gradually widens into the northern arm of Gunflint lake.

§ 12.—GUNFLINT LAKE.

Gunflint lake lies on the international boundary. The American shores are included chiefly in township 65–3, west; but they stretch eastward into T. 65–2, and westward into T. 65–4. Its extreme length is nearly eight miles, with a mean width of about a mile. Its longer axis is nearly east and west. North of the western end is a considerable expansion, connected with the main lake through the "narrows," which furnish an exit northward for the drainage. This expansion extends east and west into two bays the eastern one of which I have named for reason, Black Fly bay. The width of the expansion here is over a mile and a half. The distance from Gunflint falls southward to the Narrows is one mile.

The land on the Canadian side not having been mapped nor the shore line meandered, I have referred Canadian localities to their places in the United States survey, as if extended beyond the national boundary. I have also laid down as nearly as they could be estimated, the meander lines of the Canadian shore. Relative positions of principal points have been ascertained by taking bearings with a good pocket compass. These methods, of course are rough and unsatisfactory; but one on the spot can certainly form a conception of the situation more correctly than the reader who has not been there and has no maps to assist him. With such approximation I have presented here a map of Black Fly bay, a map of Animike bay on the extreme west, south of the Narrows, and a map of that portion of the body of Gunflint lake which is geologically of greatest interest.

The physiographic environment of Gunflint lake is wild and picturesque. It lies in a rugged valley between the Giant's Range on the north and the Mesabi Range on the south. The former stretches westward to Seagull and West Seagull lakes and eastward with a tendency northward, far into the interior on the Canadian side. This is seen lying in the southern horizon from the high elevations north of Saganaga lake. The Mesabi Range extends equally far toward the east and west; but its main mass lies nearer the lake than that of the Giant's Range. The sky-line of the Giant's Range is undulating and soft; that of the Mesabi, notched, jagged and precipitous. As we enter the body of the lake through the Narrows, one of the cliff-crowned ridges of the Mesabi Range lies in front. This fades eastward into a high pass and this is bounded by a vertical wall on the east, above which rises the massive continuation of the Range, crested characteristically by a columniform precipice. This Range, precipitous on the north, slopes gradually to Loon lake, a mile distant southward. Five miles from the western extremity of the lake appears another pass over which lies the portage to Loon lake and southward. The lake terminates eastward in a broad valley furnishing exit by Gunflint river to North lake. On the north of Gunflint lake stretch massive ridges of earthy and crystalline schists, trending diagonally east-north east. Behind these rise the higher ranges of gneisses and syenite.

The entire surface on the Minnesota side has been burned over, with the exception of limited areas. A memorandum on the surveyor's plat states that the burning occurred in 1860. Subsequently the trembling aspen and to a less extent the white birch, have taken possession of the soil-covered areas, especially along the lake shores. Seen from the lake the surface of this young forest of thickly studded and verdure-clad trees presents the appearance of a vast meadow which it might be a holiday pastime to traverse; but the geologist who draws near to this meadowy surface with the intent to pass beyond to the brown cliffs which frown upon it from the hights, will encounter steeps and slides and rocky walls and angular taluses and interwoven branches all conspiring to render his ascent slow and laborious. Along the northern side much of the original forest remains, but fallen trunks and thickly tangled bushes render travel even more difficult than on the American side, until we rise above the soil-covered areas to ridges of bald schists and syenite.

The shore-line on the southern side is little broken or indented. One well-marked peninsula occurs and another broader-mouthed, determined by subordinate ridges of the Mesabi Range. On the north, however, the shore is deeply indented by bays and promontories.

This lake, according to the barometric observations of Prof. N. H. Winchell lies 1,052 feet above lake Superior.

Geologically Gunflint lake possesses interest which is destined to render it a classic region. It touches the confines of three unconformable systems of Archæan rocks, and brings to light facts which may probably serve to relieve many of the difficulties which have beset the investigation of the ancient formations of America. The Giant's Range on the north is composed of syenite and syenitic gneiss, the slopes of which attain the lake shores around parts of the expansion. These are flanked by crystalline schists which probably abut obliquely on the lake and these are succeeded by vertical earthy schists forming ridges which run obliquely parallel with the north shore and exhibit an instructive passage downward to the mica and hornblende schists and gneisses. These earthy schists retain all the characteristic petrographic and structural characters of the argillytes and sericitic schists occurring on Knife, Fall, Long and Vermilion lakes; and are also identical in physical characters with the vertical slates seen north of Saganaga lake.

In the immediate vicinity of the massive outcrops of these vertical slates occur the black, carbonaceous, flinty and magnetitic slates plainly identifiable with the Animike formation of Hunt, and equally demonstrated by my own observations, to be the same system of rocks as by Murray and Logan were named Huronian. But these possess but a gentle dip toward the south and are abruptly unconformable with the Vermilion and Gunflint slates. They are equally diverse in petrographic characters.

Finally, a fourth vast formation, later in origin and eruptive in character, occupies most of the surface along the south shore of the lake. It crowns and characterizes the hills of the Mesabi Range, forming high columnar precipices rising above perpendicular cliffs of Animike black slate facing north, and sending down numberless taluses of angular fragments sloping steeply toward the lake shore. The same eruptions which flooded the country on the south of the lake extended to the north. The columnar hill-crests resting on nearly horizontal Animike slates occur near the western end of the lake and at several points thence eastward; but they occur also resting on the vertical slates, as seen at the great promontory of Knife lake and again on sec. 7, 65-6 on Knife lake. But, in the vicinity of Gunflint lake, the gabbro has not been found covering syenite of the Giant's Range.

This lake under the name of "Flint Lake" appears to have been traversed by Dr. Norwood in 1849; but there is difficulty in identifying his facts and localities. The formation which I here describe as Animike slate is by Norwood styled "slaty hornblende" and another rock is called "hornblende rock;" and this is represented between the slaty hornblende and a "quartz rock" described as "a short distance below" the slaty hornblende. He recognizes on the north shore a ridge of "siliceous slate somewhat chloritic," with stratification not discovered.* A reconnoissance was made along the international boundary in 1880 by professor N. H. Winchell and he has given a comprehensive general view of the geology. He noted the unconformable vertical schists on the north shore † To this subject more particular reference will be made.

More recently the shores of Gunflint lake have been examined by the geologists of the U. S. Geological Survey‡ and to their published results more especial reference will be had in my details of observations.

The report of my field observations in the vicinity of Gunflint lake will begin at the outlet on the north, and will first cover the region of the expansion, proceeding along the west shore to the Narrows, and then along the north and easterly shores in succession. It will then take the westerly, southerly and easterly shores of the main body of the lake, and lastly the north shore and its vicinity.

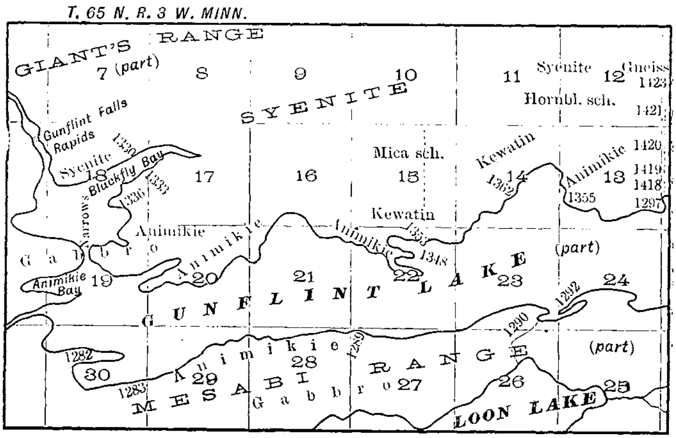


Fig. 30.—*General map of the principal part of Gunflint lake and vicinity.*

See map, fig. 41, for table of rock samples corresponding to the numbers on this map.

* Norwood, in D. D. Owen's *Geological Survey of Wisconsin, Iowa and Minnesota*, pp. 410-417

† N. H. Winchell, *Ninth Ann. Rep. Geol. Surv. Minn.* (1880), *p.* 82.

‡ See especially R. D. Irving, *Amer. Jour. Sci.* Oct. 1887.

(1). *Gunflint lake. The Expansion.*

The general features of the expansion may be learned from the small map. Figure 32, beyond.

N. E. ¼, N. E. ¼, sec. 13, T. 65–4. Here a shattered bluff of syenite attracts attention. The blocks lie along the shore in enormous masses. A photographic view was taken from a small island facing the scene.

S. W. ¼, S. E. ¼, sec. 13, T. 65–4. Bottom of western bay of the expansion. The northern shore of the bay presents continuous and conspicuous outcrops of syenite (650). At this point is good Saganaga syenite in an enormous outcrop.

North line, sec. 23, T. 65–4, head of bay. Here are only syenite bowlders.

N. E. ¼, N. E. ¼, sec. 24, T. 65–4. South side of same bay. Saganaga syenite outcrops.

N. E. ¼, sec. 24, T. 65–6. A few rods further south.

Seeing a curious crest-like formation at summit of the hill south of this western bay, I undertook to visit it. One-third of the way up, an overturned tree exposes some slaty fragments which prove to be largely magnetite—but partly changed into hæmatite. I had seen a similar stray piece of slaty magnetite at Gunflint falls.

Rock 651. Magnetitic schist fragments.

Fragments of slate as I proceed are frequently seen turned up by fallen trees; but syenite bowlders are abundant on the surface.

In one place the magnetic rock (652) was solid, and had a graywackenitic aspect.

S. W. ¼, N. E. ¼, sec. 24, T. 65–4. Near the crowning crest.

The slate becomes flinty (653) with evidences of a near outcrop.

Near here are many fragments of a diabasic character, judging from microscopic appearance.

Rock 653. Diabase or noryte, near the crest.

N. E. ¼, sec. 24, T. 65–4. On the crest half a mile south of the bay. An outcrop of clearly igneous rock, rising in a precipice facing northward, and ending in an escarpment on the west. There is a fine variety having the external aspect of diabase (655). There is a coarser variety with tabular feldspar crystals weathering pale greenish; with masses (not lamallæ) of a black mineral probably augite, and a conspicuous amount of a black shining mineral which is probably magnetite. I think the coarse variety may be called gabbro (654).

N. E. ¼, sec. 24, T. 65–4. On the return, at summit of the northern of the two ridges, I find in place, a rock inclosing schistic pieces, and otherwise consisting chiefly of grains of magnetite, with an interstitial medium of light color looking like plagioclase, and in places shining like quartz—656.

The summit of the crest visited is level for four or five rods, then a depression southward, then another level space of four or five rods.

A few rods further east I made another ascent of this hill in company with N. H. Winchell, after having studied all other points in the vicinity of Gunflint lake. I made another traverse of this ridge between Animike bay and the western bay of Gunflint swell or expansion. Syenite bowlders are abundant on the shore, and continue up the slope to the very summit. About one-third of the way up, Animike slate fragments appear. On the first low ridge, are large fragments of a rock looking like undeveloped "muscovada" (823), and in contact with magnetite. Compare with rock 656.

Rock 824. Magnetite in contact with 823.

This outcrop undoubtedly corresponds with that before seen by me at N. E. ¼ sec. 24, rock 656, further west.

A little farther up the hill are many large masses, evidently not far out of place, of a rock substantially a quartzyte (825). I have seen it elsewhere in connection with Animike slates. It consists of spherical grains of glassy quartz cemented by a white groundmass, and on a weathered surface looks finely oölitic.

S. E. ¼ N. E. ¼ sec. 24, T. 65-4. Proceeding westward along the summit of this ridge, we saw a gabbro ridge a little farther north and visited it. This, undoubtedly is the gabbro cliff seen by me before—rock 654—but approached now from a different direction. The bluff here is about ten feet high, and of coarse characteristic gabbro. This rests directly on little altered, thin-laminated slate in a horizontal position, and forms the most northerly illustration seen about Gunflint lake, of the juxtaposition of gabbro and Animike slate. We did not however, see the formations in place nearer than fifteen inches of each other; but we saw the slate in several places, as high as the bottom of the gabbro in other places.

The layers of the slate are of two kinds; 1st, a black, carbonaceous, iron-bearing rock; 2d, a heavy light gray rock. Both kinds are often opposite sides of the same laminæ. Both kinds are equally heavy. This iron is not magnetic, but in the bluff, a cause exists of disturbance of the needle.

Rock 826. Gray and black iron-bearing Animike.

We examined the fragments of slate fallen down from the cliff, in the hope of some trace of organic remains; but found nothing. There is, however, a curiously fitted and scrobiculate surface on some of the layers which I took for subsequent study.

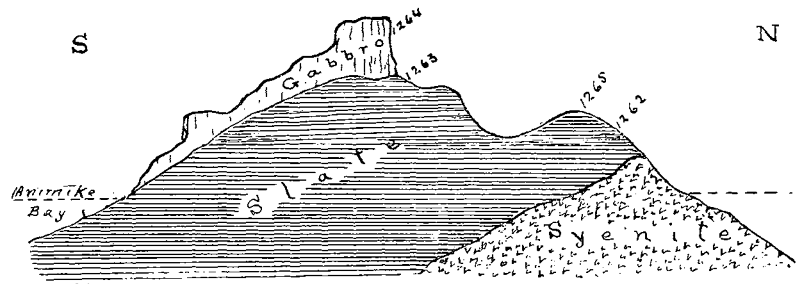
Rock 827. Animike slate with scrobiculate surfaces.

In this place occurred, also, as I have seen elsewhere in the Animike slate, surfaces of laminæ covered by concave depressions of an ovoid or spherical character, resembling what the elder Hitchcock named *Batrachoides nidificans*. I have discovered that spheroidal concretions between laminæ sometimes cause such appearance.

Rock 828. Cherty concretions producing *Batrachoides nidificans*.

S. E. ¼ N. W. ¼ sec. 19, T. 65–3. At the narrows, American side. The gabbro which covers the hill just described, abuts on the shore in rude basaltic forms 20 to 25 feet high. The level of the base of the gabbro here is fifty feet or more below the base on the crest of the ridge west of the narrows. This fact furnishes evidence that the gabbro flowed over a surface already deeply eroded. I shall present in this report much more evidence of the same purport.

A study of this gabbro-crowned ridge of Animike slate, supplemented by an examination of the slope along the north side of Animike bay (to be described) points toward relations set forth in the following diagram:



31

Fig. 31.—*Relation of gabbro, slate and syenite near the narrows of Gunflint lake.* Sections from north to south.

[NOTE.—The numbers expressed on the diagram indicate the places where rock samples were collected, as follows:

1262 is the locality for rocks 651–2.	1263 is the locality for rocks 652 (bis) and 653
1265 " " 656	1264 " " 654–5

N. H. W.]

Returning now to the north shore of Gunflint Swell, we find Black Fly bay resting on the flanks of a syenitic ridge belonging to the Giant's Range.

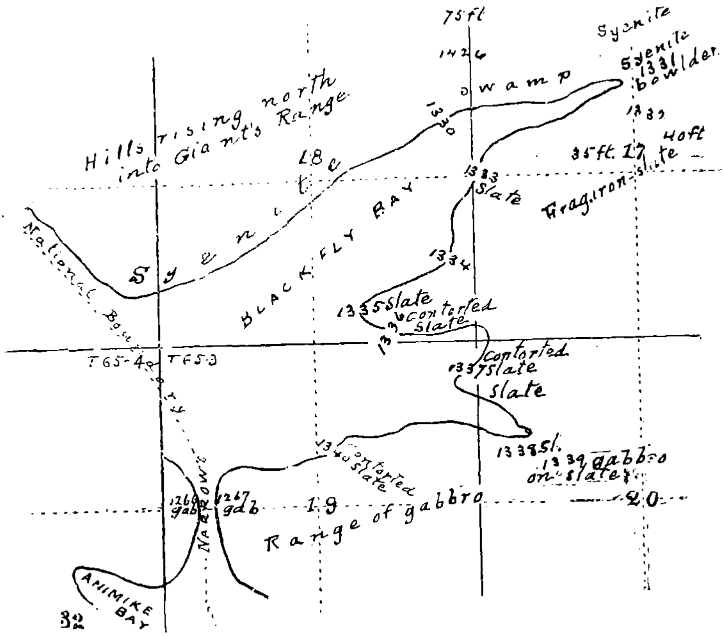


Fig. 32. *Map of localities around Black Fly bay, northwest part of Gunflint lake.* (The territory is Canadian but the lines of the American land surveys are extended over it.)

NOTE.—Locality numbers correspond to rock samples as follows:

1330 shows the locality for rock			716.	1336 shows the locality for rock			720-21.
1426	"	"	819-21.	1339	"	"	722.
1332	"	"	717-18.	1267	"	"	655 bis.
1333	"	"	719.				

[N. H. W]

Sec. 18, T. 65-3, as of Minn. Well developed syenitic gneiss (716) along the shore, with medium-sized quartz grains. The constituents have a gneissic arrangement. The same continues to the extremity of the singularly prolonged narrow point of the bay.

N. E. ¼, sec. 18, T. 65-3. Ridge of syenitic gneiss north of Black Fly bay. Examined carefully at many points and as far as the summit. The rock has a sort of groundmass of reddish and whitish feldspar, with irregularly elongated cakes of quartz, all disposed from east to west, with only a little hornblende, and that not well formed. On the whole, it much resembles the gneiss of sec. 12, 65-3 W., as of Minn., rocks 806-14, (which see beyond). It further resembles it in containing *fragments of hornblende schist,* which are all disposed in the same direction. I feel a strong confidence n the opinion that if the region of approach between the gneiss and the probable southward lying Kewatin schists were not covered by this bay, we should witness the same kind of a transition from one to the other as certainly exists north of the east end of Gunflint lake. (See descriptions further on.) It is also not improbable that such transitions sometimes occur along the line of strike of the schistic formation.

Rock 819. Syenite gneiss.

Rock 820. Hornblende schist pebble in the gneiss.

Rock 821. Contact of last two.

Extreme point of Black Fly bay. Beyond this a valley continues which is greatly obstructed by syenitic bowlders. There would have been a prospect of finding the rocks which intervene between the gneiss and the Animike hill on the south if time had been sufficient for the overland exploration. Leaving the valley I ascended the hill on the south side of Black Fly bay. It seems at first almost formed of syenite bowlders, largely of the Saganaga variety of syenite.

N. W. ¼, sec. 17, T. 65-3, as of Minn. On the hill and hillside south of Black Fly bay. Proceeding westward along the hillside just below the crest, in search of an outcrop of syenite or of slate, I found fragments of slate.

A little further along, large fragments of iron slate dipping still south—so little disturbed. Continued a quarter of a mile along this slope, finding slate fragments in extreme abundance, but not any undisturbed ledge.

Rock 717. Magnetitic slate fragments, as above.

Rock 718. Granular or oölitic magnetite.

No slatiness is seen in the oölitic magnetite, but it is included in the slate formation.

N. W. ¼, sec. 17, T. 65-3, as of Minn. Outcrop of slate by water's edge. Dip 7°, S. 20° W. (by needle). This is about sixteen rods from the syenite on the north side of the bay. The slate is banded and siliceous (719). It is the nearest seen to the syenite.

S. E. ¼, sec. 18, T. 65-3, as of Minn. Slate having same appearance as last.

S. E. ¼, sec. 18, T. 65-3, as of Minn. Extremity of cape in eastern line of Black Fly bay. Rough slate dipping 7° southward.

S. E. ¼, sec. 18, T. 65-3, as of Minn. Just south of the cape. A remarkable display. In a rounded, naked bluff fifteen feet high, is seen the aspect of a conglomerate, with many whitish constituents. Examination shows it to be a portion of the slate formation contorted in a striking manner. The laminations are still presented, and serve to evince the disturbance. There are some quartzose layers, and some quartz veins. Much of the slate has assumed a flinty constitution, and some laminæ are of red jasper. There are patches of what I have called oölitic magnetite, and areas in which the spherules are sparsely scattered in a somewhat homogeneous matrix of undetermined character. In some places, the crystalline magnetite sparkles brilliantly, and there are others in which it has been oxidized by water and burnings, into a crumbling, ferruginous mass, like the waste of a hæmatite mine.

Rock 720. Various examples of the slate of the formation.

Rock 721. Magnetite in its various conditions.

It does not appear whether this disturbance has resulted from action of the contiguous syenite or the equally contiguous gabbro. With some probability, however, it is connected with the gabbro overflow. Yet another explanation remains.

Observations elsewhere prove that the syenitic gneiss is older than the Kewatin slates and that these are older than the Animike slates; while the gabbro is more recent than the latter. Disturbances of the Animike therefore must be attributed to the latter. But it is by no means certain that the flinty and jaspery contortions above described could have been caused by an overflow of gabbro.

Neither does it appear probable that the magnetite is accumulated in quantities of commercial importance. Every occurrence is local and limited. An unlimited quantity is held in the formation; but like the magnetite of Penokee Gap, it is too much dispersed.

N. E. ¼, N. E. ¼, sec. 19, T. 65-3, as of Minn. Altered slate like that last described.

N.W. ¼, sec. 20, T. 65-3, as of Minn. Seeing a high crag off the head of this little southeastward projecting bay, I landed to visit the spot. Here a ledge of magnetitic slate outcrops.

S. W. ¼, N. W. ¼, sec. 20, T. 65-3, as of Minn. The crag proved to be an enormous buttress of coarse gabbro resting on well laminated slate, and presenting the striking profile exhibited in part in the diagram, fig. 33.

Much of the slate is flinty, and most of it contains much magnetite (722). Some of the gabbro is very coarse and tends to decay; the finer is more solid. There are patches showing large parallelopipedons of feldspar—like the sanidine in the trachyte of the Drachenfels. It tends toward rude columnar shapes, some of which are quite imitative of true basalt.

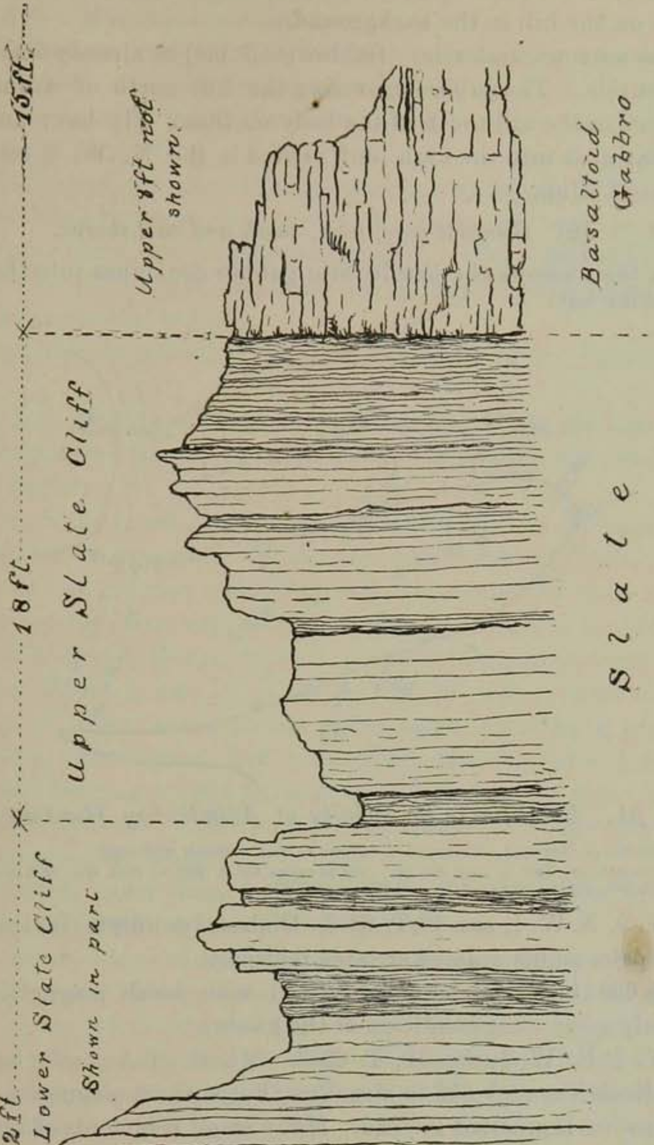


Fig. 33.—*Gabbro-crowned Animike cliff, near Black Fly bay of Gunflint lake.*

N. E. ¼, sec. 19, T. 65–3, as of Minn. Contorted slate. Gabbro can be seen on the hill in the background.

At the narrows, east side. Gabbro (655 bis) as already described on the west side. The gabbro crowning the hill north of Animike bay continues in the hill south of the body of Black Fly bay; and probably continues into the high bluff visited in the N. W. ¼, sec. 20, T. 65–3, as of Minn.

(2) *Gunflint lake, west, south and east shores.*

From the narrows the basaltiform gabbro continues into the mouth of Animike bay.

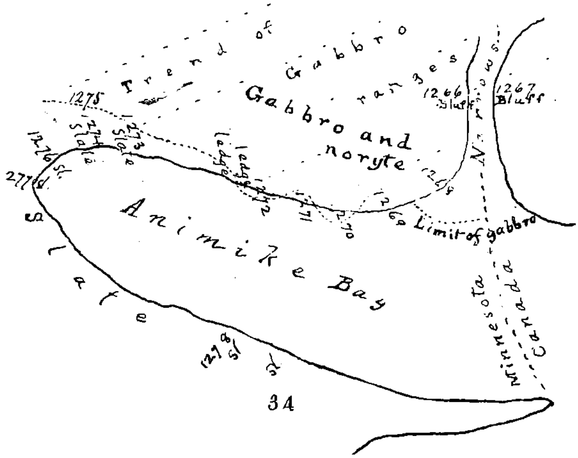


Fig. 34. *Localities in the vicinity of Animike bay, Gunflint lake.*

Halt numbers on this map correspond as follows to rock samples collected: 1267 to rock 655 bis, 1268 to rock 656 bis, 1269 to rocks 657-9, 1271 to rock 660, 1272 to rocks 661-3, 1274 to rock 664, 1275 to rocks 665-71, and 1276 to rock 672. N. H. W.

S. W. ¼, N. W. ¼, sec. 19, T. 65–3. Diabase (or noryte) inclosing nodules of pale, amber-colored striated feldspar.

Rock 656 (bis). Diabase (noryte ?) with much magnetite. Perhaps only a very fine condition of the gabbro.

S. W. ¼. N. W. ¼, sec. 19, T. 65–3. Mouth of Animike bay, north side. Rock like rock 656 in structure, but without magnetite—having a feldspathic ingredient instead. Many small fragments of black mineral sometimes resembling charcoal—perhaps anthracite. In places it holds a multitude of rounded pebbles, and forms a conglomerate with a cherty groundmass. Generally it contains magnetite in such places, and this is sometimes accumulated in much purity. The following specimens illustrate the varieties:

Rock 657. Fine gabbro without magnetite.

Rock 658. Conglomeritic variety as above.

Rock 659. Magnetitic specimens.

This formation, in spite of its massive appearance, in many places is really bedded. One of the specimens of 659 shows it. On making a trip up the hillside, I find places really slaty, and partially argillitic, but generally magnetitic.

The bedding of this formation is nearly horizontal. All the large fragments near the shore, too fresh and angular to have been much moved from place, are horizontally bedded. Not a fragment stands on edge. On the hillside, the outcropping ledge appears quite clearly to possess horizontal bedding.

So much then is settled:—these are characters of the Animike formation.

N. E. ¼, S. W. ¼, sec. 24, T. 65-4. Four rods along the shore westward, the noryte comes to the shore; as it also does six rods east of the last locality.

N. E. ¼, S. E. ¼, sec. 24, T. 65-4. North shore of Animike bay, a few rods further westward. Horizontal magnetite slate (660).

This bears an extreme resemblance to the magnetitic slates of Penokee gap—as the latter slates reminded me when there, of the Huronian slates north of lake Huron which I had then recently examined.

N. E. ¼, S. E. ¼, sec. 24, T. 65-4. North side of Animike bay. The ledge of noryte comes to the shore again, standing in great vertical flakes. But fifteen feet west, finely characteristic slate, well banded and tending readily to split, is seen resting in place (661), in a horizontal attitude. This is clear, and incapable of question. The formation is rather flinty.

Immediately under these banded slates is a massive layer of almost pure magnetite (662) at least fifteen inches thick.

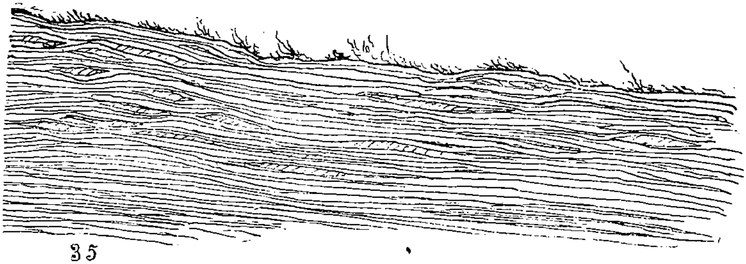
These observations show that the slates seen on the northern slope of this hill are of this formation, and that they repose on the syenite, at least on the north side, and have been overflowed by gabbro from vent remote or contiguous. A section across the hill would be therefore as already shown in fig. 31. The following observations confirm this conclusion.

Rock 662. Magnetite in a band fifteen inches thick, as mentioned above. It breaks into flakes at right angles with the bedding.

Rock 663. Magnetite from the laminated portion.

Near western extremity of Animike bay.

The slates outcrop in a low ledge on the immediate shore, and show a dip nearly south, or a little east of south, at an angle of 5°, as shown below.

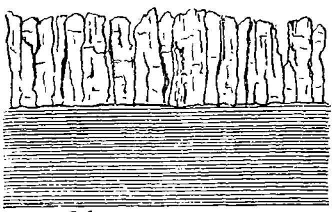


35

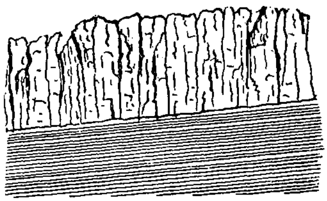
Fig. 35. *Exposure of Animike slate near head of Animike bay, Gunflint lake.*

S. E. ¼, S. E. ¼, sec. 24, T. 65-6. North of extremity of Animike bay. Twelve rods from the water, on the hillside, the slates outcrop in a thinly laminated condition (664). I counted 115 laminæ in the space of twenty-two and a half inches. The formation has a dip of 8° toward S. 20° E. It is quite magnetitic.

A few steps further up the hill. Here we have a clear demonstration of an overflow of noryte and gabbro on the slate. The following drawing was made on the spot, fig. 36.



36



37

Fig. 36. *Relation of basaltiform gabbro and slate, near head of Animike bay. Looking north.*

Fig. 37. *Relation of basaltiform gabbro and slate, near head of Animike bay. Looking west, and showing dip of the slate.*

The gabbro near the contact is charged with magnetite, but a few feet above, it is quite characteristic. The slate also becomes harder and more magnetitic near the contact.

Rock 665. Slate 1½ inch from gabbro (Ticket is on upper side.)
Rock 666. Magnetitic slate in absolute contact.
Rock 667. Gabbro in contact with 666.
Rock 668. Gabbro five or six feet higher than 667.
Rock 669. Gabbro six inches above 667.
Rock 670. Gabbro twelve inches above 667.

Rock 671. Gabbro eighteen inches above 667.

Head of Animike bay. Here within eight rods of the shore, is another contact of a similar kind, which is exposed for a distance of more than 75 feet.

Rock 672. Magnetitic slate a foot below contact with gabbro.

South of west extremity of Animike bay. A hill here 75 feet high is composed of slates similar to those seen in fig. 35.

The outcrop extends to the shore.

S. W. ¼, sec. 19, T. 65–3. Middle of south shore, Animike bay. Slate, considerably crumpled and broken; but this may be an incident of denudation.

Close by this, eastward, a larger outcrop, less slaty than usual, including large lenticular compact portions.

The next small bay south of Animike is not represented on the plat, and is separated from Animike by a long spit also not represented. Into the head of this little bay empties a deep and slow-flowing stream up which I ascended until canoe navigation was interrupted.

N. E. ¼, N. E ¼, sec. 25, T. 65–4. About a third of a mile up the river, in sec. 24, on the the south side, is a high cliff of slate, in a nearly horizontal position. I did not ascertain whether gabbro is at the top.

A great quantity of magnetitic slate has fallen down in a talus.

On the north bank of this stream, the magnetitic slate makes a low, smooth-surfaced outcrop, giving the appearance of graywacke; but examination proves its character.

Memorandum —According to the testimony of Mr. Buddle, an intelligent explorer and mine master, the same horizontal condition of this formation continues through sec 23, T. 65–4

N. E. ¼, sec. 25, T. 65–4 Magnetitic slate in great solid masses—rock 673.

N. W. ¼, sec. 30, T. 65–3. West end Gunflint lake. Here is the extraordinary occurrence of a sandy beach.

Here I found camped a party of explorers for iron. Mr. Buddle, in charge informed me that in sec. 23, T. 65–4, he had uncovered magnetic iron ore for a distance of 1,600 feet. It lies almost horizontal, and is similar to that seen in sec. 24. This is all to the south of the Giant's Range (v. page 80).

A gap through the Mesabi Range south of here, which makes a conspicuous feature in the southern horizon as viewed from the narrows, is limited on the east and west by corresponding precipitous escarpments and seems to be a suitable place for a trail southward. The

Indians consider the gap as caused by a subsidence. The cliff on the west is undoubtedly an interruption of the ridge visited about a third of a mile up the river in sec. 24. It does not appear from a distance that this range is gabbro-crowned; but from other positions along the lake the gabbro is obvious.

N. W. ¼, N. E. ¼, sec. 30, T. 65-3. North side of long point. Slate occurs all along this point and at the extremity. I made an excursion to the summit of the ridge, but found no indications of eruptive rock.

N. E. ¼, S. E. ¼, sec. 30, T. 65-3. Main shore south of point. I determined to visit the cliff about half a mile inland. This is a continuation of the ridge mentioned on sec. 24. About half the way up I found slate.

S. E. ¼, S. E. ¼, sec 30, T. 65-3. At foot of cliff. This proves to be gabbro (674) of the coaser sort. The cliff is about 15 or 18 feet high above the talus.

N. E. ¼. N. W. ¼, sec. 32, T. 65-3. At summit of hill. The outlook from here is wide and full of scenic interest. Looking northward, a range of mountains stretches east and west along the horizon, apparently six to ten miles distant. From the west it reaches to the river entering the northern swell or expansion of Gunflint lake, gradually lowering as it approaches the stream. White rocks can be seen exposed at numerous places. The same range extends on the east or Canadian side of the stream, and its slopes are very frequently marked by white syenite exposures. These hills are part of the Giant's Range.

In the nearer foreground are seen the narrows and the mouth of Animike bay and the shore-line features toward the east.

I made a sketch of this interesting landscape, and afterward decided that it ought to be photographed. Accordingly I returned to the canoe and brought photographic apparatus and Mr. Grant, and the event proved that the views obtained were entirely satisfactory. They are reserved like others for the final report.

N. W. ¼, N. W. ¼, sec. 28, T. 65-3. To this point, a mile from the point on the shore at which the cliff was visited no outcrops were seen. The slope is densely covered with young poplars. Here is a ledge of slate four or five feet high, rather thin-laminated.

N. E. ¼, N. W. ¼, sec. 28, T. 65-3. No outcrop is found here, but it seemed best to examine the fragments. They are mostly gabbro, of the variety which occurs a short distance above the slate. But some are massive magnetitic layers from the slate. The latter, to the eye, much resembles the former. Here also are some samples of the coarse gabbro.

Rock 675. Magnetitic rock, apparently from the slate.

Rock 676. A peculiar variety of gabbro.

N. W. ¼, N. W. ¼, sec. 27, T. 65–3. Small point on south shore The beach is strewn with a great assortment (677) of striking pebbles —mostly flinty and jaspery, and evidently derived from the slate.

Rock 677. Collection of jaspery and flinty pebbles.

Rock 678. Curiously banded flint pebble.

S. E. ¼, S. E. ¼, sec. 23, T. 65–3. Near west point of strait to small elongated bay, south side. A couple of rods back from the shore is a bluff of gabbro (679). It seems unusually heavy.

This bluff does not break down and form any talus.

The wall of gabbro continues east and strikes the shore before reaching the extremity of the point.

S. E. ¼, S. E. ¼, sec. 23, T. 65–3. Extremity of point at strait. Gabbro much finer than No. 679, and much less characteristic (680); but it is a prolongation of the back part of the same bluff.

Opposite (east) point of strait. Continuation of gabbro, forming a knob 60 feet high. This gabbro ridge appears to be the running out of the high range visited N. W. ¼, N. W. ¼, sec. 32, 65-3, and in which occurs the abrupt notch through the Mesabi range referred to.

The course of the range is less eastward than the axis of the lake. Hence all gabbro ranges, both sides of the lake, as will appear, make a small angle with that axis—those on the south side retreating inland toward west by south or west southwest, and those on the north side retreating inland toward east by north or east north-east. But back (south) of the range which runs out at this knob rises another similar and parallel range, on the south side of which lies Loon lake.

About a mile east of this bay occurs another, entered through a broader strait.

S. W. ¼, S. W. ¼, sec. 19, T. 65–2. Farther (eastern) point of the bay. No outcrop of rock; but a bowlder beach.

S. W. ¼, S. W. ¼, sec. 19, T. 65-2. Commencement of eastern end of Gunflint lake. Gabbro (681) in a low outcrop at the beach. All the shore along here is strewn with angular fragments resembling the same.

N. W. ¼, S. E. ¼, sec. 19, T. 65-2. A gravel beach presenting a gray appearance with the diversified colors of its pebbles blood-red, dull-red, banded, black, gray and white, all siliceous; many of them are beautifully translucent flint; others the most fine-textured jasper.

Collected an assortment (682). All these must be in place somewhere on the north shore, or below water-level, for they certainly do not so occur along the southern shore.

The remainder of the eastern end of the lake presents no rocky outcrops. Two low green points extend into the lake, bowlder-covered and sandy. A chain of small islands lies between them, and these appear to be simply bowlder-formed.

(3) *North side of Gunflint lake.*

It will be most convenient to return to the Narrows and follow the north shore toward the east.

N. E. ¼, sec. 19, T. 65-3, as of Minn. Low outcrop of dark rock appearing stratified vertically; and I can find no trace of other stratification. Still, this fine, almost aphanitic, diabase-looking rock (723) belongs to the slate formation. It contains much magnetite, and the lighter mineral looks more siliceous than feldspathic.

This condition of the Animike is to be compared with that seen on the north shore of Animike bay, especially Rock 662 from a locality not more than half a mile distant. The massive rock seen on the river shore too, with a smooth-surfaced outcrop is similar. These may all be outcrops of the same bed.

S. E. ¼, sec 19, T. 65-3, as of Minn. Outcrop similar to the last. These are striking examples of the complete disappearance of the sedimentary structure and its replacement by a system of parallel jointage in a position nearly vertical to the original bedding.

On a later occasion I visited this locality for the purpose of assuring myself that the vertical structure does not pertain to an outcrop of the vertical slates seen farther east on this shore. The following are my notes on the second visit. "The formation is not Kewatin. What I have said is correct. Although the rock is so dark and heavy, it does not affect the needle. I suspect much anthracite or graphite mingled in it.

Rock 817. Dark massive Animike.

"It is not improbable that the rock is on the border line between Animike and gabbro. However, in travelling along the north shore of Animike bay again, I notice that an identical rock is embraced *within the slates*. I obtained another hand specimen of Rock 662. It is almost incredible however that the mass at S. E. ¼, sec. 19, 65-3, should be inclosed in the slates; and the jointed condition is also against the supposition. It must be concluded that almost identical rocks are embraced in the slates and the gabbro."

Memorandum.—This is probably correct. In many places subsequently visited the line of the junction between gabbro and slate was very uncertain. Each formation has exerted an action on the other. This is revealed in approximate mineral constitution and rock structure. A rude columniform arrangement often appears in the slates for several feet below the contact. In other places however, the evidence of mutual influence is wholly wanting.

S. W. ¼, sec. 20, T. 65-3, as of Minn. Slate, exposed along the slope of the hills. In one place it presents a dip of 21°, N. 20° E ; but it varies locally, and I feel persuaded that it has fallen or slid out of position. Farther along (eastward) it dips in various directions; and, in the course of 16 rods, it presents the crumpled and altered condition of the slate seen at sec. 18, 65-3, as of Minn., rocks 720-721. The shore is strewn with angular fragments of the banded flinty slate.

N. W. ¼, sec. 21, T. 65-3, as of Minn. The formation here is in the condition of a breccia consisting of angular fragments of magnetic slate (723 bis and 818) imbedded in a matrix of finely granular rock.

This breccia crumbling to pieces makes the pebbly beach around the point.

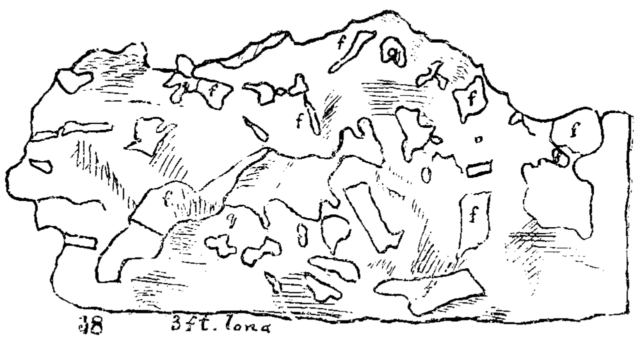
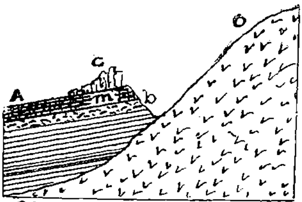


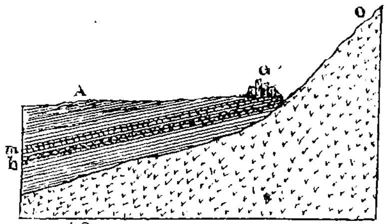
Fig. 38. *Brecciated condition of the Animike formation, north side of Gunflint lake.*

The brecciated condition can be seen along the shore for a quarter of a mile.

These localities of breccia are about a mile and a half nearly east from the interesting locality in Black Fly bay. They are all apparently outcrops of the same horizon in the Animike. The horizon is not far from the contact with older terranes; but this does not prove the brecciated bed and the (newer) magnetitic bed to hold positions near the base of the Animike. They may, on the contrary belong near the top of the Animike. But the proximity of the gabbro to the magnetitic bed would not prove this, since the gabbro simply rests on what was the actual surface at the time of overflow. The slight southward dip of the Animike, however, would indicate that the breccia and magnetite belong to the later stages of the period.



39



40

Figs. 39 and 40. *Two supposable relations of the Breccia and Magnetitic bed in the formation.*

A, Animike; G, Gabbro; O, Older terrane; m, Magnetite; b, Breccia.

The relation of the Animike to the older formation, which is shown in Fig. 39 explains how the proximity of *m* and *b* to O would be comformable with the theory that they belong in the *upper* part of the Animike. It implies that the Animike was deposited on a sinking sea-bottom—as on other grounds was probably the fact.

The relation of the Animike and older formation, which is shown in Fig. 40 explains how the proximity of *m* and *b* to O would be compatible with the theory that they belong to the *lower* part of the Animike. It implies that after the deposit of the Animike, the contiguous land was uplifted.

Observation shows that the dip of the Animike is not conformable with the visible or probably the conceded slope of the surface of the older terrane as in Fig. 40, but that it is unconformable, having a very gentle dip southward, as in Fig. 39. Hence reasoning from the facts thus far presented it may be concluded that the magnetitic bed is near the top and not near the bottom of the Animike, as has been suggested for the Thunder bay region.

Sec. 21, T. 65-3, as of Minn. Animike beds containing, as nearly as I can judge in the field, a large proportion of iron carbonate.

Rock 816. Iron carbonate with argillaceous and siliceous matter, as macroscopically determined.

Sec. 16, T. 65-3, as of Minn. Ascended a small hill forty rods back from shore, thinking possibly it might be the terminal knob of the range of vertical slates exposed a mile east of here. It proved to be underlaid by Animike. So far as I found rocks in place, I saw only a gray ledge somewhat resembling "muscovado." It seems to be composed of fine quartz and feldspar with glistening scales like sericite. There are rusted surfaces which indicate also, as I think the presence of iron carbonate.

Rock 815. Incipient muscovado?

N. W. ¼, sec. 22, T. 65-3, as of Minn. A knob of gabbro resting on Animike slates. This continues near the shore, and finally, on a change in trend of coast line, retreats across the country.

N. W. ¼, sec. 22, T. 65-3, as of Minn. A low outcrop of a dark gray rock (724) similar to that at sec 19, 65-3, as of Minn., (the magnetitic bed), and similarly jointed. But examination shows a coarser texture and some recognizable faces of dark augite. If this belongs to the Animike the rock is highly altered. It may be a portion of the gabbro immediately superjacent. Following my usage I shall designate it noryte (?).

N. E. ¼, sec. 22, T. 65-3, as of Minn. At the point of a long slender peninsula setting east southeast from the main land. A pile of thin laminated slate going to decay.

N. E. ¼, sec. 22, T. 65-3, as of Minn. Small islet of medium grained gabbro. It is cut by divisional planes running N. 60° E. into great sheets which stand like piled lumber dipping at an angle of 82°.

This is a mass of gabbro at the water level, and its continuation half a mile westward would bring it into the position of the so-callde "noryte"? rock 724.

N. E. ¼, sec. 22, T. 65-3, as of Minn. Main land directly opposite the gabbro islet. Here is a genuine surprise. Here are true argillytes (725 and 789) standing nearly vertical. They are not at all ambiguous. They are the Knife Lake slates preserving to this point, their steady verticality, and here remaining uncovered by Animike. This looks like a solution of a vexed problem. The Animike and the Vermilion slates *are not one*.

Here is no magnetite structure. The dip is S. 89°. The strike of the sheet is N. 72° E.

This spot was visited four different times. I discovered that the broad sides of the vertical sheets were sometimes marked by a "grain" like that of wood; and that it presented a pretty uniform dip of 67° eastward.

Rock 729. Slate showing sedimentary structure and grain.

These vertical slates appear close by the water's edge, the exposure being the front slope of a hill about twenty feet high. It seemed desirable to ascertain what lies back of this hill on the landward side. So crossing an intervening swampy depression I ascended the first higher hill.

S. E. ¼, sec. 15, T. 65–3, as of Minn. Summit of range one-fourth mile back from shore. Here are the ashen-bleaching argillytes. The color may be due to sericitic matter, for that is obviously present in places. Their dip is 67°, varying to 74°, in direction S. 21° E. They present a very familiar aspect. Rock 726.

Other eminences in the east and west continuation of these two ranges could be seen, presenting the same argillitic color and aspect. A higher range also now appeared farther inland, the rock exposures on which were evidently similar to those of the two front ranges. But no opportunity existed at the time for penetrating further. A subsequent exploration by Mr. Stacy will be referred to in the sequel.

The following sketch-map has been prepared for the purpose of showing as precisely as possible the interesting facts observed respecting the relations existing between the vertical argillitic slates and the Animike slates:

The locality numbers, expressed on the map, next page, correspond to the following rock numbers:

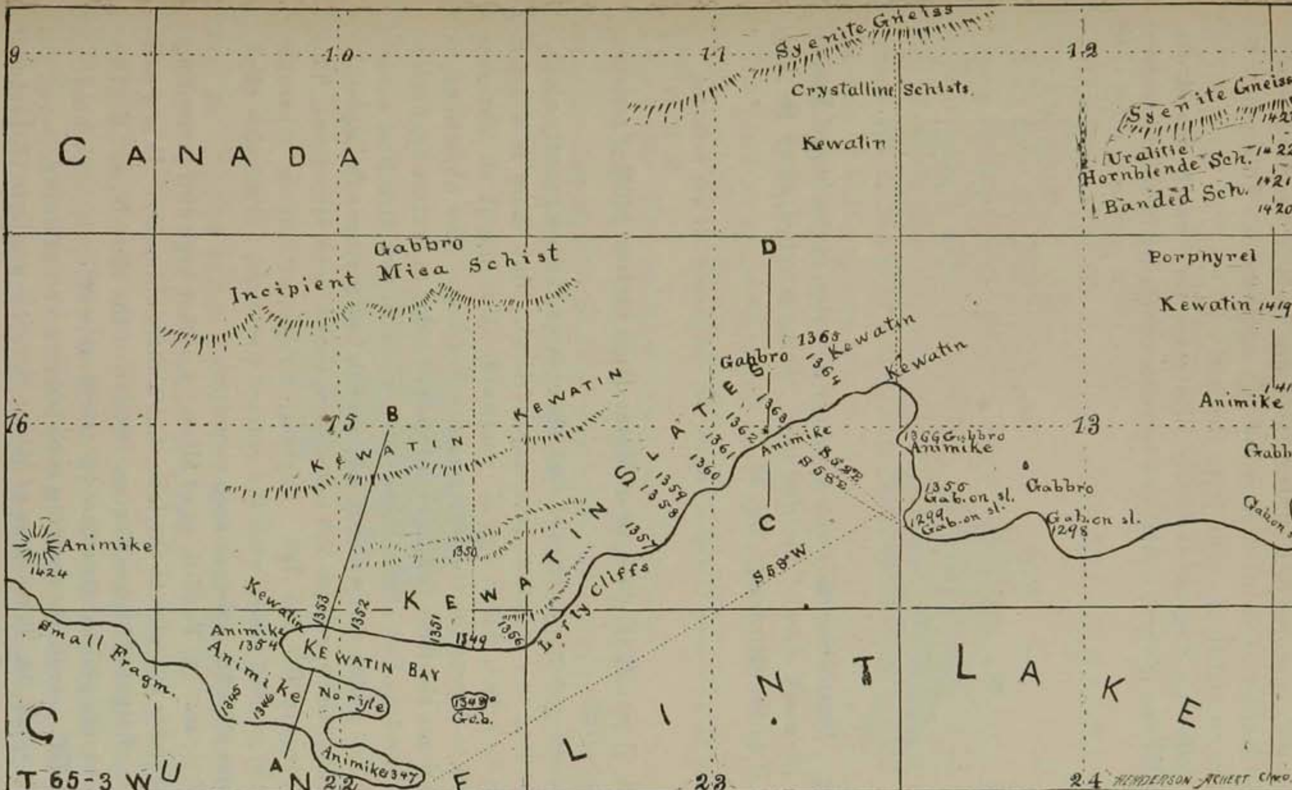
1298	indicates	the locality	for rock	688–90	1361	indicates	the locality	for rock	737
1346	”	”	”	724	1362	”	”	”	738–40
1349	”	”	”	725	1364	”	”	”	741-2
1350	”	”	”	726	1418	”	”	”	799
1351	”	”	”	727	1419	”	”	”	800-3
1356	”	”	”	728–9	1420	”	”	”	804
1357	”	”	”	730	1422	”	”	”	805
1358	”	”	”	731	1423	”	”	”	806–14
1359	”	”	”	732-6	1424	”	”	”	815

[N. H. W.]

N. E. ¼, sec. 22, T. 65–3, as of Minn. The Kewatin slates are a little sericitic—rock 727.

N. E. ¼, sec 22, T. 65–3, as of Minn. Vertical argillyte continues.

N. W. ¼, sec. 22, T. 65-3, as of Minn. Vertical argillyte. The formation continues in the hill four rods back from shore, as far as the head of little bay, and further strikes toward the main shore of the lake. But I have not been able to find these slates along the shore west of the cape. Every exposure in front of this now reveals Animike. But I feel confident the Kewatin could be traced overland far toward the head of Black Fly bay, where the Animike comes within a few feet of the syenite. The Kewatin would thus be found passing under the Animike.



41

Fig. 41. *Map of a portion of the north shore of Gunflint lake embracing the principal exposures of the vertical slates, and showing their positions relative to the Animike series.*

The survey-lines are extended over from the American side.

N. W. $\frac{1}{4}$, sec. 22, T. 65-3, as of Minn. This is the nearest approach of Animike exposures to Kewatin exposures in this direction. Here are thin laminated slates with a low dip southward. This point is less than an eighth of a mile from the last.

The following diagram evidently illustrates very nearly the structural relations of three contrasted terraces occurring in this vicinity:

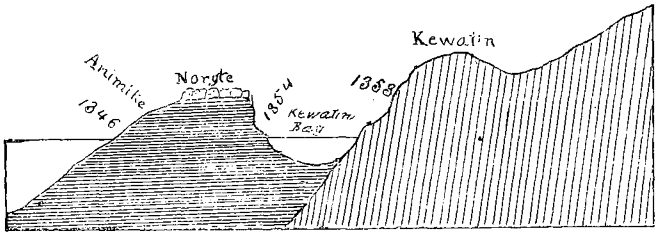


Fig. 42. *Illustrating the relations of the Kewatin, Animike and Noryte on the north shore of Gunflint lake. Being a section along the line A B on the sketch-map, fig.* 41.

In figure 42 the number 1346 shows where the rock sample 724 was collected.
N. H. W.

N. E. $\frac{1}{4}$, sec. 22, T. 65-3, as of Minn. High vertical bluff of sericitic argillyte—728.

The bluff presents a series of rock slates facing almost exactly south, and standing in a position precisely vertical. But there is a grain seen on each face, which dips 57° eastward. One might at first suspect this to denote the true sedimentary bedding. The objections to this view are the facts that no contrasts of color or texture are noticeable in the direction across these lines, while in the direction across the vertical plates contrasted bands of color and texture can be plainly seen. The rock specimen 729 taken here shows both structures. The same is true of 730 and 736. Further, no laminations or separable beds exist in conformity with the grained structure. It remains then to inquire after the cause of such structure.

S. W. $\frac{1}{4}$, sec. 14, T. 65-3, as of Minn. Another high cliff presenting vertical slates sidewise to the lake, but a little obliquely. It is a soft argillyte of a pale blue-gray color. Strike of the slate N. 42° E. Dip of the obscure grained structure 50° northeastward.

Rock 730. Argillyte showing both bedding and graining.

S. W. $\frac{1}{4}$, sec. 14, T. 65-3, as of Minn. Sericitic argillyte (731) studded with quartz grains.

This is not well marked sericitic argillyte. It closely resembles the vertical slates along the IVth Arm of Knife lake which were named provisionally porphyrellyte. This then would be quartz porphyrel. It may prove to be parophitic.

S. W. ¼, sec. 14, T. 65-3, as of Minn. Sericitic argillyte (732) densely studded with quartz grains an eighth of an inch in diameter. Otherwise this rock is like 730.

Other portions of the formation are similarly studded with grains of red feldspar

Rock 733. Porphyrel.

Some other portions abound in both quartz and feldspar. These portions have a distinctly schistic groundmass exactly as in IVth Arm of Knife lake, and become more characteristically porphyrel.

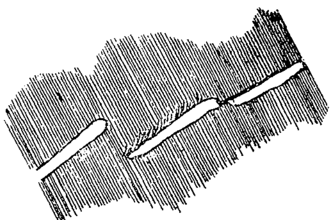
Rock 734. Porphyrel with feldspar and quartz.

A vein of white, opaque quartz (735) intersects the formation, about 16 inches wide and lying in a plane dipping S. 50° W. at an angle of about 22°. This dip however, is merely local.

The plate structure (dynamic structure) trends N. 64° E. and is exactly vertical. The fibrous structure dips at an angle of 62° eastward.

Rock 736. Plain schist showing both structures.

S. E ¼, sec. 14, T. 65-3, as of Minn. Quartz porphyrel with grained structure dipping 66° eastward. The figure below illustrates a faulted quartz vein exposed in the face of one of the slabs of the formation.



43

Fig. 43. *Faulted quartz vein. The lines show the eastward-dipping grained structure.*

S. E. ¼, sec. 14, T. 65-3, as of Minn. The hill subsides by steps northeastward parallel with the shore. I walked along in search of the junction between the Animike and Kewatin formations. The Kewatin assumes a more distinctly porphyrelloid character (737), much resembling that of Zeta lake. (Rep. 1886, pp. 158-9).

S. E. ¼, sec. 14, T. 65-3, as of Minn. This is very near the critical place. The nearest point on the north shore eastward bears S. 71° E. The strait to the little bay on the south shore bears one or two degrees east of south. On the shore, and for 25 feet above, the Animike clearly outcrops in the form of flinty and red jaspery heavy beds in a *horizontal* position on southward face. Six paces away—18 feet by measurement—the porphyritic sericito-argillytes outcrop standing in the same position as for a mile and a quarter back. The slate here contains abundance of both feldspar and quartz grains.

Beyond all possible question, we have here two formations—even two *systems*. They cannot be identified. What are they? The newer certainly is Canadian Huronian. The older is *not* Laurentian.

The Animike here is contorted-brecciated and conglomeritic. It has a slight dip south.

Rock 738. Porphyrelloid sericito-argillyte, 18 feet.

Rock 739. Flinty; contorted Animike and breccia.

Rock 740. Pebbles from Rock 739.

Walking northeastward along the hill-slope, the fragments of the two formations are found mingled together; but there is an upper limit to the Animike fragments.

The Animike retains an elevation of about ten feet above the lake. The argillitic bluff recedes to a distance of twenty-five feet from the Animike. Huge fragments of the argillyte have tumbled down over the Animike.

Next, at about twenty-five rods east from the last, the argillyte bluff comes quite to the shore again, or within twelve feet of it, for the rugged weathering and brecciated Animike holds the water-line, and appears eight feet back. Here *the two formations are within seven feet of each other*, by measurement. This is virtually a contact.

Next, within two rods more the argillyte comes down to the shore, and completely shuts out the Animike, except in a few fragments washed up from below water level.

The nearest point on the north shore eastward now leans S. 58° E.

The following diagram represents the relations of the two formations at the observed junction:

S. E. ¼, sec. 14, T. 65-3, as of Minn. The argillyte, after receding from the shore a few rods, here reappears.

I was not disappointed to find on the top of the ridge here, a cap of gabbro.

The point is now south 52° east.

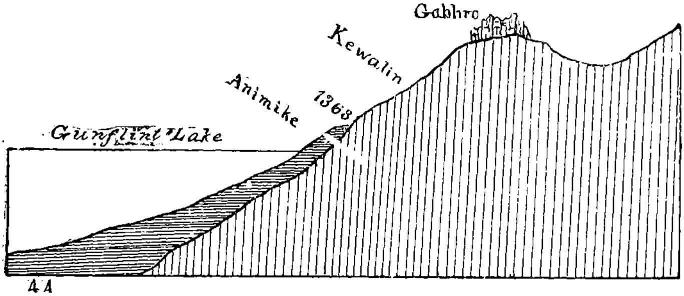


Fig. 44.—*Observed contact of Animike and Kewatin formations, north shore of Gunflint lake, being a section along the line C D of the sketch-map. Fig* 41.

Some Animike fragments lie near the beach within four rods of the argillyte.

N. E. ¼, sec. 14, T. 65–3, as of Minn. The same point bears S. 42° E. The argillyte comes near the shore again. On the beach are large angular fragments of a biotite gneiss (741). As these have not been washed from the southward lying bottom of the lake, they must have come from some short distance northward.

On the hill, the argillyte is very slaty, and the leaves consist of different qualities of rock in alternation.

Rock 742. Interbanded phyllyte.

N. E. ¼, sec. 14, T. 65-3, as of Minn. Hill one-fourth mile back from lake. The point bears S. 31° E. The argillyte is pale gray-blue, but weathers singularly light colored. The plate-structure strikes N. 50° E. The fibrous structure is much disguised by parallel joints. It dips eastward 65°—the joints 55°.

Once again, and for the fifth time I passed along the shore where the Kewatin slate comes in proximity to the Animike. Traced again the shore outcrops of Kewatin quite to the head of Kewatin bay. The rock is considerably altered. Walked again past the spot where gabbro appears above the Kewatin. It is not seen here in actual contact. In some of its conditions the Kewatin slates might be taken for bedded igneous rocks; but the beds are always vertical, and conformable with the other portions of undoubted sedimentary origin. The following further samples were collected:

Rock 785. Kewatin slate, contorted and altered.

Rock 786. Sample of rock which might be regarded eruptive.

Rock 787. Condition undoubtedly sedimentary.

Rock 788. Another sample of sedimentary condition.

S. W. ¼, sec. 13, T. 65-3, as of Minn. Twenty rods north of camp on sec. 13, 65-3. Animike abuts on the shore. It is characteristically flinty and ferruginous, and the sedimentary bedding is unmistakable; but the formation has undergone severe alteration, and breaks up in vertical columns like gabbro. I had to ascend the bluff to be sure that gabbro was not at the top.

On a subsequent occasion this spot was revisited and the following observations made: Some excellent magnetite occurs here. It pertains to a small remnant of gabbro which remains on the north side of the hill, in the position shown below:

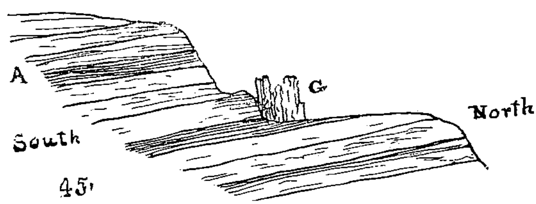


Fig. 45.—*Remnant of gabbro on a knob of Animike slates. Gunflint lake.* Looking westward. A, Animike. G, Gabbro.

It looks as if the whole bluff had been once buried in gabbro and the schist altered, then all the gabbro weathered away except the small lot as indicated on the north side of the ridge. The contact with the schist is sharp; but the schist was already in fragments, and the fluid gabbro flowed around them and into the fissures and converted the schist fragments into quartzose masses. This observation is analogous to that made on an island in lake Gabimichigama, (Report for 1886, page 172).

The slate here has a dip southward of about 15°. Further, we find some contorted fragments; and these facts rather imply that there was in this place more than a quiet overflow. Still as before intimated, the contortion of certain beds may have taken place *during the deposition of the Animike.*

S. W. ¼, sec. 13, T. 65-3, as of Minn. Good camping ground. Animike slates at the point of the promontory south of here (S. W. ¼, S. W. ¼, sec. 13) with gabbro at the summit. Gabbro continues along the ridge northeast and forms a columnar wall in the hill back of the camp. The gabbro appears to be generally intersected by east and west divisional planes, and when the exposure has a westerly aspect, it presents a columnar structure.

S. W. ¼, S. W. ¼, sec. 13, T. 65-3. At the beach, beds of flint schist;

above, gabbro. Here as elsewhere, the schist is horizontal, on a southern aspect.

On a subsequent visit I made the following notes:

The slates here are quite thin laminated, except an occasional bed of flint. The flint beds are curiously variable in thickness, and the upper and under sides do not correspond. This is shown in the following diagram:

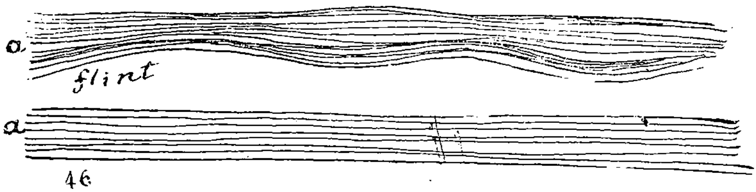


Fig. 46.—*Alternations of flint and flinty shales, Gunflint lake.* a, a, Flinty shales; b, Flint.

I find in this place an abrupt transition from slate to gabbro.

Rock 779 bis. Slate in immediate contact with gabbro.

Rock 780. Gabbro in immediate contact with slate.

Rock 781. Gabbro 1 ft. above slate.

Rock 782. Gabbro 4 ft. above slate.

Rock 783. Gabbro 10 ft. above slate.

Rock 784. Flint from one of the flint beds.

S. E. ¼, S. W. ¼, sec. 13, T. 65-3, as of Minn. At the beach, beds of a granular siliceous rock (688) with a white cement. Above, siliceous argillytes and flint-schists (689) for 20 or 25 feet. Lastly, gabbro (690) mostly of the coarser kind.

Near centre sec 18, T. 65-3, as of Minnesota. At the beach, thick-bedded siliceous magnetite and flint. A little back, fine gabbro eight feet higher.

Rock 683. Black, siliceous magnetitic schist.

Rock 684. Fine gabbro.

It is difficult here, as in many other places, to decide on ocular inspection, where the gabbro ends. Specimens from an intermediate position show blended characters.

Rock 685. Gabbrolitic magnetite.

The rock 685 is about 3 feet above 683. Still below 685, the gabbro 686 rests absolutely on the chert 687 and this on 683; so that the order from above is as follows:

684. }
685. } Gabbro.
686. }

687. Chert. } Slate formation.
683. Siliceous magnetite. }

Just east of this place, we observed a *rusted* rock which when broken open is of a gray color, and which I suspect to be a carbonate of iron.

Rock 813. Carbonate of iron (?) from Animike.

We found other rusted rocks which are black within but do not affect the needle. They are probably anthracitic or carbonaceous. Between the rusty coat and the black interior is a line of gray. It is desirable to ascertain whether the line of gray results from the oxidations of the carbon, and the union of the carbonic acid with the iron; and whether the rusty coat results from a retrograde process—the peroxidation of the iron in the carbonate thus formed.

Rock 814. Black iron ore with surface bands, from near centre of sec 18, 65–2.

N. E. ¼, N. E. ¼, sec. 18, T. 65–2, as of Minn. Extreme east end of Gunflint lake, immediately north of the mouth of Gunflint river. Here is a fine sand beach. The Gunflint river appears sluggish and marshy.

We visited near this spot the camp of a company of Canadian land surveyors in the employ of Sedgwick and Brotherton of Chicago, who had located a large tract of land on the north shore of Gunflint lake and river. The location was supposed to cover valuable deposits of iron ore, and it was desired by us to learn the precise description and visit the principal points in the tract. The parties whom we saw, however professed to be simply camp attendants and to be totally ignorant of the location of any iron deposit. They showed us, however, some samples which were represented to be inferior to the best. The specimens seen were all magnetic ore except one—that was hæmatite. I suspect they were all from the Animike, though they resembled also, ore from the gabbro.

(4) *Excursions from Gunflint lake into the interior.*

(a) *Traverse due north from a point near the centre of the S. W. ¼, sec.* 18, 62-2, *as of Minn.* The starting point was the head of the bay (see fig. 41). A track had been blazed by the surveyors of Sedgwick and Brotherton. Gabbro is found on the shore.

One-third mile north of Gunflint lake. Here occur Animike fragments and soon Animike in place, but not magnetitic argillytes. The rock is highly ferruginous and gives a brown-red streak.

Rock 799. Hæmatite rock.

Rock 812. Conglomeritic iron ore from the Animike, near the last. This rock is in a dislocated condition, and I did not ascertain the dip of the formation; but it appears much like a state of the brecciated Animike which I have before seen many times—always in near relation to the underlying older terrane.

One-half mile north of Gunflint lake. After making a small descent we come to a hill-slope in which we find Kewatin slates outcropping. They are first clean sericitic argillyte. A couple of rods further north we get porphyritic sericitic argillyte weathering much like the porphyritic porodyte of Vermilion lake.

Rock 800. Sericitic argillyte as first encountered, with fine shining scales.

Rock 801. Porphyritic porodyte.

Fifteen rods beyond, the rock is harder and more crystalline, and the shining scales are larger.

Rock 802. Semi-crystalline sericitic schist.

Still beyond, the feldspar weathers reddish, and the rock looks syenitic.

Rock 803. Syenite-looking porphyritic Kewatin schist.

Three-fourths of a mile north of Gunflint lake. A high hill composed of alternating bands of porphyritic porodyte and a rock appearing like true hornblende schist; but the hornblende is still of argillitic softness; and there are fine glistening scales which generally appear like sericite, but in places become large enough to recognize as micaceous. Interbanded with these rock-beds and laminæ are some, mostly thin (up to one-half inch) laminæ of light color, composed of feldspar about 60 per cent, the dark hornblende-like mineral about 30 per cent, and quartz grains 10 per cent.

The rock here is also in places, much contorted. All the characters indicate proximity to some dynamic agency.

Rock 804. Interbanded porphyritic porodyte, syenite and uralitic schist.

There are places where the twisting and interlaminations reproduce the features so often noticed by me last year and figured in my report. For that reason I will not figure them here. I wish to refer particularly to pages 40, 113, 87 and 96. The sinuosities and doublings of the veins are also very striking.

Highest summit of the same ridge. The breadth of the dark bands is increased. The rock is here mostly uralitic schist, but with many bands—mostly not over one or two inches—of the porphyritic porodyte, and many veins of syenite.

Some of the layers of porphyritic porodyte in the uralitic schist are far gone toward the condition of uralitic gneiss.

The belt of uralitic and mixed schist is about 18 rods wide. This is all there is along this section to represent the Vermilion (or Couchiching) group.

The light and dark bands alternate five hundred times in an exposure three rods wide.

Next ridge, one-eighth mile further north. The rock has the weathered aspect of syenite. Broken, it consists of quartz, white feldspar and uralitic hornblende.

Rock 805. Uralitic syenite gneiss.

At the foot of the next hill, one-fourth mile further north, the formation begins to assume the character of the Saganaga syenite in a gneissic condition.

Summit of range one mile north of Gunflint lake. The rock has become a muscovitic gneiss, with the feldspar and quartz in a compact mass but still granular. See the section fig. 47.

Rock 806. Muscovite gneiss.

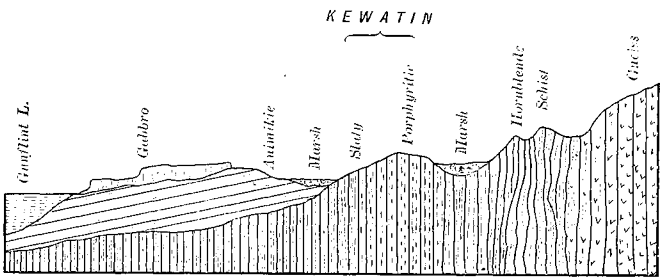


Fig. 47. *Section passed over in one mile on the north side of Gunflint lake near line between ranges Two and Three west; showing junction of Animike and Kewatin systems and transition from Kewatin through crystalline schists to gneiss.* See sketch map, Fig. 41. Vertical dimensions exaggerated, as usual.

This trip shows a gradation from the slates and porphyrel of the Kewatin through interbanded Kewatin and uralitic schist, to well established gneiss—the series of beds being conformable from end to end. The lower (porphyritic) member of the Kewatin has, in its formation, been moulded simultaneously with the uralitic schist, and belongs to the same chronological system. The uralitic schist passes by gradation into gneiss. These three existed and were formed in the same geologic age. The gneiss was *not* subsequently formed. All have been uplifted from a horizontal position simultaneouly.

Rock 807. Illustrating a transition directly from porphyritic porodyte to uraltic gneiss.

Rock 808. Transition from porphyritic porodyte to hydromicaceous gneiss.

Rock 809. Transition to mica schist.

Rock 810. From a dyke crossing the formation a little east of north and west of south.

Rock 811. Augitic? band in the uralitic schist.

It is to be especially noticed that the mode of transition from Kewatin slate to uralitic schist is different from the transition from Kewatin to gneiss. In the former case, the Kewatin becomes intersected by conformable laminæ of the uralitic schist; then thicker laminæ with thinner bands of Kewatin; but every lamina is all the time complete schist, as a rule. In the latter case, the porphyritic condition of the Kewatin begins to reveal pale dark or dun areas of limited extent; then these acquire a uralitic aspect; then farther on, a hornblendic aspect. Meantime, also, quartz, which is generally present to some extent, in the porphyry, becomes more abundant. We then have the constituents of syenitic gneiss (hornblende granite). Sometimes the dun and dark substance which arises in the porphyrel passes to mica instead of uralite and hornblende, and we get a pure gneiss.

(b) *Mr. Stacy's Traverse north from N. E.* ¼, *sec.* 22, 65–3, *as of Minn.*

On no one of my five or six visits to the place of first discovery of Kewatin slates on the north shore of Gunflint lake was it convenient for me to penetrate the interior further than a quarter of a mile. I was therefore desirous that Mr. Stacy should go over the interval between the shore and the crystalline rocks which I felt sure must exist in the higher range about three-fourths of a mile back from the shore. Mr. Stacy's detail of observations will be given from his own notes in the proper place; but I wish here, for the sake of completeness in my description of Gunflint lake geology, to record the result. After passing the valley intervening between the ridge in S. E. ¼, sec. 15, 65–3, and the higher range, the Kewatin began to be found interstratified with layers more or less inclining to a micaceous state. But before the mica schist was found completely developed, gabbro was encountered resting on the crest of the hill. It was a thin bed, but coarse in quality.

(c) *Mr. Stacy's Traverse north between secs.* 13 *and* 14, 65–3, *as of Minnesota, north shore of Gunflint lake.*

This traverse was about one mile in length. Kewatin continues for about three-fourths of a mile, when the usual transition to micaceous strata occurs. At a mile from the lake, gneiss is fully established. Syenite characteristically constituted occurs on the highest summit reached. The belt of crystalline schists is about a quarter of a mile.

These three traverses are separated by intervals of about a mile. The geological developments are in their general features identical in all. There is a transition of the same nature in all, from Kewatin slates to crystalline schists, and an identical passage from these into conformable gneissic beds.

(d) *Visit to the Iron deposits in sec.* 23, *T.* 65–4, *west of Gunflint lake.*

These deposits are embraced in the tract located under the personal direction of Mr. Buddle who stated that he was in the employ of Milwaukee parties. Reference is made to it on pages 80 and 247. It seemed eminently desirable to ascertain the geological situation of the iron, and a trip was accordingly made by my brother and myself.

The trail to the location lies along the north line of section 24, T. 65–4. Its position is at the foot of the Giant's Range. It passes over a surface apparently underlaid by Animike slates, but the syenitic bosses rise close by on the north and in places present precipitous exposures. The surface over which the trail passes is hilly, and presents a gradual ascent toward the interior.

After reaching the northwest corner of sec. 23, a branch of the trail turns southward along the west line of the section. Going south about a quarter of a mile an exposure is seen, of which the following is a section from north to south.

S. W. ¼, N. W. ¼, sec. 23, T. 65–4. Outcrop of magnetitic beds of the Animike.

The iron (829) is about six feet thick, and the two lower members aggregate about eight feet. The dip southward is about 10°. On the north is low ground, and many syenite bowlders.

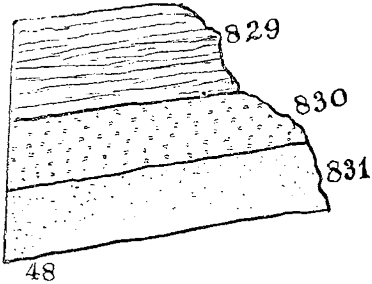


Fig. 48.—*Outcrop of magnetitic beds of the Animike.* 829, Beds of magnetic iron ore. 830, Quartzose "muscovado." 831, Bluish compact rock not determined.

Rock 829. Magnetite at surface.

Rock 830. Quartzose muscovado.

Rock 831. Bluish muscovado-like, but undetermined.

S. E. ¼, N. E. ¼, sec. 22, T. 65–4. About ten rods further west.

Here is an opening in the form of a shaft for exploration. It passes through the whole of the magnetitic beds and terminates on syenite gneiss (833). The magnetite (832) here is from three to four feet thick, but varies in quality both horizontally and vertically. Some of it is quite superior in richness. From first quality it passes down to the ordinary magnetitic Animike. It is here quite massive. The exposed surfaces are black. It is cut by joints somewhat rectangularly. It is powerfully magnetic as a mass, and in hand specimens. At the bottom of the bedded ore is a zone considerably broken and confused. It is also rather cherty.

At the plane of contact between the Animike and the gneiss is a layer of brown earthy matter (834), about four to six inches thick. In places there appears to be a sheet of Animike rusted and decayed. But the greater part of this bed plainly comes from the decay of the gneiss, for it abounds in gravel which apparently represents the quartz of the gneiss. This decay I scarcely think a result accomplished since the deposition of the Animike; for the Animike would protect the gneiss as effectually as so much superincumbent gneiss. This layer then, is an ancient soil which was formed during ages of aerial or submarine exposure, before the Animike had existed. It would not extend under the Kewatin, because there is no definite bottom to it. Its history is continuous with that of the gneiss. This soil would extend underneath the Animike and above the Kewatin.

It is noticeable also, that the "muscovado" beds are not present.

This shows that the border line of the Animike sediments moved northward during the Animike age—whether from filling of the sea, or from a moderate subsidence northward. The gneiss therefore, existed as it is before the Animike, and is certainly not later in appearance as a formation. A slight subsequent elevation of the gneissic region may have given the Animike its slight inclination.

In the following diagram, the facts are shown, as above stated, together with the supposed relation of the Kewatin to the other formations.

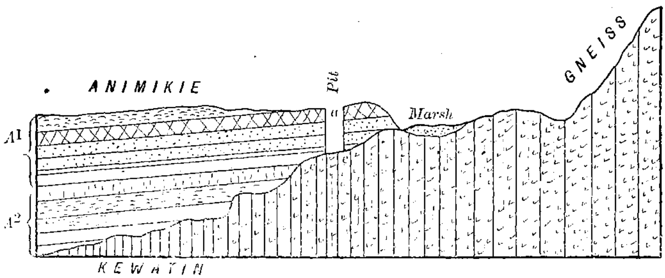


Fig. 49.—*Geological positions of the Magnetite stratum two miles west of Gunflint lake.*

Shows junction of Animike and gneiss and the supposed unconformable subterposition of the Kewatin.

G, Vertically schistose gneiss. K, Vertical Kewatin (not seen here). A1, Nearly horizontal Animike, upper beds, A2, Animike, lower beds of the vicinity (not exposed here).

a, The principal iron ore beds. *e*, Layer of gravelly earth.

(5) *Reflections on the geology of Gunflint lake and vicinity.*

The following inferences from observations made about Gunflint lake were penned on the spot, while in the presence, and under the influence, of the phenomena of which some account is given in the preceding pages. These fresh impressions may possess a value in some respects superior to that of deliberate conclusions penned after the vividness of the impressions has worn off.

It would appear that this entire region has been covered by an outflow or overflow of gabbro in a fluid state. The erosions of later times have removed a large part of it, and eaten down many feet into the slates. The slates generally are more destructible than the gabbro; and where exposed, wastage has been more rapid than on the gabbro-covered areas. Hence it is, as I suppose, that the gabbro remaining has been left crowning the summits of the hills of relief. It is not to be supposed that the gabbro was erupted along these ranges. There may have been great fissures located somewhere, through which the gabbro escaped, and from which it flowed over hundreds, perhaps thousands of square miles.

The gabbro is everywhere in visible progress of degradation. Long, massive flakes become detached and fall down—often rolling to the base of the talus. Other flakes are seen to be disengaged, waiting for a few seasons more of the leverage of expanding ice to throw them over. Meantime the shales below vanish by a process less grandiose. The work is so slow that a given surface remains relatively permanent, and vegetation takes root on it. Even trees have time to grow, while their foundation disappears beneath them. But not only herbs and shrubs, but sturdy trees yield when the time arrives for the destructive blows of the descending gabbro, or the silent undermining of atmospheric disintegration and decomposition. Though these results are coming to attainment even while we gaze on the spectacle, if we look around and contemplate the vastness of the work already accomplished, we are bewildered in the attempt to grasp the æons of time which have elapsed since the configuration of hill and valley and lake basin, as we now look upon them, has been slowly attaining its present features.

Note.—The only considerable record hitherto published of facts observed about Gunflint lake are contained in the *Ninth Annual Report*, Geology of Minnesota, 1880, pp. 81-83, and the *Tenth Annual Report*, 1881, pp. 86-88. Incidentally the geology of Gunflint lake is referred to in the *Seventh Annual Report*, 1878, pp. 11 and 21. These accounts are by professor N H. Winchell, the state geologist. Mr. Robert Bell, of the Canadian Geological Survey, who passed along the boundary in 1872, has given ten lines to Gunflint lake in the *Report of Progress* for 1872-3, pp. 92-93. Dr. J. G. Norwood in his flying trip along the boundary in 1849, made a few observations on Flint lake which may be found in D. D. Owen's *Report of a Geological Survey of Wisconsin, Iowa and Minnesota*, Philadelphia, 1852, pp. 416 and 417. No details of facts have yet been published by the United States Geological Survey, but professor R. D. Irving who has in charge the investigation of the Archæan geology of the Northwest, has made, as is understood, in person and through assistants, extended observations about Gunflint lake. Some of professor Irving's interpretations of the observations have been published in the *Third* and *Fifth Annual Reports* of the U. S. Geological Survey as already cited on page 144 and in the *American Journal of Science* III. Volume XXXIV. The present writer has described the unconformities of the Animike in *Amer. Jour. Sci.* Oct. 1887, and the *American Geologist*, Jan. 1888, pp. 14-24.

§ 13.—NORTH LAKE.

This is also known as Mountain lake; but I employ designations found on the government plats. It lies on the boundary in the form of an isosceles triangle having the axis lying in a position east-northeast and projecting into Canadian territory, while the base abuts against the United States. Accordingly, the American shore embraces only the base and one side of an irregular bay projecting westward from the northern angle, and both sides of a similar bay projecting southwestward from the southern angle at the base. It lies in township 65-2 W., and covers an area about two-thirds as large as Gunflint lake. Its altitude above lake Superior barometrically ascertained by professor N. H. Winchell is 1057 feet. On the south a ridge trending nearly east and west and about 100 feet high, separates it from South lake; and on the north lies the continuation of the Giant's Range, rising to an altitude exceeding a hundred feet. The north shore is deeply indented by bays and capes. A large part of the forest contiguous to the lake has escaped burning. A portage leads northward from the Canadian shores toward Northern Light lake and a region of considerable exploitation for iron. The boundary portage goes out from the south side of the lake in section 22, while the Gunflint river furnishes connection with Gunflint lake.

This broad stream out of North lake is somewhat choked by Juncaceæ. *Nymphæa odorata* remains in bloom to the end of August.

N. W. ¼, S. E. ¼, sec. 17, T. 65-2. North shore of Gunflint river. A low outcrop of syenitic gneiss—779.

The Gunflint river flows along the junction of the gneiss and the Animike formation. No rock exposure on the south shore as far as the rapids.

N. E. ¼, S. E. ¼, sec. 17, T. 65-2. Rapids of Gunflint river. The descent here is about four feet but our canoes were pulled up. The amount of water is small, as North lake is the source of the boundary river—of which Gunflint river is a local name. Here are many angular fragments of a dark rock graywackenitic looking; but a second visit disclosed flint schist in place on the south side.

S. W. ¼, N. W. ¼, sec. 16, T. 65-2, as of Minn. At the widening of Gunflint river. Syenite gneiss (744) comes down to the north shore, containing abundance of well-defined black hornblende and white feldspar with a glassy quartz.

N. E. ¼, N. E. ¼, sec. 16, T. 65-2. South side of bay near entrance to the lake. Stratified beds of flint having a southeasterly dip of about 8°.

N. E. ¼, N. E ¼, sec. 16, T. 65–2. Extremity of point. Massive dark granular rock (745) with much magnetite and disseminated specks of red feldspar. This rock is like some seen where we first enter Animike bay from the north.

S. E. ¼, N. E. ¼, sec 16, T. 65-2. South side of point. Rock much like the last. There appears to be a red-weathering feldspathic constituent—in places white or yellowish weathering; also a dark greenish mineral forming a sort of groundmass for the delicate plates of glassy feldspar seen on fresh fracture. There are rude indications of horizontal bedding.

Rock 746. Diabasic? rock.

S. W. ¼, N. E. ¼, sec. 16, T. 65-2. A low outcrop of gabbro (747) of finer than medium texture.

S. W. ¼, S. E. ¼, sec, 16, T. 65-2. South side of second point. A low outcrop of gabbro of character like the last.

Further toward the southwest on the shore no outcrops were found. The south shore, from the western extremity to the portage is also without exposures.

On a second visit to North lake I made a visit with my brother to the north shore at departure of the trail to Northern Light lake. This is at the head of the bay in N. E. ¼, S. W. ¼, sec. 10, as of Minnesota. A quarter of a mile from the shore a hill rises on the right 75 to 100 feet high and at its foot (on the west) are formed fragments of flint schist and magnetitic schist. These had apparently descended from the hill; but we saw no Animike rocks in place. We found gabbro in place, however, down at the level of the trail.

N. E. ¼, N. W. ¼, sec. 10, T. 65-2, as of Minn. North shore of North lake on trail to Northern Light lake, about half a mile from North lake. Here we found gneiss (778) in place, with black mica and much glassy feldspar with some opaque feldspar.

Some examination was made beyond this point but without observing any change in the geology. Obviously, we find here the foot of the Giant's Range, with hills of gabbro-crowned Animike close following on the south. The situation corresponds geologically with that of Black Fly bay at the west end of Gunflint lake.

Dr. Norwood has the following observations on North lake:

"On the long point which projects into Mountain (North) lake, near the termination of the portage (from South lake, as understood) the rock is schistose, and alternates with thin flinty layers. About a mile below this point, on the north side of the lake, is a low exposure of granite, which slopes down to the margin of the ake. It is in low bosses, from ten to thirty feet in hight, which are bare, or only covered with mosses and lichens. Back of this is a high ridge, bearing east and west, which ascends by a series of steps or plateaus, covered principally with mountain ash and small maple. About one-fourth the hight of the ridge is a granite exposure *in which masses of hornblende rock were found completely enveloped.* Still higher up, where the hornblende rock is traversed by small granitic veins, it becomes somewhat altered in character, and resembles diallage rock. The top of the ridge is composed of coarsely crystalline hornblende. This exposure, like the one on the dividing ridge (between North and South (?) lakes) shows clearly the evidence of having been subjected to igneous action since its upheaval I think it highly probable that it had a schistose structure prior to the eruption of the granite. On the top, many large, weather-worn fragments of granite occur, but no vein of that rock was seen."*

The statements made above in reference to the "hornblende rock" are not consistent with my present knowledge of the region.†

§ 14.—SOUTH LAKE.

South lake, the next eastward along the boundary lies mostly in Town 65–2, west, and its environment is physiographically similar to that of North lake. A range of hills from 50 to 150 and 200 feet in altitude skirts the south shore; but there are few rock exposures along that shore. On the north the features are similar, but with frequent low outcrops. The north shore remains largely in the possession of green timber of the original growth. Much growing birch and some poplar occupy the lakeward slopes of the south side; but they are young trees dating from the last general burning.

The general geology of both shores is Animike, consisting chiefly of thin-bedded black slates; but these are capped extensively, especially along the north shore, by sheets of gabbro.

The elevation of South lake, as barometrically ascertained by N. H. Winchell, is 1,057 feet above lake Superior. This is exactly the same as found for North lake, and indicates that perhaps a slack water communication exists between the two. Yet the known topography does not favor such a connection; and the fact that South lake is drained into lake Superior, and North lake into Hudson's bay would imply that the identical elevations are simply a coincidence without special cause.

The portage from North to South lake lies chiefly in N. W. ¼, sec. 22, T. 65–2 W. It passes southeasterly over a depression in the ridge lying off the south shore and is about a quarter of a mile in length.

S. E. ¼, N. W. ¼, sec. 22, T. 65-2. About half way over the port-

---

* Norwood in Owen's Geological Survey of Wis., Iowa and Minn.

† See reference to same region in Ninth Ann. Rep. Minn. pp. 60-61. The "hornblende rock" locality of Norwood is very likely the same as that at which N. H. Winchell obtained his rock No. 305.

age. A low ledge of gabbro (748) extends along the east side of the portage. It contains in places much magnetite.

Reaching the north shore of South lake, only about a mile of that shore belongs to the United States. The course of the survey is first westward along the north shore to the western extremity and thence eastward along the south shore. The north shore is mostly covered by gabbro.

S. W. ¼, S. W ¼, sec. 22, T. 65-2. Here are low-lying, thick beds of magnetitic Animike,—749.

S W. ¼, S. W. ½, sec. 22, T. 65-2. A crumbling bluff of gabbro of medium texture. A gabbro cliff, sometimes degraded to a crumbling slope, extends along this north shore.

No exposures of rock in place occur along the south shore of South lake. The shore is lined with rounded bowlders mostly syenitic. Just after passing the inflow of the little stream in sec. 24, a hill rises on the south, on the slope of which crumbling gabbro is seen; but no rock appears in place along the entire south shore.

On a later occasion I coasted along the entire northern shore of South lake.

N. W. ¼, sec. 24, T. 65-2, as of Minnesota. Projecting cape about midway of the north shore. Outcrop of compact, medium-grained heavy gabbro,—777.

I observed gabbro at ten localities along the Canadian shore of South lake. They are mostly exposures near water-level, or not over ten or fifteen feet above.

Dr. Norwood has recorded remarks on the geology of the shores of South lake (which he calls Ashawiwisigaton) which are quite unintelligible to me. Proceeding from the eastward he says: "The twelfth portage is four hundred and forty paces in length, and leads over a low ridge, with numerous bowlders of syenite, gneiss and granite, scattered over it to Ashawiwisigaton lake. The ridge is composed of a syenitic rock underlying hornblendic slates at the west end. On the shores of Ashawiwisigaton lake, there are constant exposures of metamorphic slates in low ledges, rising only a few feet above the water level. The last high mural precipice seen along the boundary line (traveling westward) was near the lower end of this lake. On the *American* side, is a ridge of syenite four hundred feet in hight, with a rounded outline and rather gentle slopes." (Of this he gives a figure.)

This statement is unaccountable to me, since I find Animike slates and gabbro along the north shore, and the same slates, at least at one point, within sight on the south shore.

But he further says: "The thirteenth portage is 540 paces long, and leads over the dividing ridge between the tributaries of lake Superior and those of Hudson's bay to Mountain (North) lake. The rock forming the summit of the ridge is *syenite*, associated with massive hornblende. (This does not appear on the portage nor on the summit. On the contrary, gabbro appears along the portage). On the long point which projects into Mountain (North) lake, near the termination of the portage, the rock is schistose, and alternates with flinty layers."*

§ 15.—RAT LAKE.

This is a very small lake not deserving of mention except in a complete enumeration. It is reached by portages both from the west and the east. It is about half a mile long from north to south, and a quarter of a mile wide from east to west. The portage to it from the west is at least a quarter of a mile long—three times the length shown on the plat. The little stream destined to become Pigeon river flows on the north of the trail. Rat lake is mostly filled with reeds and rushes.

S. E. $\frac{1}{4}$, N. E. $\frac{1}{4}$, sec. 19, T. 65-1, as of Minn. East side of Rat lake near portage eastward. A small hill having on the slope gray slates in horizontal outcrop, and at the summit a fine, iron-gray rock with vertical jointage like gabbro, and no horizontal bedding. It is the same kind of rock as I styled fine noryte in Animike bay, and I will so style it here.

Rock 750. Gray Animike slate.

Rock 751. Fine noryte resting on the slate.

§ 16.—ROSE LAKE.

Rose lake, also called Mud lake, is a slender serpentine body of water lying on the national boundary in Town 65-1 west. Its width along the western half is not over a quarter of a mile. In the middle is a deep broad bay setting southward, and the eastern half has a mean width of about two-thirds of a mile. Four deep broad capes indent the shore-line on the north. High Animike hills, gabbro-crowned overlook the lake from the south from altitudes of 125 to 300 feet. The immediate shore is fringed with a dense forest of young

* On this ridge and adjacent geology, see also *Ninth Ann Rep Minn. Surv* 1880, p. 80-81.

birches along the western half, while old Norway pines and spruces replace them along the eastern half. The country along the north shore is but little elevated, and is largely covered with original forest, the birch and poplar being most conspicuous toward the western end. Within a mile of the eastern extremity the Arrow river goes out from the north shore toward Arrow lake three-fourths of a mile distant. Nearly opposite the exit of this stream, Pigeon river goes out on the south side, but eastward toward Rove lake. The lake is reported 1,022 feet above lake Superior.

Actual outcrops of rock along the shore lines are few; but such as occur reveal the uniform presence of the black nearly horizontal Animike slates overlaid by gabbro.

N. E. ¼, S. E. ¼, sec. 19, T. 65-1. End of portage from Rat lake. Low outcrop of gabbro (752), fine and abounding in magnetite.

Rose lake mountain to the south of this locality rises with a parabolic sweep from the shore to the vertical gabbro wall which rests on its summit. It stands a quarter of a mile back from the western part of the lake. It rises fully 200 feet, and from its isolation it seems very conspicuous. The gabbro structure is distinctly basaltic. I took a photograph from the nearest point opposite, but the distance was rather too great.

Rose lake is shallow and much grown with rushes. An extraordinary amount of white birch grows on the south shore; but as the land rises these give way to spruces, which alone hold possession of the high ridges.

S. E. ¼, N. E. ¼, sec. 20, T. 65-1. The gabbro (753) comes down to the shore, and that at a point only about three-fourths of a mile distant from the summit where it stands 150 feet high. It is not likely, however, this difference in altitude indicates the original thickness; for the Animike must have been much eroded before the gabbro was erupted.

N. W. ¼, N. W. ¼, sec. 21, T. 65-1, as of Minn. Gabbro, with lumps of waxy feldspar, up to one and a half inches in diameter. This is like gabbro seen on Animike bay and in many other places.

S. E. ¼, S. W. ¼, sec. 22, T. 65-1. A beetling bluff of columnar gabbro (754) at entrance to the bay protruding southward toward Duncan's lake. At base, near the water, it is fine and graywackenitic-looking, but contains fine prisms of glassy feldspar. On the opposite side of the bay is a gabbro-crested hill 150 feet high.

N. E. ¼, N. W. ¼, sec. 27, T. 65-1. Stair portage to Duncan's lake. A smart stream comes roaring down in a cataract of at least sixty feet. The portage is much worn. It ascends by a series of steps cut in the earth and rocks. This is a frequented route to Birch lake, Daniel's lake and the whole region southward. Gabbro is the formation passed over here, and gabbro reveals itself on all hands, in decaying cliffs and rubbish-strewn slopes.

Dr. Norwood calls this stream the Wisacodé river. He says the portage over is about a thousand yards long, and crosses a ridge over three hundred feet in hight.

S. E. ¼, S. E. ¼, sec. 22, T. 65-1. Animike slates (755) outcrop in the usual horizontal position. They are here a heavy black thin bedded argillyte.

From mouth of Stair Portage bay one sees on the Canadian side, an enormous gabbro bluff facing westward. I estimate it as 75 feet perpendicular.

There are no more exposures eastward as far as the portage. This does not go out at the stream as indicated on the plat; but over a quarter of a mile beyond.

N. E. ¼, N. E. ¼, sec. 24, T. 65-1. On the portage from Rose lake to Rove lake, one-third of mile from the latter. Magnetitic and brecciated Animike—rock 756.

This is the variety which seems to stand vertical. I looked carefully for the Knife lake slates, but the formation was always gabbroloid—not well formed gabbro.

This portage proves to be about a mile and a half long, by the windings. It is comparatively little frequented. It is hilly and stony and overgrown. It is to be avoided as much as possible. I have a suspicion that the usual route is south of the boundary, by Duncan's, Birch and Daniel's lakes.

I looked for signs of Animike slates all the way, but only saw quite numerous fragments of black slate, about a third of a mile from Rove lake

§ 17.—ROVE LAKE.

Rove lake lies in sections 19, 20, 21, 22, 15 and 16 of Township 65-1E. having a length of about four miles, with a mean width of half a mile or less. It consists of two parts connected by a narrow neck of slack water. The eastern part is called Watab lake by Dr. Norwood, and the western part is spoken of simply as "several small ponds connected by a narrow stream." The eastern part is arcuate in form and lies with its mean axis precisely northeast. The western part which is a genuine lake, with a wide constriction near the eastern end, lies in a direction east southeast. Near the western end of the eastern part is a deep constriction narrowing the lake to fifty feet. The land on the north is a point projecting northeastward, with a little bay behind it. The point is about eight rods wide, and the bay about twelve. The point I named Camp Reunion. Almost directly opposite rises the loftiest slate and gabbro hill thus far seen. This I named Mount Reunion. In entering the lake from the narrows this hill is a very conspicuous and impressive feature. It appears as if a mountain had been cleft asunder by a vertical blow and one-half completely removed. Photographic views were taken of this, but they will not appear in the annual report. At the summit is a vertical cliff of gabbro rudely columnar estimated at 80 feet in hight. This faces southwest, west and north. Beneath this vast wall is a precipice of slate whose horizontal stratification is apparent from Camp Reunion. The tendency to columnar features extends down thirty feet into the slate. This portion of the mountain presents also a vertical face, and is estimated at 80 feet. Below this lies a talus of dark angular fragments sloping at an angle of 45° toward the lake. The upper portion of this is naked for an altitude of fifty feet. The lower portion of the slope becomes less steep, and is concealed and partly covered by a dense growth of young poplars (*Populus tremuloides*). The vertical altitude of this part of the talus is about 75 feet. Mount Reunion therefore is estimated to have an elevation of 286 feet above Rove lake. Dr. Norwood puts it at "over 300 feet," and this may be more accurate.

Mount Reunion is the first of a succession of lofty hills ranged along the south side of Rove lake, each of which is vertically chiseled off on the lakeward aspect, and all of which run together at their bases into one continuous range. Their altitudes reach well toward three hundred feet. Still, outcrops along the water-line are few; and the lower flanks of the range are covered with a belt of handsome green poplars, grown since the last general burning. The north shore is depressed, and rocky outcrops are there also of rare occurrence. The point called Camp Reunion is a mass of angular, hard ringing fragments of a dark, cryptocrystalline rock having a very eruptive aspect.

At the west end of Rove lake are three abandoned log cabins. They appear to contain merely a few articles used in a winter camp, and are reported as belonging to the Mayhews at Grand Marais. On the north a road had been at some time cut out. Southward a cut-out road or portage extends to Daniel's lake and thence to Grand Marais.

N. E. ¼, S. E. ¼, sec. 20, T. 65-1E., as of Minn. Camp Reunion. This point is an old pile of gabbro all gone to fragments. There is very little soil, and that is mingled with the ashes of a former burning. The point is now all densely overgrown with young poplars, birches, pines and alders. The fragments are all quite angular. The point seems a mere pile of them 10 or 12 feet high. A few rounded syenite bowlders are intermingled.

N. E. ¼, N. W. ¼, sec. 21, T. 65-1E., as of Minn A low outcrop of rock with dark weathered surface like iron (757), and when broken, still looks in color and texture like fine iron—darker than steel. It is also very heavy. It belongs to that formation so often seen outcropping similarly, and always resembling iron. This, as in other cases, is considerably below the level at which Animike is seen on the mountain side. If the iron bed belongs in the Animike as I have heretofore been led to believe, its position here must be at least 200 feet below the summit of the formation, or there must be a fault between this point and the mountain along the south shore. But I have supposed the Animike iron bed to belong near the top of the formation; and if this is altered Animike there certainly is a fault along the axis of Rove lake. If, on the contrary, this iron bed belongs in the gabbro, which for the present seems likely, it is not the equivalent of the bed seen about the west end of Gunflint lake but of the deposits subsequently seen about Iron lake. This being assumed, it becomes evident that the overflow of gabbro covered a country already deeply eroded—a surface already very ancient. Hence, when later erosion carried away the gabbro along the slope (as at A, fig. 50 the slate became exposed, and gabbro remained both at the higher level and a lower.

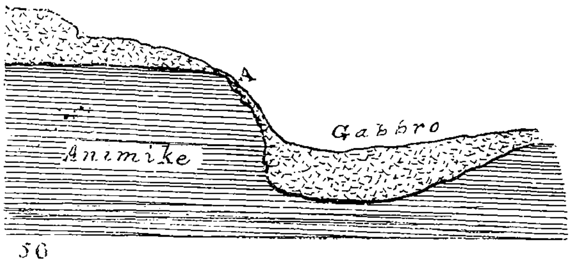


Fig. 50.—*Eroded surface receiving a flow of gabbro.*

N. E. ¼, N. W. ¼, sec. 22, T. 65-1E. A rod back from the shore and concealed by bushes is a wall of vertically jointed compact rock, composed of a dark base and uniformly distributed specks of red feldspar. This is the same as often seen heretofore.

Rock 758. Fine noryte?

N. W. ¼, N. E. ¼, sec. 22, T. 65-1E. This is only half a mile from the last. Outcrop of decaying, rusty black, horizontally lying Animike slates (759), with fine noryte above, in clear contact. The noryte is exactly like that last mentioned.

The little used portage from Rove lake to Mountain lake is about a third of a mile long.

N. W. ¼, N. W. ¼, sec. 23, T. 65-1E. On the portage. Noryte outcrops in angular-splitting masses at frequent intervals along the portage.

§ 18.—MOUNTAIN LAKE.

This lake is six and a half miles in length, lying on the boundary in Towns 65-1 and 2 east, and with an average breadth of about half a mile. The south, or Minnesota shore is little indented; but the north shore presents two deep bays penetrating half a mile inland, and several land indentations. Off the south shore is a continuation of the high range described under Rove lake, and it is similarly broken into a succession of imposing, gabbro-capped hills, with parallel-bedded dark schists underlying and fragmental taluses stretching toward the lake. Several of these hills reach an altitude of 250 to 300 feet above the lake; and farther back are summits said to be feet 375 high—being 1,527 feet above lake Superior and 2,129 feet above sea-level. The north shore is not elevated and the surface comes down generally to the lake-level. This is specially true of the western part. Farther in the back ground, however, hills are seen rising apparently, in one instance, as much as 200 feet above the lake. Notwithstanding the rocky character of the region on the south, the outcrops are few. The talus appears generally to have reached the water-line. On the north shore, however, which I meandered watchfully, I recorded, besides the stops which will be described, twenty-two low outcrops of gabbro.

The vertical gabbro crests along the south shore appear to be generally 50 to 75 feet high; and the vertical slate cliffs next below are of about the same hight. The line of junction between the gabbro and the slate can be seen distinctly from the lake; and the horizontal position of the slates is very obvious. The vertical hight of the talus of the principal summits is about 75 feet.

The original forest of the south shore has been destroyed by burning. The only trees living are a new growth of poplars fringing the beach. Burnings have not reached the north shore except toward the eastern end. In the middle portion of the north shore, a heavy green forest stretches into the interior. In the western part are dense forests of poplar and birch, which appear to be a second growth.

Meander corner between secs. 19 and 20, T. 65-2E. The fragments found here—for no outcrop occurs between the western end and this point—consist of crumbling argillyte of dark color, and of gabbro. Some of the gabbro is very coarse, and also crumbling. Both rocks are much peroxidized.

The shore is exceedingly monotonous. Between the water-line and the talus is a slope of about fifteen degrees uniformly covered with a dense growth of young poplars. The soil on which they grow consists mostly of angular fragments of gabbro and crumbling sheets of dark argillyte. Above this green, wooded slope comes the talus, consisting of large fragments of the same sort, on which there is no soil, or safety for tree growth. Over this, fragments large and small, are occasionally precipitated, to be hurried down the talus slope of about 45°. This work must be more rapid in winter and spring. Evidently the mass of the talu is augmenting, its vertical hight increasing, and that of the precipice diminishing. Evidently, also, the precipitous face will eventually become covered by the growing talus, and, evidently, since this work is not already accomplished, the present course of change has been in progress but a limited period.

N. W. $\frac{1}{4}$, N. E $\frac{1}{4}$, sec. 21, T. 65-2E. Nearly opposite the eastern constriction of Mountain lake. Here, a rod back from shore, is a slope of 45°, composed of angular fragments. The rock is a darker variety of noryte (760), than I have seen before. It is also exceedingly fine, and heavier than usual. I would call it diabase, except that its association with gabbro perhaps indicates the presence of a basic plagioclase.

Near the east end of the lake, the gabbro range is lower, and the crowning cliff has already become concealed or nearly so, by the rising talus, which here slopes almost to the water's edge. But at the end are two bluffs with high precipices remaining. These appear to have been originally higher than the last mentioned.

In the hill at the end of the lake the slates can be seen beneath the precipice of gabbro.

On the return I meandered the entire northern shore of Mountain lake. Along the whole shore the only rock in place is gabbro. It occurs mostly in low bluffs at the water's edge—some of it in heavy, nearly horizontal beds. But there are some cliffs close on shore with an elevation of 15 to 20 feet. The exposures are decidedly frequent.

I landed at twenty-four points—all of gabbro. Yet there are considerable stretches without outcrops.

N. W. ¼, S. E. ¼, sec. 14, T. 65-2E. Portage out of Mountain lake eastward. On the Canadian side of the stream, on which the portage lies, I ascended the hill to the summit, and found it formed of coarse crumbling gabbro. The gabbro makes here, as everywhere, a coarse brown soil colored by iron peroxide.

This is the hill on which I discovered the unusual species of blueberry mentioned in the introduction. Here also I observed the shad-frog mentioned.

This portage eastward out of Mountain lake, also little traveled, is about a third of a mile long, and joins the Pigeon river below the rapids. The river soon widens, and is so filled with scouring rushes as to be nearly impassable. This swell is known as "Upper Lily lake."

After a quarter of a mile of boatable water, another much neglected portage of a quarter of a mile occurs, on the Canadian side of the rapids, leading to another small swell in the river which is sometimes denominated "Lower Lily lake." This continues for a quarter of a mile, when other rapids occur, and we enter on the portage which terminates on Moose lake. This portage lies also on the north side of the river, and is about two-thirds of a mile in length. A range of gabbro continues along the south side thus far, but it is less than a hundred feet in hight. The portage is bad.

S. W. ¼, S. E. ¼, sec. 13, T. 65-2E. American side, near entrance to portage from Lower Lily lake to Moose lake. Coarse gabbro (761) with a large percentage of iron.

Similar gabbro occurs at the portage on the Canadian side.

N. E. ¼, N. E. ¼, sec. 24, T. 65-2 E. On the same portage, one-eighth mile from Moose lake. On the Canadian side, a knob of Animike breccia outcrops from the hill slope.

On the American side of Pigeon river, a range of gabbro overhangs the stream, all the way to Moose lake.

§ 19.—MOOSE LAKE.

Moose lake lies in the western half of Township 65-3 east. Its longer axis stretches east southeast and is three and a half miles long. The lake has a mean width of a mile. The contiguous country presents an aspect not materially different from that surrounding Mountain and Rove lakes. The gabbro-crested hills on the south attain elevations as great; and the north shore is similarly depressed. A mile back, however, on the Canadian side, reveals toward the northeast two strikingly elevated summits, but perhaps not over three hundred feet.

The country on the south side is mostly burnt over; but near the shore is frequently stocked with young poplars. On the north side Norway pines abound on the west and also on the east, but considerable burnt country intervenes.

There are few outcrops on the shore-line of the south side. I noted gabbro at seven points in low outcrops, along the Canadian side.

After examining the south shore for the distance of a mile and a half, from the west end, and finding no rocks in place, I ascended the hill about eighty feet and discovered a ledge of slate. There is no gabbro visible from this point, but it can be seen from the opposite shore at a higher altitude, resting on horizontal slate.

S. E. ¼, S. W. ¼, sec. 20, T. 65 3E. The slate is much shattered, and the talus slope is mostly overgrown with small cherry bushes. Most of the slate is in layers from half an inch to an inch thick; some in beds of several inches and quite solid. The solid beds are dark, fine-grained, heavy, identical with the fine rock which I have often seen, always feeling doubtful about its relations to erupted material. Here it is distinctly embraced in beds of sedimentary character. If eruptive, they can only be intrusive. The thinner layers, however, are similar in color, texture and weight. Occasionally, is a layer of darker color, evidently from the abundance of magnetite.

Rock 762. Three varieties of Animike.

Farther east, this same cliff is completely covered by the talus slope, but so recently that no soil has yet accumulated for the growth of shrubs, except in patches

Still farther east, the ledge reappears, and the uncovered talus slope is about two rods wide. The slate ridge gradually approaches the shore Here is an other occurrence of gabbro. This is in the N. W. ¼, N. E. ¼, sec. 28, T. 65-3E. Gabbro is again seen, a quarter of a mile east, on another hill not over 50 feet in hight.

S. E ¼, S. E. ¼, sec. 21, T. 65-3E. Half mile from foot of Moose lake. Outcrop of horizontally bedded slate. The beds are two to four inches thick, and of similar character to that last described.

S. E. ¼, S. W. ¼, sec. 22, T. 65-3E. At portage east out of Moose lake. Gabbro on Canadian side, coarse, altered by weathering, as usual, with much magnetite—763

Rock 764. Animike from shore fragment—apparently almost pure magnetite.

N. W. ¼, S. E. ¼, sec. 18, T. 65-3E., as of Minn. North shore of Moose lake. A low outcrop of probably gabbro, of dark gray color, and scattered slender crystals of glassy feldspar. I have seen the sort before.

Rock 776. Peculiar gabbro. North shore of Moose lake.

I passed along the entire north shore and identified gabbro at several localities, but saw no slate. There is no range of hills along the shore.

§ 20.—NORTH FOWL LAKE.

This and South Fowl lake are by Dr. Norwood designated jointly "Lac du Coq"; but in the terms of the Webster-Ashburton treaty they are named as in this report. North Fowl lake has an outline resembling the vertical section of a fleshy mushroom. The stem is directed southward. The north and south dimension of the lake is two miles, and the width of the cap is two miles. The lake is nested in a depression among high gabbro-crowned hills These are not less conspicuous on the Canadian than on the American side.

The portage east out of Moose lake is really about three-fourths of a mile long, though the plat shows less. It is crooked, rough and overgrown with bushes: and like the other trails along this part of the boundary appears to be little used. The clearing at the termination marks the site of a former winter house of the Hudson's Bay company. Pigeon river is now a good sized creek, flowing more rapidly than Burntside river, but probably carrying about the same amount of water.

A gabbro and slate range runs parallel with the river, on the south side, and the same range extends along the southwest shore of North Fowl lake. The gabbro, which was nearly interrupted along Moose lake, near the shore, shows a thickness here of 40 to 60 or 75 feet. The gabbro crests also, lie nearer the level of the lake. A very high gabbro cliff, however, is seen on the Canadian side, which I estimate at 250 feet above the lake; and a series of four others, diminishing in altitude, succeeds southward.

On the American side, in section 26, is the highest precipitous face of gabbro which I have seen. I think what is visible above the talus rises 90 feet—all gabbro—and its base is not over eight feet above the lake. The range strikes from here southward.

This lake is much grown with rushes and wild rice, especially on the American side.

A gabbro range is seen again on the south, gradually rising toward the northeast; and behind this, more easterly, another. Both present precipitous fronts toward the lake. Still farther south is a higher range, rising probably 300 feet, and showing a long perpendicular wall facing northward. This is a mile from the lake, on the American side,—the intervening distance being low and level, and beginning with an extensive tamarack and spruce swamp. These, however, face South Fowl lake, and separate it from Roy lake.

Coming into Pigeon river again, we find a broad, deep, clear, stream, forty feet wide, and bordered by a marsh averaging a quarter of a mile. The marsh abounds in wild rice, cane and an aquatic grass

Pigeon river issues half a mile northeast of the extreme point of North Fowl lake. At that extreme point, a small stream comes in from Roy lake, discharging the waters of Roy, John, McFarland and Pine lakes. In ascending this stream, within less than half a mile, *vertical*, thin-bedded slates are seen in the bottom, obstructing navigation. They are of an ashen color, and apparently would make good roofing slates. This is in sec. 2, T. 64, R. 3 E. This information is obtained from Capt. Wm. P. Spalding, of Sault Ste Marie.

Supposing the information correct, the vertical ash-colored slates can be no other than the Kewatin formation so extensively developed north of Gunflint lake. This, then, is the most easterly point at which that formation has been identified in northeastern Minnesota.

On sections 4 and 5, T. 64-2E. Capt. Spalding has located a quartz vein said to bear native silver and gold on the foot wall. Close by, are what he regards as "ancient diggings," on the south side of "lake Miranda." I have not seen Capt. Spalding's location, but I have seen a sample of the gangue said to hold silver and have in my possession numerous photographs of the vertical quartz vein and the surrounding region.*

§ 21.—SOUTH FOWL LAKE.

South Fowl lake, the last on the national boundary, trends m ridionally with its longer axis which is a mile and a quarter in length.

* For an account of Spalding's mining location. and of the "ancient diggings," so-called, see N. H. Winchell, in *Seventh Ann. Rep. Geol. Minn*, pp. 18-20. The same *report* contains accounts of all other mining locations in the vicinity. See pages 11 to 22.

A further description of the geology of the region by N. H. Winchell is contained in the *Ninth Ann. Rep.*, pp. 77-79.

The east-west diameter is two-thirds of a mile. The stream connecting it with North Fowl lake is broad and deep, with a barely perceptible current. It widens gradually into the lake. The upper end of the lake presents a wide expanse of wild rice and grasses and seems to be a continuation of the river.

The high gabbro hills mentioned above look down on the lake from the west and south. The outlet is through a gabbro gateway. Through this the river passes over a succession of rapids for over a mile; and nowhere below do the conditions exist for the accumulation of another lake, until the stream is discharged into lake Superior.

S. W. ¼, N.E. ¼, sec. 12, T. 64-3E. An exposure on the hill side a quarter of a mile west of the outlet of South Fowl lake a few rods back from the shore was examined. It is nothing but the familiar coarse crumbling gabbro.

S. W. ¼, N. E. ¼, sec. 12, T. 64-3E. West side of outlet of South Fowl lake. On this side of the gabbro gateway rises a precipitous wall to a hight of nearly 200 feet above the lake. The vertical ascent is about 120 feet. The gabbro where unweathered, is of medium coarseness, abounding in magnetite.

In the midst of the face of gabbro is a vertical dike 27 feet wide, which exhibits a horizontal bedded or quasi-columnar structure. The beds (or columns) are six to ten inches thick, and placed between the vertical columns of gabbro, present from the lake, the appearance of a tier of shelves. The dike intersects the whole exposed face of the gabbro from summit to upper boarder of the talus. It wears away more rapidly than the gabbro, and hence appears in a shallow recess.

The dike rock is very fine-grained, dark gray and nearly crypto-crystalline; but under the lens, reveals the existence of a dark constituent intimately mingled with a translucent, waxy feldspar. It has a high specific gravity.

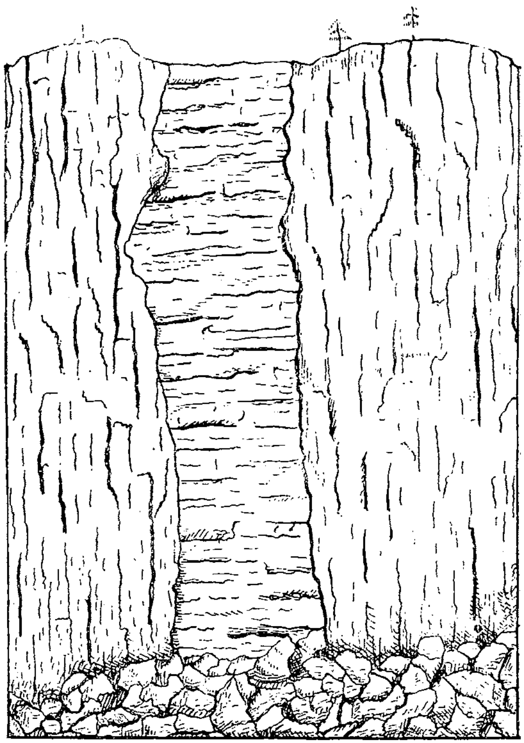
In a fissure of the gabbro, I found some crystals of dolomite and quartz.

Rock 765. Gabbro from Pigeon river gateway.

Rock 766. Dolomite and quartz, from the gabbro.

Rock 767. Diabase from the dike.

A photographic view of this cliff was taken from the Canadian side, Pigeon river gateway, where rises a gabbro bluff which I estimate at 150 feet high, with a vertical ascent of 75 feet. These are the two sides of the gateway, through which the Pigeon river passes by a succession of cascades out of the last lake in the boundary series. The



51

Fig. 51 —*Horizontal columnar structure in the dike on the shore of South Fowl lake. The dike intersects gabbro having a vertical columnar structure.*

gabbro, as everywhere, assumes a columnar structure. I find here no continuation of the dike (of rock 767).

N. E. ¼, S. E. ¼, sec. 12, T. 64-3E. Gateway mountain, commencement of portage out of South Fowl lake, southeastward. Here on the south side is a hill topped with gabbro and 125 feet high. On the north is a towering precipice three hundred feet above the lake, whose jagged outline projects itself against the sky almost in the neighborhood of the zenith. There hang huge parallelopipedons of gabbro awaiting the next season's frosts to be thrown down. Here by the trail, are the enormous masses which were projected from that giddy altitude by some previous season's frosts—ten by fifteen feet in dimension—lying here mostly moss-grown and crumbling away while the centuries roll around. Here are some too, freshly fallen, and above are the scars showing whence they were detached. It is a wonderful place, and provokes a multitude of reflections which must not here be indulged in. This high hill, for clearness of description I call Gateway mountain.

With the view of approximating its true altitude, I used my clinometer and found the angle of elevation to the summit 62°. I simply estimate my distance from the foot of the perpendicular, at 140 feet, and from these data I calculate trigonometrically an altitude of 263 feet. As my point of observation was at least 25 feet above the lake, the altitude of Gateway mountain as thus obtained, is 288 feet. Norwood says it is 306 feet, but does not state whether this is a rough estimate or the result of actual observation.

I took a successful photograph of Gateway mountain with point of view at Halt 1398 *

A small spring of ice-cold water issues from the accumulation of *debris* in the gorge between Gateway mountain and the portage trail, and it has been suggested that it may be supplied from a store of ice covered and protected by the mass of fragments.†

S. E. ¼, N. E. ¼, sec. 18, T. 64-4E. South end of Long portage, out of South Fowl lake. Walked first over the portage and returned, exclusively for observation. I find it about a mile and a half by the windings. The portage is uncommonly good, though sinuous. I do not understand why so much better than any seen this side of Rove lake.‡ I can conjecture, however, that the Fowl lakes yield crops of wild rice which bring the Grand Portage Indians up here.

I saw no rock in place on the way; but of course, many gabbro bowlders, and quite a quantity of fragments of black, thin-laminated slate. The country from the eastward slope of this portage, presents a changed aspect. No high ridges intercept the distant view. There are no gabbro knobs or ranges visible after leaving those magnificent monuments of a fiery flood which looks down on us at the Gateway.

I had not intended to travel farther along the Pigeon river; but the interest excited by the changed features of the wilderness led to a change of plan.

* A view of the same is given in Irving's "Preliminary Paper" on the Archæan of the Northwest, *Fifth Ann. Rep. U. S. Geol. Surv*, 1883-4, facing p. 204. The mountain, however, is not in Minnesota but in Canada, being east both of Pigeon river and of the portage.

† N. H. Winchell in Ninth Ann. Rep. Minn. Surv., pp. 74-75.

‡ The whole season's exploration was made withont a guide. Nor had any person in my party been through the region previously.

§ 22.—PIGEON RIVER.

The features of the country along the Pigeon river southeast of South Fowl lake will be briefly described in connection with the localities noted. The river, from the foot of the Long portage, continues of nearly uniform width to the next rapids. It is a broad, deep stream, flowing with a current of about a mile an hour. The borders are filled with wild rice and other aquatic grasses. Not much timber is seen on either side. Some scattered tamaracks and clumps of spruces occur. No high land, even in the distance—no upland in the vicinity. Only occasionally clusters of poplars. At length after an interval of two miles, in section 21, T. 64-4E., a small ripple is seen in the current, occasioned apparently by bowlders; but sixteen rods beyond, the sound of rapids is heard.

N. W. ¼, N. E. ¼, sec. 21, T. 64-4E. Fourth portage. This portage is about three-fifths of a mile long, in a mean direction east by south. It strikes the river again on an east-southeast stretch. No rock in place is seen on the way, and but few bowlders. These are gabbro. At the end of the portage, a mountain is seen in the southeast, stretching from southward to northward, but wooded to the summit.

N. W. ¼, N. E. ¼, sec. 21, T. 64-4E. A quarter of a mile further north. Went up to the rapids a few rods above the eastern end of this portage, but found only bowlders as an explanation. Went then, west again to the top of the ridge apparently causing this abrupt northerly bend in the river; following it north to the turn in the stream; but found nowhere any outcrop. I had expected to find evidence of a dike trending north.

N. E. ¼, S. W. ¼, sec. 22, T. 64-4E., as of Minn. Olivine knob. At length we come to a hill on the Canadian side, a quarter of a mile back from the river, whose white-shining rock-exposures remind me again of syenite. I plunged through the intervening swamp and climbed the slope to the summit. It weathers granite-fashion. It is of pepper and salt color. Whitish feldspar is very determinable; and there is a little transparent feldspar. Beside these, are abundant grains of a smoky mineral, and not a few of magnetite. The smoky mineral is harder than feldspar, and weathers conspicuous on the rock surface. When broken, the grains present glassy surfaces. Evidently they answer the description of olivine. This hill is 125 feet high.

Rock 768. Granular olivine gabbro or noryte.

I find incorporated in this formation at the summit of the hill, some characteristic coarse gabbro (769).

From the summit of this hill I take a survey of the surrounding country. West northwest, spreads an area two miles wide and eight miles long, through which we have followed Pigeon river. It is dotted with tamaracks and spruces, but most of the surface is occupied by alders or marsh grasses.

South 40° west is a knob which has an eruptive contour, with a smaller knob for each shoulder. The range to which these belong extends about westward to a point S. 85° W. from here, and about one and a half miles distant. From behind this rises a much higher mountain, which seems to be about six miles away. From where it appears, it trends away, west of north, and ends in what appear to be gabbro bluffs N. 80° W. from here. They face northward. They seem to be southwest from South Fowl lake. In the nearer ground, N. 75° W., is another bluff, also facing northward. Still nearer, about three miles distant, N. 70° W., is another bluff of less magnitude. On the north is a mountain-like ridge, about three miles distant, running east and west. In a hill on the north, half a mile away, about 75 feet above the river, are outcrops of light color, resembling the rock in this mountain.

N. W. ¼, S. W. ¼, sec. 22, T. 64-4E. Third portage. The rapids between the two gabbro hills are portaged on the left of the stream. Portage one-third of a mile, direction a little east of south.

Below these rapids, for a mile and a half, the stream is swift, and interrupted by many bowlders of trap. In places, it widens out and becomes very shallow. In one place it divides, and runs among many islands. Neither stream has water enough for safe canoeing, and navigation is very difficult. The bowlders passed, the stream becomes 50 to 60 feet wide, and three feet deep. This is a long stretch of a mile, flowing eastward.

At this place one sees in the east, at the distance of a mile or two, a trap-looking hill seventy-five feet high. The stream flows directly toward it until within a quarter of a mile, when it turns abruptly northward and then eastward, to pass around the hill.

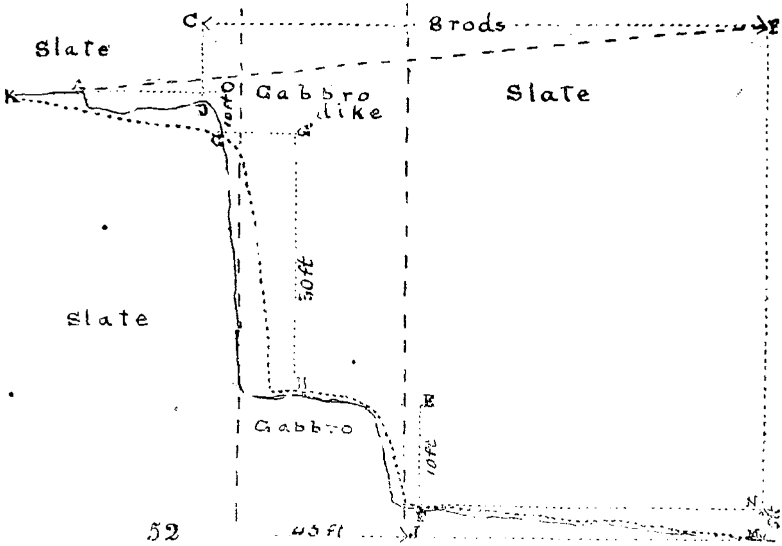
T. 64-5E. has not been surveyed because lying in the Indian Reservation. At a point in the pass between the hill above mentioned and a smaller one on the Canadian side, I ascended the latter. I found it a very compact and hard sort of gabbro (770) with much olivine and magnetite.

The cliff on the American side looks exactly like this.

Partridge portage. The stream along the stretch of a mile between the last and this point is bordered by weeds and flows quietly through a level tract.

The plane is mostly a clearing, but some poplar, birch and firs remain. Partridge portage is about a quarter of a mile long, fairly good.

Partridge falls. The Minnehaha of the boundary.



52

Fig. 52.—*Diagram of Partridge falls in Pigeon river.*

The measurements given are estimated. The diagram is not drawn to a scale.

A. The highest rock above the falls.
B. The hight at which it reached at the foot of the descent.
C B. Eight rods, distance from brink of falls to foot of rapids.
D. Standing rock at brink of falls (place of Indian in photograph.)
E F. Ten feet, hight of lower falls.
G H. Thirty feet, hight of upper falls.
I J. Width of dike of gabbro, 45 feet.
K G. Rapids above the falls. Descent, O G. 20 feet.
F M. Rapids below the falls. Descent, M N. 5 feet.
K G H F M. Surface of water.

The above diagram shows the more important facts. The highest rock, A, slopes upward at such angle that if continued to the standing place, D, close to the falls, it would be ten feet above it. A dike of gabbro, which seems to be of the same character as the gabbro of the country, intersects the formation between the two falls and is about

45 feet wide. If this proves to be the same as the ordinary gabbro, it would seem probable that it was contemporaneous in eruption, and that this was one of the fissures from which the flow came which inundated the country. Further, as no gabbro appears on the surface in the vicinity, there is evidence of much erosion of gabbro. And still further, if one gabbro vent of small dimensions existed, not unlikely the whole escape of the outflow was through numerous vents of moderate capacity, rather than one or two great fissures.

The strike of this dike is N. 55° W. and it stands about vertical. N. H. Winchell says, "W 5° N." (Ninth Rep. p. 74).

The dip of the slates here is up-stream, and since the stream here flows northwardly, the dip is southward, Norwood says, "Above the falls, the dip of the slate is northwest, 80°." Below, he says the dip is "reversed to the southeast, at an angle of 17°." N. H. Winchell says, on the contrary, "The brink of the falls is of slate, ripple-marked, dipping south about 12°;" and Bell says "the slate dip south about 20°."

Rock 771. Animike black slate from Partridge falls.

Rock 774. Gabbro from dike at Partridge falls.

Rock 775. Specimen illustrating jointage of slate.

I took much pains to get good positions in the gorge below the falls, for photographic views, and obtained four successful ones. A very good general view of Partridge falls is published in professor Irving's "*Preliminary Paper*" *

Grand portage, seven miles from lake Superior. The river through the stretch of two and a half miles between Partridge falls and this point, pursues a very sinuous course over a grassy plain evidently underlaid by Animike black slates in a position nearly horizontal. At this portage is an old clearing of a few acres, overgrown with wild grasses. Dr. Norwood states that this "was once the site of Fort Charlotte, for many years the most important post of the Northwest Fur Company."

The rapids here pass over a dark gray, partly thick-bedded slate, dipping southward about 6°.

Rock 772. Prevailing character of the slate, at the upper end of the Grand portage.

Rock 773. Darker, thick-bedded slate.

The Pigeon river valley, east of the great swamp—that is, below the gabbro range, is decidedly tillable. Most of it is upland, with a good natural soil, as evinced by the rank growth of herbaceous ve t..

* *Fifth Ann. Rep. U. S. Geol. Surv.* facing page 203.

ation. There are few hills, and seldom outcropping rocks. The country has been once burned over, on both sides of the river, and many of the dead pine trunks still stand to attest the once vigorous growth of the forest. The Indian Reservation, on the American side, as far as can be seen, is a level, arable and valuable tract.

It may be added, for the purpose of completing a view of the boundary as far as Pigeon Point, that its physical and geological features below the upper end of the Grand portage are already pretty well understood, and have been described with more than his usual detail by Dr. Norwood, assisted by Major Richard Owen. His descriptions embrace also the shore line between Pigeon Point and Grand Portage bay, as well as the geology of the Grand portage.* A careful report on the same district has been published by Prof. N. H. Winchell.† An exposition of some special features has recently been published by professor W. S Bayley.‡

The course of this report now returns westward to Red Rock lake with a view to considering in regular succession a series of lakes lying next south of the boundary series, to which our attention has thus far been confined.

§ 23.—RED ROCK LAKE.

The passage from the west long arm of Saganaga lake to Red Rock lake is narrow and obstructed by syenitic bowlders. A small stream flows out of the latter lake. Red Rock lake is practically a continuation of the west long arm mentioned. It is similarly indented by long capes, with alternating deep, irregular, mostly club-shaped bays. Its shores are exceedingly rocky, and buttressed by frequent high, often precipitous boses of syenite. A few intervening soil-covered tracts occur on which grow small spruces and Jack pines. The region possesses little value either or timber or agricultural purposes.

From Saganaga lake sec. 28, 66-5, syenite continues unchanged in character to Red Rock lake. When the shallow passage between the two is not canoeable, a short portage may be found over the hill on the east side. The direction of the current is out of Red Rock lake, but the stream is hardly a rapid.

N. W. ¼, S. E. ¼, sec. 28, T 66-5. Passage from Saganaga to Red

---

* Owen's Geolog. Survey of Wis, Iowa and Minn, pp. 397-109.

† *Ninth Ann. Rep. Geol. Minn.* 1880, pp. 61-73. Mining geology also in *Seventh Ann. Rep.* Minn 1878, pp. 14-19. See also *Tenth Ann. Rep.* 1881, pp. 43-49.

‡ Bayley, *On some peculiarly spotted rocks from Pigeon Point, Minn. Am Jour Sci.* III, xxxv 388-93, May, 1888.

Rock lake. Syenite, still weathering conspicuously rough, with large quartz grains.

S. E. ¼, S. W. ¼, sec 28, T. 66-5. Syenite (576) unchanged.

S. E ¼, S. W. ¼, sec. 33, T. 66-5. Numerous examinations made from the last point to this reveal no important variations in the character of the syenite. A t this place is a lofty vertical wall of syenite, some of whose faces are covered by an orange-colored lichen (577). This, I suspect, is the particular "red rock" from which the lake is named. (Compare "Painted Castle," p. 115, Report of 1886). The syenite is still unchanged.

The syenite continues without change to the southern extremity of the lake.

No water communication exists between Red Rock and West Seagull lakes. The portage goes out at the extreme southwestern angle of the former. It passes over a depressed ridge, through open woods consisting of Jack pine and spruce, with a few poplars. It is an unfrequented trail, but quite practicable. We chopped out a number of trees fallen across the path.

§ 24.—WEST SEAGULL LAKE.

West Seagull lake lies in the northwestern part of T. 65-5, with an extreme length north and south of about two miles and a breadth a little less On the plat it presents a strinkingly irregular figure; and the numerous large islands included cause an appearance of a jagged inlet winding and ramifying through a wilderness of rocky knobs. The exposures of syenite are almost continuous until we approach the southern extremity. In this region the syenite becomes chloritic, gneissic and even schistic. On the west of Seagull lake, in section 7, Mr. Stacy reports "conglomerate and syenite interbedded"; but I had left the region before obtaining this information. Mr. Stacy compared the conglomerate with that of Ogishke-muncie; but I feel strongly persuaded that the two are very different. The latter is remote from syenite and has never been seen interbedded with crystalline schists—still less gneisses. I suspect the West Seagull conglomerate is to be compared with that of Wonder Island in lake Saganaga; and I think undoubtedly the greenstone pebbles and bowlders disseminated through this syenite-gneiss formation generally are closely connected with the history of these conglomeritic beds and patches.

S. E. ¼, N. E. ¼, sec. 5, T. 65-5. South end of portage from Red Rock lake. Syenite exactly as on Red Rock lake.

S. E. ¼, S. W. ¼, sec. 5, T. 65-5. West side of north part of lake. Here are vast exposures of syenite (578) along the west shore. It looks white at a distance and presents a wide shining treeless area rising toward the interior. On examination, it closely resembles that so prevalent; but the quartz grains are a little smaller, and the surfaces of the rock do not weather so rough.

A high range is seen on the east and southeast, appearing 300 feet high. It appears to be southwest of Seagull lake and east of Frog Rock lake.

S. W. cor. sec. 8, T. 65-5. Syenite without conspicuous quartz grains, and with a chloritic mineral in place of hornblende (579). Portions of the rock abound in the chloritic mineral. The formation resembles that seen on entering Saganaga lake

Rock 580. Chlorite syenite, highly chloritic, like Pipestone chlorite gneiss. (Compare Report for 1886, pp. 105-6- 176-7).

N. E. ¼, N. W. ¼, sec. 17, T. 65-5. A quarter of a mile beyond the last point. The formation has become graywacke-like. It attains, as usual for the graywackenitic rocks of the entire region, a very massive development. This is near the southern point of West Seagull lake.

Rock 581. Graywacke, dark and fine.

N. E. ¼. N. W. ¼, sec. 17, T. 65-5. Southern point (head) of West Seagull lake. Massive graywacke (502) a little slaty in places.

N. W. ¼, N. E. ¼, sec. 17, T. 65-5. One-eighth mile northeast of southern point of West Seagull lake. At the beach, chlorite schist. A few steps back, syenite gneiss with red feldspar, alternating and mixed with chlorite schist. One example follows:

The schist in places approaches the condition of a greenstone. The gneiss has the common character, with pale red feldspar and scattered grains of quartz.

Rock 573. Gneiss and chloritic rock in contact.

The small island off this locality is composed of chlorite syenite; and the point projecting in from the east is the same.

S. E ¼, S. W. ¼, sec. 8, T. 65-5. Island north of the extremity of the point last mentioned. Quartziferous granular felsyte (843) very similar to that seen in the west long arm of Saganaga lake.

This island is scarcely half a mile north of the head of West Seagull lake, and the "point" is nearly midway between them.

The cape jutting northward less than half a mile east, is composed of chlorite syenite; while the large island between the cape and the east shore is of syenite of the usual sort for this region.

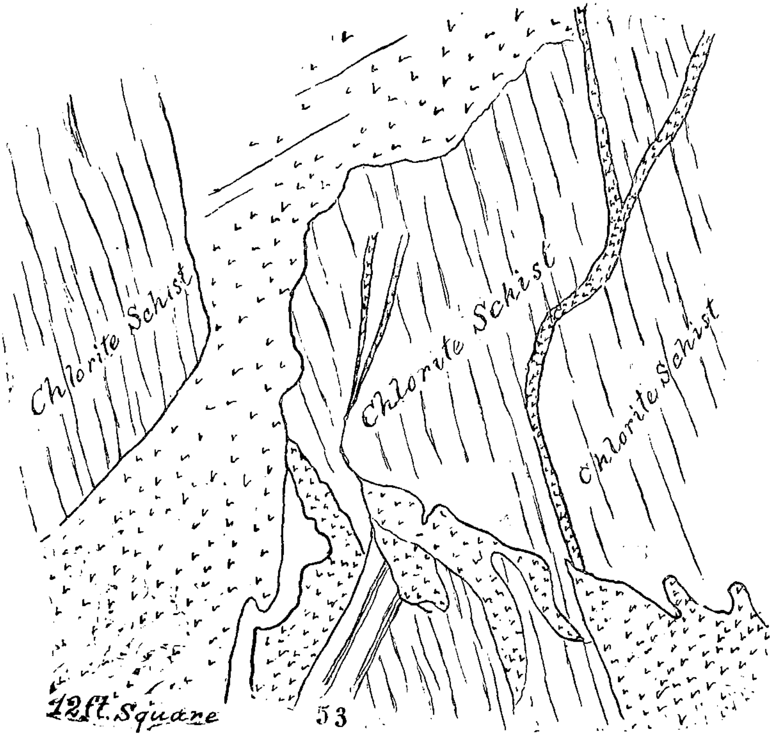


Fig. 53.—*Intermixture of syenite gneiss and chlorite schist, West Seagull lake.*

S. E. ¼, N. W. ¼, sec. 9, T. 65-5. East side of West Seagull lake. Syenite (594) with well formed hornblende; but the grains of quartz are not remarkably large, nor do they stand conspicuous on weathered surfaces.

S. E. ¼, S. W. ¼, sec. 4, T. 65-5. Neck of the most eastward bay of West Seagull lake. Syenite with large quartz grains.

S. E. ¼, N. E. ¼, sec. 9, T. 65-5. On the rapids from West Seagull to Seagull lake. Chlorite syenite.

The stream connecting these two lakes is over half a mile long, flowing toward Seagull lake. The rapid requires no portage.

§ 25.—SEAGULL LAKE.

This is located mainly in T. 65–5, but extends half a mile into T. 66–5 and 4, and a mile and a half into T. 65–4, thus covering the corner of four townships. The features of the lake in the vicinity of the four corners are shown in the sketch-map, figure 54, which shows the connection with Saganaga lake through the arm called Seagull river. This lake has an extreme length, northeast and southwest, of about six miles, with a main breadth of nearly two miles. The west body of the lake is a clear expanse of three square miles only interrupted by small islands near the western shore. The east body however abounds in large islands which occupy half the area. Cucumber island is two miles and a half long, with a mean breadth of nearly half a mile. A high ridge runs longitudinally through it. The original forest still stands, composed largely of Norway pine and spruce. In the region west of Cucumber island, the large, lofty, bald syenitic islands rise very conspicuously. On the north shore is a syenite promontory which attains an elevation of 150 feet. Two interesting features are presented by the syenite of this lake. First, its passage through chlorite syenite on the south, toward the chlorite schist and argillytes pertaining to the Knife lake belt, and Second the general dissemniation of greenestone pebbles in the gneiss which proves premonitory of the contiguity of actual conglomerate patches imbedded in the gneissic terrane, as already described on Wonder island in Sagnaga lake, and mentioned in connection with West Seagull lake.

Partaking of the general sterile character of the entire region traversed by the Giant's Range, the vicinity of Seagull lake possesses few inducements for settlement, and gives no promise of important mineral discoveries. Building stone is the chief product of the region

There seems to be no portage around the rapids between West Seagull and Seagull lakes. The stream is mostly broad and sufficiently deep for canoeing; but some of the rapids are rather exciting.

N. E ¼, S. E ¼, sec. 9, T. 65–5. South of the mouth of the stream. Chlorite syenite.

S. W. ¼, S. W. ¼, sec. 10, T. 65–5. Island nearest the last. Syenite with partially developed hornblende.

S. W. cor. sec. 10, T. 65–5. Point of cape from the west. Syenite like last, but the hornblende is imperfect.

N. E. ¼, N. E. ¼, sec. 16, T. 65–5. Entrance to broad westward bay. Syenite with hornblende distinct.

N. E. ¼, S. E. ¼, sec. 16, T. 65–5. Nearest island to south point of bay. Syenite as before.

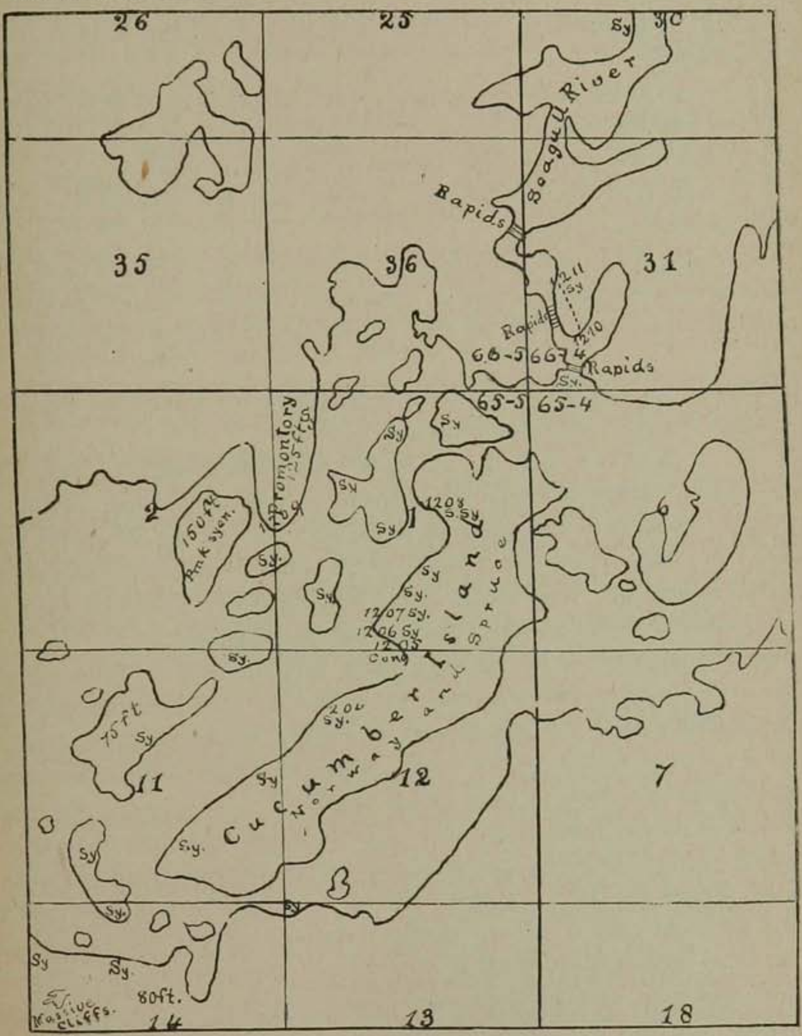
S. W. ¼. S. W. ¼. sec. 15, T. 65–5. Near southern extremity. Syenite weathering white. This may be compared with syenite (578) on west shore of West Seagull lake. The quartz exists in large grains.

N. W. ¼, S. E. ¼, sec. 15, T. 65–5. Syenite (595) very well marked, but the hornblende is somewhat chloritized.

The islands in this vicinity are of syenite. A high massive cliff extends along south side of narrow, eastward projecting bay. The two capes next northeast are of common syenite, and a high cliff is exposed on the southern one.

Observation of many shores and islands on the southeastern and central parts of the lake proves them all to be formed of the prevail- syenite.

The remainder of this lake is illustrated by the following map:



54

Fig. 54.—*North part of Sea Gull lake, Ts. 66-5 and 4 and 65-5 and 4.* Land and water contours in a granitic region.

37

The numbers on the last map refer to rock samples as follows:

1207 shows the locality for rock		597.	1209 shows the locality for rocks		599–607.
1208	" "	598.	1210	" "	608.

N. H. W.

N. W. $\frac{1}{4}$, sec. 12, T. 65-5. Cucumber island. Syenite with coarse grains of quartz,—596.

S. E. $\frac{1}{4}$, S. W. $\frac{1}{4}$, sec. 1, T. 65-5. West side of Cucumber island. Chlorito-graywackenitic conglomerate (597). Apparently not Ogishke conglomerate, but very similar to that which will be more particularly described in connection with the promontory on the west shore—rocks 599-607.

It must be noted that this conglomerate, like that at Wonder island is inclosed in the syenitic terrane. Still it differs from that in having a graywackenitic groundmass instead of a syenitic one.

S. E. $\frac{1}{4}$, S. W. $\frac{1}{4}$, sec 1, T. 65-6. A few rods north of the last. Saganaga syenite.

S. E $\frac{1}{4}$, S. W. $\frac{1}{4}$, sec. 1, T. 65-5. One-eighth of a mile north of the conglomerate, Cucumber island. Saganaga syenite. I made frequent examination to learn whether the syenite and the conglomerate alternate.

Centre of sec. 1, T. 65-5. Near north end of Cucumber island. Saganaga syenite (598), the quartz very coarse.

S. W. $\frac{1}{4}$, N. W. $\frac{1}{4}$, sec. 1, T. 65-5. See sketch-map, fig. 54. A vast and imposing promontory of syenite, slightly pinkish at a distance, in consequence of pale red feldspar. The grains of quartz are coarse, as usual. The hornblende is in small individuals, and they and the quartz are well isolated, but the feldspar tends to form a groundmass though distinctly and coarsely crystalline.

The syenitic mass is not homogeneous in composition, Some portions are a very fine-grained granulyte with very little hornblende, but these portions *have the appearance of foreign masses, though some of them are several feet in length*, with a width of a foot and less—sometimes like sheets three or four inches thick.

What is more remarkable, the syenite mass contains distinctly limited, rounded pebbles, two to six inches in diameter, and of a dark color. These are not homogeneous in composition, but apparently finely diabasic. They are so firmly imbedded in the solid, vertical wall, or so inaccessible that it was found impracticable to procure samples or even inspect them very closely. Other rounded pebbles, however, are not distinctly diabasic, though perhaps essentially so. The principal mass is a blue-green-blackish substance, which may be either augitic or chloritic; but imbedded in this are needles and laminæ of glassy feldspar.

But besides these, are pebbles or pieces, generally smaller than the others, which are composed of a chloritic substance, and, if I mistake not, themselves contain angular fragments like the chloritic conglomerate, number 597.

Again a chloritic rock material is sometimes included between masses of syenite-like sedimentary sheets, with the fine lamination, or at least, structural lines running parallel with the syenite surfaces. Parts of these sheets contain irregularly disseminated fragments of pink feldspar.

Rock 599. Saganaga syenite—ordinary appearance.
Rock 600. Fine granulyte included in above.
Rock 601. Syenite including pieces of chlorite rock.
Rock 602. Piece of included chlorite rock.
Rock 603. Included chlorite schist.
Rock 604. Pebble of fine syenite.
Rock 605. Same fine syenite stratified.
Rock 606. Pebble of chloritic diabase.
Rock 607. Syenite with carbonate of copper.

All the islands in this vicinity were visited, but common Saganaga syenite everywhere prevails.

S. W. ¼, sec. 31, T. 66-4. South end of portage around rapids into so-called "Seagull river"—short navigable rapids having been already passed twenty rods to the south. Still syenite (608), but the hornblende is here more abundant and blacker. The quartz is much less abundant, and the feldspar individuals are well isolated.

This portage is about a quarter of a mile, along the east side of the rapids.

The "rapids" so-marked on the plat, a few rods farther north may be navigated.

§ 26.—LOON LAKE.

Loon lake lies in the southern part of T. 65-3W. It is nearly four miles long east and west, and for most of its length half a mile wide, but expanding toward the eastern end to more than a mile in width. On the south side of the lake is a high mountainous peninsula, a mile and a quarter long, trending east and west, with an isthmus ten rods wide and bounded on the south by a slender arm of the lake about fifteen rods broad. Loon lake is hemmed in by lofty ranges of gabbro-covered Animike slate hills lying on the north and south, but much more precipitous and lofty on the south.

The whole region has been burned over; but small patches of the original forest remain, and low lying slopes are already reclothed with thrifty young trees of poplars and birch.

This lake lies wholly within the Animike region, and many characteristic cliffs of gabbro-covered black argillyte and siliceous schist rise along the south shore. Porphyries abound on the north shore.

The principal portage to Loon lake passes out from the western extremity of the little peninsula in sec. 23, on the south shore of Gunflint lake. It winds over a pass in the Mesabi range, a distance of three-quarters of a mile. The portage is little frequented and rather difficult from the intervention of hills, rocks and fallen timber.

S. W. ¼, N. E. ¼, sec. 26, T. 65-3. Near termination of portage, on the west. An unusual rock. A groundmass of a gray color, apparently composed of feldspar and augite. Abundant parallelopipedons of a waxy, striated feldspar disseminated through the groundmass.

Rock 691. Porphyritic noryte.

It occurs in a low exposure close to the water on the north shore.

N E. ¼, S. W. ¼, sec. 26, T. 65-3. Half a mile further west. Gabbro (692) in a low outcrop.

N. W. ¼, S. W. ¼, sec. 26, T. 65-3. Forty rods still west. A very interesting rock resembling syenite, very hornblendic or perhaps augitic, with reddish feldspar in small grains generally distributed, and in places clustered.

Rock 693. Resembling syenite, but probably gabbrolitic.

A few steps back, a more massive outcrop occurs, which, while containing some reddish feldspar, has a decidedly gabbrolitic aspect, especially on weathered surfaces. Contains also, a whitish feldspar.

Rock 694. Gabbrolitic rock.

S. W. ¼, S. W. ¼, sec. 26, T. 65-3. Forty rods west of the last. Syenite looking rock again (695) but it is probably noryte.

It has a dark crystalline groundmass, reddish feldspar prisms and grains disseminated; also a most abundant dull waxy feldspar.

S. E. ¼, S E. ¼, sec. 27, T. 65-3. Close by the last. Appears like a simple, fine-grained diabase; but, considering the association, I shall set it down as noryte—696.

S. E. ¼, S. E. ¼, sec. 27, T. 65-3. Within ten steps of rock 696. A low, exposed point of rock like that of rock 691. The weathered surface is remarkable. There appears a groundmass composed of fine black crystals mingled with sharp-cornered slightly larger crystals of a reddish feldspar. In this groundmass are disseminated white-weathering crystals and masses of a pale waxy feldspar attaining dimensions up to an inch and more in diameter.

The freshly broken surface presents a groundmass with the elements less individualized, and the coarse feldspar pale-waxy, faintly striated —it being very difficult under a Coddington lens to detect the lines.

Rock 697. Porphyritic noryte.

This would be an admirable rock for inside decoration, its red-specked groundmass studded with pleasingly tinted, four-angled crystals and rounded forms of feldspar.

S. E ¼, S. E. ¼, sec. 27, T. 65-3. Close by rock 697. Resembling outcrop, rock 693—syenite-looking.

S. W. ¼, S. E. ¼, sec. 27, T. 65-3. Twenty rods west. Compact, medium-grained gabbro (698), with plates and masses of shining magnetite.

S. W. ¼, S E. ¼, sec. 27, T. 65-3. Less than a mile and a half from where I first struck this lake. Gabbro above medium coarseness.

S. W. ¼, S. W. ¼, sec. 27, T. 65-3. Porphyritic noryte identical with that of rock 697, but the reddish constituent of the groundmass much less abundant, and hence not so fine for decorative purposes.

S. W. ¼, S. W. ¼, sec. 27, T. 65-3. Close by the last. Fine, uniformly tinted noryte (699), with considerable fine, disseminated pyrites.

S W. ¼, S. W. ¼, sec. 27, T. 65-3. Four rods west of 699. Formation appears bedded, with a low dip northeast; but examination shows it a fine dark gray homogeneous rock with thin scales waxy-translucent; and I feel compelled to put this down also in the same group as the other varieties seen.

Rock 700. Noryte exceedingly fine, almost aphanitic.

S. E. ¼, S. E. ¼, sec. 28, T. 65-3. Porphyritic noryte in a high exposure.

S. W. ¼, S. E. ¼, sec. 28, T. 65-3. One mile from western extremity of Loon lake, north shore. Gabbro (701) of medium coarseness again.

N. W. ¼, N. W. ¼, sec. 33, T. 65-3. Half mile from west end of lake. Low exposure of porphyritic noryte.

N. W. ¼, N. W. ¼, sec. 33, T. 65-3. Formation like that at rock 700, but a little coarser.

Rock 702. Fine-grained noryte.

Within a few feet occurs the porphyritic noryte, and then, a few feet further, the fine noryte recurs.

A few rods further west, the noryte is coarser.

Next comes the porphyry again — a large outcrop.

The fine noryte recurs — all the exposures toward the western extremity of the lake being larger than those more easterly.

N. E. ¼, N. E. ¼, sec. 32, T. 65-3. Near west end of lake. Noticing a whitish sort of rock exposed in the hill north of the western end of the lake, I went up to it, and found it simply gabbro with a dark waxy or reddish feldspar which weathers nearly white, and produces a striking speckled appearance on the rock. Some of this is porphyritic.

Rock 703. Gabbro, with weathered surface and peroxidized iron in a portion.

Rock 704. Gabbro with large augitic crystals weathered out.

S. W. ¼, N. E. ¼, sec. 32, T. 65-3. End of lake. A high cliff at the west extremity of the lake exposes some white-weathering gabbro quite conspicuously. Examination shows other portions very fine (705); and some portions have weathered with a conspicuous iron stain, giving the appearance of an iron mine.

Noryte or gabbro, crumbling and rusty, extends eastward along south shore, falling down from ledges 40 feet above, and forming a talus.

N. E. ¼, N. W. ¼, sec. 32, T. 65-3. Half mile from west end. An exposure of slate, about 25 feet high, having a dip of 16° in a direction S. 80° E. (according to needle, which may be locally affected.) The slate occurs in beds three to four inches thick. Some of them are hard and ringing when struck with the hammer, having a very compact and fine-grained structure, iron-gray in color, and with abundant fine scale-like mineral disseminated through it, shining like pyrites, but possibly magnetite. Some samples have a shining, pyrites-like mineral accumulated in little circular areas, giving the appearance of thin fish-scales.

The form of the rock first described is exactly that of 699 and 700, which I did not recognize as slate, though the latter was observed to be actually bedded.

Rock 706. Slate, prevailing condition.

Rock 707. Slate, with dark, scale-like areas.

S. E. ¼, N. E. ¼, sec. 34, T. 65-3. Middle of south side. Large angular fragments of solid gabbro.

N. W. ¼, N. W. ¼, sec. 35, T. 65-3. Close by the last. Compact slate, like that of 706 and 707, in a low outcrop.

N. W. ¼, N. W. ¼, sec. 35, T. 65-3. Very near the last. Fine, gabbro-looking, but the formation is in massive beds dipping E. S. E. about 8° or 10°, and I suspect it belongs to the slate formation.

Rock 708. Gabbroloid slate?

Above 40 feet, the rock looks more massive.

A gabbro-like crest continues along this ridge, terminating in a hill about 150 feet high, with a precipitous brow hanging perpendicularly 35 feet.

1. N. E. ¼, N. W. ¼, sec. 35, T. 65–3. One-fourth mile from the last. The brow of gabbro almost overhangs this spot; but at the bottom here is an exposure of slate dipping 13° in a direction about south (according to the compass and according to estimation). The slate is mostly hard and ringing, dark gray, and exceedingly fine textured. Some of the thinner layers are darker and more argillitic. In bands or zones there are laminæ not over a thirty-second of an inch thick.

Rock 709. Prevailing character of the slate.

Rock 710. A thin layer, dark, argillitic.

Rock 711. Thin laminæ.

Rock 712. Specimen about 8 feet above water.

Rock 713. Specimen 20 feet above water.

Moving out into the lake, the bedded structure can be distinctly seen to a hight of 80 feet. Above this for 40 feet, the rock has a massive gabbro-like aspect.

N. W. ¼, N. W. ¼, sec. 36, T. 65–3. East end of long peninsula. Gabbro.

On the main land south of the peninsula, are exposures along the brow of the ridge, which weather like gabbro. No outcrop, however, appears along the shore.

N. E. ¼, N. W. ¼, sec. 36, T. 65–3. East end Loon lake. A good exposure of a massive character, without an indication of bedding. But examination shows it to be of the character of the magnetitic slate.

Rock 714. Magnetitic slate, showing no bedding.

N. W. ¼, N. W. ¼, sec. 36, T. 65–3. Near point of cape. East end. A fine-textured, uniformly dark gray rock, in which the elements of a noryte can be discerned.

S. W. ¼, S. W. ¼, sec. 25, T. 65-3. On the cape, north of point. A cliff of slate 125 feet high, having gentle dip southward.

This is succeeded easterly by a precipice of gabbro. This, at the eastern end forms a perpendicular face 35 feet high, with quite a basaltic aspect. Below is a talus reaching to the beach.

N. E. ¼, S. W. ¼, sec. 25, T. 65–3. East end, north bay. A low outcrop of medium texture gabbro.

N. E. ¼, S. W. ¼, sec, 25, T. 65–3. Close by the last. Heavy-bedded, eruptive-looking slate—same as at rocks 699, 700 and 706-7.

N. E. ¼, S. E. ¼, sec. 26, T. 65–3. One-third mile west of the last. Low exposure of coarse-grained gabbro.

Rock 715. Coarse-textured porphyry.

Above this is the porphyritic noryte. My use of different terms—noryte and gabbro—cannot be made precise in the field. I name the rock noryte when both the basic plagioclase and the augite are of granular form—they are also generally fine. I call it gabbro when their forms are lamellar or coarsely crystalline—in which case magnetite is more conspicuously present, and sometimes olivine. I think, after making the tour of Loon lake, that perhaps all the erupted rocks are gabbrolitic essentially.

On the portage to Gunflint lake, one-eighth mile from Loon lake. Gabbro of medium texture.

§ 27.—IRON OR MAYHEW LAKE.

This is a long, narrow, east-west lying lake, three miles of which are in the extreme southern part of T. 65–2 W. and one mile in the southeast corner of T. 65–3 W. Its average width does not exceed twenty rods. The shores are only moderately elevated, but generally rocky and irregular in outline, and extending on the south side into one narrow bay three-quarters of a mile in length with its axis southwest by west. The borders of the lake are shaded by a light forest. The narrowness of the lake causes the opposite forests to seem to shut together and exclude the visitor from connection with the world. He seems imprisoned in a narrow slit, from which the strongest impulse is to escape.

The rim of the lake is mostly massive gabbro. This in places is so strongly charged with magnetite that one might truthfully conceive of the prison-lake as iron-bound. The abundance of magnetite caused attention within a few years to be directed to the region, but investigation showed the ore to be strongly titaniferous. Results of details of observations and a chemical analysis are given in the tenth annual report on the geology of Minnesota, pages 80, 81, 82 and 83.

The lake is 161 feet higher than Gunflint lake and 1,213 feet above lake Superior. It is nearly at the elevation of the high gabbro bluffs of the adjacent lakes, Gunflint, Loon, Mountain and others; and this may explain the low-lying relative position of the gabbro shores and islands.

An obscure portage trail goes out from Loon lake at a point on the south shore precisely south of the east point of the long peninsula. It is about half a mile in length and ascends steeply to the summit of the intervening ridge whence a slight descent leads to Iron lake.

S. W ¼, S. E. ¼, sec. 36, T. 65-3. Iron lake. An island half a mile east of end of portage. A naked, crumbling gabbro dome.

Rock 790. Gabbro, coarse, crumbling, highly magnetitic.

The rock is of similar character on the south shore opposite.

N. W. ¼, S. W. ¼, sec. 31, T. 65.2. North shore. Black sheets of magnetite are seen spreading out in the gabbro in an irregular way. Here and there fragments of the gabbro are involved in it. The appearance is as if the magnetite had existed previously and been introduced into the mass of fluid gabbro, and never generally diffused. There is sometimes a green mineral like copper carbonate which I reserved for subsequent examination.

Rock 791. Magnetite in gabbro, with green mineral. Iron lake.

This locality was revisited and more carefully studied. It furnishes a large quantity of titaniferous iron ore.

But the most interesting fact is the occurrence of gabbro unconformable on a sedimentary rock which appears thus far, to belong to the Animike (794). I think it will go with the "Muscovado," studied last year, and which, after careful examination in many places, I concluded to be sedimentary. It contains some quartz and much glassy feldspar. I think it is this bed which in the tenth annual report, p. 81, is referred to as a "gray quartzyte (apparently)," and also, as "appearing like a granular gray quartzyte, but really consisting of the minerals that go to make gabbro."

I find in this vicinity fragments of Animike slate, well rusted; but when broken, a black, lustreless mineral appears which can be traced in outline into the rusted coat. This must be examined.

Rock 795. Rusted Animike slate.

Rock 796. Titaniferous gabbro, with red zone.

This is to be used to ascertain whether the red zone results from change of the magnetite or of olivine.

Rock 797. Muscovado, from fragments on the gabbro—some clearly stratified.

Rock 798. Hornblendic and greenstone pebbles, mixed together in a groundmass of syenite. From a bowlder.

North shore Iron lake east end, in sec. 33, T. 65-2 One of numerous exposures of gabbro containing much magnetite.

Rock 792 Gabbro with titaniferous iron.

Rock 793. From a bowlder, but known to belong to the Animike of Gunflint lake. The rustiness of the exterior awakens curiosity. The rock is to be investigated for chalybite or ankerite. [P. S.—The rock effervesces with acid; but the fully changed red portion does not].

The course of the descriptions here returns west again and takes up the geology of certain lakes belonging to the second series south of the boundary series.

§ 28.—FROG ROCK LAKE.

This small lake is in the western part of T. 65-5, lying chiefly in sec. 18, but extending to the middle of sec. 17 and a short distance into sec. 19. It is southwest from West Seagull lake and drains into it and thence into Seagull and Saganaga. It is surrounded by low, mostly naked hills of dark, solid, eruptive-looking rocks, some of which seem to be highly altered or siliceous conditions of the Kewatin series. It is however, the region of passage from the vertical crystalline schists of West Seagull lake to the vertical earthy schists and conglomerate of Ogishke-muncie lake. Some of the eruptive-looking masses rise in rounded domes 25 to 50 feet above the lake. In the eastward direction are seen hills which appear to be 200 feet high.

I devoted considerable time to this lake and hoped to get an insight into its geology; but the situation is difficult and I can hardly do more than reproduce the facts as I observed them.

The principal approach to the lake is from West Seagull, along a portage about a third of a mile in length, which passes over a treeless hill abounding in geological interest, with the sound of the cascades in the connecting stream arising on the west. We return to the northern extremity of that portage.

N. E. ¼, N. W. ¼, sec. 17, T. 65-5. Near foot of portage, not far east of portage landing. The rock exposed on shore is similar to that of 540, Knife lake, but distinctly more schistic, and much less quartzose. It is a felsitic, chloritic argillyte (844) of irregular structure.

Within eight rods, the formation passes to a fine argillo-micaceous schist, of quite normal structure. Still further it becomes greenish, harder, less distinctly bedded, with crystals of feldspar and veins and aggregations of quartz (compare below, rocks 582-90). Further still, the rock becomes a porphyrelloid graywacke of greenish color, containing both opaque and glassy feldspar crystals (compare under rocks 583-90).

Rock 845. Argillo-micaceous schist.

Rock 846. Porphyrelloid graywacke (compare 584).

On an earlier trip over this portage the following observations were recorded:

Massive domes of graywackenitic rock appear, alternating with a handsome and rather striking porphyrel.

One-eighth mile on the portage. The porphyrel contains mostly oblong forms of feldspar, some of which are angular and others rounded. There are also scattered cuboids of quartz exactly like those seen in the characteristic Saganaga syenite—but these are not everywhere distributed. The groundmass appears highly chloritic, and the feldspar individuals are not sharply isolated from it.

In places, the graywacke is quite chloritic, and angular fragments of itself or a less chloritic rock are imbedded in it. This, on the whole, presents a resemblance to the Stuntz conglomerate. In some specimens, the included fragments are more decidedly of the aspect of the Stuntz conglomerate.

Rock 583. The prevailing graywacke.

Rock 584. The prevailing porphyrel.

Rock 585. Conglomeritic, chloritic graywacke.

The graywacke contains iron enough to impart sensibly increased weight. In places it is crystallized in seams and fissures as hæmatite. The rock is also intersected with veins of quartz and of epidote.

In the chloritic portions, where the conglomeritic condition appears, the rock reminds me of that on the south side of Fall lake. But these portions also, are most abundant in iron, and sometimes give a reddish streak (586). In places, the included fragments have a parallel-laminated structure, as if from a sedimentary rock.

Rock 586. Chloritic groundmass with much iron.

Rock 587. Fragment of included laminated, angular mass, with iron and an epidote seam.

As I proceed over the hill, the country rock becomes still more chloritic—in places, hard and jointed; in others standing in vertical irregular, cuneiform laminæ (589). It is cut by occasional veins of quartz (590), one of which is a foot wide.

Frog Rock lake, head of rapids out. Here is a dike of beautiful diabase (591), over which the stream takes its first plunge. But in the midst of the diabase, I find fine graywacke; as if two dikes approached each other.

Rock 592. Graywacke between two masses of diabase.

I took a photographic view of the falls at this place.

S. E. ¼, N. W. ¼, sec. 17, T. 65-5. North shore a few rods from outlet. Compact, massive, bluish rock, weathering schistic, but like felsyte within.

Rock 847. Felsyte schist.

S. E. ¼, N. W. ¼, sec. 17, T. 65-5. Twenty rods further west. Similar to last, but greener. Rock 848.

S. W. ¼, N. W. ¼, sec. 17, T. 65-5. Low dome of handsome diabase (849) in form of a dike.

S. W. ¼, N. W. ¼, sec 17, T. 65-5. Chlorite granulyte—rock 850.

S. W. ¼, N. W. ¼, sec. 17, T. 65-5. Less than half a mile from outlet of lake. A low outcrop of a green rock, composed of a green fibrous mineral and a little light feldspar. A greenstone, rock 851.

S. W. ¼, N. W. ¼, sec. 17, T. 65-6. Here (852) the greenstone contains a little more feldspar, and is intersected by a dike of diabase; but no well defined line of contact between the two can be found.

S. E. ¼, N. E. ¼, sec. 18. T. 65-6. Greenstone of a finer texture and harder. Rock 854.

N. E. ¼, N. E. ¼, sec. 18, T. 65–6. Solitary rock.

Rock 855. Greenstone, a little coarser than Rock 854.

S. W. ¼, N. E. ¼, sec. 18, T. 65-5. Greenstone of average character. Glacial striæ S. 19° W.

S. W. ¼, N. E. ¼, sec. 18, T. 65-6. High bluff of sericitic felsyte, similar to rock 847, 848.

Rock 855 bis. Sericitic felsyte schist.

N. W. ¼, S. E. ¼, sec. 18, T. 65-5. Here a dike of compact, fine-grained diabase intersects Rock 855.

S. W. ¼, N. E. ¼, sec. 18, T. 65-5. High bluff of greenish rock, intermediate in appearance between the greenstone and the sericitic felsyte.

Rock 856. Like 855, but harder and darker.

Near centre of sec. 18, T. 65-5. Bluff of fine, grayish-green rock, appearing like the sericitic felsyte schist in a finer state.

Rock 857. Fine, grayish-green sericitic or chloritic felsyte.

Near centre sec. 18, T. 65-6. Camp. A low outcrop of sericitic felsyte (schist?), rock 858; dark, nearly black, rough-weathering, presenting externally quite a resemblance to the chloritic rock at Kawasachong falls, Fall lake. In the irregularities of the surface, one can trace, sometimes, courses of fibrous or laminated structure, mostly curved or even abruptly bent; sometimes a jam of lenticular and cuneiform pieces apparently due to systems of jointage; sometimes, an indescribably rough and jagged aggregate of shapeless pieces. If numberless little balls of stiff flour-coated dough should be pressed together from opposite directions, they would become flattened and lenticular, and would adhere imperfectly; and if then hardened. the mass would present somewhat the structure of this rock, especially if hard baked and subjected to surface abrasion. The pits and cavities of the weathered surfaces of the rock are indefinitely shapeless and ragged, and vary in depth to 4, 6 or 8 inches. No unequivocal bedding can be detected; but there is a prevailing trend in the constituent lenticules; and at intervals, a coincident general division of the mass by planes dipping about 60° westward, and trending S. 10° W. These statements, however, do not apply to all localities in this vicinity.

On breaking the rock, one is impressed first, by its comparative softness. The finger nail will scratch it slightly. Then there appears a sericitic or talcose constitution. This is seen in the smooth surfaces of some of the joints; and in the soft and easily bruised state of consolidation; and also, in the fibrous nature of some of the jointed surfaces. The color is a pale greenish or bluish drab. Some of the fracture surfaces reveal thin scales partly disengaged, and these are waxy translucent. They pass into the general substance of the rock; and it is apparent that this material constitutes the principal part of the mass. It is softer than feldspar and harder than talc. It approaches calcite. Some of the jointage surfaces have a dark green, shining and chloritic appearance.

This detailed description will not all apply to the rocks not denominated greenstone, so far as seen on this lake; but the general features here described are the same as those designated "sericitic felsyte schist;" and perhaps those called simply "felsyte schist." Special comparison should be made. The description does *not* apply in any particular to the rocks denominated greenstone. Yet, I cannot affirm that these two classes of rocks do *not* graduate into each other. Nor can I affirm that this rock is *not* eruptive, even if it does not go with the greenstones.

If this rock is shown to be eruptive, I shall be willing to admit the chloritic rock at Kawasachong falls to be eruptive also.

While the observations from Saganaga lake southward to Frog Rock lake remain fresh in memory, I wish to make a revision and comparison of data as far as can be done in the field, in order to leave a record of the impression which the facts make upon the mind of an observer passing over the ground. This interval covers the mode of transition from syenite to the Kewatin schists which extend from the region of Vermilion lake. Structurally, the absence of any unconformity is an important fact. Petrographically, the frequent gradual passage from rocks usually called eruptive to rocks retaining distinct traces of sedimentation is a curious, almost an anomalous fact. In order to reach a better comprehension of the latter fact I make a careful comparison of rock specimens. The first result is as follows:

A. The following are nearly identical with each other: 858, 857, 855, 854, 853, 850, 847, 844, 840.

B. The following are similar to class A, but somewhat harder: 856, 848.

C. Like A in groundmass, but with minute shining scales: 845, 844

D. Like C, but porphyrelloid: 584, 846, 860, 885.

E. Having a groundmass like A: 843, 837, 836.

F. Haxing the feldspar constituent altered toward a sericitic condition: 841, 838 (approaching class E)

It appears, therefore, disregarding the diabases and greenstones, that a progressive change in the character of the country rock can be traced from sec. 14, 66-5, in Saganaga lake, to the present point. In my uncertainty as to the nature of the prevailing and characterizing mineral—whether parophitic, talcose, serpentinoid or sericitic—I will here call it Kewatin stuff; since it is similar to the mineral which I find generally in Kewatin rocks. (See especially Knife lake, IVth Arm, north and south bifurcations). There is one pause in the passage, and that is to develop the micaceous (Vermilion) phase, at the interval between West Seagull and Frog Rock lakes. Recalling what is recorded in connection with West Seagull lake, rock 593, I will endeavor to note the succession from the Saganaga syenite southward.

1. Saganaga syenite with constituents well isolated.

2. Saganaga syenite or gneiss, quartz elongated, feldspar having a partial groundmass character.

3. Syenite without hornblende.

4. Hornblende wanting, feldspar transitional to Kewatin stuff.

The course is now two-fold.

5 (a). Quartz and *Kewatin* stuff—no feldspar except in porphyrelloid condition.

6 (a). Crystalline schist, or (b) Kewatin rock.

7 (a) Graywacke, or (*b*) Kewatin rock.

5 (b). Quartz and *Chloritic* stuff—sometimes feldspar.

6 (c). Chlorite schist, or (d) Kewatin rock.

7 (c). Graywacke, or (d) Kewatin rock.

All these stages of progress can be traced from Saganaga lake to this place. The syenite indeed reappears south of the lake; but I think a line of travel could be found along which there would be no retrogression. The reappearance of syenite results probably from the fact that the south border of the syenite is not a straight east and west line, but crosses more than once the line traveled, thus:

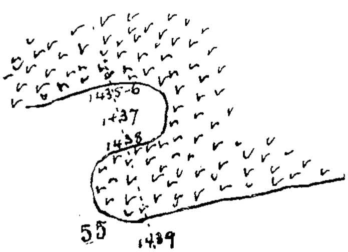


Fig. 55.—*Supposed southern border of Saganaga syenite, three times crossing line of observation.*

NOTE.—In this figure the numbers refer to rock samples collected as follows:

1435 shows place of rock	835-7.	1438 shows place of	842.
1436 " " "	838-41.	1439 " "	843.

[N. H. W.]

I venture to think, therefore, (1). That we have the crystalline schist stage (Vermilion) from the south part of West Seagull lake to the north part of the portage to Frog Rock lake.

(2). We have the Kewatin stage thence to this point and beyond. The inference is that the rock here is *sedimentary*, and not eruptive; and that therefore, the Kawasachong rock is also *not eruptive*.

(3). The greenstone is an overflow, which perhaps has covered the whole region, and has powerfully altered the underlying Kewatin; but this was probably the northern and thin portion of the sheet; and it has been removed at many points. I should look for it to be thicker toward the south.

West of centre of sec. 16, T. 65-5. N. W. bay of Frog Rock lake. Rock on shore entirely like that of 858. But here a structure can be seen trending east and west. Back of this, a rock bluff rises 40 or 50 feet above the lake, facing south. It presents the same ragged exterior; but fresh-broken, appears more greenish, approaching quite closely the Kawasachong rock.

Rock 859 Chlorite felsyte (schist?)

Another crag 85 or 100 feet high, adjoins this on the east, but it is composed of entirely similar materials. Whatever these rocks are, their equivalent is unquestionably found in the Kewatin of the Vermilion belt.

From this summit, I see high hills 10 or 15 miles distant, bearing S. 60° W. These must be on lake Kekequabic or beyond. Also S. 30° E., a high range which perhaps passes south of Ogishke-muncie. From here eastward, gradually receding, can be seen mountain ranges, extending to S. 60° E.

Rock 860. Porphyrelloid chlorite felsyte (schist?) west of centre of sec. 18, 66-5.

Rock 861. Aphanitic diabase, intersecting the formation.

Rock 862. Less fine diabase, same dike.

S. E. ¼, N. W. ¼, sec. 18, T. 65-5. N. W. cor. of lake. Precisely the same as last two points noted.

N. E. ¼, S. W, ¼, sec. 16, T. 65-5. West side of lake. At this interesting outcrop the formation is a fairly characterized sericitic schist, standing in thin, lenticular laminæ at a dip of 88° in a direction S. 78° E. It is composed of Kewatin stuff, with a few fine grains of quartz, and sinuous films of rusty matter. It presents so many points of resemblance to the prevailing rock that I am sure it goes with the sericitic felsyte schist, and determines that to be a bedded rock of sedimentary origin, as I have conditionally concluded. This is the true continuation of the schists of Vermilion lake; and all the rocks not greenstones and diabases, around this lake, *are to be so re-regarded.*

Rock 863. Sericitic schist, with some gravel.

Four rods north of this outcrop, the formation is a little more solid, and the Kewatin stuff is a little greenish, with the same rusty films and spots.

Rock 864. Sericitic schist, near 863.

Eight or ten rods toward the south. Rock with indistinct schistic structure, and having a great resemblance to rock 863; but quite as much resembling the prevailing rock of the region. It is a connecting link between the Kawasachong rock (858) and the sericitic schist of 863.

Rock 865. Sericitic chlorite felsyte.

N. E. ¼, S. W. ¼, sec. 18, T. 65-5. West side of lake. Bluish green rock, similar to prevailing rock, but mostly with a slaty structure. On the whole, a rude slaty structure is quite apparent.

Rock 866. Bluish argillo-felsitic schist.

Rock 867. Rock 8 rods farther along the shore, south.

Centre S. W. ¼, sec. 18, T. 65-5. Near entrance to most westerly bay. Rock (868) distinctly schistose, a little sericitic, with many bluish-green chloritic points.

Point of land S. W. ¼, sec. 18, T. 65-5. A rock of smoother aspect. It is mostly hard and tough, but also gives indications of argillitic constitution. It contains purple spots, mostly undefined, but not as hard as jasper. There are also *small pebbles* of dark greenstone. Under the water is an obscure appearance of larger pebbles and broken fragments. I conjecture this to be the eastward extension of the *Ogishke conglomerate.*—rock 869.

A little farther along (northwest) up the little bay, the conglomeritic character is more distinct, and I can perceive that the pebbles are aggregated in courses standing almost vertically. Adjoining this, the rock has a rough chloritic aspect, entirely conformable in position with the conglomerate.

Centre S. W. ¼, sec. 18, T. 65-5. East side little bay. Rock (870) of a quasi-diabasic aspect, but also with appearance of the country rock. Considerable argillitic material, and locally a slaty structure.

Extremity of little bay, centre S. W. ¼, sec. 18, T. 65-5. Conglomerate, with large pebbles of chlorite syenite.

Rock 871. Chlorite syenite pebble, from conglomerate.

S. W. ¼, S. W. ¼, sec. 18. T. 65-5. Point of same bay. Mouth of stream coming in at point of little bay. Rock (872) quite distinctly schistic and sericitic. The strike is S. 10° W., and it therefore passes west of the conglomerate seen near here.

S. W. ¼, S. W ¼, sec. 18, T. 65-5. Still within little bay. Compact, sericitic-looking rock (873), but not very schistose.

S. W. ¼, S. W. ¼, sec. 18, T 65-5. Mouth of bay, west side. Bluish, compact, but slightly argillitic rock (874).

S. W. ¼, S. W. ¼, sec. 18, T. 65-6. Compact, slightly argillitic, but with purplish tints, as if from obliterated pebbles (875).

A couple of rods further along (southeast), the rock is softer again, and lighter colored. Still, in a couple of rods it becomes undistinguishable from that of 858. It is the same at the next outcrop, but softer. The same continues along the southwest shore.

S. W. ¼, S. W. ¼, sec. 18, T. 65-5. A high boss of greenstone-like rock (876) pretty hard and compact, and generally rather fine—in part very fine, hard and ringing. This appears after an eighth of a mile from the last outcrop of schist.

This "greenstone" does not terminate at any particular place along the shore into the southern bay of the lake. It gradually assumes a rougher exterior and a softer character and passes insensibly into a rock like that of 858.

Rock 877. Greenstone passing into chlorite schist.

Rock 878. Greenstone 30 feet from 877, more approximated to chlorite schist.

N. E. ¼, N. W. ¼, sec. 19, T. 65-5. Extreme southern shore Greenstone (879) like that of rock 876.

The same continues along the southern shore of the south bay of the lake.

N. W. ¼, N. E. ¼, sec. 19, T. 65-5. Southeast angle, southern bay. A cliff near shore which proves to be undoubtedly Kewatin.

Rock 880. Sericitic argillyte.

N. W. ¼, N. E. ¼, sec. 19, T. 65-5. East side of south bay. Greenstone like.

Eight rods further south. Low, smooth outcrop of diabasic rock, greenstone like, with fragments of light green diabase-like rock.

Rock 881. Diabasic conglomerate.

Four rods further north. The rock is more argillitic.

Rock 882. Chloritic argillyte.

S. E. ¼, S E. ¼, sec. 18, T. 65-5. Southeast bay. Sericitic schist (883) irregularly schistose, with strike nearly north and south.

Four rods further north it is a little bluer.

S. E. ¼, S. E. ¼, sec. 18, T. 65-5. Southeast bay. Sericitic argillyte, but becoming bluer and harder.

S. E. ¼, S. E. ¼, sec. 18, T. 65-5. East side. Same as rock 858.

A few rods still farther north. Greenstone.

§ 29.—TOWN LINE LAKE.

A small lake on the line between Ts. 65-5 and 65-6, having a length east and west, of two-thirds of a mile and a mean width of 40 rods. It is utterly destitute of scenic or agricultural interest. The primitive forest is mostly destroyed, but second growth poplars are becoming abundant. Geologically it lies on the transition from the normal Kewatin schist to the conglomerate and associated rock masses surrounding Ogishke-muncie lake.

The portage out of Frog Rock lake to Town Line lake is at the nearest approach of the two and is not over an eighth of a mile long.

S. W. ¼, N. W. ¼, sec. 18, T. 65-5. West end of portage. A knoll of chloritic sericitic schist (884).

S. W. ¼, N. W. ¼, sec. 18, T. 65-5. North side. Incipient porphyrel (885). Some of the weathered surfaces are decidedly speckled.

S. W. ¼, N. W. ¼, sec. 18, T. 65-5. North side near town line.

Ogishke conglomerate pretty well developed. Contains red jasper (886), not as a pebble, and this is banded and associated with hæmatite.

S. W. ¼, N. E. ¼, sec. 13, T. 65-6. West end. Conglomerate, but not coarse, somewhat porphyritic, (887).

S. W. ¼, N. E. ¼, sec. 13, T. 65-6. West end. Outcrop of rock composed largely of quartz grains, with sericitic stuff in the interstices (888) Contains also, small pebbles or grains of *slaty material.*

S. E. ¼, N. E. ¼, sec. 13, T. 65-6. South side. A higher outcrop of similar grit (889), but inclining more to a grayish color. Rock quite schistose. Strike S. 20° W. Dip vertical.

Compare the gravelly schists on Ensign lake. Report of 1886, and on Ogishke-muncie lake, below.

S. E. ¼, N. E. ¼, sec 13, T. 65-6. South side of narrows.

The rock is compact, almost wholly of quartz grains, with a light colored cementing material, which becomes pinkish on weathering.

Rock 890. Quartz grit.

S. W. ¼, N. W. ¼, sec. 18, T. 65–5. South side on town line. Porphyrel, as on opposite shore, rock 855.

S. W. ¼, N. W. ¼, sec. 18, T, 65–5. South side. Ragged rock, like rock 858.

A little farther east, it is succeeded by a sericitic rock, like that on Town Line lake, rock 884.

The portage from Town Line lake to Ogishke-muncie is execrable. The bad trail leaves the former lake eight or ten rods north of the stream which comes in with rapids, and leads to the inlet on Ogishke-muncie; but the stream must be forded twice before sufficient water can be reached to float a canoe; or else one must make his way along a steep hill-side through thick brush to reach the spot. The black flies too, as late as the 12th of September, were innumerable and insatiate.

§ 30.—OGISHKE-MUNCIE OR KINGFISHER LAKE.

This lake was visited in 1886,* and considerable study was bestowed

---

* *See Fifteenth Ann. Rep.* 1886, pp. 150–167.

upon it; but it was not much investigated in the region northeast of the narrows in section 23, T. 65-6. The two parties in this part of the State made a rendevous, therefore, on Camper's island, for the purpose, among other objects, of completing the survey.

S. E. ¼, N. W. ¼, sec. 24, T. 65-6. Here is a bluff of crumbling schistic rock (891) forming an earthy talus. It is a sericitic, gritty, irregularly bedded, slate. Strike in the direction of the little bay, N. 40° E.

Adjoining this, on the southeast, within four rods, is a bluff of characteristic, coarse conglomerate. Other ridges succeed southeastward, which are also conglomerate.

The unplatted little lake on the southeast is at least 20 feet above Ogishke-muncie.

N. W. ¼, N. E. ¼, sec. 24, T. 65-6 Here, six or eight rods back from the shore, and separated from it by a narrow valley, rises a ridge 25 feet wide and 20 feet high, from low ground each side, trending southwest and northeast, of a rusted exterior and very rough and brecciated aspect. An unmistabable bedding is present standing in a vertical position. When broken, the rock appears composed of calcareous or dolomitic matter, which, in places, is light colored and characteristic. Everywhere, however, it has an uneven, semi-brecciated structure, and it incloses fragments which are pretty slaty in color and substance. Some of the surfaces of the formation are smooth, sericitic-looking and often argillitic.

Rock 892. Brecciated dolomyte (limestone?)

Following along the strike of the formation southwestward, a few rods, it is seen in places quite argillitic, with a sericitic aspect.

Rock 893. Sericito-argillitic dolomyte.

The ridge on the southeast within eight or ten rods, and rising 30 feet above the dolomyte ridge, is composed of silico-argillaceous material, partly quite solid, and partly laminated and crumbling.

Rock 894. Silico argillaceous slate.

The ridge on the northwest side of the dolomitic one is formed of hard material, breaking in many angular pieces. Under the lens, it appears formed of small spherical grains of quartz imbedded in a groundmass which, in places is very scant, and in others, half the bulk of the rock. It has a felsitic aspect. It is simply Kewatin stuff. I notice also, numerous small siliceous scales. This ridge fronts the lake and is only about 16 rods from the southeast ridge, with the lower, dolomitic ridge between.

Rock 895. Felsitic grit (or argillo-felsitic).

This groundmass is not harder than calcite, and cannot be purely felsitic. Nearer the lake are good vertical argillytes.

Near this, south of the prolongation of this ridge, I find the rock a rough-weathering sericito-argillitic slate, like the bluff, rock 891.

N. W. ¼, N. E. ¼, sec 24, T. 65-6. High ridge on lake border, having a vertical, slaty structure, except in places, where it *looks* eruptive. It is composed mostly of argillitic material, but contains many grains of quartz.

Rock 896. Gritty argillyte.

In places, the formation contains large pebbles, and the intervening groundmass weathers white, and reveals a distinctly fibrous structure. In the same places, the fresh-broken surfaces scarcely reveal the existence of pebbles.

N. W. ¼, N. E. ¼, sec. 24, T. 65–6. The next ridge southeast of rock 896, composed of very hard, diabasic-looking material *which contains pebbles.*

Rock 897. Matrix of diabasic conglomerate.

Along side of this, however, and eight feet lower, a distinctly slaty rock outcrops (898), having a sericitic-argillaceous aspect—and the two graduate together.

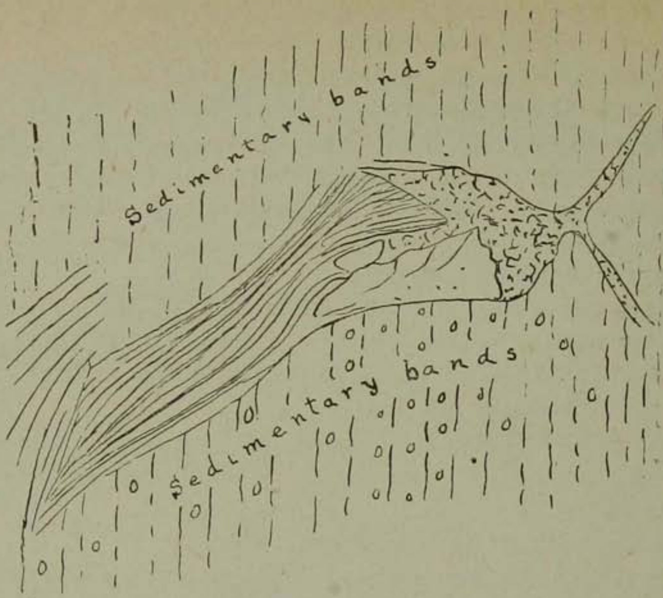
Next higher ridge ten rods southeast. Indistinctly conglomerate, with groundmass containing many dark green grains and lumps, some quartz particles, and much argillo-felsitic matter.

Rock 899. Argillo-felsitic groundmass.

The highest hill about one-fourth mile back from the lake. The formation is thoroughly conglomerate, but very compact and frequently hard—sometimes ringing. A few rods further southeast, the formation reveals a structure which is sedimentary beyond possible question. Parallel bands of graywackenitic material can be traced for 30 feet in a direction N. 20° W. In the same place, other structure lines can be seen, bending around what appear to have been separate masses of the same rock.

The surface of the rock is studded with spheroidal concretions (900), which have been cut in section and have hollow centers apparently by the solution of the interior portion. They are not pebbles, for they are all very similar, and besides, reveal, in some cases, concentric lines. See the figure.

In a neighboring spot, the strike of the beds is quite different, and there are concomitant indications that these portions of the formation are simply huge fragments of the general mass, which were displaced during the deposition of the original sediments.



56

57

Fig. 56.—*Rock surface in Ogishke conglomerate, showing sedimentary structure.*

Fig. 57.—*Spheroidal concretions in matrix of Ogishke-conglomerate.*

In further tracing these stratified materials, I find in one place a continuous sweep through about 85° of a circle. This is fifteen feet wide, and the circuit is about forty feet.

§ 31.—CRAB LAKE.

This is a small lake lying in the north half of sec. 14, T. 65-6, environed by a lonely and desolate wilderness and set in a massive rim of graywackenitic and slaty rocks, rising in frequent dark-weathered and rounded bosses. Guided by the government plat, I entered from the most northern extremity of Ogishke-muncie lake, supposing there would be a portage of a few rods; but it proved to be about half a mile, without the least signs of a trail. There is a low valley running through, densely grown with alders and other shrubs. On the north of this is a high ledge, difficult to climb. But the best transit is made by leaving the valley and working along on the ledge; and it is finally necessary to cross the west end of the ledge, to descend to the lake.

The fact is, the lake begins at least a quarter of a mile west of the point indicated on the plat.

The government plat of this lake is so erroneous that I undertook to reconstruct it. I find, however, that some of my memoranda are ambiguous; and I therefore refrain from making alterations except in the southeastern part. The northern portion, however, is egregiously wrong.

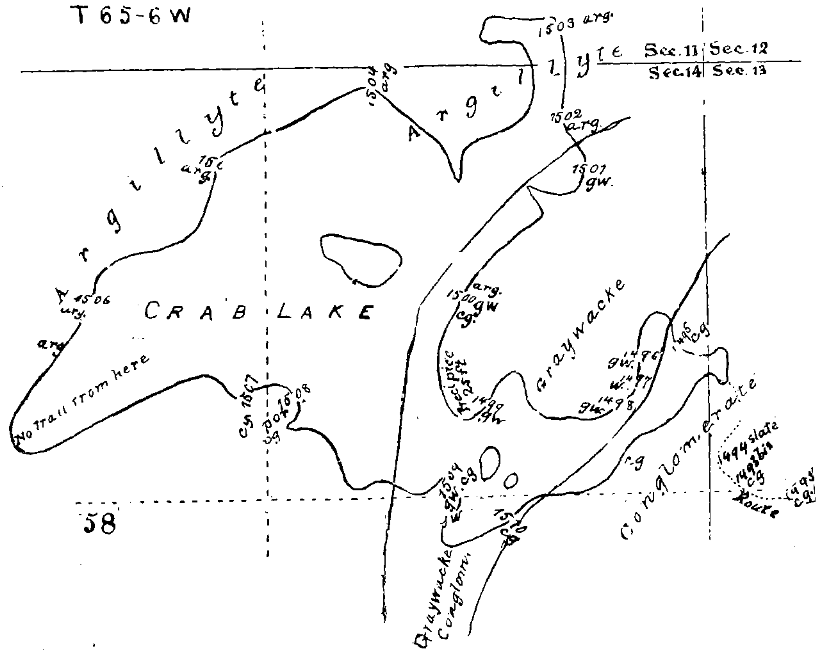


Fig. 58.—*Sketch-map of Crab lake, with notes of localities and geology.*

NOTE.—On the above map.

No.	1493 indicates the locality for rock			901-3.
"	1493 bis	"	"	904.
"	1494	"	"	905.
"	1495	"	"	906.
"	1496	"	"	907.
"	1499	"	"	908.
"	1500	"	"	909.
"	1502	"	"	910.
"	1503	"	"	911.
"	1504	"	"	912.
"	1506	"	"	913.
"	1507	"	"	914.
"	1508	"	"	915.

N. H. W.

N. W. ¼, sec. 13, T. 65-6. On the portage. High precipice north of the stream flowing from Crab lake to Ogishke-muncie. Here are various conditions of the conglomerate.

Rock 901. Conglomerate.

Rock 902. Porphyrel.

Rock 903. Matrix showing bedding lines.

Fifteen rods farther west, same ridge. Conglomerate, with large quartz grains.

Rock 904. Porphyritically quartzose conglomerate.

S. W. ¼, N. W. ¼, sec. 13, T. 65-6. Same ridge, 30 rods farther west. The formation has become a thin-bedded slate, but with some strata massive and finely arenaceous.

Rock 905. Argillyte, somewhat arenaceous.

S. E. ¼, N. E. ¼, sec. 14, T. 65-6. Near east end of lake, north side, conglómerate, but fine, gritty, and not characteristic.

Rock 906. Fine gritty conglomerate.

S. E. ¼, N. E. ¼, sec. 14, T. 65-6. Gritty graywacke, with horizontal bedding, but evidently superinduced.

S. E. ¼, N. E. ¼, sec. 14, T. 65-6. Graywacke (907), not gritty, weathering with a cellular surface.

S. E. ¼, N. E. ¼, sec. 14, T. 65-6. Great bosses of graywacke.

S. W. ¼, N. E. ¼, sec. 14, T. 65-6. Great mass of graywacke (908), without trace of bedding, like rock 907, but with many minute glistening feldspar surfaces.

This is followed by a very bold cliff standing vertically, and rising 35 feet above the lake. This subsides as we round the promontory, and for a few rods, no outcrop occurs.

S. W. ¼, N. E. ¼, sec. 14, T. 66-5. Mostly graywacke, but sparingly conglomeritic.

Rock 909. Graywacke or groundmass.

Then succeeds another cliff 25 feet high, of graywacke, continuing to next locality.

N. E. ¼, N. E. ¼, sec. 14, T. 65–6. Graywacke.

A low marshy place appears, at nearly the most northern arm of the lake.

N. E. ¼, N. E. ¼, sec. 14, T. 65 6. Argillyte fairly characterized.

Rock 910. Argillyte with crystals of feldspar.

S. E. ¼, S. E. ¼, sec. 11, T. 65-6. Compact argillyte (911), irregularly slaty.

N. W. ¼, N. E. ¼, sec. 14, T. 65-6. Characteristic dark gray argillyte (912), slaty.

N. E. ¼, N. W. ¼, sec. 14, T. 65-6. Regular Knife lake argillyte.

S. E. ¼, N. W. ¼, sec. 14, T. 65-6. Characteristic slaty argillyte (913).

S. E. ¼, N. W. ¼, sec. 14, T. 65-6. Conglomerate (914), but the pebbles are mostly quartzose and cherty—a few of dark flint.

As before, when the pebbles are small, many of them are subangular.

S. W. ¼, N. E. ¼, sec. 14, T. 65-6. Rock approaches the graywackenitic groundmass material seen on the north shore of the lake; but it is manifestly conglomeritic, and contains also crystals of a light feldspar. Except this, it is similar to rock 906, but finer.

Obscurely porphyrelloid, graywackenitic conglomerate.

S. W. ¼, N. E. ¼, sec 14, T. 65-6. Graywackenitic matrix of conglomerate. Similar rock continues eastward along the southern shore.

N. E. ¼, S. E. ¼. sec. 14, T. 65-6. Conglomerate. Graywackenitic conglomerate continues to the place of beginning.

§ 32 —ZETA LAKE.

This small lake, lying wholly in sec 28, T. 65-6, is partly described in the Report of 1886.* A few additional notices are here given. It has two portages eastward—one on the south into Dike lake and thence into Ogishke-muncie; and one on the north directly into Ogishke-muncie. As the former was traveled by me last year, I chose now the latter. It goes out of Ogishke-muncie south of the point shown on the plat. It is a quarter of a mile long, and very bad, over rocks and through a swamp. The northeastern part of Zeta lake exists only on the plat. The lake comes to a point in the S. W. ¼, N. W. ¼, sec 27, T. 65-6.

S. W. ¼, N. W. ¼, sec. 27, T. 65-6. East end of portage from Ogishke-muncie. Characteristic conglomerate.

S. W. ¼, N. W. ¼, sec. 27, T. 65–6. West of same portage, Zeta lake. Conglomerate.

Rock 916. Conglomerate with pebble of the most abundant kind. It is a porphyritic rock in this case, with a feldspathic groundmass. But the groundmass (917) of the conglomerate itself tends to be porphyritic.

§ 33.— EPSILON LAKE.

Epsilon lake was partially seen by me in 1886.* It is a mile and a quarter in length with a mean breadth of a quarter of a mile, and bent

* Fifteenth Ann. Rep. Minn. Geol. Surv., pp. 156, 158-9.

arcuately in secs. 29, 20 and 21, T. 65-6, having the convexity turned northward. It is bounded by rocky knolls and ridges on the north, east and southeastern shores. The south shore is forest covered and no exposures of rock appear on it; but half a mile back is a range reaching an elevation of 125 feet or more. From the range on the north we look down on the Fourth Arm of Knife lake 250 feet below, and 190 feet below Epsilon lake. We approach this lake from Zeta lake, through a steep and rocky defile with a descent of 75 feet, and find a portage out on the north into Knife lake by a descent of about 90 feet.

N. E. ¼, N. W. ¼, sec. 28, T. 65-6. At the foot of the descent from Zeta lake. A precipice of dark argillyte rises on the east. The rock is entirely free from pebbles, and very characteristic. The strike is N. 30° E., and the dip is S. 75°. But I notice on the sides of the sheets, as in the Kewatin of Gunflint lake, some striations, or a fibrous structure dipping 54° W. The dip is such that *the Ogishke conglomerate is overlying.*

S. E. ¼, S. W. ¼, sec. 21, T. 65-6. Bold promontory northeast side of lake. Slates varying from vertical to steep southeast dip. In structure ranging from proper slaty to fissile-slaty, and weathering somewhat like Kawasachong rock — but not chloritic.

N. E. ¼, S. W. ¼, sec. 21, T. 65-6. Southwest angle of same promontory. Argillyte, which on shore dips north at an angle of about 50°, but on the summit of the hill back, which I ascended, dips S. at an angle of 67°, and strikes N. 35° E. So it appears that a large mass at the point of the hill has been dislocated.

I notice here some bands running across the faces of the laminæ, which dip westward at an angle of 14°.

Rock 918 Argillyte with the banding spoken of above.

Examining further, I find these bands are the outcrop of sedimentary planes on the surfaces of the schistic plates. They show the real dip of the sedimentation, which here is S. 60°.

Re-examining the dip at the point of the hill, I find it about 50° toward southwest, and to exist in the true sedimentary bedding. I still think, however, that this mass is displaced.

Rock 919. Argillyte with sedimentary banding passing at right angles through the schistic laminæ.

N. E ¼, S W. ¼, sec 21, T. 65-6. West base of same promontory. Slate bluff with *bedding structure dipping* 23° *toward S.* 40° *W. The schistic planes stand vertical.*

N. W. ¼, S. W. ¼, sec. 21, T. 65-6. North side of lake east of portage. Slate (920), but more ancient looking than what I saw at the west base of the promontory. The schistosity runs as usual; but there are no separate bedding planes. *These appear to conform with the schistosity.* The rock looks exactly like the Kewatin of Gunflint lake.

The suggestion arises that we have here slates of *two different systems*, the upper of which are Animike. But since the schistosity is the same in both, the action which caused the schistosity was a post-Animike one, and was felt here, but not as far east as Gunflint lake. But there must also have been a pre-Animike squeezing. Even at Gunflint lake the Kewatin is squeezed vertically, while the Animike is almost undisturbed.

These slates in weathering, slide down the high hill with a decidedly sericitic habit and aspect.

N. W. ¼, S. W. ¼, sec. 21, T. 65-6. North side Epsilon lake. Finding the formation so different, I went back to find the junction of the two. It occurs here. On the south is the southward bedded slate (921) with vertical schistosity. On the north is rough, older-looking slate, with vertical schistosity, and no grain or ribbons of bedding in discordance with the schistosity. After considerable search, however, I found structure lines *conformable with the schistosity*, and giving evidence of sedimentary character.

Rock 922. Slate showing discordance between schistosity and sedimentary bedding.

The bedding on the south side dips S. 43°. It is a good ordinary argillyte. The other rock is less regular in its slatiness. The two outcrops are separate bosses ten feet apart; but it would not have been difficult with a pick and spade, to trace the formations into actual contact. The situation is this:

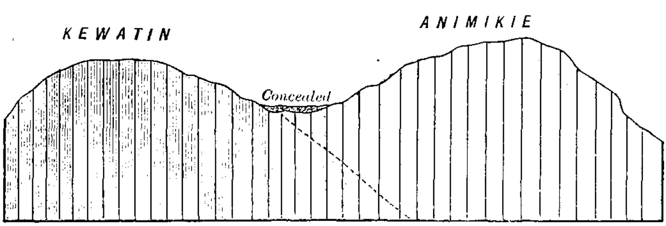


Fig. 59.—*Contact of Kewatin and Animike systems north side of Epsilon lake.*

N. W. ¼, S. E. ¼, sec. 20, T. 65-6. Ridge west of portage entrance.

The formation of this ridge is Kewatin; and it is a prolongation westward of the high ridge, rock 920; while rocks 920 and 921 are from the eastward prolongation of the same, with some additional beds on the south. I find the bedding structure (923) here corresponds with the schistic.

N. E. $\frac{1}{4}$, S. W. $\frac{1}{4}$, sec. 20, T. 65-6. Continuation of same ridge one-fifth mile further west. Slates near shore; but poroditic slaty and porphyrelloid farther back on the summit of the 80-foot hill.

Rock 924. Slate showing bedded and schistic structures conformable.

Rock 925. Poroditic porphyrelloid slate.

S. W. $\frac{1}{4}$, S. E. $\frac{1}{4}$, sec 20, T. 65-6. Northwest shore of lake. More argillitic — slaty, but the structures are the same. Kewatin slate continues along the remainder of the north and west sides of the lake.

A casual observation of the south shore of the lake indicated no important exposures; but it is to be regretted that a more careful examination was not made, since it seems probable some trace of Animike schists, southward-dipping, might have been discovered. The formation at the outlet of Delta lake, was observed last year and reported "fine hard argillyte, rather slaty." It is so near the point above described at the foot of the descent from Zeta lake that probably the formation is the same. Similar Argillitic slates were observed in places all the way from Kekequabic lake and no discordance was noted between schistosity and bedding; but it would be well to re-examine the exposures.

From the west part of Epsilon lake I noticed at the distance of a mile or so, southwesterly, a high peak. Thinking I might find there a cliff of Animike slates crowned with gabbro I determined to visit it.

S. E. $\frac{1}{4}$, N. W. $\frac{1}{4}$, sec. 29, T. 65-6. Near south extremity of lake. Pulpit Rock. Ten rods back from the lake rises a sheer vertical rock of 25 feet above the lake, cut down on all sides by smooth vertical planes. It is some sort of greenstone, and has a decidedly greenish color and sub-granular texture, soft and chlorite-like, with needles and amygdules of calcite — rock 926, noryte?

On the south, at the distance of twenty feet, this eruptive mass comes in contact with porphyry But the junction is not abrupt. There are interbedded alternations of the noryte and porphyry, as if both were sedimentary; but these alternations are not repeated many times. The porphyry has a purplish base and lamellar crystals. The following alternations were seen:

Porphyry. | Noryte. | Porphyry. | N. | P. | Noryte. |

Rock 927. Noryte and porphyry in contact.

Rock 928. Fragments of porphyry in modified noryte.

Proceeding southward a quarter of a mile, the porphyry continues. It is a handsome rock.

Rock 929. Specimens of purple porphyry.

S. E. ¼, N. W. ¼, sec. 29, T. 65-6. South of west end of Epsilon lake.

High, prominent mass of porphyry, presenting characters of an eruptive formation. The porphyry contains now fewer crystals and is replete with green amygdules.

In our progress south, I found apparently a lost, but large piece of iron jaspilyte handsomely banded. The following is the plan of structure and coloration.

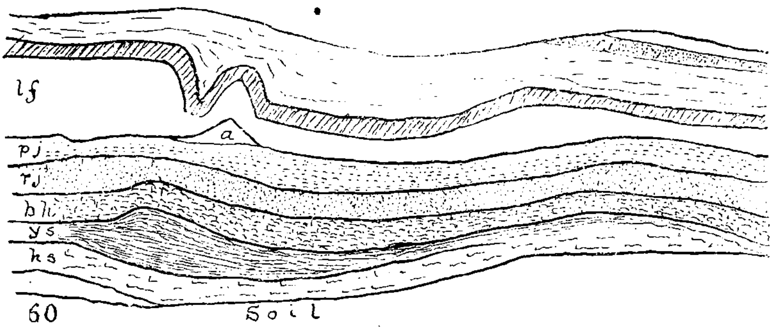


Fig. 60.—*Banded hœmatitic jaspilyte, Epsilon and Kekequabic lakes. Not in place.*

rj. red jasper.

pj. purple jasper.

lf. light flint.

bh, black hæmatite.

hs., hæmatitic schist.

ys, yellow schist.

This bears a close resemblance to jaspilitic schists heretofore found in the vertical Kewatin slates. (See p. 197, in this Report, and many observations west of Knife lake).

S. E. ¼, N. W. ¼, sec. 29, T. 65-6. Nearly midway between Epsilon and Kekequabic lakes. The porphyry has increased in amount of green amygdular mineral, until on a fresh surface, it begins to resemble the noryte; but still differs by the presence of a ground-mass of whitish color, and weathering quite white.

Rock 930. Porphyritic greenstone.

Rock 931. Fragment of Kewatin showing two structures.

At a point near the base of the high bluff, the porphyry shows flowage lines as illustrated below.

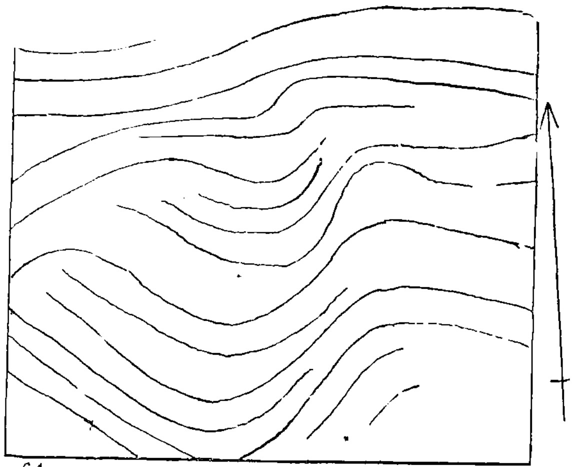


Fig. 61.—*Structure lines in porphyry, near Grant's peak.*

N. E. ¼, S. E. ¼, sec. 29, T. 65-6. Summit of Grant's peak. This is a high and sightly place about midway between lakes Kekequabic and Epsilon. From here I see the west end of the Kekequabic, Alpha and Beta lakes, much of Epsilon and all the IVth Arm of Knife except the eastern half of the two terminal branches. I see the Twin mountains, Mallman's peak and Prospect peak south of Ogishke-muncie lake. This peak I name in recognition of the valuable services of a most faithfuth assistant, Uly. S. Grant, of Minneapolis.

This peak is about 200 feet high, and presents on the eastern aspect, a perpendicular precipice of 100 feet.

The following are some bearings from Grant's peak:

Mallmann's peak, S. 42° W.

East Twin mountain, S. 56° E.

West Twin mountain, S. 36° E.

Prospect mountain and middle of Beta lake, east.

Entrance North Branch, IV Arm Knife lake N. 10° E.

These bearings are in harmony with the locations of points on the plat, except that of Prospect mountain; and I think perhaps some summit east of Fox lake was mistaken for Prospect mountain.

Grant's peak seems to be a mass of purple porphyry of a truly eruptive character.

Rock 932. Purple amygdaloidal porphyry, Grant's peak.

The numerous other hills east, west and south, for the distance of half a mile, appear also like similar, rounded bosses of porphyry.

After returning from a tour of half a mile and back, over this purple porphyry, I am not possessed of a full conviction of its truly eruptive character. I find many structure-lines which conform to the stratification of the surrounding country. It has of course been in a highly softened condition, and in that state has been moved.

Rock 933. Varieties of the purple porphyry, Grant's peak.

§ 34.—GARDEN LAKE.

On the return to Vermilion lake, my brother and I determined to re-examine some points on and near Garden lake; and especially the abandoned iron location marked on the plat as "Silver City"—an absurd designation which ought to fall into disuse. This region was examined by both of us in 1886;* but we had just returned from very extended observations of iron-occurrences in the Animike slates, and it was desirable to ascertain whether this experience would modify the determination recorded last year. I think I may say those determinations were not changed.

On the portage from Fall lake to Garden lake. A trench has been extended east and west on both sides of the upper portage, and iron-jasper exposed most of the distance; but in walking along it I saw no good ore.

Near Silver City. A quartzyte (or rather quartz schist), standing vertical, and striking east and west, interlaminated with green chloritic matter, in which are imbedded octahedrons of magnetite. Needle is here reversed.

Rock 980. Quartzyte and magnetite.

Within two rods of the excavation is an exposure of siliceous slate, thin-bedded and dipping 74° N. 60° W. This certainly has quite an Animike aspect.

Rock 981. Magnetitic siliceous slate.

Passing along beyond the excavation, we find interbandings of magnetitic quartz-schist and something appearing like incipient mica schist. Also sericitic or brownish quartz-schist (981) and dark quartz-schist.

Farther on, mica schist becomes still more developed; but the magnetitic quartz-schist prevails.

Rock 983 Mica schist and magnetitic quartz-schist.

Sometimes the mica schist is interbanded with chlorite schist similar to that containing octahedrons of magnetite.

---

* Reported on in *Fifteenth Ann. Rep. Geol. Surv. Minn.*, pp. 67-73, 329.

Rock 984. Mica schist and chlorite schist.

Rock 985. Hornblende schist associated with above.

These observations extend to the rapids out of White Iron lake. I ascertained last year that syenitic gneiss makes its appearance near the head of the rapids. The group of strata just mentioned, therefore, must be regarded as exemplifying the usual transition from the earthy (Kewatin) schists to the truly crystalline schists and gneisses. The peculiarity of this region is the repletion of the schists with hæmatite and magnetite. Their conformability, however, with the entire system of schists — earthy and crystalline — and their close stratigraphic proximity to the gneisses, preclude the admission of the existence here of a super-Kewatin formation.

N. E. ¼, S. E. ¼, sec. 28, T. 63-11. Garden lake. Low outcrop which seems to be on the dividing line between sericitic schist (very porphyrellyte-looking) and mica schist. I preserved specimens in two stages.

Rock 986. More porphyrellitic,

Rock 987. More micaceous.

These additional observations illustrate the genesis of mica and hornblende out of the common material characterizing the Kewatin slates, and which for convenience I have called Kewatin stuff.

At Tower, at the end of the season, the iron mines were revisited.

Stone iron mine. A structure bearing some resemblance to a dike existed here last year,* but at the present time, the disintegration of the south wall has almost completely removed the portion taken for a dike, and dispelled all possible illusion.

Vermilion Iron Mines. The rapid decay of the sericitic schist under the influence of the weather, is shown in the large quantities of crumbling schist and white powder (988) formed in an open and unworked excavation.

It is to be ascertained why the crumbling is so much more complete here and the color so much whiter than in ordinary exposures of the sericitic schists.

From an opening for iron about five miles southeast of Tower, I was handed the following specimens:

Rock 989. Fine banded quartzyte (quartz-schist) associated with iron ore.

Rock 990. Graphite, from the above opening.

This association reminds one of observations recorded above at the old working known as Silver city. The opening from which they

* Described in *Fifteenth Ann. Rep. Geol. Surv. Minn* pp. 24, 234-6.

were obtained is about 20 miles in a right line from the head of Garden lake; but both localities lie very nearly on the belt of the "Vermilion group" of crystalline schists.

§ 35.—GENERAL SUMMARY OF FACTS OBSERVED.

The details of observation recorded on the preceding pages possess a high degree of geologic interest. These, with the details published in 1886, furnish the means for arriving at an improved conception of the nature, age and relations of some of the oldest systems of rocks known to the geologist, and called collectively Archæan or Azoic. In most other sections of the country presenting Archæan rocks at the surface, we find them so greatly and so irregularly disturbed, that extreme difficulty arises in the attempt to make out a complete order of superposition. For this reason, geologists have been widely at variance in the views presented. Generally, we have acquiesced, in a provisional way, in the judgment reached, some years since, by the Canadian geological survey that the entire series of pre-palæozoic strata consists of two divisions, known as the Laurentian system below, and the Huronian, above. Some, however, have recognized three, four or five systemic divisions. Even Sir William Logan was inclined to make two systems of the Laurentian. On the other hand, others have failed to see the grounds for any systemic divisions of the Archæan rocks; and have maintained that it is unwise to attempt a division of them until their characters and relations should be more completely understood. Divergence of opinion has been so wide, and recorded conclusions so uncertain, that within a few years the summary judgment has been pronounced that "our chances of having at some future time a clear understanding of the geological situation of northeastern North America would be decidedly improved if all that has been written about it were at once struck out of existence."*

These statements are made to illustrate the extreme difficulty of the investigation of the Archæan rocks in the regions hitherto studied; and to emphasize the importance of careful and competent observations in a region where the Archæan series, as in northeastern Minnesota, has escaped most of those physical disturbances which have involved other districts in confusion almost inextricable. After the abundant details of facts accumulated during two seasons, upon the Archæan rocks of Minnesota, a report might well be regarded incomplete without a concise summary of the general nature of the facts,

* Whitney and Wadsworth: *The Azoic System and its proposed subdivisions.* Bull. Mus. Comp. Zool. Geol. Series, I, 520.

and a brief indication of the inferences which they seem to sustain. In this place however, the reader will not anticipate any exhaustive discussions. What I have to offer in this conclusion will be more in the nature of a syllabus of the full discussion of which the facts recorded might serve as a basis

All the clastic rocks in the northeastern angle of Minnesota, omitting here all reference to the red sandstone, present an ancient, prepalæozoic aspect. Associated with them are eruptives of various sorts, which probably rose to the surface at very diverse epochs. The clastic rocks are destitute of fossil remains, as far as known. Most of them have been subjected to metamorphic actions; and to a large extent, these have been intense. Enormous masses have assumed a condition fully crystalline.

Within the region here considered, the geographical distribution of the several terranes is east-northeast in the Vermilion district, and nearly east in the district eastward from Knife lake. Throughout the entire region, the clastic rocks—not excluding the so-called granites and syenites—present a bedded structure, sometimes indeed obscure, but everywhere discernible over all considerable exposures. Among the granites and gneisses the bedding may possibly be regarded as the result of foliation alone; but I have been led to think that its direction was predetermined by planes of sedimentation. This question however, at an appropriate time, will receive special consideration. For similar reasons, I regard the bedding of the crystalline schists as primitively sedimentary. The two older systems of rocks have their planes of bedding nearly vertical—inclining only a few degrees in one direction or the other. The bedding of the newer system is nearly horizontal—inclining five to fifteen degrees southward in the regions here reported on.

1.—*Granitoid and gneissoid rocks.* Within the district under consideration, occur three areas of granite or granitoid gneiss, which I will here designate 1.—The Basswood granite, 2.—The White Iron granite, and 3.—The Saganaga granite. The names are taken from lakes lying within these areas respectively. The former two were described, as far as the writer's personal observations extended, in the 15th annual report (1886). The Basswood granite occupies all the Minnesota shores of Basswood lake, except the southwestern shore of Arm I. The shores of Arm V have been but partially explored, but that arm lies wholly within the granitic field as traced out. From Basswood lake the southern border of this area extends west-southwest to Burntside lake, bringing all except the southwest bay and southern shore of that lake within the granitic area. In my own examinations I have not traced this boundary further west, but it is known to strike Vermilion lake in such a way that most of the northern shore lies within the granitic area. From Basswood lake I have traced this granitic mass along the national boundary to the middle of Iron lake. Other researches show that the entire region between Vermilion and Burntside lakes and the national boundary is occupied by an unbroken extension of the Basswood granite.

The White-Iron granite occupies all the shores of White Iron lake, except those of the northern extremity. Eastward from this, its northern boundary runs a little south and then a little north of the Kawishiwi river, and thence to the western side of Snowbank lake. All except a part of the northwest shore of this lake lies within the White Iron granite area. Farther east, this granitic mass is lost beneath a vast sheet of gabbro. This gabbro covering extends in the same direction as far as lake Gabimichigama, and apparently beyond. To the south of the northern boundary of the White Iron granite as thus traced, this granitic mass has not been explored by the writer, except on the shore of the lake, and at the point where it crosses the railroad between Two Harbors and Tower.

The Saganaga granite occupies all the shores and islands of the lake of that name, except the northwest shore. It does not include Oak lake; but Red-rock, West Seagull, Seagull, Granite and Pine lakes lie wholly within it. On the south it extends to Gunflint falls of the Boundary river, and its southern border has been traced east by north into Canada, along a line about a mile north of Gunflint lake, reaching the shore at the rapids of Gunflint river, and continuing half a mile north of the most projecting bays of North lake. From the western limit east of Oak lake, and west of West Seagull, the Saganaga mass trends into Canada in a mean direction east by north.

It will be noticed that the Saganaga granite lies in the direction of the prolongation of the White Iron granite; but the two are not in continuity at the surface. All the shores of Ima lake, five miles east of Snowbank, are bordered by gabbro, and this rock has been traced northward to Kekequabic, around whose shores the earthy schists are found in place. Thus the whole breadth of the belt of White Iron granite traced from the west, is cut off at the surface and concealed. A little further east, in the mountain range south from Ogishkemuncie lake, a different eruptive, apparently more recent, occupies the surface. About Gabimichigama, the surface is held again by gabbro which extends eastward indefinitely. But in the fifth range of townships west, quite another terrane — the Animike — is seen emerging from beneath the gabbro. This, without attaining here any considerable breadth on the north of the gabbro limit, is found thinning out against the southward slopes of the Saganaga granite. As a fact of surface observation therefore, the Saganaga area is completely isolated from the White Iron area. So far as the facts thus stated go, it seems probable that the two must be regarded as continuous underneath the covering of more recent terranes — the Animike, the gabbro and the greenstone. This view is sustained by the continuity of trend of the neighboring vertical schists through the basin of Knife lake and its long-extended Fourth Arm. It is further evinced by the similar constitution and structure of the Saganaga and White Iron granites. But the separateness is indicated on other grounds to which I shall refer, and my conclusion is that the White Iron and Saganaga granites have only a deep-seated connection.

As repeatedly illustrated in the details of observations reported, these granitic masses exhibit everywhere a vertically bedded structure. This is generally somewhat distinct, and the terrane is a characteristic gneiss. The bedding is most distinct in the neighborhood of the crystalline schists which everywhere flank the granitoid masses. It grows less distinct as we recede from their neighborhood. The nearest approach to the massive condition of a typical granite is noticed along the shores of Crooked and Iron lakes, at a distance of about 18 miles from the schists of Burntside lake. But even in Iron lake the bedding in many places, is quite unmistakable. This bedding, it is almost needless to say, is the usual schistosity of the crystalline rocks.

Bedding of a different sort is occasionally met. The terrane is divided by numerous planes nearly horizontal. At times resulting layers are less than half an inch in thickness; generally, they exceed an inch. The dividing planes do not possess the regularity and rigidity of proper joints, and their cause appears to be extremely different. Slow weathering seems to be indicated by the usual relation of the bedding planes to surfaces of exposure. The most striking examples of this structure occur on the northern shores of Basswood lake, in range nine west.

The characteristic mineral contents of the granitoid rocks are quartz, orthoclase and hornblende or mica. These constituents vary greatly in relative proportions. In the Basswood granite, the quartz grains are generally not over a tenth of an inch in diameter. In the White Iron Granite, they occasionally attain a diameter of a quarter or third of an inch, and in the Saganaga Granite, large grains of quartz are generally dispersed, and become a characteristic feature of that terrane, very often reaching half an inch in diameter. The dark mineral of the Basswood granite is very generally mica—for the greater part biotite, but often hydromica. Muscovite prevails along Crooked and Iron lakes, and biotite and hydromica at Burntside lake. In certain conditions of the formation, the biotite is extremely fine, badly characterized, even under the lens, and seems to be in a nascent state. From such a condition of the rock we pass in one direction, to a well defined mica-granite, and in the opposite, to a well defined hornblende-granite. The transition is transverse to the axis of the bedding. In the White Iron and Saganaga masses, the dark mineral is chiefly hornblende. But not unfrequently it is augite, and very commonly the mineral has reached by the process of change, an earthy and viriditic aspect. In the Baswood area in the vicinity of Pipestone falls, a chloritic mineral usurps the place of mica or hornblende, and instead of occurring in distinct grains or individuals, blends off on the borders into the contiguous feldspar. This condition of the granite is found also in the southern part of lake Kekequabic, and again in the southern part of West Seagull and Seagull lakes, and in the west one of the long Arms of Saganaga lake. Quartz, in these cases, occurs but sparingly. Chlorite-syenite is a condition appertaining to the vicinity of the schists which flank the granitoid masses on both sides.

As to the feldspathic constituent, it is prevailingly orthoclase. This on fresh fracture is white in some districts and red in others. In some regions, the white or pale orthoclase weathers red. This is the case along the shores of Crooked lake, where the wide-extended, bare surfaces acquire a blood-red hue. In other regions, as along the west side of West Seagull lake, the white orthoclase weathers white, and the granitic hills gleam with a brilliance almost dazzling At some places on White Iron lake the orthoclase occurs in individuals an inch in diameter. In other regions, the orthoclase is badly individualized, and forms an imperfect groundmass for the other minerals. Beside orthoclase, triclinic feldspars are generally present in subordinate proportions. Occasionally, by the adventitious absence of the dark minerals, the rock becomes a true granulyte, but generally with an excess of orthoclase. On the contrary, the granulyte is eminently quartzose at the head of the small bay near the west end of lake Saganaga.

The physical structure and mineral constitution of the granitoid masses are subject to marked and sometimes abrupt variations. In the middle of lake Saganaga, I found an island composed of good mica-gneiss. On all sides the formation is syenite. In the westerly one of the two long arms of Saganaga lake, the syenite on one of the islands becomes abruptly quartzose to excess, and simultaneously the orthoclase becomes a feldspathic matrix, and then nearly disappears, and an argillaceous, sericitic, schistic rock takes the place of the syenite. But this is immediately succeeded, on the nearest island, by the ordinary syenite of the region.

A highly striking and significant feature of the Saganaga and White Iron syenites is the presence of rounded pebbles sparingly disseminated, but at certain points aggregated in such numbers as to form a real conglomerate in the midst of the syenite. Many particulars of these occurrences have been recorded in my notes on Seagull, West Seagull and Saganaga lakes, to which reference may be made.

These observations are quite analogous to others made in New England and reported in a comprehensive way in the Geology of Vermont.* In most of the instances cited by Dr. E. Hitchcock, the pebbles are embraced in "talcose schists;" but he mentions cases in Massachusetts and Vermont, of which he says: "We define this rock as a conglomerate with a cement of syenite or granite, or as a syenite or granite with pebbles in it, sometimes thickly and sometimes sparsely disseminated." The rounded pebbles on Ascuteny are "black rounded masses which are for the most part, crystalline hornblende with some feldspar." "At Granby, the pebbles, manifestly rounded, are either mica schist or white, almost hyaline quartz" On the other hand, the pebbles occurring in the Saganaga syenite are mostly greenish, lamellar, augitic and chloritic; but some of them are composed of augite and a feldspar having the microscopic appearance of orthoclase. Quartz is conspicuously absent. To the interpretation of these facts I will briefly return in another connection.

The gneiss and granites are extensively traversed by quartzose and granulitic veins. These have been fully illustrated in the annual report. Dikes of diabase are abundant. Occasionally, as in Burntside lake, they appear to be rather dioritic.

2. *Vermilion crystalline schists.* The vertically schistose gneisses are flanked by vertical crystalline schists having a variable width. These have been designated by the geological survey of Minnesota, "The Vermilion group." Along the south side of the Basswood granite, they occupy an average width of half a mile — but varying from a quarter of a mile to two miles. The belt has been traced quite distinctly from Vermilion lake to near Carp lake — taking in the south shore of Burntside, passing north of Long, including the north part

* Volume I, pp. 28-45; especially pp. 40 and 41.

of Newton, occupying the west side of Arm II of Basswood lake, the southern swell of Arm III, and the southern extremity of Arm I. The continuance of this belt of crystalline schists has not been observed further east. It is supposed to strike northeasterly into Canada, lying somewhat to the north of Sucker and Pseudo-messer lakes.

Another belt of the crystalline schists extends along the north flank of the White Iron granite. It touches the northern extremity of White Iron lake, and is well exposed at the rapids out of the lake. Its westward continuation I have not traced. Eastward I have not been able to trace it continuously farther than the western border of Range X; but it ought to be found on Triangle lake, and thence to Snowbank, near the western extremity; where evidences of its proximity have been observed. Eastward of Snowbank lake, its non-appearance may be attributed to the bed of gabbro which conceals the eastward prolongation of the White Iron granite. Farther east, we find the southern slope of the Saganaga granite encroached upon by the Animike slates; but north of Gunflint and North lakes, the fringe of crystalline schists appears, resting against the vertical beds of gneiss. This region is within the Canadian Dominion, and no attempt has been made to trace it farther.

The crystalline schists along the southern border of the Basswood granite, consist chiefly of muscovite and biotite schist; but with occasional hornblende schist and rarely a dioryte schist. Generally, these schists are not well characterized, being fine-grained, and in many places transitional in constitution. On the south side of Burntside occurs a good scythe-stone—a fine, homogenous muscovite-schist —but a mile or two further east, a massive hornblende schist usurps its place. In the belt as observed north of Gunflint and North lakes, biotite and hornblende both occur, sometimes in mixture and sometimes in alternation.

The mode of transition between the gneisses and crystalline schists is noteworthy. It is never abrupt. It is a structural gradation. In the neighborhood of the line of junction, beds of gneiss and beds of schist occur in many alternations. On the gneissic side of the line, the schistic beds are at first several inches in thickness, and of frequent occurrence, or else thin, and correspondingly augmented in number. As we recede from the line, the schistic beds grow thinner and occur less frequently. On the schistic side of the separating line, occur some gneissic bands of various thickness, all conformable with the schists; and often large angular fragments of gneiss, little or not at all displaced from bedded conformity with the schist. These phenomena were so fully described and illustrated in the fifteenth report that I have given them a less conspicuous place in the present one. One striking instance however, is described, occurring north of Gunflint lake, in which I estimated about five hundred thin bands of hornblende schist intersecting the gneiss within a breadth of forty-five feet. I have also described in this region, a direct mineralogical transition from earthy and sub-crystalline schists to gneiss, without the intervention of proper crystalline schists. The earthy schist becomes at first porphyritic with feldspar, and then with feldspar and quartz. While the proportion of these minerals increases, the groundmass resolves itself into nascent mica and then into well-formed individuals of biotite or hornblende, or both together. The significance of these structural and mineralogical transitions will be referred to in another connection.

3. *Kewatin semi-crystalline schists.*—In his "Report on the Geology of the Lake of the Woods Region" for 1885,* Mr. Andrew C. Lawson has applied the term "Kewatin" to certain schists occurring in the vicinity of that lake and holding position immediately above the granitoid gneisses. The geological survey of Minnesota has for two years employed this term, slightly modified, to designate provisionally a series of earthy and semi-crystalline schists holding a position next above the crystalline schists. In our usage therefore, the term is less extensive in application than in the original proposal of Mr. Lawson. Without citing at present, the classes of strata embraced under this designation in Canada, I will proceed at once to a summary description of the strata to which we have applied it in Minnesota.

(1). Distribution. These rocks occupy the whole of the south and east shores of Vermilion lake as far as Mud Creek bay and somewhat beyond. Thence the southern boundary of the belt passes half a mile south of Burntside and half a mile north of Long lake, and thence through Newton lake nearly to the most southern bay of Basswood and Arm I of the same lake. It continues eastward so as to pass between Basswood and Carp lakes, and thence northeastward into Canada—the northern limit of the belt lying north of Sucker, Pseudomesser and Knife lakes, and far north of Ottertrack, Oak and Saganaga lakes. All these lakes lie wholly within the Kewatin belt, except Saganaga, which only encroaches upon it along the northwestern border.

The southern limit of the Kewatin belt has been traced from a point south of Eaglenest lakes, T. 62-15, to the northern extremity of White Iron lake, thence across the north part of Farm lake, to Triangle and

* Geological and Natural History Survey of Canada, 1885, CC.

Snowbank lakes. Following the west shore of Snowbank it leaves the north shore within the granitic area, but bends southward to cut off the eastern extremity of the lake, and proceeds thence to the vicinity of Kekequabic, where for the distance of two miles, it is overlapped by the gabbro sheet. East of the middle point of this lake, the system is revealed again, if we may venture to regard the Ogishke conglomerate as a part of it. But the southern border is overlapped by greenstone. As far east as the north shore of Gabimichigama, the system is largely exposed, with its character well preserved. Eastward of this, for twelve miles, the writer has not observed the Kewatin rocks. But north of Gunflint they recur in unmistakable character and continue eastward near the north shore o North lake into the remoter regions of Canada.

It will be observed, from the foregoing description, that no connection has been actually traced between the Kewatin schists north of Gunflint lake and those as far west as Knife lake. Along the national boundary, the Knife lake schists have been traced to the crystalline area of Saganaga lake, and thence along the northwest and north sides of that lake. The southern limit of the Knife lake schists and the Ogishke conglomerate, on about the meridian of the west end of Saganaga, is lost to view. Does it turn northward so as to throw the whole breadth of this Kewatin belt to the north of the Saganaga granite; or is the Kewatin belt here split—one branch passing to the north and the other to the south of the Saganaga granite? In the former case, the Saganaga granite would be continuous with the White Iron granite. In this case, the Gunflint Kewatin would be a distinct belt, and its westward continuation would have to be sought along the southern border of the White Iron granite. But even if in position there, it might be concealed by overflows of gabbro and greenstone, or by the vast Animike system. The strike of the Animike beds north of Gunflint is so much north of east as to suggest the opinion that the belt is separated from the main or northern belt by the interposition of the White Iron-Saganaga granitoid range. At the same time, its lithological characters very closely resemble those of the Knife lake Kewatin; and since rocks which I strongly incline to believe Kewatin, are traced eastward from Ogishke-muncie, through Town-line and Frog-rock lakes well toward the southern side of the Saganaga granitoid area, it rather appears probable that the Gunflint Kewatin is really a southern bifurcation of the Knife lake Kewatin.

No exposure of the Kewatin series has been observed by myself farther east than North lake, in the meridian of Range II west. But I have information apparently reliable, of its occurrence in a limited exposure as far east as South Fowl lake, in sec. 1, T. 64, R. 3E. In the opposite direction it is found, according to a private letter from Mr. H. V. Winchell, in sec. 11, T. 59, R. 14W. It strikes here N. 80° E. The position seems to be on the south of the White Iron granite range.

(2). General lithological characters of the Kewatin schists. Vertical bedding is almost everywhere, within the region examined, distinct and unambiguous. In certain places, however, the bedding is obscure, or even completely obliterated. Such obscuration may often be traced in the action of erupted masses; but more often the hardened and metamorphosed condition of the strata is not ascribable to any visible cause. Passages from the more earthy to the more hardened condition take place along the direction of the strike, as also in a direction at right angles with it. The strike of these vertical schists is in general east-northeast in the region west of Saganaga lake, and somewhat more easterly in the region east of it. The directness of the strike is as remarkable as its persistence. The flexures of the strata are but moderate. It is only on the south of Ogishke-muncie, and about Fox and Agamok lakes that evidences of considerable disturbance are manifest Some of these features were described and figured in the report for 1886, pp. 168, 169, 375-378. On the north of Sagaga lake the strike still holds steadily east-northeast, and on the north of Gunflint lake it is not very different.

The beds for the greater part are even and continuous, and the cleavage is coincident with the bedding. The planes of sedimentation may frequently be detected by means of the usual banding. The universal coincidence of these, when discoverable, with the planes of the cleavage system, affords good evidence that the cleavage planes everywhere point out the direction of the original sedimentation.

Often, however, the bedding becomes irregular, the rock being resolved into a mass of lenticular and cuneiform pieces a few inches in length. This condition may pass by rapid transition into that of regular bedding.

In lithological composition the Kewatin schists present notable diversification. The principal rock species are: (1) Graywacke, (2) Argillyte, (3) Sericitic schist, (4) Chlorite schist, (5) Porphyrellyte schist, and (6) Hæmatite. The *graywacke* generally occupies a position nearest to the crystalline schists. Often, however, the sericitic and argillitic rocks graduate into a graywackenitic formation.

The best characterized graywackes are obscurely bedded, dark gray and composed of fine grains of quartz and feldspar mostly but not exclusively monoclinic, all imbedded in a sparse or copious groundmass of a silico-argillaceous character. Disseminated through the rock are generally some black specks of an anthracitic character. Peroxide of iron also, is often present. From the condition thus described the variations are very marked. Often through an excess of quartz and a high silicification of the groundmass, the rock becomes impure-flinty, and under the influence exerted by heat, has acquired a ringing hardness, accompanied by two or three sets of jointage planes, which divide the mass into cuneiform portions. It thus seems to answer the description of *hornfels*. This condition is approximated very frequently. But, far from being persistent, we often see it pass rapidly into a well-bedded terrane. In another direction, the felsitic constituent exists in increased quantity, and the dark aspect of the other ingredients gives the rock a diabasic look, especially when, as is mostly the case, all bedded structure is completely disguised. At times it is almost impossible to decide macroscopically whether the rock is a real diabase, an anamesitic doleryte, or only an altered and aberrant graywacke. (Rep. XV, p 27.) As an instance of this may be mentioned the rock about the shores of Flask lake, in T. 64-9 W. Another is near the northern entrance to Garden lake (XV Rep., pp. 125-6, 68.) It is seen equally well developed on the north shore of Frog Rock lake and the southern part of Crab lake.

Another member of the Kewatin series is *argillyte*. In position it generally lies next the principal mass of graywacke. Argillytes well characterized exist in great abundance. Such may be seen from Vermilion lake to Knife lake. Newfound lake and Moose lake in T. 64-9 W., lie in the midst of an area of such argillytes. The slate is bluish or buffish, highly argillaceous, and cleaves smoothly and with great facility. Such slate exists less exclusively in the basins of Long, Fall, Ensign and Knife lakes. Other argillytes equally slaty and smooth-cleaving, but of a dark almost black color, are widely distributed and abundant. Of rare occurrence in the vicinity of Vermilion lake, they are quite increased in volume along some parts of Fall lake, and become predominant around the shores of the western part of Knife lake. Dark argillytes are also associated with the conglomerate of Ogishke-muncie, but these require separate mention. Many of the argillytes of Knife lake acquire a considerable percentage of silica, and become siliceous argillytes, retaining generally their free cleavability and characteristic color, which is mostly dark. The silicification of the argillytes has frequently gone so far that the rock is a strict *siliceous schist*, retaining generally, a dusky color, but sometimes acquiring a marked translucency. Generally, strata or laminæ of siliceous schist, flint, or red jasper alternate with laminæ or beds of dark siliceous or characteristic, argillyte. With these, sometimes, are laminæ of hæmatitic siliceous schist. In a large detached mass of this kind, found at the western extremity of Knife lake, the various laminæ were strikingly contorted. This mass was supposed to be not far removed from place; but no such character has been seen by the writer actually in strata of the Kewatin series so far west as Knife lake. But jaspery hæmatite has been observed between Nameless and Sand lakes, in T. 62–14. On the contrary, similar characters have been observed in the Animike schists north of the west end of Gunflint lake, and less contorted at other points along the north shore.

Besides the transitions above mentioned, the argillytes of Knife lake exhibit many transitions to *sericitic schist*. This may be observed taking place in the direction of the strike and also across it. Transitions to graywacke have been mentioned. The impression made upon the observer by these passages is a conviction that all these species of rock have been originally the same; and out of the same material, varying conditions, primary and secondary, have produced the diversified states of rock above described.

Another species of rock belonging to the Kewatin series is *sericitic schist*. This is generally of a light brown color and a silky or soapy feel. It is always distinctly and thinly laminated. By access of argillaceous matter, it often passes into a brown argillyte. When in a state of characteristic purity, it sometimes effloresces under exposure to the weather, giving rise to a powder, white like flour or tinged with iron peroxide. This schist is most abundant in the western part of the region studied, where it is associated with beds of hæmatite. Eastward, it becomes a brown, smooth sericitic argillyte, but has only a local distribution. It occurs on the north side of Ensign lake, at one or two points in the northwest part of Frog Rock lake, and at several points on Town Line lake. Outcrops are also seen on the south side of Ogishke-muncie lake. A frequent characteristic of the sericitic argillyte is the occurrence of disseminated grains of free quartz. This character is quite striking at one point on the north of Ensign lake, on the south shore of the north part of Ogishke-muncie lake, and at two points on Frog Rock lake and several on Town Line

A fourth species of schist is *chloritic*. In full development it possesses a dark earthy green or bluish color, moderate hardness, and generally an imperfect and irregular bedding. The general trend of the structure is always conformable with that of the adjacent schists. An instance of the highest development of this schist may be seen at Kawasachong falls, in the stream flowing from Garden into Fall lake. As the nature of this rock is not yet settled by common consent, it is frequently referred to in this report as the "Kawasachong rock." A full account of its occurrence at this place may be found in the Fifteenth Report, pp. 319-322. The fully developed condition of the rock may also be seen at many other points—notably on the north side of Frog Rock lake, where I made a detailed study of it (page 306), and at the northern extremity of Pseudo-messer lake, in Canadian territory. It is reported largely distributed on the south of Long lake about the new iron mines.

Chlorite schist presents countless cases of gradation into sericitic schists and argillyte; insomuch that in my detailed descriptions frequent mention is made of "chloritic-sericitic schists" and "chloritic argillyte." The chloritic constituent also very frequently invades the graywackes. The question of the eruptive origin of any part of the chlorite schist will be considered hereafter.

A fifth species of schist occurring in the Kewatin series is *porphyrellyte*—a name of purely provisional import, and used here, while the rock awaits due investigation, simply to avoid the misapplication of any well-known term. This species of schist has been found existing in immense volume and over a wide extent of territory, especially between Sucker and Gunflint lakes. In tracing out the schists recognized as sericitic and argillitic, it was noticed that they sometimes acquire gradually a constituent which imparts a somewhat waxy lustre and waxy transparancy on thin edges. In the earlier observations about Vermilion lake, the siliceous constituent was sufficient to give considerable hardness to the rock, and such schists were set down as "felsitic." My earlier notes in 1886 contain occasional mention of "felsitic-sericitic schist" "felsitic argillyte" and even of "felsyte schist"—all the determinations, it will be remembered, simply macroscopic, and made in the field. In proceeding eastward similar rocks were occasionally noted; but in entering Sucker lake from the west, it was first noticed that the so-called "felsyte schist" was deficient in hardness, and I felt inclined to regard it as an "argillaceous felsyte schist." Uncertain of its real nature, I continued to note its occurrence in increasing abundance, as far as lake Kekequabic. Here, on

Stacy island, I found distinct and numerous feldspar crystals imbedded in it. Having a groundmass apparently feldspathic to a partial extent, this formation might have been set down as porphyry. But it was obviously of sedimentary origin, and was interbedded with slates. Also in the immediate vicinity, the forms of pebbles were traceable in the rock. Exactly similar observations were subsequently made on both sides of the narrows between Zeta and Dike lakes, T. 65-6W. (Fifteenth Rep., p. 158), but most satisfactorily on the north side. As the rock clearly was not an erupted and true porphyry, I designated it *porphyrel.* This pseudo-porphyry was subsequently met many times. Finally, along the two terminal bifurcations of the Fourth Arm of Knife lake, I was specially impressed by two groups of observations. *First,* the groundmass of the porphyrel was entirely too soft to admit the hypothesis of a felsitic nature; and *secondly*, the feldspar crystals appeared and disappeared at frequent intervals, while at some intermediate points they were very few in number, and sometimes appeared to be just emerging into existence from the general groundmass. (See rocks 549 and 954–5.) In all these cases the formation preserved a rude and irregular stratification. On the north bifurcation of the Fourth Arm of Knife lake, *porphyrellyte* is the prevailing rock; and it rises in many massive bluffs on both sides. In a small bay near the eastern extremity, it becomes a porphyrel, and here, as at Kekequabic (west end of Stacy island and rock 360) and Zeta lakes, the outlines of pebbles may be traced. At the "Promontory of Knife lake," which separates the Fourth Arm from the body of the lake, an argillaceous porphyrellyte is capped by a thick sheet of gabbro (p. 209). A more characteristic porphyrellyte is capped by gabbro on the eastern shore of the southward projecting bay near the eastern end of Knife lake (p. 206). On the north side of Gunflint lake, the vertical schists range from porphyrellyte to argillaceous porphyrellyte and porphyrel. The latter acquires also, in some parts of this region, abundant grains of quartz.

In most of the localities where porphyrellyte occurs it is found alternating with argillyte — sometimes of a slate color and sometimes dark or almost black. The local relations of these different varieties of schist are well illustrated on the south side of the north bifurcation of the Fourth Arm of Knife lake. The passage is both along the strike and across it — in either case reflecting light on the genetic relations of the two. In the same region, but chiefly on the north shore, the porphyrellyte may be seen passing into a hardened flinty argillyte, as also into a condition having a diabasic aspect — hard, and almost without bedding. A puzzling condition occurs on the north side of Frog Rock lake, where toward the east, felsitic-looking bosses alternate with diabase-looking bosses, chloritic bosses and real diabase. Never, however, as far as I have traced the Kewatin schists, does the translucent, waxy constituent permanently disappear. This seems to be the fundamental material out of which nature has produced not only porphyrellyte and porphyrel, but also some sericitoid and argillaceous schists, and even some hard diabase-looking rock-masses. These indications led me to designate as "Kewatin stuff" the fundamental mineral which has revealed itself under so many aspects.

The diversification of porphyrellyte may be traced in another direction. Already when making observations in the vicinity of Vermilion and Eagle Nest lakes, I discovered small serpentinous lumps (XV Rep. p. 32) and thin films in that modification of Kewatin rocks reported as "porodyte"— after Wadsworth. I recorded the opinion that the rocks of that vicinity were pervaded generally "by a magnesian element." Next, I subsequently observed in the southern bifurcation of the Fourth Arm of Knife lake, that porphyrellyte passes by insensible gradations into porodyte; and I learned that Knife lake porodyte is only another of the modifications of "Kewatin stuff." Again, the obscurely conglomeritic character of some examples of porphyrel has been noted in several places. Now let the feldspar crystals disappear from conglomeritic porphyrel, and it approaches closely to some states of the so-called "Stuntz conglomerate"—of which I shall have a word further to say. It thus appears that the basal substance of porphyrellyte reveals its existence under a very interesting variety of modifications.

The nature of that basal substance remains to be determined. But meantime, while awaiting opportunity to make appropriate investigation, I have considered the possibility that Kewatin stuff is essentially *parophite*, a form of pinite, a hydrous, aluminous alkaline silicate. Such composition would account for porphyritization with either feldspar or quartz, or both conjointly; and as magnesia is a constant alkaline constituent (together with potash) we have means of explaining the occurrence of serpentinous lumps in the porodyte of Vermilion lake — if indeed, they be not parophite or agalmatolite instead.* The formation here considered seems to bear no relation to the "Serpentine Group" of Rominger.†

* Parophite is a name proposed by Dr. T. S. Hunt, from the resemblance of the rock to ophite or serpentine. See Report, *Canadian Geological Survey*, 1851-2, pp. 95–99; *Geology of Canada*, 1863, pp. 484-6.

† Rominger, *Geological Survey of Michigan*, vol. iv, pp. 13?–143.

Should it be supposed that the porphyrel above referred to is probably a true erupted porphyry the following may serve as adequate reasons for thinking otherwise:

(a) The vertical structure which exists seems to include the vestiges of an original sedimentary stratification. This structure is the result of stratification and schistosity combined. Sometimes the slatiness is conspicuous (Rock 955).

(b) The porphyrel, in numerous cases, reveals the original presence of pebbles, the outlines of which are now obscured, and *the nature of which has probably been changed.*

(c) The porphyrel passes insensibly into porphyrellyte which (besides retaining its traces of stratification) exists in such volume that it would strain credulity to believe it eruptive.

(d) The groundmass of the Ogishke conglomerate — beyond all question fragmental in origin — sometimes, as has been stated in the former part of this report, develops feldspar crystals, and becomes in form and substance, an argillaceous porphyrel.

(e) Porphyrel and porphyrellyte are found interstratified with dark siliceous argillytes. See page 324.

(3) The Ogishke dolomyte. Having stated concisely the characters of the predominating rocks of the Kewatin series, I make brief mention next, of lithological features more or less local and exceptional. *Dolomyte* has been observed at only one locality. That is near the shore of the northeastern part of Ogishke-muncie lake. It is vertically bedded, mostly impure, stained with iron oxide, crumbling, pervaded by sericitic matter and passing laterally into conformable beds of sericitic schist. The strike is parallel with the axis of this part of the lake. It was traced only a few rods. For further particulars, see pp. 95, 316.

(4) The hæmatite lodes of the Kewatin. These have not fallen within the scope of observations made in 1887. Such facts as were observed in 1886 may be found recorded in the fifteenth annual report.

(5) The conglomerates of the Kewatin. The *Ogishke conglomerate* is limited to the vicinity of Ogishke-muncie lake. On the west it is seen first at Stacy island in Kekequabic lake; but occurs also along the north shore of the eastern part of the lake. Its northern boundary passes a little north of Alpha, Beta and Gamma lakes, sec. 29, T. 65–6, and thence eastward to the portage between Zeta and Dike lakes, thence to the portage between Zeta and Ogishke-muncie lakes, thence northeastward so as to cut off half a mile of the eastern end of Crab

lake; thence east to the northern side of Town Line lake; thence southeast to the centre of sec. 18, T. 65–5, on the northwest shore of Frog Rock lake. From here the boundary is lost. The conglomerate does not appear on the west or south shore of Frog Rock lake. From the point of occurrence last mentioned the boundary must pass southwest. Section 24, T. 65–6, is within the conglomerate area. The southern border is found near the outlet of Agamok lake, in sec. 36, T. 65–6, and again near the centre of sec. 35, T. 65–6, on the mountain slope, a mile south of Ogishke-muncie. But from here the boundary bends suddenly northward to the N. E. ¼, sec. 26, T. 65–6, and thence southeast to S. E. ¼, sec. 27, T. 65-6. Thence the southern border bends southeasterly, passing to the east of Twin peaks in S. E. ¼, sec. 34, T. 65–6. The continuation westward is now unknown for the space of two miles, the southern boundary being struck again on the southeast of lake Kekequabic in sections 31 and 32, T. 65–6. The area thus circumscribed has an extreme length of eight miles and an extreme breadth of two miles or a little more.

The Ogishke conglomerate is composed of beds standing vertical, with slight inclinations one way and the other. There seems to be a general strike in an east and west direction, and in places this strike is distinct for a quarter of a mile or more, especially near the borders of the conglomeritic area. Within the area, the strikes are mostly obscure; but when distinct, they conform to the general trend. In many places however, the strike seems to vary much from the normal direction. This is seen along the immediate shore of the lake, and on the mountain slope south of it, as also in the vicinity of Fox and Agamok lakes. In the last named region, a centre of disturbance seems to be revealed (Fifteenth Report, pp. 168-9). It must be noted however, that the magnetic needle, around the shore of Ogishke-muncie, deviates with much irregularity.

Considering more carefully the lithological character of the beds, we find the groundmass in which the pebbles are imbedded, to be essentially a dark slaty argillyte, varying from a typical argillyte through all the conditions already noted in the argillytes of the Kewatin series—cleavable, badly cleavable, siliceous, feldspathic, hard-baked and "diabasic." The pebbles are not uniformly distributed through the formation. They lie in courses coincident with the strike, and their longer axes generally lie in the same direction Some of the slaty beds are well filled with pebbles large and small; others contain but few, and these mostly small. Again, we find many beds entirely destitute of pebbles; and this condition exists in places across a breadth of ten or twelve rods, to be succeeded again by conglomerate. The transition is apt to be abrupt. A bed well filled with pebbles is likely to be succeeded by beds without pebbles, and possessing all the characters of an ordinary argillyte (See Fifteenth Rep. p. 163). These variations are well seen around the shores at the west end of Ogishke-muncie.

The limits of the conglomerate area are not abrupt They are indicated by the gradual diminution in the proportion of pebbles, and in their size. In the direction of the longer axis of the area, this is well seen at Stacy island in lake Kekequabic, while the vanishing point in the opposite direction is seen in the northwestern part of Frog Rock lake. In this direction the diminution in the size of the pebbles is a more signal feature than in the transverse direction. On the mountain south of Ogishke-muncie the country rock undergoes a change into a formation resembling greenstone; and in this large bowlders are sparsely disseminated. A similar observation is made on the north of Ogishke-muncie. In the greenstone condition, the outlines of the pebbles become much obscured, while at the east and west extremities of the conglomerate area, the diminished pebbles remain well isolated.

Another course of variation is observed in the vicinity of Ogishke-muncie lake. The same transitions in the state of metamorphism of the mass of the formation take place as have been noted in reference to the graywackes and argillytes farther west. In limited districts the smooth rounded bosses of the conglomerate present a striking resemblance to diabasic outbursts. But these in most cases, are distinctly siliceous; in others, the groundmass contains numerous individuals of feldspar. Many times the pebbles are nearly or quite concealed by the change which has affected the formation. Sometimes the forms of pebbles are completely undiscoverable above the water-line, while sufficiently distinct beneath it. These conditions are best exposed on the western and southern shores of Ogishke-muncie. On the eastern shore, north of the northern narrows, and at a distance inland, the diabasic aspect of the formation and the obscurity of the pebbles are very noticeable features.

Another feature of the highly metamorphic conditions of the formation is the *metamorphism of the pebbles*, as well as the groundmass. By this means the mineral nature of the pebbles is approximated to that of the groundmass, and thus the obscurity of their outlines is caused. The pebble-bearing "green rock" on the mountain south of Ogishke-muncie, seems to be one of the results of metamorphic change

(Fifteenth Rep., p 165). But I do not mean to assert the absence of erupted greenstones in other parts of the same range. A similar change has been suffered in the ridge a mile north of Ogishke muncie.

As to the pebbles themselves, it may be stated that their most conspicuous features are their strictly smoothed spheroidal forms, the diversity of their mineral characters and their prevailing arrangement in courses. Evidently, these rock-fragments have been long rolled on some ancient beach. Their sizes range from a quarter of an inch to ten inches; and the groundmass is locally composed largely of the same materials in a finer state. This is seen on the main land north of Camper's island. Without attempting a complete enumeration of kinds, the following may be named: (1). Syenite, resembling Saganaga syenite but with little hornblende; (2). Greenstone; (3). Porphyry; (4). Red jasper; (5). Flint; (6). Quartz, opaque, white; (7) Petrosilex; (8). Ordinary syenite with black hornblende; (9). Dioryte, coarse, with dark green hornblende; (10). Dioryte, fine, with dark green hornblende, (11). Porphyroid, weathering light and cellular; (12). Siliceous schist; (13). Carbonaceous, siliceous argillyte—sparingly. The foregoing list was made out on Camper's island near the narrows in Ogishke-muncie lake. This is about the centre of the most characteristic portion of the formation. In all directions from here the diversification of the pebbles diminishes. On Stacy island however, in Kekequabic lake, the conglomerate is slightly brecciated, and the fragments consist of fine diabase, dark siliceous schist, red jasper and black flint, all imbedded in a matrix of dark color, looking somewhat like the overlying dark slate.

The relative age of the Ogishke conglomerate is a difficult question which cannot be regarded as settled. The *prima facie* evidence would make it a part of the Kewatin system, conformable in structure and consecutive in history. The fundamental rock-stratum holding the pebbles is essentially an argillyte presenting the same characters and subject to the same variations as the argillyte of Knife and Pseudomesser lakes and the region further west. On the northern boundary the formation visibly passes from Ogishke-muncie by diminution and final loss of pebbles, into the argillyte of Zeta and Epsilon lakes From Kekequabic, it graduates similarly into the argillytes of Pickle, Spoon, Plum and Knife lakes. On the west it is traced by absolute continuity into the argillyte of the western Arm of Knife lake, and thence through Sucker, Ensign, Newfound and Moose lakes. The argillytes and associated schists of the series as found at Ensign and contiguous lakes, are admittedly in continuity with the argillytes and associated schists found at Long, Sand, Eagle Nest and Vermilion lakes. Moreover, we find in the area of the conglomerate itself, local developments of sericitic schists, such as farther west are so largely associated with the argillytes. These are found on the shore of Ogishke-muncie lake south of Camper's island, and farther north on the south shore, associated with the dolomyte above described. Such schists are elsewhere found within the conglomerate area, on Town Line and Frog Rock lakes. To make the identification more complete, the sericitic schists of Frog Rock and Town Line lakes are filled with quartz grains, precisely as the recognized Kewatin sericitic schists are charged with them on the north shore of Ensign lake. Finally, as the porphyrellyte of Zeta, Dike, Knife and Gunflint lakes becomes locally charged with feldspar crystals, so the groundmass of the conglomerate becomes similarly charged at many points on Zeta, (rocks 916-17,) Kekequabic and Ogishke-muncie lakes. Lithologically and stratigraphically, therefore, the identification seems to be complete.

The structural continuity can be traced still farther east and northeast. The vertical porphyrellyte schists of the eastern part of Knife lake alternate with dark argillytes traced from the western part of the lake, and are to a large extent, in continuity with some members of them. At the northeastern extremity of Knife lake, the argillaceous porphyrellytes disappear from observation in the direction of the northwest shore of lake Saganaga. Along that shore they are re-discovered. In the regions last mentioned, the argillaceous porphyrellytes exhibit characters exceedingly similar to the schists seen north of Gunflint lake and traced still farther east. We seem to discover therefore, an unbroken continuity between the western schists and the eastern. The Ogishke conglomerate lies between the two; and in making their connection they seem to pass through the area of the Ogishke conglomerate On structural as well as lithological grounds, the conglomerate seems to belong to the Kewatin series.

As to its position in the Kewatin series we have some facts to aid the formation of a judgment. The conglomerate is succeeded northward from Ogishke-muncie and Kekequabic lakes, by vertical schists in the following order: 1st. Dark argillytes (Pickle, Plum and Knife lakes); 2d. Graywackes (IVth Arm Knife lake), porphyrellytes (IVth Arm Knife lake) and porodytes and Stuntz conglomerate (IVth Arm, southern bifurcation); 3d. Porphyrellytes (IVth Arm, northern bifurcation, and thence across the main body of the lake into Canada). There is some appearance of a reversal of the order of succession in the recurrence of a broad belt of porphyrellytes; but neglecting that question, the occurrence of porodyte and Stuntz conglomerate on the north indicates a high stratigraphic position for the conglomerate; since porodyte, in the vicinity of Vermilion lake, holds place near the base of the Kewatin series. Moreover, porphyrellyte, passing downward into porphyrel, is found at Gunflint lake, to stand in close relations with the crystalline schists.

Again, it has been shown (Fifteenth Rep., p. 165) that on the southern border of the conglomerate area, the prevailing dip of the beds is northward at an angle of 50°; while it is shown in this report (p. 322) that at the southern point of Epsilon lake—just north of the limits of the conglomerate, the argillyte has a southward dip of 75°. These indications, so far as they go, place the Ogishke conglomerate in a synclinal basin, at the top of the Kewatin series.

It will be remembered that reasons exist for concluding that the Kewatin series bifurcates in this vicinity, one branch passing to the north and the other to the south of the Saganaga granite. Thus a triangular space exists between the diverging branches on two sides and the (apparently) obtuse termination of the granitic mass on the west. It is not clear how these relations would help to an understanding of the geological history of the conglomerate. If, however, the superposition of the conglomerate is correctly induced, there must have existed at one time, a sea or bay of limited extent, in which coarse pebbles from rapidly crumbling shores were copiously accumulated. As probably the uplift of the granitic mass has taken place since that time, and the schists thus thrown into their disturbed positions, the configurations now apparent would convey no conception of the relations of land and water during the formation of the conglomerate.

A different conclusion in reference to the age of the Ogishke conglomerate may possibly be entertained. That view identifies it with the Animike series; and I postpone the consideration of it until that series shall have been sketched.

It is not to be supposed that the small area of Ogishke conglomerate above described is the only conglomeritic product of that epoch. It is worthy of inquiry whether the wide-spread pebbles of the Saganaga granite, and which culminate in abundance on Wonder island in Saganaga lake, and on the west of Seagull lake, may not have been derived from the same sources of supply. It is true the pebbles in the granite are much less diversified in character, and approach generally the nature of greenstones. But it has been shown that the pebbles of the conglomerate approach a similar condition in situations where thermal agencies have acted most efficiently. As in the gneisses, such agencies have been far more transforming than in any terrane retaining some portion of its original sedimentary arrangements, the difference in the nature of the pebbles in the two formations is not sufficient ground for denying their community of origin. It is also true that in regions further south, bowlders closely resembling the indurated portions of the Ogishke conglomerate are of frequent occurrence. The relation between this conglomerate and those described by Sir William Logan, and ascribed to the Huronian, cannot be here considered. I will only express my present conviction that the Ogishke conglomerate may be identified with that occurring at the mouth of the Doré river, near Gros Cap, lake Superior;* but seems a different one from the "slate conglomerate" of the valley of the Thessalon river north of lake Huron.†

The *Stuntz conglomerate*, as above indicated, is not to be confounded with the Ogishke conglomerate. It holds a lower stratigraphical position, is generally more obscure in its characters, and has a matrix possessing less a slaty than a porodytic character. Its lateral development is also inconsiderable. Its name is derived from Stuntz bay of Vermilion lake, in the vicinity of which the formation is most clearly exposed; but I have also identified it on the south shore of Knife lake. At some points about Vermilion lake it appears as an ordinary conglomerate, with pebbles quite foreign to the matrix in which they are imbedded; but in other situations, the matrix assumes a diabasic appearance, and the pebbles are but imperfectly differentiated from it. This feature is analogous to conditions found in the Ogishke conglomerate. It is the latter condition only which occurs on Knife lake.

As only a small development of this formation has fallen within the field of my own observations, I have no occasion to make further mention of it.

(6) Relation of the crystalline and Kewatin schists. The Kewatin schists above described pass downward somewhat abruptly into the crystalline schists of the "Vermilion group." In stratigraphic relations the two series are everywhere perfectly conformable. The possibility is recognized, however, of an original unconformity which has been destroyed by violent lateral pressure after upheaval. Yet, I think such original unconformity improbable in this case. Nevertheless, a geologic break must be recognized in the interval between them. The conditions under which the upper and more earthy have

* *Geology of Canada*, 1863, pp. 52 and 53.

† In this I differ for the time being from my brother (*American Geologist*, 1, p. 14). But final studies will probably bring us into harmony.

resulted are thoroughly different from those under which an entire group of rocks underlying has been crystallized and foliated. There is no historic continuity between them. They belong to different ages.

Mineralogically, the relations of the two series possess much interest. In spite of the inferential break between them, the metamorphic agencies which have given exclusive character to the lower seem to have encroached slightly upon the older beds of the higher. In repeated instances I have noted a gradual passage from graywacke to fine mica- or hornblende schist. But a more striking observation is the passage of porphyrellyte to gneiss, as already described. The process shows how, in some cases, the interposition of crystalline schists between the Kewatin schists and the gneiss has been prevented. It also serves to establish an affiliation between schists admittedly sedimentary in origin and schists sometimes relegated to the category of eruptive rocks.

(7) Are any of the chloritic or sericitic schists of the Kewatin eruptive? I have stated that the fully developed chlorite schist, known to our Survey as Kawasachong rock, presents some characters which suggest an eruptive origin. It has a rather remote resemblance to some old decayed diabases in which a rudely bedded structure has been imparted by pressure and cleavage. In some cases it seems to present the condition of an obscure dike, conformable with the bedding of the country rock; but generally, it would be regarded rather as a vast overflow. The deficiency of siliceous matter favors the same view

The following facts of observation may be mentioned as opposed to this view. The "Kawasachong rock" appears to be absolutely continuous with schists which are simply chloritic and admittedly of sedimentary character. These are continuous with schists described as "chloritic-sericitic" or "chloritic-argillitic." It has the same vertical bedding, though obscured, and this conforms with that of the adjacent schists. These chloritic rocks then, are all one mass, and of one origin. Again, if the Kawasachong rock were an eruption, it should disclose somewhere, unmistakable lines of limitation. Instead of this it always fades into the contiguous schist, and loses its proper characters, without the possibility of fixing its bounds These limitations are wanting equally in a vertical and a horizontal direction. And lastly, in addition to being incorporated as a constituent in a system of schists, its volume is too vast, and too widely distributed to permit the probability of its eruptive character.

Similar statements may be made *pro* and *con*, respecting the origin of the sericitic schists, or any portion of them. The discovery of bedding as a result of pressure and motion—even bedding in many eruptive masses, should not lead to the following of a fashion which ignores the obvious and primary significance of the bedded arrangement in rocks.

4. *The Animike series.*—The term Animike is introduced into Minnesota geology, from its use by Dr. T. S. Hunt as the designation of a remarkable series of schists occurring on the west shore of Thunder bay of lake Superior.* Their identity with the typical Huronian rocks found north of lake Huron, was detected by professor R. D. Irving, and is fully established by personal studies made by my brother and myself in 1887.†

(1) Distribution. The Animike rocks stretch from Thunder bay southwestward as far as Duluth, and still beyond to the Mississippi river. The lake-shore belt however, from Grand Portage, for an average width of about twenty miles, is occupied by rocks of the Kewenian or copper bearing series—including portions of the lake Superior sand-stone. I have studied them along the international boundary from Grand Portage to Gunflint lake, from which they continue westward for at least four or five miles, and possibly to the vicinity of Ogishke-muncie lake. There is reason to suppose that some of the black slates as far west and north as Knife lake belong to this series.

At Gunflint lake and eastward, the formation assumes a striking character, and contributes to a peculiar physiognomy. The surface presents a series of ridges or ranges approximately parallel, but much broken in their continuity east and west. The ridges have the appearance of a succession of monoclinals dipping southward. The basal portions of the ridges consist of strata of the Animike series, dipping gently southward, and presenting on the south an easy declivity, while the north is precipitous and exposes the edges of the strata. The summits are crowned with gabbro. The numerous lakes occupy the depressions between, so that the southern shore of each lake presents a frowning precipice while the northern shore is low, but often gabbro-covered, with the surface gently rising northward. It is nat-

*Hunt, *Trans. Amer. Inst of Mining Engineers*, vol. i, p. 339. Full descriptions of the formation may be found in Logan's *Geology of Canada*, 1863, pp. 66-70; and more extended in Irving's *Copper-bearing Rocks of Lake Superior*, in monographs of the United States Geological Survey, vol. v, pp. 367-386. Also, Third Annual Report U. S. Geol. Surv., pp. 157-163. Consult also, Bell, in Geological Survey of Canada. Report for 1866-69, pp. 318-19, and Report 1872-73, pp. 92-3.

†N. H. Winchell "*On the Original Huronian,*" American Geologist, I., pp. 11-14, Jan. 1888

Prof. Irving went further, and identified with the Huronian, the iron-bearing rocks of Marquette, Menominee, Gogebic and Vermilion lake.

ural to conjecture that the region has been cut by a system of east-west faults; but this conjecture is not yet confirmed. It is possible that these long basins are the result of extensive erosion, and that the surface had been worn nearly to its present aspect before the gabbro overspread it.

(2) General lithological characters. The Animike formation, throughout its extent from Thunder bay to Gunflint lake, and for at least two miles beyond, lies nearly in a horizontal position, having a dip of five to fifteen degrees toward the south-southeast. With great uniformity, the beds lie evenly and without distortion, bending or undulation. An exception to this is found in Black Fly bay, near the western end of Gunflint lake where the siliceous and magnetitic layers are contorted in a striking manner. A similar condition of the formation was seen on the north side of the lake. In this vicinity, it sometimes assumes the state of a breccia (Fig. 38). The dips of the strata in this vicinity are somewhat irregular (See p. 251).

Lithologically the formation is essentially argillitic. At a majority of exposures near the water-level it is a soft, smooth-laminated, dark or even black, slaty argillyte. In places it crumbles, and on weathering it turns brown and sometimes rusty. Wherever the elevated cliffs have been examined, the prevailing character of the rock is dark, laminated argillyte, presenting a face nearly perpendicular, with a talus at the base equal in hight to the slaty precipice. Much of the argillyte however, is siliceous, and this condition is commonest in the higher portion of the cliff. All degrees of silicification occur, even while the thin lamination is retained. In the extreme state the silica replaces most of the other matter, and the rock becomes a siliceous schist. Seldom, however, does extreme silicification pervade uninterruptedly a vertical thickness exceeding two to four inches. A siliceous layer of this kind is apt to be succeeded by one or more layers of dark argillyte. Above these, other siliceous layers may follow, and other argillitic ones. The siliceous beds extend horizontally for distances of some rods, but generally, with very variable thickness. Examined more carefully, the siliceous beds are found to be sometimes homogeneous and almost glassy quartz; more frequently less pure, and traversed by fine lines or bands. The material is sometimes a proper flint stained smoky or gray. Sometimes it is a beautiful red or black jasper. These jaspery and flinty bands broken up along the shore, have given origin to large quantities of beautiful colored and banded pebbles accumulated at certain points. The most accessible exposures of the siliceous—especially the jaspery, bands, are found on the north shore, though most of the pebbles are accumulated on the east and southeast shores. The brecciated and contorted conditions of the formation involve the portion with siliceous bands.

(3) The magnetitic beds. Embraced in the Animike slates are beds charged with magnetite, hæmatite and siderite. These also hold position in the higher parts of the cliffs along the south shores of the lakes; and frequently the richest impregnation is in close proximity to the overlying gabbro. On the north and west sides of Gunflint lake, magnetitic beds lie near the water-level, and for some miles west of the lake they are quite extensively exposed or accessible. The principal beds are two to four feet in thickness. In the richest condition the magnetite attains a high percentage of the whole mass, and is black, coarse-granular, and metallic in lustre. But from this condition the percentage of iron graduates down to a quantity barely perceptible. These fluctuations in richness exist both in a vertical and a horizontal sense. The magnetitic beds on the north and west shores are generally uncovered; but on the north shore of the Animike bay, near the west end, a heavy gabbro deposit is found above the Animike at an elevation of about twenty to thirty feet. The same relation to the gabbro deposit obtains along the south shore of this and other lakes at levels ten times as high. The indication from these facts is that the iron holds place in the upper part of the formation, but apparently, not at the top in all cases. The difference of topographic level on opposite sides, also indicates an uplift along the south side, and a fault along the axis of the lake, as before suggested. The stratigraphic position of the magnetitic beds is also indicated by their position near the surface of the formation at the test-pits two miles west of the head of Animike bay. The subject is considered with full details, on pp. 267,268, illustrated by figures 48 and 49. The magnetite has by some writers been located in the lower part of the Animike; and on the theory of the formation of the lake-basin by erosion, the position of the magnetitic beds along the north shores, would give color to such an opinion.

The siliceous and magnetitic beds being both located in the upper part of the formation—at least in the same part of it—the two characterizing constituents are often found in the same stratum. But besides the frequent silicification of the formation in proximity to the overlying gabbro, it is quite frequently found changed in such a manner as to simulate the aspect of the gabbro. After studying, inch by inch, the petrographic condition of the slate, from a point five feet below the gabbro up to actual contact, I find sometimes a progressive assimilation to the gabbro, so that the actual plane of contact would be unidentifiable if a similar graduation existed at all neighboring points in the vicinity. The fact is singular that in some cases the black slate preserves its characters little changed quite up to the base of the gabbro. I think it may be stated that the change is greatest where the magnetite is most abundant. In one place where examinations were made, the magnetitic bed was found uncovered at the lake shore, and the gabbro was discovered in the vicinity, at an elevation 30 feet higher, resting on dark slates. These slates were much less altered than in other places of contact with the gabbro. They were also less magnetitic. The indication is that above the main bed of magnetite is a series of slates magnetitic or not. When not so, they have suffered less change than when otherwise.

Some of the ferriferous beds appear to be simply hæmatitic I have surmised that this condition has sometimes resulted (as it certainly has in some gabbros) from a change of the magnetite. Equally probable is the production of hæmatitic beds from an original sideritic condition. Such condition is conjectured as present in many cases, but opportunity has not as yet been afforded for settling the question.

A terrane of an obscure character remains to be mentioned. This is known to the Minnesota Survey as "muscovado," and sometimes also to the writer, as "gabbroloid." It is composed, as far as field studies enable me to judge, of a fine granular mass of feldspar and quartz in an almost impalpable groundmass of the same materials mingled with aluminous matter. It often contains fine scales of biotite, grains of olivine and specks of carbonaceous or anthracitic matter. It has, therefore, some relation to graywacke. On the southern shore of lake Gabimichigama, it does not reveal any bedded structure (XV Rep., pp. 70-1,) but rests on the obscure vertical edges of a graywackenitic terrane. On an island in the eastern part of the lake, muscovado fragments overflowed by gabbro are seen to have a stratified structure (XV Rep., p. 171). It is probably the same rock which was seen on an island in Illusion lake (XV Rep., p. 145). On the north shore of Iron lake (this Report, p. 305), "muscovado" occurs which contains much glassy feldspar and has been reported a quartzyte. Its position here is beneath a mass of magnetitic gabbro, and its structure is obscurely bedded. It occurs also on the north shore of Animike bay, under a feeble development, and here appears to lie beneath the magnetitic bed of the Animike. Finally, at the iron location two miles west of Gunflint lake, a couple of beds aggregating eight feet in thickness, and approaching "muscovado" in character, are seen immediately beneath the magnetitic bed. It is not seen at the test-pit. because its position is lower than the lowest bed exposed in the pit, as shown in Figure 49.

It appears, therefore, that this terrane is a member of the Animike. If it is properly identified at Gabimichigama lake, the inference is, that the thin border of the Animike reaches as far north as that point; and that further exposures of Animike ought to be found by exploring further south—for instance, on the shores of Little Saganaga. It will be noticed, however, that the muscovado of Gabimichigama *retains its characteristic horizontal position, and that a vertically bedded terrane underlies it.*

There is indication that the very highest beds of the Animike are simple argillytes with little magnetite or none; and that the absence of the magnetite explains the comparatively unaltered condition of the slate where the gabbro rests upon it. These beds, however, do not appear to be over twenty or thirty feet thick.

Nothing can be stated with definiteness respecting the total thickness of the Animike series in Minnesota. The maximum thickness observed in one place is in the cliffs of Rove lake and of North and South Fowl lakes. Mount Reunion of Rove lake exposes a bluff of slates to the hight of about 100 feet above the lake. The lower 50 feet however, are concealed by a talus. At the outlet of South Fowl lake is a hill which I calculated to be 288 feet high. As about two-fifths of the altitude is gabbro, the thickness of the underlying Animike is about 175 feet, if it extends to the water-level.

Probably it extends much lower. The distance from this point in a straight line to Partridge falls is 6.7 miles. The direction of Pigeon river between the two points is about southeast, and the whole descent may be estimated at 100 feet. The dip of the Animike slates is about 8° toward S. 10° E. The distance between South Fowl lake and Partridge falls corresponds to a distance of 5½ miles across the strike of the schists; and this distance, with dip assumed, corresponds to a vertical thickness of 4,032 feet. If to this we add the hight of the schists at South Fowl lake, we should get 4,200 feet as the apparent thickness of the Animike between the two points assumed. This would not be the total thickness, since it is known to continue still farther in the direction of the dip.

From the lithologic details given, as well as from the slight inclination of the formation, it becomes very apparent that the Animike of Minnesota is the equivalent of the "slate conglomerate" of the typical

Huronian of Canada, as described in the earlier pages of this report. Another determination of even greater importance is afforded by the facts to which I now proceed to refer.

(4) Unconformities of the Animike. Professor Irving of the United States geological survey, had ranged under Huronian not only the Animike slates of Minnesota and other regions, but also the slates holding the vast hæmatite deposits of Vermilion lake and other districts in the lake Superior basin. But it has been my good fortune to make observations which demonstrate that the Animike and Kewatin rocks belong to different geological systems. A brief announcement of observations made in August, 1887, was published in October,* and some additional details in December last.† Fuller details are embodied in § 12 of this report. It is therefore only necessary in this place to summarize the facts to which I refer. With professor Irving it was a problem not satisfactorily resolved, to reconcile the horizontal position of the Animike slates of Gunflint lake and Thunder bay with the vertical position of the schists called in this report Kewatin, on the supposition which he made, that the horizontal and vertical slates are identical, and both Huronian. With this problem before my mind, I sought diligently for the continuous passage of the horizontal schists of the east into the vertical schists of the west. The vertical schists were lost, going eastward, on the southeast side of Seagull lake. The horizontal (Animike) schists were found seven miles further east, at the western extremity of Gunflint lake. I was preparing to undertake the arduous task of exploring the intervening region, when fortunately, I rediscovered the vertical schists on the north shore of Gunflint lake. The Animike beds had been seen on the east and on the west of this point. I therefore studied, foot by foot, the region separating these vertical schists from the Animike on the east, and traced the two, unchanged in attitude, to within seven feet of actual contact. They were there as contrasted in petrographic characters as in stratigraphic position. The one was *not* continuous with the other They were not only two different formations; they were *two systems*. The reader will turn to the earlier part of this report for the details of facts. The vertical schists were subsequently found in this vicinity under a great development,‡ but reaching the shore of the lake only for a limited distance.

* *Amer. Jour. Sci.*, III, vol. xxxiv p. 314.

† *Unconformities of the Animike in Minnesota*, American Geologist, pp. 14-21, Jan. 1888.

‡ Later, I noticed that these schists had been mentioned by my brother as early as 1880, in the *Ninth Annual Report, Geology of Minnesota*, p. 82; and he then pronounced them "another and distinct formation from the slates at Grand Portage." They were apparently referred to again in the *Tenth Report*, 1881, p. 88.

In the last elaborate paper published by professor Irving, he gives a figure* quite similar to my figure 44, but he falls into an error in the interpretation of the facts. Regarding the flat-lying Animike as identical with the iron-bearing formation of Vermilion lake, he thinks the vertical schists shown in the figure to belong wholly to the crystalline series. They *are* the crystalline series at the right of the figure; but at the left they graduate, as at Vermilion lake, into the entirely conformable, hæmatitic, Kewatin series. Thus the Animike slates are truly unconformable with the hæmatitic schists. There is another difficulty in professor Irving's interpretation. On his view, the iron-bearing series is abruptly unconformable with the older crystalline schists. The fact is, that every observation made in Minnesota, bearing on the relations of the two, shows the Kewatin iron-bearing schists completely *conformable* with the crystalline schists. This objection can hardly be disposed of.

But the unconformity of the Animike with the Kewatin schists does not depend for proof on a single illustration. On the north side of Epsilon lake, T. 65-6, the two formations are found again in contact. The unconformity is disguised by a common system of vertical cleavage planes running through them; but by careful search I succeeded in finding the sedimentary ribboning of the Kewatin slates coincident with the cleavage, while the conspicuous ribboning of the Animike slates made a large angle with the cleavage. These facts are illustrated in figure 59 of this report.

After leaving the field I received information of another stratigraphic unconformity in the far east, in sec. 1, T. 64-3E. While this report is in press, I learn of still another, far to the southwest. Mr. H. V. Winchell writes, under date of Aug. 5, 1888: "Horizontal, black Animike quartzyte containing iron ore, lying (unconformably) on the vertically bedded Kewatin, which strikes N. 80° E. is found in sec. 11, T. 59-14W. The Animike is found nearly at the top of the Giant's range," This locality is about fifteen miles south of Tower.

The superposition of the (supposed *upper* beds of the) Animike slates on the flanks of the Saganaga gneiss has been described in this report, and illustrated in figures 48 and 49. It seems probable that many of the depressions in the old eroded surface of the Kewatin, in the region from Gunflint lake to Knife and Sucker lakes, were filled with the sediments of the Animike. Subsequently the whole region, and both systems of strata have been subjected to the common action

* In the second part of a memoir published in the *Amer. Jour. Sci.*, III, vol. xxxiv, p. 261 fig. 9.

which has imparted to both that wonderfully persistent and uniform vertical schistosity which is so striking a feature.

I have heretofore recorded my impression that certain black argillytes found in the vicinity of Negaunee, Michigan, as well as similar argillytes seen in the Gogebic range, are probably members of the Animike. It seems probable also, that the black fine-grained slates and interlaminated siliceous beds of Carp river, in the Upper Peninsula of Michigan, may sustain the same relations. A similar judgment may be passed on the slates of l'Anse and Huron bay—the lighter colored of l'Anse creek constituting an upper division. the banded slates alternating with compact siliceous beds partly light and partly dark constituting a middle division, and the roofing slates, a lower division. It is worthy of inquiry also whether the dark slates described by Houghton, in the interior, southeast from the Porcupine Mountains and the Montreal river, may not also be equivalents of the Animike. Some of the quartzytes and argillytes of the Menominee river, were referred by Houghton and Emmons, as the latter states, to the Taconic; but it is not unlikely that they represent the Animike.*

(5) Must the Ogishke conglomerate be assigned to the Animike? I have already, in speaking of the Kewatin series, given reasons for thinking the Ogishke conglomerate should be included in it. There are also reasons for suspecting it to be a part of the Animike. The dark colored argillytes into which we trace the beds of the conglomerate by strict continuity, bear strong resemblance to the slates of Gunflint lake. If we pass northward from Kekequabic, across the strike of the region, we come upon the Knife lake siliceous argillytes, which resemble the more characteristic siliceous argillytes of the Animike. These slates are also locally ferruginous, and the jaspilitic banded example illustrated in figure 20, is supposed to have been derived from the Knife lake slates—though this is only a conjecture. This example bears a striking resemblance to the jaspery schists on the north shore of Gunflint lake. A similar loose piece, less contorted, was seen between Epsilon and Kekequabic lakes. This is illustrated in figure 60. The presumption is that this was derived from Animike. Kewatin slates are near on the north, but they are argillaceous and porphyrellitic.

Again, the slates involved in the Ogishke conglomerate appear to lose their steady verticality in the region of Agamok, and the north shore of Gabimichigama. It is possible that this is the region of pass-

* This in fact, has already been suggested by Irving and by Hunt.

age from the flat-lying schists of Gunflint lake to the vertical schists of Knife lake.

In addition, it may be mentioned that the peculiar rock known in our survey as muscovado, is found on the southern shore of lake Gabimichigama (where sometimes it is micaceous), and something similar on an island in Illusion lake (XV Rep., p. 145). In these regions, the vertical Kewatin has not been certainly identified. On the other hand, muscovado of similar character is found at several points already mentioned, and at some of them it appears to be an upper bed of the Animike. I have already recorded my readiness to admit that it represents the Animike on lake Gabimichigama.

The objections to these views which present themselves to my mind are as follows: 1. The evidence already cited, that the Ogishke slates and conglomerates are embodied conformably in the great mass of the Kewatin series. 2. The fact that the Kewatin series in the region of Vermilion lake includes conspicuous siliceous and jaspilitic, as well as ferruginous, layers. These are fully described and illustrated in the fifteenth annual report. 3. If the Ogishke slates are a part of the Animike, they carry with them the vast series of slates on the north, into which they pass by transitions and intercalations which proclaim a historic continuity. But most of these northern schists would not be claimed for the Animike. In fact, the northern porphyrellytes are not distinguishable from the porphyrellytes of Gunflint lake, which lie discordantly beneath the Animike. 4. If the Animike slates change, in the neighborhood of Ogishke-muncie lake, from a gently inclined, to a vertical position, it is inexplicable that in Epsilon lake, two miles northwest of Ogishke-muncie, the Animike slates should be found again with an inclination in the same direction as they show at every other point in Minnesota. 5. Even if the thin edge of the Animike reaches as far as Gabimichigama, it will be observed that it appears to lie in a horizontal position upon the obscure edges of an older series, which probably represents the Kewatin. Its presence, therefore, would not help to the identification of the Ogishke conglomerate with the Animike.

5. *Eruptive rocks.* On this subject I am not prepared to offer many generalizations. I wish to exclude from this connection most of the granitoid and gneissoid rocks, as well as the crystalline schists, and the chloritic and sericitic schists. It is very evident that heat has played a most important part in the geologic history of the region, but in conceding the enormous influence of thermal agencies, I feel constrained to assume a somewhat conservative position.

(1) The great gabbro flood. I agree fully with American geologists in assigning a primitive molten condition to the sheet of gabbro which covers so many hundreds of square miles in the northwest. But its wide extent, considered as a molten flood, is a fact which excites amazement. My own observations have traced it over an area of twenty townships, or 720 square miles. In the surveyed and platted portion of Minnesota, west of the Grand Portage Reservation, it is reported as covering an area of thirty-two townships, or 1,152 square miles. There are about seven townships more in which the surface is occupied by more recent eruptives, which, in all probability, overlie a sheet of gabbro; giving us a total of thirty-nine townships, or 1,400 square miles, once, in the history of the state, covered by a glowing flood of molten rock.

The upper surface of the gabbro sheet lies at the present time at elevations very different at different points. While we must conclude that the surface over which it poured had already undergone vast erosions at the epoch of the gabbro outburst, it becomes, to my mind, more and more probable that great upheavals of the earth's crust have been suffered since the epoch of the outburst. I incline to think this the explanation of the saw-teeth configuration of the vertical section from north to south. There must have been, then, an action analogous to that which produced the famous "monoclinals" in the geology of the plateau region of the continental interior. At what epoch since the gabbro outflow the disturbance took place, I know no means of determining. It may have been geologically late. In considering the erosive retrocession of some of the cliffs, I have been impressed with the incompleteness of the work which has been begun, and apparently only begun. I am prepared to believe that the dislocations of the country do not antedate the continental glaciation.

In their physiognomy, the gabbro masses present a rude resemblance to basalt. Though the columnar structure is exceedingly incomplete, it becomes a conspicuous feature under the influence of perspective. Distance smooths and completes the rude and ill defined figures which rise like a colonnade from the cornices of the lofty structures reared by hundreds of regular horizontal courses of stone-work. From lake to lake, from ridge to ridge, these mimic forms succeed with such uniformity and impressiveness, that even the geologist begins to fancy himself wandering among the ruins of some desolated ancient city.

Scarcely any other structure is discernible in the gabbro mass. At times indications appear of the existence of imbricating layers having a gentle dip, as if the fluid rock had swept over the country in successive tides. For the greater part, the rock is massive in aspect except along the faces of the crowning cliffs. This is particularly the case with the occurrences along the northern shores of the lakes. Except, when weathered, the gabbro is solid and tough; but in some regions, as around Ima and Frazer lakes, entire exposures lie in a rusted and crumbling condition. A similar condition is seen in the high cliffs at the west end of Loon lake

In texture the gabbro is characteristically coarse. Sometimes some of the constituent minerals are half an inch in diameter. From this they graduate down to an extreme degree of fineness, so that it becomes impossible to decide macroscopically whether the rock is a gabbro, a noryte, a diabase, or only an altered condition of a contiguous formation.

No thorough examination has been made by me of its mineral constitution. Macroscopically, there is generally no difficulty in determining the presence of dark labradorite, lamellar augite and magnetite. In some regions olivine is not only conspicuously present, but forms a large percentage of the mass. The most noteworthy instance of this kind is in a knob on the north side of Pigeon river, rock 768-9, a few miles west of the Grand Portage. In some regions, a reddish feldspar is present, and this often occurs in crystalline grains, giving the formation a porphyritic character. This condition prevails along the north side of Loon lake. At the western end of this lake, the reddish feldspar weathers white, and the high cliffs present a brilliant appearance in the sunlight. In this vicinity much of the iron in the gabbro has undergone peroxidation, and the surfaces of cliffs have a rusted appearance, suggesting the approach to a mine of hæmatite. Red feldspar in smaller grains is met with along the north side of Animike bay of Gunflint lake, and several other points.

• Magnetite is a constituent universally present. It generally exists in separable grains or crystalline forms. Sometimes however, it increases in abundance, and becomes a sort of cellular, hard, black groundmass. Still again, it usurps almost completely the place of the other minerals, and the gabbro becomes essentially a solid, black mass of magnetite. It is seen in this condition at one or two points on the north side of Iron or Mayhew lake, and is said to occur similarly on Pewabic and Tucker lakes. This magnetite, however, is shown by chemical analysis to be highly titaniferous. For further particulars, the reader may refer to § 27.

There is little probability that the flood of gabbro escaped through a single fissure. At several points it has been seen forming dikes.

At Partridge falls, on Pigeon river, a dike of gabbro appears to be connected with the gabbro overflow.

(2) Diabase, noryte and porphyry. Proper eruptive porphyry is found at several places. The most extensive as well as the most characteristic occurrence observed by me is found south of the western end of Epsilon lake. It appears first near the point of the lake, in alternation with a noryte-looking eruptive, but is traced southward a distance of half a mile, where it rises in a knob about 200 feet above the lake, which I named Grant's peak. It overlooks Kekequabic and several other lakes, and is a mile east by north from Mallman's peak. The porphyry where first observed, has a purplish groundmass, and contains green lamellar crystals. Near this, the lamellar crystals become fewer, and the base is replete with green amygdules which, farther on, constitute temporarily most of the formation, but still with some whitish groundmass. In this vicinity, flowage lines are very apparent. The great mass forming the peak is a purplish amygdaloidal porphyry. The porphyritic eruption appears to exist in other smaller knobs rising in the vicinity.

Near the south end of Moose lake (the one in T. 64-9W) rises a bold precipitous knob of erupted matter, consisting of rather coarse crystals and fragments of labradorite and augite without magnetite or olivine. This I have provisionally recorded as noryte. The gabbro already described in places appears destitute of magnetite, and seems to approach the condition of noryte. It is finer than the well developed gabbro, and holds a place near the bottom of the gabbro mass. For the latter reason it might be presumed that magnetite is present in small quantity, and that the rock is merely a variety of gabbro.

The dikes of the country are almost universally of diabase, if one may decide on macroscopic inspection. But they present an endless diversity of conditions. They are rather fine-grained, and sometimes almost aphanitic. Generally they occupy fissures with definite walls. The contiguous rock is sometimes greatly altered in the usual way but many times the alteration, even in argillyte, is very slight. The attitude of the dikes is almost always nearly vertical; but I saw one on the IVth Arm of Knife lake (rocks 947-52) dipping 30° N. N. E I have not discovered any system in the direction of trend. Occasionally, a dike has seemed to be of a dioritic character. This I noticed most particularly on some of the islands in Burntside lake (XV Rep. p 44).

The petrographic investigation of the eruptive rocks of my field is an important work, mostly remaining to be done.

6.—*Vein rocks.* Most of the rocks which I am led to class as veins appear to me to have had a non-eruptive origin. The majority of them are granulitic in mineral nature, consisting of quartz and orthoclase. Often one or the other is deficient in quantity. Frequently a small percentage of mica is present; and sometimes the vein consists of good granite. Veins of this class are apt to be tortuous, and some of them are surprisingly so. They seldom exceed four inches in diameter, and generally are less. They abound in the vicinity of the passage of gneiss into the crystalline schists. They do not maintain a uniform width for any considerable distance, like the dikes, but rapidly diminish and disappear. Unlike the dikes they exhibit many ramifications. In some cases, these are so numerous as to give the formation a reticulated structure. Many veins are filled with pure white quartz. The larger ones, which attain a breadth of over two feet, pursue somewhat persistent courses, but they are not much inclined to branch. Sometimes quartz veins of slender diameter are seen intersecting beds of schist in many directions in a reticulating fashion; and sometimes I have traced a transition from an earthy schist to a granulitic or quartzitic rock effected simply through the excessive abundance of small interlacing quartz veins. Compare XV Rep., p. 136.

Within my observations, veins of quartz carry few metallic compounds except pyrites. In several cases, this mineral has been explored, and even mined, in the belief that silver or gold would be found associated; but all such enterprises are now abandoned. Active work however, is carried on in T. 64-3E., upon a quartz vein said to carry silver, and believed to have been worked by a prehistoric race. See further, § 21 of this report.

§ 36.—SYSTEMATIC RESULTS OF THESE ARCHÆAN FIELD-STUDIES.

1. *Horizons of geologic discontinuity.* The most recent formation embraced in the field which I have investigated is that above designated the Animike series. This beyond question, represents the characteristic portion of the Huronian, as defined by the Canadian geologists from the typical region north of lake Huron.* With equal

* Undoubtedly, I think, the Canadian geologists also named as Huronian, rocks in other regions of very different character, and holding a different position in the general series. The only circumstance justifying the identification, apparently, was their superposition on beds of a crystalline character. I have maintained that the beds normally subjacent to the typical Huronian are simply deficient, north of lake Huron, but make their appearance upon the shores of lake Superior, where they were mistakenly parallelized with the Huronian of lake Huron. Precisely the same approximation of the Animike and gneiss exists at the west end of Gunflint lake, and continues westward along the south flank of the Giant's range. The phenomena here and in Canada are explained by the supposition of a progressive subsidence of the granitic regions during the deposition of the Animike

certainty, the Animike does *not* rest directly on crystalline schists and gneisses. It rests on another, older-looking series of schists, standing vertically, and presenting an enormous unconformability; this shows the occurrence of events in the interval between the two series, of such transforming and revolutionary character as are generally held to separate two geologic ages and two systems of strata. The petrographic contrasts of the two series have the same significance. The economic products are similarly contrasted. The Animike series embraces great beds of magnetite; the older series, great beds of hæmatite and limonite. The members of the Animike series are all conformable in stratification, and appear to belong to one age, with its varying conditions of sedimentary accumulation.

If the older looking schists below are systemically detached from the Animike by a mechanical break, they are not less certainly detached from the still older crystalline and foliated beds by a mineralogical break which expresses a profound change in the conditions of chemical activity, and thus implies a break in the tenor of geologic history, which must have been also of a revolutionary character. It appears necessary to isolate the hæmatite-bearing beds from the crystalline schists as well as from the Animike. Thus is a stratigraphic system disengaged and delimited with the distinctness and certainty, which we must for convenience designate by a name. The term Kewatin, which I have provisionally employed, was not proposed in a sense so restricted, but embraced, with newer strata, the entire series of crystalline schists. It is probable that some one of the numerous names proposed by geologists for supposed divisions of Archæan or Eozoic rocks, may prove to have the same extension as is here given to the system immediately subjacent to the Animike or Huronian. It is quite possible also, that an older term will be found, covering the range of strata embraced in the actual and original Huronian. In this connection, I will not attempt to decide, but employ provisionally the term Huronian now so well understood. For the subjacent system I will employ also provisionally, the term *Marquettian*; but, if another name proves hereafter to be equivalent, I hope the term here suggested will never be cited as a synonym; for of synonyms the excess is already burdensome. As to the known rocks older than the Marquettian, they are united in one division by their common crystalline character, and by their structural conformity. That real unbedded granites and syenites exist I have no reason to doubt, but they are not embraced in the field here reported on. Even when found, I should feel led to connect them in geological history with the gneisses, and embrace them in the same system. For this lowest and crystalline system the term Laurentian has been employed, and I will here use it—also provisionally.

Undoubtedly, in the physical history of the earth's crust, other and older terranes have existed and disappeared—or perhaps even still exist; but they are for the present subjects of merely theoretical study, and of course, have no place in a report on facts of observation.

2. *Succession and subordination of terranes.* These views, presented in their application to Minnesota, are summarized in the following table:

HURONIAN SYSTEM. (Compare §2 of this report). Over 4,082 feet.

Magnetitic Group. 32 feet.

Dark, laminated, shaly argillyte, sometimes magnetitic, 29 feet.

Magnetitic beds, often uppermost, 8 feet. Place of sideritic bed?

Muscovado, uppermost when the two above are wanting, 4 feet.

Siliceous Group. 50 feet.

Siliceous argillytes and siliceous and jaspery schists, 50 feet.

Argillitic Group. 4,000 feet.

Dark, laminated, shaly argillytes, over 4,000 feet in Minnesota.

(Bottom of the system not reached at contacts seen with gneiss and Marquettian).

MARQUETTIAN SYSTEM. 27,500 feet.

Ogishke Group. 10,000 feet, but local. (Perhaps half this).

Ogishke conglomerate, slaty and diabasic. 4,500 feet each side of synclinal.

Ogishke dolomyte, included in the conglomerate. 10 feet.

Conglomerate greenrock. 500 feet each side of synclinal.

Tower Group (Earthy schists). 15,000 feet.

Sericitic and argillitic schists, with beds of hæmatite, 5,000 feet.

(These sometimes changed to chloritic schists).

(They pass eastward into schists prevailingly porphyrellitic).

Stuntz conglomerate, porodyte and porphyrel, 20 feet.

Graywacke Group. 2,500 feet.

Graywacke and hornfels.

Graywacke with indications of fine mica and hornblende ("Nascent mica schists.")

LAURENTIAN SYSTEM. 89,500 feet.

Vermilion Group. Over 1,500 feet.

Crystalline schists—micaceous, hornblendic, dioritic, granulitic.

Gneissic Group. Over 88,000 feet.

Chlorite gneiss. (Not universally developed).

Saganaga, White Iron and Basswood gneisses.

Thus the crystalline schists and gneisses fall entirely within the Laurentian system. There are no Huronian gneisses in Minnesota. We find nothing of "older" and "newer" gneisses. We find no "clay-slates" beneath the horizon of the crystalline schists. But I cannot deny the existence of a different state of things in other regions. To me it seems probable, however, that a comparatively undisturbed region, like northeastern Minnesota, must approach near to a normal exhibit of the real succession of the Archæan rocks.

§ 37. SOME VIEWS ON PRIMITIVE GEOLOGIC HISTORY.

In concluding my report for 1886, I recorded some statements indicating my tendency, on a provisional interpretation of the observations then completed, to ascribe a more important agency to metamorphism, in the history of Archæan rocks, than it had been customary for German students of geognosy and petrography to admit. I have now extended my field studies of rocks of this age over another season; and I confess I have not discovered reasons for renouncing the opinions heretofore shadowed forth. The facts stated and illustrated in my former report still exist; and many more facts of the same tenor have been noted during the season of 1887. While I cannot appropriately enlarge, in this place, upon the bearing of these facts, I desire to emphasize the conviction that nearly all the bedded terranes of northeastern Minnesota have been once marine sediments; and have reached their present conditions through the action of molecular, and to some extent, mechanical forces, in the presence of heat, water and natural re-agents.

As to the eruptive origin of the hæmatites and associated jaspilytes, the evidences of it are so slender that the doctrine would only excite my wonder, if it were not held by a few geologists of good reputation. The difficulties of that view are many, but I must embrace another occasion to set them forth. As to the eruptive nature of certain chloritic and sericitic schists, I have already said enough to give expression to my present dissent. But I wish to be understood as holding the question open for further evidence. The gabbros, norytes, diabases and dolerytes I freely admit to have reached the surface in a state probably molten. The crystalline schists appear to me to have been original sediments which have been partly decomposed and fixed in new combinations while in a semi-plastic state occasioned by heat nd alkaline waters. In the gneisses, the same class of changes appears to me to have been carried further. Even here, the impress of original stratification is retained. I have no reason to doubt, however, that terranes exist in which these changes have proceeded so far as to obliterate all traces of original stratification. Such a result would require the attainment of a condition of semi-fluidity such that pressure—of steam, gases or crustal movements—would readily squeeze the product into fissures through the less softened strata, or into spaces between them. Thus would result the phenomena of granitic veins without the necessity of postulating a deep molten source for any of the older granites.

I repeat the conviction heretofore expressed, that probably none of our granites, viewed as changed sediments, represent the oldest sedimentation on the globe. It is puerile to imagine that the history of the world has not been long enough, and its early epochs revolutionary enough to have transformed and blotted from recognition the earliest deposits of the ocean. More puerile is the fancy that in the widespread areas of granite and gneiss nature has preserved patches of the original fire-formed crust of the planet. Equally inadequate, it seems to me, is the opinion that these granitic patches are cooled outbursts from a molten interior, through a crust either sedimentary or igneous in origin. Such views belong to the infancy of the science, and survive only in conservative minds A present crystalline condition is a fact which bears on the mineralogical relations of a rock, but of itself sheds no light on rock-histories. It testifies to a present fact, not to a past genesis. Of the latter a wider range of evidence must speak. The revelations of the polarized ray are almost a work of magic, but there is danger of over-estimating their significance. Petrographic studies possess too much interest and value to be weighted with the responsibility of sanctioning theories of general geogony which demand the widest possible range of investigation, under the guidance of broad and many-sided intelligence.

Mem.—In connection with the conglomerate at Wonder island, in the Saganaga gneiss, see descriptions of the Obermittweida conglomerate described by various authors, especially by Professors Hughes and Bonney in *Quarterly Journal of the Geological Society* for Feb. 1, 1888, pp. 20-31, and the further citations there given.

APPENDIX I.

CATALOGUE OF ROCKS WITH CORRESPONDING LOCALITIES.

[Localities are given more precisely in the report.]

Rock No.	BRIEF DESCRIPTION.	Report, 1886.	REGION.	Sec.	Town.	Range.
		Page.				
1	Graywacke	19	Vermilion lake	20	62	15
2	Graywacke slate	19	"	20	62	15
3	Graywacke slate, thick	20	"	20	62	15
4	Graywacke slate, thin.	20	"	20	62	15
5	Argillitic graywacke slate	20	"	20	62	15
6	Argillyte	20	"	20	62	15
7	Porphyritically quartzose porodyte	20	"	20	62	15
8	Sericitic schist	22	"	21	62	15
9	Sericitic schist w. quartz grains	22	"	21	62	15
10	Quartz veins in graywacke schist	22	"	21	62	15
11	Older system of dikes (so-called)	22	"	21	62	15
12	Later system of dikes (so-called)	22	"	21	62	15
13	Porodyte (so-called).	23	"	21	62	15
14	Poroditic felsyte	23	"	34	62	15
15	Porphyritically quartzose porodyte	23	"	34	62	15
16	Quartzyte (so-called)	23	"	34	62	15
17	Dark augitic sch. w. fels. and q.	23	"	34	62	15
18	Compact graywacke	23	"	3	61	16
19	Graywacke	24	"	3	61	16
20	Felsitic schist	26	"	6	62	14
21	Chloritic sericitic schist	26	Mud creek and lake	5	62	14
22	Sericitic schist with rusty blotches	26	"	5	62	14
23	Graywacke	27	"	5	62	14
24	Quartzose porphyry	27	"	3	62	14
25	Quartz porphyry	27	"	3	62	14
26	Felsyte, bluish, fine compact	27	"	3	62	14
27	Anamesyte-like	27	"	3	62	14
28	Anamesyte-like	27	"	3	62	14
29	Chloritic sch. very irregular	27	"	3	62	14
30	Quartz porphyry	28	"	3	62	14
31	Graywacke, compact	28	"	12	62	14
32	Jaspery hæmatite	28	Sand lake	13	62	14
33	Graywacke, partly chloritic	29	"	14	62	14
34	Graywacke, massive, chloritic	29	"	14	62	14
35	Graywacke, massive, metallic	29	"	14	62	14
36	Black jasper schist..	29	Armstrong river	..	..	..
37	Chloritic schist, dark	29	"	..	..	..
38	Graywacke, epidotic w. heulandite	30	Eagle Nest lake	22	62	14
39	Graywacke, ferruginous	30	"	22	62	14
39*b*	Sericitic schist, compact	30	"	24	62	14
40	Chloritic sericitic schist	30	"	24	62	14

APPENDIX 1.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886.	REGION.	Sec.	Town.	Range
		Page.				
41	Chlorit. ser. sch., compact	30	Eagle Nest lake	26	62	14
42	Chlorit. ser. sch	30	"	25	62	14
43	Ser. sch. jaspery, ferruginous	31	"	36	62	14
44	Ser. or damourite schist	31	"	36	62	14
45	Chlor. ser. sch. with q. and f	31	"	34	62	14
46	Ser. sch., soft portion	31	"	34	62	14
47	Petrosilex and felsyte, bedded	31	"	34	62	14
48	Ser. sch., granular, compact	32	"	34	62	14
49	Quartzitic ser. sch., thick-bed	32	"	34	62	14
50	Chlor. ser. sch. w. pyrites	32	"	34	62	14
51	Ser. sch., thin laminated	32	"	34	62	14
52	Quartz vein, ferruginous	32	"	34	62	14
53	Pyrites in quartz	32	"	34	62	14
54	Epidotic graywacke sch	33	"	27	62	14
55	Epidote crystallizing	33	"	27	62	14
56	Chloritic sch., heavy-bed	34	"	29	62	14
57	Chloritic sch. forming vein	34	"	29	62	14
58	Labradorite? chiefly	35	"	19	62	14
59	Ferruginous jasper	35	"	19	62	14
60	Quartz porphyry	35	"	19	62	14
61	Graywacke mica schist	38	Creek to Burntside L	36	63	14
62	Granite vein	38	"	36	63	14
63	Graywacke mica schist	39	Burntside lake	32	63	13
64	Mica sch., fine, compact	39	"	32	63	13
65	Mica schist	39	"	32	63	13
66	Mica schist	39	"	32	63	13
67	Argillitic mica schist	39	"	29	63	13
68	Mica schist	39	"	21	63	13
69	Hornblende sch., massive	42	"	23	63	13
70	Dike in hornblende sch.	42	"	23	63	13
71	Hydromica granite	43	"	24	63	13
72	Granite	44	"	18	63	12
73	Hornbl. sch. in granite	44	"	18	63	12
74	Dioryte	45	"	13	63	13
75	Dike matter	44	"	18	63	12
76	Compact dioritic sch	52	"	23	63	13
77	Hydromica schist	52	Burntside river	24	63	13
78	Graywacke	52	"	24	63	13
79	Hydromica schist	52	Long lake	30	63	12
80	Fibrous hydrom. sch. in dike	52	"	30	63	12
81	Sericitic sch., greenish	53	"	29	63	12
82	Fine dioryte?	53	"	29	63	12
83	Dioritic schist	53	"	29	63	14
84	Ser. sch. porphyrit, w. h.	4	"	29	63	12
85	Argillyte	54	"	29	63	12
86	Sericitic schist	54	"	29	63	12
87	Chloritic argillyte	54	"	29	63	12
88	Ser sch., smooth, leather colored	55	"	29	63	12
89	Ser. sch., finely mottled	55	"	29	63	12
90	Argillyte	55	"	29	63	12
91	Chloritic graywacke	55	"	28	63	12
92	Argillyte	55	"	23	63	12
93	Graywacke.	68	Head of rapids, Fall R	20	63	11
94	Graywacke	68	Garden lake	20	63	11
95	Graywacke	70	"	28	63	11

APPENDIX I.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886.	REGION.	Sec.	Town.	Range.
		Page.				
96	Chlor. sericitic schist	70	Garden lake	28	63	11
97	Sericitic schist	70	"	28	63	11
98	Sericitic schist	70	"	28	63	11
99	Chloritic graywacke, w. red m	70	"	27	63	11
100	Quartz	70	"Silver City"	29	63	11
101	Sericitic mica schist	71	Garden lake	32	63	11
102	Micaceous hornblende sch	71	"	32	63	11
103	Hornblendic magnetic sch	71	"	32	63	11
103*b*	Nascent mica schist	74	White Iron lake	32	63	11
104	Granulyte vein	74	"	32	63	11
105	Biotite syenite	74	"	32	63	11
106	Syenite w. fragments of h. sch	74	"	32	63	11
107	Syenitic gneiss	75	"	31	63	11
108	Syenite with vein	75	"	31	63	11
109	Syenite, much red orthocl	75	"	31	63	11
110	Muscovite schist	75	"	6	62	11
111	Muscovite schist	75	"	6	62	11
112	Syenite w glassy feldspar	75	"	1	62	12
113	Hornblendic? (augitic?) mic. sch	76	"	12	62	12
114	Augite or chlorite rock	76	"	12	62	12
115	Syenite w. glassy feldspar	76	"	12	62	12
116	Augite rock	76	"	12	62	12
117	Red syenite w. vein of syenite	76	"	25	62	12
118	Syenite gneiss	77	"	12	62	12
119	Muscovit. hornb. sch and syen	77	"	12	62	12
120	Syenite	79	"	6	62	11
121	Biotitic quartz diabase	79	"	6	62	11
122	Biotitic diabase w. orthocl	79	"	6	62	11
123	Biotitic syenite	79	"	6	62	11
124	Felsitic and earthy rock	79	"	6	62	11
125	Felsitic and earthy rock	79	"	6	62	11
126	Micaceous graywacke schist	80	"	32	62	11
127	Felsitic hornblendic sch	72	Garden lake	20	63	11
128	Sericitic siliceous schist	72	"	20	63	11
129	Mica schist	73	"	28	63	11
130	Diabase from dike	81	Farm lake	3	63	11
131	Porphyritic syenite	81	"	3	63	11
132	Black mineral	82	"	34	63	11
133	Porphyritic mica schist	82	"	34	63	11
134	Hydromica schist	89	"	34	63	11
135	Porphyry (porphyrel?)	73	Garden lake	21	63	11
136	Banded jaspilyte	69	Near Garden lake	30	63	11
•137	Best iron ore	69	"	30	63	11
138	Chlorite rock	......	Falls of Fall R	17	63	11
139	Sericitic schist, black cryst	66	Fall lake	18	63	11
140	Felsitic schist	60	"	17	63	11
141	Sericitic schist	62	"	16	63	11
142	Sericitic schist, greenish grains	64	"	9	63	11
143	Sericitic schist	64	"	9	63	11
144	Sericitic argillyte	62	"	10	63	11
145	Sericitic argillyte	62	"	11	63	11
146	Sericitic schist	62	"	11	63	1
147	Sericitic schist	62	"	2	63	11
148	Sericitic pseudo-conglomerate	62	"	36	64	1
149	Sericitic schist, chloritic spots	63	"	35	64	1

APPENDIX 1.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886	REGION.	Sec.	Town.	Range.
		Page.				
150	Sericitic schist, yellowish	66	Fall lake	18	63	11
151	Sericitic schist, blue	66	"	18	63	11
151b	Sericitic chloritic schist	66	"	13	63	12
152	Chloritic schist	56	Long lake	22	63	12
153	Petrosilex	56	"	22	63	12
154	Wackenitic chlorite schist	57	"	20	63	12
155	Augite (chiefly)	57	"	20	63	12
156	Biotite granite	45	Burntside lake	13	63	13
157	Hydromica granite	45	"	13	63	13
158	Noryte	45	"	13	63	13
159	Granite	46	"	12	63	13
160	Interbedded granite and dioryte	46	"	12	63	13
161	Bedded dioryte	46	"	12	63	13
162	Micaceous hornblende schist	46	"	12	63	13
163	Diallage?	47	"	12	63	13
164	Granite with green feldspar	48	"	12	63	13
165	Mixture of biotite and augite	49	"	1	63	13
166	Diallagic biotite schist	49	"	36	64	13
167	Biotite hornblende schist	50	"	36	64	13
168	Dioryte	50	"	36	64	13
169	Masses of hornblende	50	"	14	63	13
170	Mic. sch. and granulyte interbedded	50	"	14	63	13
171	Dioryte schist	51	"	35	64	13
172	Large crystals of orthoclase	51	"	34	64	13
173	Coarse Muscovite gneiss	51	"	34	64	13
174	Compact sericitic schist	94	Saturday lake	36	64	11
175	Sericitic chloritic argillyte	94	"	36	64	11
176	Siliceous sericitic argillyte	94	Urn lake	30	64	10
177	Doleryte	94	"	30	64	10
178	Amygdaloid	94	"	30	64	10
179	Porphyritic granulyte	95	"	29	64	10
180	Fine mica schist	95	Portage	20	64	10
181	Hornblende schist	95	Bassw'd (Bassi-menan) L	16	64	10
182	Syenite—two varieties	97	"	16	64	10
183	Graywackenitic mica schist	98	"	15	64	10
184	Mica sch. passing to gneiss	98	"	15	64	10
185	Mica sch. w. colored bands	98	"	14	64	10
186	Syenite	99	"	12	64	10
187	Syenite w. crystallized hornbl. (see corrections and additions)	99	"	33	65	9
188	Syenite	99	"	34	65	9
189	Hornblende schist	99	"	34	65	9
190	Transition from syenite to schists	100	"	2	64	9
191	Argillyte	120	"	12	64	9
192	Argillitic sericitic schist	121	Carp lake	12	64	9
193	Sericitic argillyte	121	Newfound lake	12	64	9
194	Argillitic sericitic schist	122	"	14	64	9
195	Graywacke schist	122	"	11	64	9
196	Chloritic sericitic schist	122	"	15	64	9
197	Diabase from dike	123	Moose lake	22	64	9
198	Ser. sch. from contact w. dike	123	"	22	64	9
199	Sericitic slate	123	"	21	64	9
200	Diabase	123	"	31	64	9
201	Argillyte	123	"	29	64	9
202	Chloritic sericitic schist	124	"	29	64	9

APPENDIX I.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886	REGION.	Sec.	Town	Range.
		Page				
203	Porphyritic diabase	125	Snowbank lake	33	64	9
203b	Diabase	125	"	27	64	9
204	Syenite	126	"	35	64	9
205	Syenite	126	"	35	64	9
206	Syenite w greenish hornbl	127	"	31	64	8
207	Fine compact gneiss	127	"	31	64	8
208	Fine compact gneiss	127	"	31	64	8
209	Interbedded gneiss and hornbl. sch	127	"	31	64	8
210	Graywackenitic mica sch	128	"	29	64	8
211	Graywackenitic mica sch	128	"	29	64	8
212	Mica schist	128	"	29	64	8
213	Syenite	128	"	29	64	8
214	Gneiss	128	"	29	64	8
215	Very coarse syenite	128	"	29	64	8
216	Graywackenitic chlor. sch	128	"	29	64	8
217	Mica schist, very fine	129	"	20	64	8
217b	Graywacke schist	130	"	19	64	8
218	Dioryte schist	130	"	19	64	8
219	Gneiss	130	"	19	64	8
220	Syenitic hornblendic schist	131	Boot lake	20	64	8
221	Felsitic schist	131	"	21	64	8
222	Sericitic schist	131	"	16	64	8
223	Sericitic schist	133	Ensign lake	15	64	8
224	Compact argillitic schist	133	"	15	64	8
225	Thin, laminated argillyte	133	"	15	64	8
226	Argillitic sericitic schist	134	"	16	64	8
227	Argillitic sericitic schist	134	"	17	64	8
228	Sericitic schist	134	"	17	64	8
229	Felsitic schist (poroditic?)	134	"	8	64	8
230	Sericitic felsitic schist	134	"	8	64	8
231	Chloritic sericitic schist	136	"	8	64	8
232	Schist in contact with dike	136	"	9	64	8
233	Dioryte in the above schist	136	"	9	64	8
234	Syenite in schist 565	136	"	9	64	8
235	Chloritic sericitic schist	136	"	9	64	8
236	Relation of quartz and schist	136	"	9	64	8
237	Chloritic sericitic schist w. q. grains	137	"	9	64	8
238	Argillyte and quartz	137	"	8	64	8
239	Sericitic argillyte	134	"	7	64	8
240	Argillyte	135	"	8	64	8
241	Sericitic sch. and lamina of q	137	"	9	64	8
242	Plicated sch. w. q. laminæ	137	"	9	64	8
243	Ser. sch, w. q. and fels. grains	138	"	10	64	8
244	Argillyte w. q. grains	138	"	10	64	8
245	Felsitic argillyte	138	"	10	64	8
246	Gravelly sericitic schist	138	"	10	64	8
247	Diabase from dike	139	"	11	64	8
248	Quartz and black argillyte	139	"	11	64	8
249	Diabase from dike	140	"	15	64	8
250	Argillyte, fine, dark	142	Sucker lake	34	65	8
251	Dike material (peculiar)	121	Carp lake	1	64	9
252	Chlorite rock	102	Newton lake	34	64	11
253	Aphanitic, siliceous sericit. sch	102	"	34	64	11
254	Aphanitic sericitic, schist	102	"	34	64	11
255	Sericitic schist	102	"	34	64	11

APPENDIX I.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886.	Region.	Sec.	Town.	Range.
		Page.				
256	Sericitic sch. w. shining scales.........	103	Newton lake.........	26	64	11
257	Nascent mica schist..	103	"	22	64	11
258	Syenitic gneiss........................	104	Pipestone falls.......	22	64	11
259	Syenitic gneiss........................	104	"	22	64	11
260	Graywacke schist......................	104	"	22	64	11
261	Magma of gneiss..........	104	"	22	64	11
262	Rock 261 in contact w. gneiss..........	104	"	22	64	11
263	Micaceous hornblende schist...........	104	"	22	64	11
264	Micaceous hornblende schist...........	105	Basswood (or Bassi-	22	64	11
265	Uralitic syenite.........................	105	menan) L..........	15	64	11
266	Chlorite granite.........................	106	"	15	64	11
267	Menaccanitic hornblende sch	106	"	15	64	11
268	Chlorite schist	106	"	23	64	11
269	Chlorite gneiss.	106	"	23	64	11
270	Syenite gneiss with chlorite...........	107	"	14	64	11
271	Chlorite schist.....	107	"	14	64	11
272	Chloro-syenitic gneiss	107	"	12	64	11
273	Mica-hornblende schist..........	107	"	12	64	11
274	Gravelly chlorite rock........... ..	107	"	12	64	11
275	Mica schist	108	"	12	64	11
276	Dioryte. (also rock 524, Rep. 1887, p.196)	108	"	31	65	10
277	Menaccanitic schist....................	109	"	29	65	10
278	Muscovite granite (silvery m.).........	114	Crooked lake........	13	65	11
279	Dioryte (lamellar hornbl.)..............	115	"	11	65	11
280	Dioryte schist.......	117	"	13	66	11
281	Dioryte schist.........................	117	"	13	66	11
282	Biotite schist.........................	117	"	14	66	12
283	Biotite gneiss.........................	117	"	15	66	12
284	Decaying gneiss.......................	118	"	8	66	12
285	Biotite gneiss.........................	118	"	5	66	12
286	Red biotite gneiss.....................	118	Iron lake...........	C	a	n.
287	Biotite gneiss.........................	119	"	6	66	12
288	Biotite muscovite schist.....	119	"	C	a	n.
289	Distinctly bedded gneiss...............	119	"	C	a	n.
290	Quartz, feldspar and mica............	119	"	C	a	n.
291	Muscovite chlorite gneiss	119	"	C	a	n.
292	Chloritic sericitic schist...............	60	Fall lake......	19	63	11
293	Diabase from dike......................	60	"	19	63	11
294	Chloritic sericitic schist	110	Basswood or Bassi-menan L	22	65	10
295	Noryte	145	Ima lake	13	64	8
296	Transitional doubtful rock	145	"	13	64	8
297	Transitional rock......................	145	"	13	64	8
298	Gabbro, fine	146	Thomas lake.........	20	64	7
299	Fine-grained gabbro	146	"	32	64	7
300	Formative gabbro	146	"	32	64	7
301	Gabbro..............................	146	"	32	64	7
302	Chloritic gneiss	149	Kekequabic lake.....	2	64	7
303	Compact chloritic gneiss	149	"	2	64	7
304	Compact chloritic gneiss.......	149	"	35	65	7
305	Chloritic porphyrel..................	150	"	36	65	7
306	Argillitic slate.........................	150	"	36	65	7
307	Conglomerate.........................	150	"	36	65	7
308	Porphyritic diabase schist............	151	"	31	65	6
309	Porphyritic diabase...................	151	"	30	65	6
310	Dark siliceous slate...	151	"	30	65	6

APPENDIX I.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886.	REGION.	Sec.	Town.	Range.
		Page.				
311	Slate-colored slate, softer	151	Kekequabic lake	30	65	6
312	Dike-rock across slate	151	"	30	65	6
313	Fine, hard, bluish slate	152	"	32	65	6
314	Argillyte	157	Ogishke Muncie lake	28	65	6
315	Porphyrel	157	"	28	65	6
316	Porphyry	157	"	28	65	6
317	Diabase?	157	"	28	65	6
318	Conglomerate	157	"	28	65	6
319	Porphyritic conglomerate	159	"	28	65	6
320	Diabasic groundmass of congl	159	"	28	65	6
321	Slaty, micaceous argillyte	159	"	28	65	6
322	Slate and granular rock	159	"	28	65	6
323	Slate with pebbles	159	"	28	65	6
324	Conglomerate ill defined	159	"	28	65	6
325	Black siliceous argillyte (see corrections and additions)	160	"	27	65	6
326	Diabasic groundmass	162	"	23	65	6
327	Slate and groundmass	162	"	23	65	6
328	Green, diabasic groundmass	162	"	23	65	6
329	Diabasic groundmass	162	"	23	65	6
330	Sericitic schist	162	"	23	65	6
331	Sericitic chloritic schist	162	"	23	65	6
332	Sericitic, 1st gradation	162	"	23	65	6
333	Sericitic, 2d gradation	162	"	23	65	6
334	Sericitic, 3d gradation	162	"	23	65	6
335	Porphyritic schist	164	"	26	65	6
336	"Green rock"	165	"	35	65	6
337	Green rock, from summit	165	"	35	65	6
338	Porphyritic rock	165	"	26	65	6
339	Eruptive rock	161	"	26	65	6
340	Slate	161	"	26	65	6
341	Porphyritic, but gravelly	166	"	22	65	6
342	Greenstone conglomerate	166	"	22	65	6
343	Porphyry pebble	166	"	22	65	6
344	Porphyritic matrix	166	"	22	65	6
345	Gravelly matrix	166	"	22	65	6
346	Greenstone (like 342) columnar	166	"	22	65	6
347	Erupted rock	168	Gabimichigama lake	25	65	6
348	Flinty slate	169	"	25	65	6
349	Graywacke-like	170	"	36	65	6
350	Muscovado-gabbro?	170	"	36	65	6
351	Graywacke-like	170	"	1	64	6
352	Massive graywacke	170	"	1	64	6
353	Micaceous gabbrolyte?	170	"	1	64	6
354	Gabbro	171	"	12	64	6
355	Gabbro	171	"	12	64	6
356	Gabbrolyte	171	"	1	64	6
357	Band of iron-bearing rock	171	"	1	64	6
358	Sideritic? rock	171	"	6	64	6
359	Porphyrel	158	Zeta lake	28	65	6
360	Porphyrel	153	Kekequabic lake	29	65	6
361	Porphyrel	153	"	29	65	6
362	Porphyrel	152	"	29	65	6
363	Graywacke-like	152	"	30	65	6
363*b*	Dike-rock	153	"	31	65	6

APPENDIX 1.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886	REGION.	Sec.	Town	Range.
		Page.				
364	Chlorite schist	153	Kekequabic lake ...	31	65	6
365	Porphyrel	153	"	36	65	7
366	Green rock	153	"	36	65	7
367	Chloritic conglomerate	154	"	36	65	6
368	Green, conglomeritic sch	154	"	34	65	7
369	Green, conglomeritic sch	154	"	34	65	7
370	Fine, reddish, granulitic sch.	155	"	3	64	7
371	Granulitic schist	155	"	3	64	7
372	Gabbroloid rock	155	"	4	64	7
373	Gabbroloid	155	" ...	3	64	7
374	Gneissic rock	155	"	3	64	7
375	Chloritic gneiss	155	"	2	64	7
376	Subgranular felsyte	156	"	2	64	7
377	Felsitic schist	149	"	3	64	7
378	Porphyritic gneiss	149	"	2	64	7
379	Green-rock and granulitic.	149	"	2	64	7
380	Chlorite gneiss.	......	"	2	64	7
381	Porphyrel	......	"	36	65	7
382	Porphyrel	150	"	36	65	7

Rock No.	BRIEF DESCRIPTION.	Report, 1887	REGION.
		Page.	
383	Fine red quartzyte (Port Finley)	145	Port Finley, Canada.
384	Diabase	145	Bruce mines, Canada.
385	Diabase	146	"
386	Diabase	.....	"
387	Quartz from copper vein	......	"
388	Limestone	.....	"
389	Diabase slate, fine	147	Thessalon, Canada.
390	Same with chloritic lustre.	147	"
391	Diabase, average condition	147	"
392	Diabase slate, chloritic, etc	148	"
393	Quasi-amygdaloid	149	"
394	Diabasic slate w. amygdules	149	"
395	Gray quartzyte	150	1½ mile N.W.fromThessalon
396	Dark gray quartzyte	150	" [Can.
397	Slate in quartzyte	151	"
398	Diabase in dike	151	"
399	Red quartzyte	151	" [Can.
400	Diabase	151	2½milesN.W.from Thessalon
401	Quartzyte	152	3 miles N W. from Thessalon
402	Diabase	152	5½milesN.W.from Thessalon
403	Diabase	153	" [Can.
404	Quartzyte	153	"
405	Quartzyte, greenish, fine	154	2 miles N. from Thessalon.
406	Quartzyte, red, conglomeritic	154	¾ mile from Ansonia, Can.
407	Diabase	154	"
408	Quartzyte, red	156	Near Ansonia. Can.
409	Yellowish, cherty limestone.	156	"
410	Pinkish, cherty limestone	......	"

APPENDIX I.—Continued-

Rock No.	BRIEF DESCRIPTION.	Report, 1887	REGION.
		Page.	
411	Brecciated diabase	155	At Ansonia, Can.
412	Slaty diabase		
413	Diabase	161	Blind river, Can.
414	Red quartzyte	161	"
415	Diabase, pale green feldspar	162	
416	Diabase, pink feldspar	162	
417	Diabase, lamellar augite	162	
418	Siliceous slate	161	Blind river, Can.
419	Felsyte-like, red feldspar	163	"
420	Same, becoming dioritic	163	"
421	Same, completely dioritic	163	"
422	Chloritic shale fr. joint	163	"
423	Chloritic mass	.....	
424	Quartzyte, gray and red	163	Blind river, Can.
425	Red petrosilex	163	"
426	Diabase	163	"
427	Flint	163	"
428	Diabase	156	1 mile W. of Ansonia, Can.
429	Feldspar	156	"
430	Rock of	156	S.W.¼ sec. 8, Lefroy, Can.
431	Same, more slaty	....	
432	Felsyte slate	......	
433	Diabase slate	......	[Can.
434	Flinty felsyte	157	½ mile S. W. from Ottertail,
435	Feldspathic slate	156	20 rods S. of Ottertail, 4-cor's
436	Granulyte from a pebble	......	[Can.
437	Noryte	158	Near Ottertail, Can.
438	Cherty limestone	.....	Valley of Thessalon, near
439	Cherty limestone (organic?)	158	Thessalon, Canada.
440	Noryte	158	2 miles N. from Ottertail, Can.
441	Animike slate	159	2 miles S. from Murray's Cor-
442	Felsyte becoming granulyte	159	ners, Can. "
443	Noryte	159	"
444	Slate inclosing pebble	159	Murray's Corners, Canada.
445	Hæmatite in quartzyte	159	"
446	Fissile slate	160	Two miles S. E. from Otter-
447	Pale pink quartzyte	160	tail, Canada. "
448	Diabase, light blue.	155	Ansonia, Canada.
449	Cherty limestone, pale pinkish	155	"
450	Cherty limestone coarser	......	"
451	Diabase slate embraced in above	155	"
452	Yellowish cherty limestone	155	"
453	"Soap rock" of miners	172	Sec. 19, T. 47 27, Ishpeming,
454	Slate passing to hæmatite	172	Mich. "
455	Conglomerate over hæmatite	172	Old Saginaw mine, Ish., Mich.
456	Slate	174	1½ miles N. W. from "
457	Quartzyte	174	" "
458	Sericitic slate	175	2½ " "
459	Porphyrel in contact w. same	175	" "
460	Conglomeritic schist	175	
461	Siliceous dark band in same	175	At the bridge, Deer lake "
462	Vertical slaty rock	175	W. side of " " "
463	Gray and red quartzyte	176	" " "
464	Pure amorphous talc	176	2½ miles E. from Ropes gold
465	Crystalline talc	176	mine. "

APPENDIX 1.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1887. Page.	REGION.
466	Gold bearing quartz	176	Ropes gold mine.
467	Slate of the country rock	......	"
468	Sericitic lamina	176	2½ miles N. W. from Ish., M.
469	Green argillyte	177	Ishpeming, Mich.
469a	Green argillyte (analysis by Taft)	177	"
470	Ashen argillyte	177	"
470b	Ashen argillyte (analysis by Taft)	177	"
471	Specimens with Martite crystals	177	"
472	Quartzose chlorite schist	177	"
473	Dioryte (so-called)	177	Michigamme, Mich.
474	Granite (so-called)	177	1 mile N. Michigamme, M.
475	Quartzyte and granite in contact	178	" "
476	Greenstone dike in granite	178	" "
477	Lamina of sericitic matter	178	" "
478	Quartzyte	178	Near Michigamme, Mich.
479	Interlaminated sandst. and hæmat	178	Swan mine, Negaunee, Mich.
480	Chalcedonic silica and hæmat	178	" "
481	Jasper and hæmatite	178	" "
482	Quartzose chloritic rock	178	Buffalo mine, "
483	Slate	178	Near the " "
484	Black argillyte	178	" " "
485	Slate	179	" " "
486	Quartzyte, north-dipping	179	Iron Cliffs mine, "
487	Quartzyte	180	" "
488	Quartzyte	180	Near Teal lake, "
489	Talcose schist	181	Bluff street, Marquette, M.
490	Vitreous talcose schist	181	Bluff street, Marquette, Mich
491	Ambiguous, perhaps eruptive	181	"
492	Felsitic schist	181	Near lighthouse, " "
493	Porphyrel	182	Lighthouse point, " "
494	Sericitic felsitic schist	182	" " "
495	Schist, showing cross banding	....	" " "
496	Great greenstone dike	.....	" " "
497	Altered schist with cross banding	......	" " "
498	Dike rock (east and west)	......	" " "
499	Brecciated mass	......	
500	Slate	186	N'r Colby mine, Bessemer "
501	Iron ore, Valley mine	..	Valley mine, " "
502	Syenite	187	N'r Aurora mine, Ironw'd "
503	Quartzyte	187	" " "
504	Black slate	188	½ mile E. Iron King m'n "
504a	Granulitic gneiss (pink)	189	Penokee Gap, Wis.
505	The dark rock	189	"
506	Same, with vein of felsyte	190	"
507	Dark and pink mixed	190	"
508	Nascent mica schist	190	"
508a	Porphyrelloid rock	190	"
509	Hornblende schist	190	"
510	Hornblende (?) rock	190	"
511	Quartzyte, w. some feldspar	191	"
512	Vitreous quartzyte	191	"
513	Quartzyte with crystals fels	191	"
514	Hornblende schist	......	"

APPENDIX 1.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1887.	REGION.
		Page.	
515	Siliceous schist	191	Penokee Gap, Wis.
516	Siliceous schist banded	191	"
517	Siliceous argillyte	191	"
518	Sericitic argillyte	191	"
519	Magnetitic siliceous schist	192	"
520	Magnetitic schist	192	"
521	Black, carbonaceous argillyte	192	"
522	Dark speckled argillyte	192	"
523	Graywacke, fine	195	Portage, Mud l'k to Burntside lake.

Rock No.	BRIEF DESCRIPTION.	Report, 1887.	REGION.	Sec.	Town.	Range.
		Page.				
524	Chlorite rock—pipestone	108 (Rp '86) 196	Pipestone rapids	..	..	..
525	Felsitic argillyte	196	Sucker lake.	32	65	8
526	Banded jaspilo-hæmatitic	144 (Rp '86) 197	Knife lake.			
527	Siliceous argillyte	198	"	27	65	7
528	Flinty argillyte	198	"	26	65	7
529	Siliceous argillyte	198	"	26	65	7
530	Greenish bands in last	198	"	26	65	7
531	From a bowlder	198	"	26	65	7
532	Diabasic schist	199	"	24	65	7
533	Diabasic conglomerate	199	"	24	65	7
534	Felsitic siliceous schist	199	"	19	65	7
535	Diabasic slate and argillyte	199	"	20	65	7
536	Fine, slaty argillyte	199	"	22	65	7
537	Stuntz conglomerate	199	"	21	65	6
538	Stuntz conglomerate	200	"	20	65	6
539	Siliceous argillyte	202	"	17	65	6
540	Graywacke	203	"	18	65	6
541	Graywacke	203	"	18	65	6
542	Slaty graywacke	203	"	24	65	7
543	Stuntz conglom. fr. bowlder	203	"	23	65	7
544	Flinty argillyte	204	"	14	65	7
545	Stuntz conglomerate	204	"	14	65	7
546	Sericitic felsitic schist	204	"	14	65	7
547	Porphyritic Stuntz conglom	204	"	14	65	7
548	Silicious argillyte	204	"	12	65	7
549	Poroditic rock	204	"	12	65	7
550	Porodyte	205	"	7	65	7
551	Porodyte	207	"	6	65	6
552	Porodyte	208	"	32	66	6
553	Fine-textured graywacke	210	Otter Track lake	32	66	6
554	Diabase	210	"	32	66	6
555	Graywacke	210	"	32	66	6
556	Chlorite gneiss	210	"	28	66	6
557	Graywacke	210	"	33	66	6

APPENDIX 1.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1887. Page.	REGION.	Sec.	Town.	Range.
558	Argillyte	210	Otter Track lake	28	66	6
559	Dark, fine graywacke	210	"	27	66	6
560	Graywacke	210	"	23	66	6
561	Siliceous argillyte	211	"	23	66	6
562	Siliceous argillyte	211	"	24	66	6
563	Porphyroid graywacke	211	Oak lake	24	66	6
564	Compact granulyte	211	"	24	66	6
565	Compact granulyte	213	"	24	66	6
566	Argillyte, characteristic	213	Saganaga lake	24	66	6
567	Graywacke interstratified	213	"	24	66	6
568	Porphyroid graywacke	213	"	24	66	6
569	Quartzose granulyte	213	"	24	66	6
570	Coarse chlorite syenite	214	"	19	66	5
571	Chlorite syenite	214	"	18	66	5
572	Syenite	214	"	18	66	5
573	Syenite	214	"	9	66	5
574	Fine syenite	214	"	10	66	5
575	Syenite	215	"	22	66	5
576	Syenite	293	Red Rock lake	28	66	5
577	Syenite with orange lichen	293	"	33	66	5
578	Syenite	294	W. Seagull lake	5	65	5
579	Chlorite syenite, gen. condit	294	"	8	65	5
580	Chlorite syenite, highly chloritic	294	"	8	65	5
581	Graywacke, dark and fine	294	"	17	65	5
582	Graywacke (*see errata*)	294	"	17	65	5
583	Graywacke	307	Frog Rock lake	17	65	5
584	Porphyrel	307	"	17	65	5
585	Conglomeritic, chlorit. grayw	307	"	17	65	5
586	Chloritic groundmass w. iron	307	"	17	65	5
587	Included angular mass	307	"	17	65	5
588	(Wanting)	....	"	17	65	5
589	Laminated chlorite rock	307	"	17	65	5
590	Quartz from a vein	307	"	17	65	5
591	Diabase	307	"	17	65	5
592	Graywacke	307	"	17	65	5
593	Gneiss and chlorite rock (*see erratum*)	294	W. Seagull lake	17	65	5
594	Syenite	295	"	9	65	5
595	Syenite	297	Seagull lake	15	65	5
596	Saganaga syenite	298	"	12	65	5
597	Graywackenitic conglom	298	"	1	65	5
598	Saganaga syenite	298	"	1	65	5
599	Ordinary Saganaga syenite	299	"	1	65	5
600	Fine granulyte included	299	"	1	65	5
601	Syenite with chlorite rock	299	"	1	65	5
602	Piece of included chlorite rock	299	"	1	65	5
603	Included chlorite schist	299	"	1	65	5
604	Pebble of fine syenite	299	"	1	65	5
605	Same fine syenite stratified	299	"	1	65	5
606	Pebble of chloritic diabase	299	"	1	65	5
607	Syenite with carbon. copper	299	"	1	65	5
608	Syenite	216	"	31	66	4
609	Saganaga syenite	216	Gull river	19	66	4
610	Saganaga syenite	216	Saganaga lake	18	66	4
611	Syenite with pebble	216	"	18	66	4
612	Syenite with pebble	217	"	5	66	4

APPENDIX 1.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1887, Page.	REGION.	Sec.	Town.	Range.
613	Saganaga syenite	217	Saganaga lake	4	66	4
614	Saganaga syenite	217	“	34	67	4
615	Lamellar augite, coarse	222	“	34	67	4
616	Lamellar augite, fine	222	“	34	67	4
617	Lamellar augite, w. feldsp.	222	“	34	67	4
618	Augite, feldspar and epidote	222	“	34	67	4
619	Soft lamellar mineral	222	“	34	67	4
620	Pale green augite	222	“	34	67	4
621	Augite hyposyenite (?)	222	“	34	67	4
622	Greenish, transparent augite	222	“	34	67	4
623	Like 615, but pale green	222	“	34	67	4
624	Saganaga syenite w. pebbles	222	“	34	67	4
625	Saganaga syenite	223	“	22	67	4
626	Syenite from dike	223	“	22	67	4
627	Saganaga syenite	223	“	20	67	4
628	Red fels. and chlor. horbl	223	“	20	67	4
629	Black syenite	223	“ } Canada.	20	67	4
630	Diabase	223	“	20	67	4
631	Thin lamellar augite like 615	223	“	20	67	4
632	Like 628	224	“	20	67	4
633	Micaceous gneiss	224	“	17	67	4
634	Showing slatiness	224	“	6	67	4
635	More solid portions	224	“	6	67	4
636	Showing the cleavage	224	“	6	67	4
637	Showing warped parallel lam.	224	“	6	67	4
638	Quartz from a vein	224	“	6	67	4
639	Syenite and chlor. syenite	224	“	6	67	4
640	Biotite gneiss	226	“	..	67	4
641	Chlorite-augitic rock	226	“	33	67	4
642	Mostly lamellar augite	226	“	33	67	4
643	Feldspar and q. from dike	226	“	33	67	4
644	Formation containing the dike	226	“	33	67	4
645	Saganaga syenite	227	Granite lake	27	66	4
646	Saganaga syenite	229	Boundary lake	36	66	4
647	Saganaga syenite	229	“	1	65	4
648	Saganaga syenite	232	“	12	65	4
649	Gneissic syenite (No. 822)	233	“	13	65	4
650	Saganaga syenite	237	Gunflint lake	13	65	4
651	Magnetitic schist fragments	237	“	24	65	4
652	Magnetitic graywacke	237	“	24	65	4
652*b*	Flinty slate	......	“	24	65	4
653	Diabase	237	“	24	65	4
654	Gabbro	237	“	24	65	4
655	Diabase	237	“	24	65	4
656	Magnetite and feldspar	238	“	24	65	4
655*b*	Gabbro	244	“	19	65	3
656*b*	Diabase with much magnetite	244	“	19	65	3
657	Like 656*b*. without magnetite	244	“	19	65	3
658	Conglomeritic variety	245	“	19	65	3
659	Magnetitic specimens	245	“	19	65	3
660	Magnetitic slate	245	“	24	65	4
661	Slate from ledge	245	“	24	65	4
662	Magnetite from band	245	“	21	65	4
663	Magnetite from laminated portion	245	“	21	65	4
664	Specimen of the slate	246	“	24	65	4

APPENDIX 1.—Continued

Rock No.	BRIEF DESCRIPTION.	Report, 1887.	REGION.	Sec.	Town.	Range.
		Page.				
665	Slate 1½ in. from gabbro	246	Gunflint lake	24	65	4
666	Magnetitic slate from contact	246	"	24	65	4
667	Gabbro in contact w. 666	246	"	24	65	4
668	Gabbro 5 or 6 feet higher than 667	246	"	24	65	4
669	Gabbro 6 in. above 667	246	"	24	65	4
670	Gabbro 12 in. above 667	246	"	24	65	4
671	Gabbro 18 in. above 667	247	"	24	65	4
672	Magnetitic slate, a foot below contact	247	"	24	65	4
673	Magnetitic slate	247	"	25	65	4
674	Gabbro from cliff	248	"	30	65	3
675	Magnetitic rock (from slate?)	249	"	28	65	3
676	Peculiar gabbro	249	"	28	65	3
677	Collection of pebbles	249	"	27	65	3
678	Curiously banded flint	249	"	27	65	3
679	Gabbro	249	"	23	65	3
680	Gabbro	249	"	23	65	3
681	Gabbro	249	"	19	65	2
682	Siliceous pebbles	250	"	16	65	2
683	Siliceous, magnetitic schist, black	261	" Canada.	18	65	2
684	Fine gabbro	261	" Canada.	18	65	2
685	Gabbrolitic magnetite	261	" Canada.	18	65	2
686	Gabbro	261	" Canada.	18	65	2
687	Chert	261	" Canada.	18	65	2
688	Granular rock from the slate	261	" Canada.	13	65	3
689	Flint schist	261	" Canada.	13	65	3
690	Gabbro	261	" Canada.	13	65	3
691	Porphyritic noryte	300	Loon Lake	26	65	3
692	Gabbro	300	"	26	65	3
693	Gabbrolitic rock	300	"	26	65	3
694	Gabbro	300	"	26	65	3
695	Noryte—syenite-looking	300	"	26	65	3
696	Fine noryte	300	"	27	65	3
697	Porphyritic noryte	301	"	27	65	3
698	Gabbro w. much magnetite	301	"	27	65	3
699	Noryte	301	"	27	65	3
700	Noryte almost aphanitic	301	"	27	65	3
701	Gabbro	301	"	28	65	3
702	Fine noryte	301	"	33	65	3
703	Gabbro weathered	302	"	32	65	3
704	Gabbro w. large crystals	302	"	32	65	3
705	Fine noryte	302	"	32	65	3
706	Slate, prevailing condition	302	"	32	65	3
707	Slate, with scale-like areas	302	"	32	65	3
708	Gabbroloid slate	303	"	35	65	3
709	Prevailing character slate	303	"	35	65	3
710	Thin layer dark argillitic	303	"	35	65	3
711	Thin laminæ	303	"	35	65	3
712	From 8 feet above water	303	"	35	65	3
713	From 20 feet above water	303	"	35	65	3
714	Magnetitic slate, wavy bedding	303	"	36	65	3
715	Porphyry, coarse-textured	304	"	26	65	3
716	Gneissoid syenite	240	Gunflint lake Canada.	18	65	3
717	Magnetitic slate	240	" Canada.	17	65	3
718	Granular or oölitic magnitite	240	" Canada.	17	65	3
719	Siliceous slate, nearest syen	241	" Canada.	17	65	3

APPENDIX I.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1887.	REGION.	Sec.	Town.	Range.
720	Slate—varieties	242	Gunflint lake.	18	65	3
721	Magnetite—varieties	242	"	18	65	3
722	Magnetitic slate	242	"	20	65	3
723	Magnetitic slate, diabase looking	250	"	19	65	3
723b	Breccia of magnetitic slate	251	"	21	65	3
724	Fine noryte	253	"	22	65	3
725	Argillyte in vertical position	253	"	22	65	3
726	Vertical argillyte	254	"	15	65	3
727	Sericitic argillyte	254	"	22	65	3
728	Sericitic argillyte	256	"	22	65	3
729	Two structures in slate	253	"	22	65	3
730	Argillyte showing two struct	256	"	14	65	3
731	Argillyte with quartz grains	256	"	14	65	3
732	Quartz-porphyritic slate	257	" } Canada.	14	65	3
733	Porphyritic sericito-argillyte	257	"	14	65	3
734	Porphyrelloid slate	257	"	14	65	3
735	White opaque quartz	257	"	14	65	3
736	Plain schist with two structures	257	"	14	65	3
737	Porphyrelloid rock	257	"	14	65	3
738	Porphyrelloid slate	258	"	14	65	3
739	Flinty contorted Animike and breccia	258	"	14	65	3
740	Pebbles from Rock 739	258	"	14	65	3
741	Biotite gneiss from fragments	259	"	14	65	3
742	Interleaved phyllyte	259	"	14	65	3
743	Graywacke	270	North lake	17	65	2
744	Syenite	270	"	16	65	2
745	Granular magnetitic rock	271	"	16	65	2
746	Diabasic (?) rock	271	"	16	65	2
747	Gabbro	271	"	16	65	2
748	Gabbro and much magnetite	273	South lake	22	65	2
749	Magnetitic Animike	273	"	22	65	2
750	Gray Animike slate	274	Rat lake (Can.)	19	65	1
751	Fine noryte	274	"	19	65	1
752	Gabbro	275	Rose lake	19	65	1
753	Gabbro	275	"	20	65	1
754	Gabbro	275	"	22	65	1
755	Animike argillyte	276	"	23	65	1
756	Magnetitic Animike	276	"	24	65	1
757	Iron rock	278	Rove lake	20	65	1E
758	Fine noryte	279	"	22	65	1E
759	Black rusty Anim. slate	279	"	22	65	1E
760	Fine dark, heavy noryte	280	Mountain lake	21	65	2E
761	Coarse gabbro w. magnetite	281	"	13	65	2E
762	Three varieties of Animike	282	Moose lake	20	65	3E
763	Coarse gabbro	282	"	22	65	3E
764	Animike with pure mag.	283	"	22	65	3E
765	Gabbro	285	South Fowl lake	12	64	3E
766	Dolonnyte and quartz fr. gab	285	"	12	64	3E
767	Diabase from dike	285	"	12	64	3E
768	Olivinitic trap	288	Pigeon river	22	64	4E
769	Gabbro	288	"	22	64	4E
770	Olivinitic gabbro	289	" (Can.)	..	64	5E
771	Animike slate	291	Partridge falls	..	64	5E
772	Slate, prevailing character	291	Grand Portage (on	..	64	5E
773	Darker, thick bedded slate	291	" Pig R)	..	64	5E

APPENDIX 1.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886	REGION.	Sec.	Town.	Range.
		Page				
774	Gabbro from dike	291	Partridge Falls	..	64	5E
775	Jointage of slate	291	"	..	64	5E
776	Peculiar gabbro	283	Moose lake. (Canada.)	18	65	3E
777	Gabbro	273	South lake. (Canada.)	24	65	2
778	Gneiss	271	North lake. (Canada.)	10	65	2
779	Syenite gneiss	270	" (Canada.)	17	65	2
779b	Slate, in cont. w. gabbro	261	Gunflint lake. (Canada.)	13	65	3
780	Gabbro in cont. w. slate.	261	" (Canada.)	13	65	3
781	Gabbro 1 ft. above slate	261	" (Canada.)	13	65	3
782	Gabbro 4 ft. above slate.	261	" (Canada.)	13	65	3
783	Gabbro 10 ft. above slate	261	" (Canada.)	13	65	3
784	Flint from flint bed	261	" (Canada.)	13	65	3
785	Kewatin slates contorted	259	" (Canada.)	14	65	3
786	Sample of supposed eruptive	259	" (Canada.)	14	65	3
787	Condition admitted not eruptive	259	" (Canada.)	14	65	3
788	Condition also not eruptive	259	" (Canada.)	14	65	3
789	Other examples from same place as 725	253	" (Canada.)	22	65	3
790	Gabbro	305	Iron lake	36	65	3
791	Magnetite in gabbro	305	"	31	65	2
792	Gabbro with titaniferous iron	305	"	33	65	2
793	Animike rock fr. bowlder	306	"	33	65	2
794	Muscovado	305	"	31	65	2
795	Rusted Animike slate	305	"	31	65	2
796	Titaniferous gabbro	305	"	31	65	2
797	Muscovado	305	"	31	65	2
798	Pebbles in syenite bowlder	305	"	31	65	2
799	Hæmatitic rock	263	Gunflint Lake. (Canada.)	18	65	2
800	Sericitic argillyte	263	" (Canada.)	18	65	2
801	Porphyritic porodyte	263	" (Canada.)	18	65	2
802	Semi-crystalline sericitic sch	263	" (Canada.)	18	65	2
803	Syenitic-looking Kewatin	263	" (Canada.)	18	65	2
804	Porphyritic porodyte	263	" (Canada.)	12	65	2
805	Uralitie syenite gneiss	264	" (Canada.)	12	65	2
806	Muscovite gneiss.	264	" (Canada.)	12	65	2
807	Transition to gneiss	265	" (Canada.)	12	65	2
808	Transition to gneiss	265	" (Canada.)	12	65	2
809	Transition to mica schist	265	" (Canada.)	12	65	2
810	Dike rock	265	" (Canada.)	12	65	2
811	Augitic? band in schist	265	" (Canada.)	12	65	2
812	Conglomeritic iron ore	263	" (Canada.)	18	65	2
813	Iron carbonate fr. Anim.	262	" (Canada.)	13	65	2
814	Black iron ore	262	" (Canada.)	18	65	2
815	Incipient muscovado	253	" (Canada.)	16	65	3
816	Iron carbonate beds	252	" (Canada.)	21	65	3
817	Dark Animike with iron	250	" (Canada.)	19	65	3
818	Brecciated Animike	251	" (Canada.)	21	65	3
819	Syenite gneiss	241	"	18	65	3
820	Hornblende schist pebble	241	"	18	65	3
821	Contact of last two	240	"	18	65	3
822	Diabase from dike (649)	233	"	13	65	4
823	Formative muscovado	238	"	24	65	4
824	Magnetite in contact w. 823	238	"	24	65	4
825	Oölitic quartzyte	238	"	24	65	4
826	Iron-bearing Animike	238	"	24	65	4
827	Slate w. scrobiculate surface	239	"	24	65	4

APPENDIX 1.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1887. Page.	REGION.	Sec.	Town.	Range.
828	Cherty concretions (Batrachoides).......	239	Gunflint lake........	24	65	4
829	Magnetite at surface	266	West of Gunflint lake	23	65	4
830	Quartzose muscovado..................	267	"	23	65	4
831	Bluish, muscovado-like................	267	"	23	65	4
832	Hæmatite	267	"	22	65	4
833	Gneiss under hæmatite................	267	"	22	65	4
834	Ancient soil between the two...........	267	"	22	65	4
835	Quartz	215	Saganaga lake	14	66	5
836	Samples of the formation	215	"	14	66	5
837	Samples 8 rods north	215	"	14	66	5
838	Sample from	215	"	14	66	5
839	Weathered surface	216	"	14	66	5
840	Rounded included mass................	216	"	14	66	5
841	With reddish-weathering fels	216	"	14	66	5
842	Viriditic syenite..................	216	"	14	66	5
843	Quartziferous granular felsyte..........	294	W. Seagull lake.....	8	65	5
844	Felsi-chlorite argillyte.................	306	Frog Rock lake......	17	65	5
845	Argillo-micaceous schist	307	"	17	65	5
846	Porphyrelloid graywacke	307	"	17	65	5
847	Felsyte schist..........................	303	"	17	65	5
848	Felsyte schist..........................	308	"	17	65	5
849	Diabase from dike.....................	308	"	17	65	5
850	Chlorite granulyte.....................	308	"	17	65	5
851	Greenstone......................	308	"	17	65	5
852	Diabase	308	"	17	65	5
853	Greenstone w. much feldspar...........	308	"	17	65	5
854	Greenstone of fine texture..............	308	"	18	65	5
855	Greenstone coarser	308	"	18	65	5
855*b*	Sericitic felsyte schist..................	308	"	18	65	5
856	Like 855*b* but harder..................	308	"	18	65	5
857	Sericitic or chloritic felsyte........	308	"	18	65	5
858	Sericitic felsyte (schist?)...............	308	"	18	65	5
859	Chloritic felsyte..........	312	"	18	65	5
860	Porphyrelloid chlorite-felsyte...........	312	"	18	65	5
861	Aphanitic diabase	312	"	18	65	5
862	Diabase, same dike....................	312	"	18	65	5
863	Sericitic schist.........................	312	"	18	65	5
864	Sericitic schist.........................	312	"	18	65	5
865	Sericitic chlorite felsyte......	312	"	18	65	5
866	Argillo-felsitic schist....................	313	"	18	65	5
867	Rock 8 rods farther along shore	313	"	18	65	5
868	Chloritic sericitic schist................	313	"	18	65	5
869	Obscure conglomerate	313	"	18	65	5
870	Compact chloritic argillyte.............	313	"	18	65	5
871	Chlorite syenite pebble.........	313	"	18	65	5
872	Sericitic schist.......................	313	"	18	65	5
873	Sericitic schist.................	313	"	18	65	5
874	Compact argillitic rock	313	"	18	65	5
875	Like 874 but w. purplish tints...........	313	"	18	65	6
876	Greenstone-like	313	"	18	65	5
877	Greenstone passing to chlor. sch........	314	"	18	65	5
878	Greenstone 30 ft. fr. 877...............	314	"	18	65	5
879	Greenstone...........................	314	"	19	65	5
880	Sericitic argillyte......................	314	"	19	65	5
881	Diabasic conglomerate..................	314	"	18	65	5

APPENDIX I.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886.	REGION.	Sec.	Town.	Range.
		Page				
882	Chloritic argillyte	314	Frog Rock lake	18	65	5
883	Sericitic schist	314	"	18	65	5
884	Chloritic sericitic schist	315	Town Line lake	18	65	5
885	Incipient porphyrel	315	"	18	65	5
886	Red jasper and hæmatite	315	"	18	65	5
887	Porphyritic conglomerate	315	"	13	65	6
888	Sericitic grit	315	"	13	65	6
889	Sericitic grit	315	"	13	65	6
890	Quartz grit	315	"	13	65	6
891	Sericitic schist	316	Ogishke Muncie lake	24	65	6
892	Brecciated dolomyte	316	"	24	65	6
893	Sericitic argillitic dolomyte	316	"	24	65	6
894	Silico-argillaceous slate	316	"	24	65	6
895	Felsitic grit	316	"	24	65	6
896	Gritty argillyte	317	"	24	65	6
897	Diabase conglomerate	317	"	24	65	6
898	Sericito argillaceous slate	317	"	24	65	6
899	Argillo-felsitic groundmass	317	"	24	65	6
900	Spheroidal concretions	317	"	24	65	6
901	Conglomerate	320	Crab lake	13	65	6
902	Porphyrel	320	"	13	65	6
903	Matrix showing bedding lines	320	"	13	65	6
904	Porphyritically quartzose congl	320	"	13	65	6
905	Argillyte	320	"	13	65	6
906	Fine gritty conglomerate	320	"	14	65	6
907	Graywacke	320	"	14	65	6
908	Graywacke	320	"	14	65	6
909	Graywacke or groundmass	320	"	14	65	6
910	Argillyte w. crys. of felds	320	"	14?	65	6
911	Compact argillyte	320	"	14?	65	6
912	Argillyte	320	"	14	65	6
913	Slaty argillyte	321	"	14	65	6
914	Conglomerate	321	"	14	65	6
915	Porphyrelloid conglomerate	321	"	14	65	6
916	Conglomerate (Ogishke)	321	Zeta lake	27	65	6
917	Groundmass of conglom	321	"	27	65	6
918	Banded argillyte	322	Epsilon lake	21	65	6
919	Banded argillyte	322	"	21	65	6
920	Kewatin slate	323	"	21	65	6
921	Animike slate	323	"	21	65	6
922	Schistosity and bedding	323	"	21	65	6
923	Sedimentary and schistic struc	324	"	20	65	6
924	Two structures conformable	324	"	20	65	6
925	Poroditic porphyrelloid slate	324	"	20	65	6
926	Noryte?	324	"	29	65	6
927	Noryte and porphyry in cont	325	"	29	65	6
928	Fragment of porphyry in noryte	325	"	29	65	6
929	Purple porphyry	325	"	29	65	6
930	Porphyritic greenstone	325	"	29	65	6
931	Kewatin, showing two structures	325	"	29	65	6
932	Amygdaloid porphyry	326	"	29	65	6
933	Varieties of purple porphyry	327	"	29	65	6
934	Kewatin argillyte	200	Knife lake	17	65	6
935	Finely porphyritic schist	200	"	17	65	6
936	Porphyrelloid rock	200	"	17	65	6

APPENDIX I.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1887	REGION.	Sec.	Town.	Range.
		Page.				
937	"Pulpit rock" noryte	200	Knife lake	16	65	6
938	Gray felsitic slate	200	"	16	65	6
939	Interlaminated argillyte	200	"	16	65	6
940	Gray felsitic rock	200	"	16	65	6
941	Banded argillyte	200	"	16	65	6
942	Stuntz conglomerate	200	"	16	65	6
943	Siliceous argillyte (Animike?)	200	"	16	65	6
944	Stuntz conglomerate	201	"	15	65	6
945	Diabase from dike	201	"	15	65	6
945b	Porphrel with fragments	202	"	16	65	6
946	Argillyte (Animike?)	202	"	16	65	6
947	Diabase from dike	202	"	16	65	6
948	Slate in contact	202	"	16	65	6
949	General character of slate	202	"	16	65	6
950	Coarse material interbedded	202	"	16	65	6
951	Fine, hard, diabase-looking	202	"	16	65	6
952	Conglomeritic or brecciated	202	"	16	65	6
953	Chlorite argillyte	202	"	17	65	6
954	Porphyrellyte	205	"	12	65	7
955	Slaty porphyrellyte	205	"	12	65	7
956	Siliceous porphyrellyte	205	"	7	65	6
957	Porphyrellyte	205	"	7	65	6
958	Conglomeritic porphyrel	205	"	7	65	6
959	Porphyrellyte	205	"	7	65	6
960	Gabbro with magnetite	206	"	7	65	6
961	Flinty porphyrellyte, contact	206	"	7	65	6
962	Magnetitic gabbro, contact	206	"	7	65	6
963	Gabbro	206	"	7	65	6
964	Gray semi-crystalline slate	208	" Can.	..	65	7
965	Average gabbro	.....	"	21	65	7
966	Gabbro slate	209	"	21	65	7
967	Olivinitic gabbro	209	"	21	65	7
968	Greenstone	209	"	21	65	7
969	Magnetitic gabbro	209	"	21	65	7
970	Gabbro w. white feldspar	209	"	21	65	7
971	Gabbro from N. bluff	209	"	21	65	7
972	Gabbro w. much olivine	209	"	21	65	7
973	Siliceous schist	210	"	..	..	..
974	Gabbro	197	Canadian Lake.. } Canada.	..	..	..
975	Argillyte becoming mica schist	197	"	..	..	..
976	Kawasachong argillyte	197	Pseudo-messer L.	..	..	..
977	Porphyrel	197	"	..	..	..
978	Micaceous green rock	.....	"	..	..	..
979	Sericitic schist	327	Pipestone Falls	..	..	..
980	Quartzitic argillyte	327	Garden lake	29	63	11
981	Magnetitic siliceous slate	.....	"	29	63	11
982	Banded quartzyte	327	"	29	63	11
983	Mica sch. and magnetit. quartz	.....	"	29	63	11
984	Mica and chloritic schist	328	"	29	63	11
985	Hornblende sch. w. above	328	"	29	63	11
986	Porphyrellitic schist	328	"	28	63	11
987	Micaceous schist	328	"	28	63	11
988	Crumbling sericitic sch	328	Vermilion mines near Tower			
989	Fine banded quartzyte	328	" "			
990	Graphite, near Tower	328	" "			

APPENDIX II.

Catalogue of lakes and portages along the national boundary.

LAKE SUPERIOR. **1.** Grand Portage. 8 miles. XVI Report, p. 291.	
PIGEON RIVER. **2.** Partridge Portage. .25 mile. XVI Report, p. 289.	
PIGEON RIVER. **3.** English Portage. .33 mile. XVI Report, p. 289.	
PIGEON RIVER. **4.** Portage. .6 mile. XVI Report, p. 288.	
PIGEON RIVER. **5.** Long Portage. 1.5 miles. XVI Report, p. 287.	
SOUTH FOWL LAKE. (No portage.)	*South Fowl Lake* (Treaty). *Lac de Coq* (Norwood).
NORTH FOWL LAKE. **6.** Portage. .75 mile. XVI Report, p. 282.	*North Fowl Lake* (Treaty). *Lac de Coq* (Norwood).
MOOSE LAKE. **7.** Portage. .66 mile. XVI Report, p. 281.	
PIGEON RIVER. **8.** Portage. .25 mile. XVI Report, p. 281. Twin Lily Lakes.	*Lower Lily Lake* (Norwood).
PIGEON RIVER. **9.** Portage. .25 mile. XVI Report, p. 281.	*Upper Lily Lake* (Norwood).
MOUNTAIN LAKE. **10.** Divide Portage. .33 mile. XVI Report, p. 281.	*Hill Lake* (Norwood).
ROVE LAKE.—East part. (No portage.)	*Watab Lake* (Norwood).
ROVE LAKE.—West part. **11.** Portage. 1.5 miles. XVI Report, p. 276.	"*Several small ponds connected by narrows*" (Norwood).
ROSE LAKE. **12.** Rat Portage. .25 mile. XVI Report, p. 274.	*Mud Lake* (Norwood and N. H. Winchell).

Catalogue of lakes and portages along the national boundary.

RAT LAKE. **13.** Portage. .25 mile. XVI Report, p. 274.	12th portage (Norwood).
SOUTH LAKE. **14.** Watershed Portage. .33 mile. XVI Report, p. 272.	*Ashawiwisigaton* (Norwood). 13th portage (Norwood).
NORTH LAKE. (No portage - rapids) XVI Report, p. 270.	*Mountain Lake* (Norwood).
GUNFLINT LAKE. **15.** Gunflint Falls Portage. .10 mile. XVI Report, p. 233.	*Flint Lake* (Norwood).
BOUNDARY RIVER. **16.** Blueberry Portage. .13 mile. XVI Report, p. 232.	
BOUNDARY RIVER. **17.** Lost River Portage. .5 mile. XVI Report, p. 230.	
PINE LAKE. **18.** Twin Bay Portage. .25 mile. XVI Report, p. 229.	
BASIN LAKE. **19.** Portage. .25 mile. XVI Report, p. 228.	
BOUNDARY RIVER. (No portage—3 rapids—chutes.)	
GRANITE LAKE. **20.** Upper Granite Falls Portage. .12 mile. XVI Report, p. 227.	Banks' Pine L. (N. H. W.)
BOUNDARY RIVER. **21.** Granite Falls Portage. .10 mile. XVI Report, p. 227.	
SAGANAGA LAKE. **22.** Oak Portage. .10 mile. XVI Report, p. 211.	*Saigaganaga* (Treaty). *Seiganaga* (Bell).
OAK LAKE. **23.** Portage. .25 mile. XVI Report, p. 211.	*Swamp L.* (Treaty). *Poplar L.* (Bell).
OTTER-TRACK LAKE. **24.** Little Knife Portage. .10 mile. XVI Report, p. 208.	*Cypress L* (Treaty). *Otter L.* (Bell).

Catalogue of lakes and portages along the national boundary.

KNIFE LAKE.
25. Portage.
.3 mile.
XV Rep , p. 144.

POTATO LAKE.
26. Portage.
.3 mile.
XV Rep., p. 144.

SEED LAKE.
27. Portage.
.25 mile.
XV Rep., p. 144.

MELON LAKE.
28. Portage.
.10 mile.
XV Rep., p. 144.

Big Knife Portage.
.75 mile.
XVI Rep., p. 196.

MAPLE LEAF LAKE.
Portage.
.10 mile.
XVI Rep., p. 196.

PSEUDOMESSER LAKE.
29. Portage.
.25 mile. XV Report, p. 142.

Sucker or Carp (N. H. W.)
Carp or Sucker Portage (Bell).

SUCKER LAKE.
(No portage.)
XV Report, p. 141.

Birch Lake (Bell).

CARP LAKE.
30. Prairie Portage.
.15 mile. XV Report, p. 120.

BASSWOOD (or Bassimenan) LAKE.
31. (No. 1 rapids), Portage.
.10 mile. XV Report, p. 111.

Lac du Bois Blanc (Treaty).
Whitewood L. (Bell).

BOUNDARY RIVER.
32. (No. 2 rapids), Portage.
.25 mile. XV Report, p. 112.

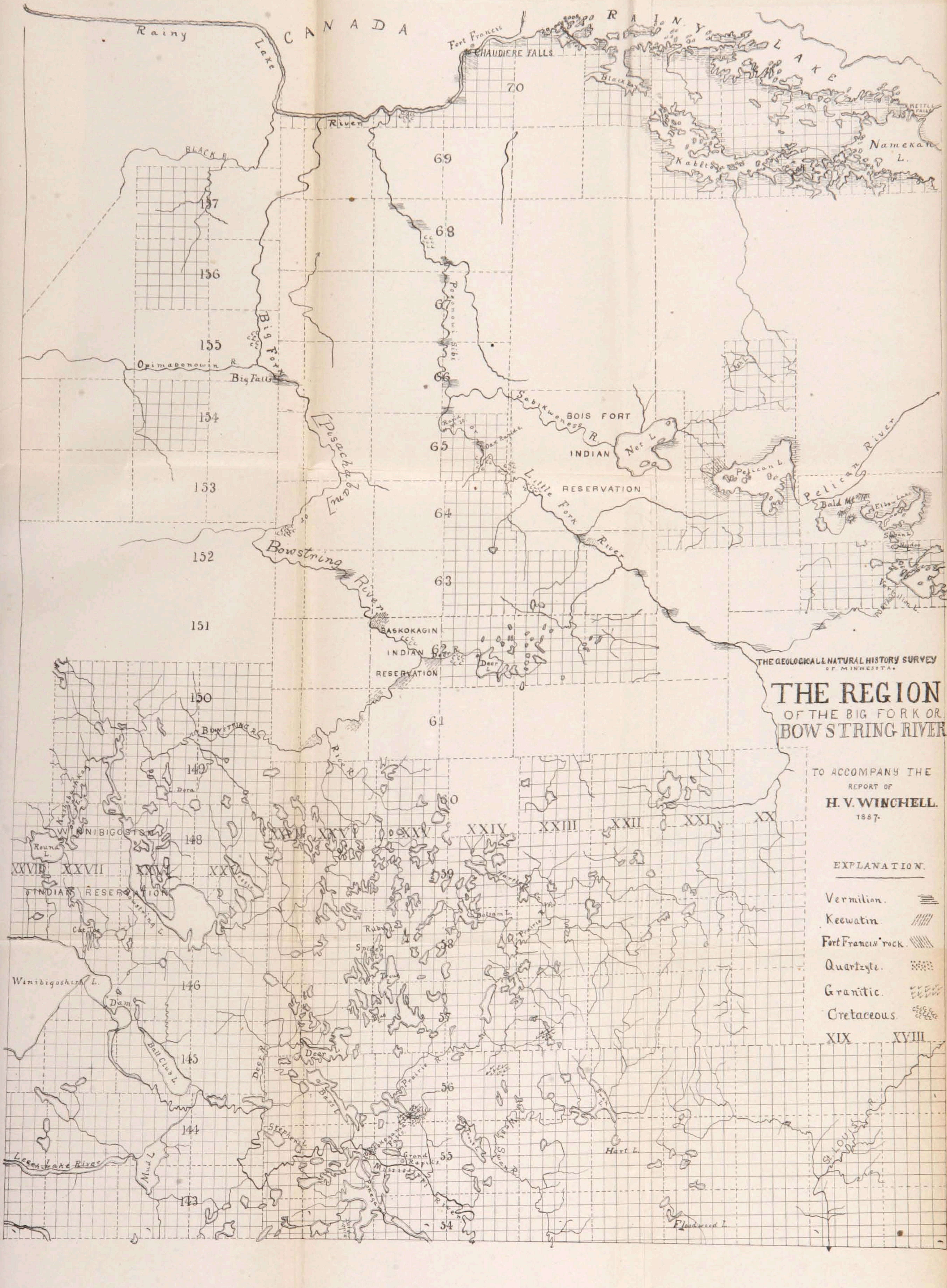
BOUNDARY RIVER.
33. (No. 3 rapids), Portage or chute.
.10 mile. XV Report, p. 112,

BOUNDARY RIVER.
34. (No. 4 rapids), Portage.
.25 mile. XV Report, p. 112.

BOUNDARY RIVER.
35. (No. 5 rapids), Portage.
.10 mile. XV Report, p. 113.

Catalogue of lakes and portages along the national boundary.

BOUNDARY RIVER. **36.** (No. 6 rapids), Portage. .35 mile. XV Report, p. 114.	
BOUNDARY RIVER. **37.** (No. 7 rapids), Portage. .15 mile. XV Report, p. 114.	
BOUNDARY RIVER. **38.** (No. 8 rapids), Portage.	
CROOKED LAKE. **39.** (No. 9 rapids), Portage. .15 mile. XV Report, p. 118.	
IRON LAKE.	



THE GEOLOGICAL & NATURAL HISTORY SURVEY OF MINNESOTA.
THE REGION OF THE BIG FORK OR BOW STRING RIVER.
TO ACCOMPANY THE REPORT OF H. V. WINCHELL. 1887.
EXPLANATION.
Vermilion.
Keewatin.
Fort Francis' rock.
Quartzyte.
Granitic.
Cretaceous.
CANADA
Rainy Lake
RAINY LAKE
Fort Francis
CHAUDIERE FALLS
River
Black Bay
Namekan L.
Kabetogama
BLACK R.
Opimabonowin R.
Big Falls
Big Fork
Pegamowi Sibi
Sabikweness R.
BOIS FORT INDIAN RESERVATION
Net L.
Little Fork River
Pelican L.
Pelican River
Bald Mt.
Elbow Lake
Vermilion L.
Bowstring River
BASKOKAGIN INDIAN RESERVATION
Deer R.
Deer L.
BOWSTRING R.
Rice R.
Dora L.
WINNIBIGOSHISH INDIAN RESERVATION
Round L.
Cass L.
Bowstring L.
Winibigoshish L.
Dam
Ball Club L.
Leech Lake River
Mud L.
Deer R.
Deer L.
Prairie R.
Balsam L.
Ruby L.
Spider L.
Trout L.
Blue L.
Grand Rapids
Mississippi River
Swan R.
Hart L.
Floodwood L.
St. Louis River
70
69
68
67
66
65
64
63
62
61
60
59
58
57
56
55
54
157
156
155
154
153
152
151
150
149
148
146
145
144
143
XXVIII
XXVII
XXVI
XXV
XXIV
XXIII
XXII
XXI
XX
XIX
XVIII

REPORT OF H. V. WINCHELL.

REPORT OF OBSERVATIONS MADE DURING THE SUMMER OF 1887.

By Horace V. Winchell.

Region traversed. During the months of July and August, an exploration covering a wide extent of territory was carried on. The writer, together with Mr. H. W. Fairbanks, of the University of Michigan, Mr. W. F. Trussell, of the University of Minnesota, and two Indian canoe-men, started from Tower, on Vermilion lake, with two birch-bark canoes and the necessary equipment for such a trip. The route, as here described, can be traced on the accompanying map.

The Little Fork river was reached by a four and a half mile portage from Vermilion lake. Eight days were spent in descending that stream to Rainy Lake river. No settlers were seen and not a traveller whether Indian or white man in that space of time.

We then ascended this large river, which forms the boundary line between the United States and Canada, as far as Fort Francis, which is situated at Chaudiere falls at the west end of Rainy lake. Our course for the next two weeks was along the south shore of Rainy lake through Black bay and into Namekan or Sturgeon lake by a portage of three-quarters of a mile; through Namekan lake to the east end, and south to Sand Points lake, through which Vermilion river runs before reaching Namekan and Rainy lakes, then north-west into Rainy lake again and back to Fort Francis along the south shore of the lake. It may be remarked that the water in all of the lakes and streams traversed during July and the first half of August was unusually high. It rained almost every day and sometimes continuously for a period of 24 hours while we were there. The Indians and white settlers along Rainy lake and Rainy Lake river said that it had been many years since they had known the water to be so high. This was unfortunate for geological investigation; as the outcrops were fewer and the exposure far less extensive than at times of low water.

From Fort Francis, Rainy Lake river was descended to the Big Fork river. Ascending this rapid stream by dint of hard paddling, poling and portaging, about 150 miles south and southwest, a portage of three-quarters of a mile took us across the divide between waters flowing north and south. This portage leads from Round lake into a small lake just south of it which is tributary to lake Winibigoshish and the Mississippi river. We next went down the Mississippi to Prairie river, making a stop at Pokegama lake to examine the hills at the south end, then up Prairie river and into the country which it drains, and finally down the Mississippi to Aikin on the Northern Pacific railroad. The month of September was spent in examining Elbow, Pelican, Net and Trout lakes. In this work the party consisted of W. F. Trussell, Frank Sopher a man who was acquainted with the region, and the writer. Some time was lost on account of high winds which rendered it impracticable to travel in a canoe.

Naturally the character of the country varies greatly in different regions. In the vicinity of Rainy, Namekan, Net, Pelican and Trout lakes it is very rocky, and all around the shores are numerous rock exposures; while west of these lakes the surface of the country consists of drift deposits and the underlying rock appears only at rapids or waterfalls in the streams and a few places in the midst of the forest. A large area of the land traversed by the Big Fork and Little Fork rivers is within the limits of the glacial lake Agassiz. This region is now covered with a fine growth of timber, both hard and soft wood, and is excellent farming land. It is slightly rolling or else flat and well watered by these large rivers and their numerous tributaries. Much of the pine that stood within a few years along these streams has been stolen and floated down to Lake of the Woods. This unlawful destruction of some of the finest of our Minnesota pine seems to be carried on every winter, as many of the logs freshly cut still lie around.

The following report is merely a transcription and rearrangement of the notes taken on the trip and follows very nearly the order of the journey. No attempt has been made to study the specimens collected. It will be a subject for future investigation to inquire into the lithological characters and relations of these rocks.

LITTLE FORK RIVER.

No exposures of solid rock are seen on the four and a half mile portage which starts from Vermilion lake in sec. 21, 63-18 and leads to the Little Fork. The portage crosses two large swamps and several small ones.

Some large irregular masses of biotite mica-schist give indication of the underlying rock. These chunks are cut by granite and syenite intrusions. Beds of drift gravel and sand are seen.

When the Little Fork is reached the character of the country is found to have undergone a marked change. There is more soil, clay and till, and consequently a larger and more luxuriant growth of forest-trees and shrubs.

The portage trail runs west for about a mile and then S. W. or S. S. W. The trees are poplar, pine, birch, elm, balm of Gilead, willow, spruce and tamarack. The country is low and not hilly. The Indian chief "Wakemaup" reports native copper in the rock at the falls twenty miles below here; he says he has cut it with his knife.

Descending the river in a general north-west direction the first rock is met with at about two miles. This is a low outcrop of massive dioryte. The outcrop is on the north side of the river and is seen for an extent of several rods, No. 75 (H).

There are occasional granite boulders in the river. The course of the stream is west for several miles.

About three miles below is Rapid No. 1.* The river falls about two feet in ten rods or less. Near the river the rock is a siliceous mica schist containing calcite and a varying amount of feldspar. On the ridge south of the river the schist becomes a fine biotite granite and contains veins and lumps of muscovite granite. It also effervesces with acid, and contains considerable pyrites. The exposure is not sufficient to determine the strike or dip. Nos. 76 (H), 76 A (H) 76 B (H). This schist seems to be uplifted by a moderately coarse, dark, tough massive rock somewhat like 75 (H) but coarser and containing magnetite (?). It has come up through the schist in places and forms a ridge running nearly north and south across the river. No. 77 (H).

About four miles below this rapid another short rapid is encountered. It is about 60 feet long and the river falls about a foot. This is Rapid No. 2. It is over mica schist or hydro-mica schist. Dip S, 70°, Strike and schistosity N. 80° E. The exposure rises only three or four feet above the water and extends but a few feet. It is coarsely fissile. A few large granite boulders lie about. White or bur oak, basswood, elm and ash trees appear among the other forest trees here. No. 78 (H).

About three-fourths of a mile below Rapid No. 2, Rice river joins

* The water was so high in this river in 1888 that an Indian said it was "all one rapid," under which circumstances the rapids here enumerated would be indistinguishable.

the Little Fork; and a short distance below the confluence is a fall of about three and one-half feet and a rapid fall of a foot or two more. Rapid No. 3. This fall is over mica schist: some of it is very hard and siliceous, some soft, micaceous and fissile. There are beds of quartzyte and veins or beds of quartz in it. Dip. S. 60°—70°. Glacial striæ N. 20°E. strike east and west. The rock rises eight or ten feet above the water at the falls. The gorge is 40—50 feet wide and affords a good place for a dam.

In some places the beds of schist and quartzyte are much mixed up and cross and cut each other in all directions. No. 79 (H).

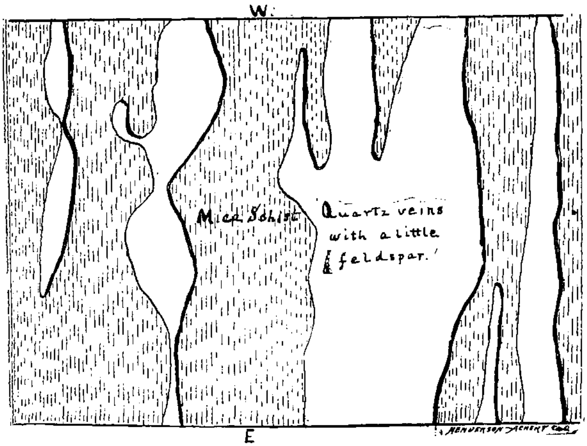


Fig. 1.—*Rapid No. 3, Little Fork river.*

About a quarter of a mile below the last is Rapid No. 4. It is a short rapid over boulders of granite.

A mile farther down is Rapid No. 5, about a quarter of a mile long. It produces a fall of six or eight feet in the river. There are a great many boulders of all sizes in the river and along the banks; no limestone boulders are to be seen as yet.

The rock is typical mica schist containing much fine biotite. There are inclusions of gneiss and syenite. The strike at the upper end of the rapid is S. 20° E. Dip is W. 80°. There are a few light-greenish felsitic pieces in the river that look as if they came from the rapids; but no rock like them could be found in place. They contain much pyrite which may be Wakemaup's "copper."

Two miles and a half or three miles below this is Rapid No. 6. It is about ten rods long and the fall is six or seven feet.

The rock is mica schist cut by a few granite intrusions. It is quite solid and compact but does not appear in any large outcrops. This rapid is just above the mouth of a river that comes in on the north side.

Between Rapids No. 5 and No. 6 are several places where there are boulders to be seen in the river and along the banks. This was not so above Rapid No. 5; perhaps because of the high stage of the water at the time.

The river continues in a western direction, sometimes running off for quite a while in a S. W. course.

Some of the schist at Rapid No. 6 contains so much feldspar and quartz that it might properly be called gneiss; and some has so little mica and feldspar as to constitute a grayish quartzyte.

Three miles farther down is a low outcrop of mica schist cut by gneiss. No. 80 (H) shows the contact. It is on the south side of the river.

About four miles below is a small outcrop in the bank on the north side of the river. It is a greenish schist much like the Vermilion lake graywacke, containing a few mica scales and some pyrites. No. 81 (H).

About a mile below this are the "Big Falls" of the Little Fork. The fall is about 16 feet over a very much jointed, but quite fine-grained and compact green schist. It stands nearly vertical or with a high dip to the west. The strike is irregular but generally about N. 20° E. It is a rock that varies a great deal in different beds or layers. Some strata are very siliceous and hard with a tendency to basaltic structure; some very fissile and sericitic and some highly ferruginous with pyrites. Most all of it seems to contain considerable dolomite or calcite not only in seams but in the rock itself. There is also a greenish-black mineral or ore found in the seams. No. 82 A (H). Numerous quartz veins penetrate the rock, and part of it seems to contain much feldspar or felsyte. See No. 82 (H). This is Rapid No. 7.

No rock *in situ* is seen until Rapid No. 8 is reached, about 1½ miles below the falls. This is a low outcrop of the same rock as that at the falls. One who has come down the river from the region of mica schist to this fine-grained schist containing little or no mica cannot fail to have noticed the gradual change in this rock and the similarity of contiguous outcrops which go to prove it all of one formation.

About half a mile below this is Rapid No. 9, perhaps four rods long with a fall of about two feet.

Here there is an exposure of micaceous syenite gneiss which appears to be horizontally bedded. It is cut by veins of syenite and gneiss. There are large lumps of green material in the rock. No. 83 (H.)

About three miles below the last is Rapid No. 10; boulders being the only rock seen in that distance. This rapid is 12 or 15 rods long and descends 5 or 6 feet over a bed of boulders as far as could be seen. There are some rough pieces that seem to be broken from the underlying rock, and are of the gneiss and mica schist formation. The rock here has more quartz and feldspar than is the case generally farther east. Some of it is syenite containing a little mica. Sometimes, as for example on the portage around the south side of the "Big Falls," large masses of amphibolyte are seen that appear to be near home; but it was not seen in place. It is a heavy, massive, crystalline rock, apparently composed entirely of hornblende. It is noticeable that boulders and gravel in the stream are becoming of more frequent occurrence; and the country has a heavier covering of drift—gray clay with a few boulders. The land is low, but not swampy, and is good for farming. The river is large and still runs mainly west. Balm of Gilead and poplars constitute at least half the forest; ash and oak are numerous, and a few box-elders are seen.

About a mile and a half below Rapid No. 10 is a bank of gravel and boulders, among which are seen pieces of limestone. No. 84 (H.)

From here down the boulders are very numerous. About two miles and a half below is Rapid No. 11 over boulders of syenite containing a variable amount of hornblende. The rapid is short and the fall is not more than two feet.

A quarter of a mile farther is Rapid No. 12, only about a rod long, with a fall of about a foot. About three quarters of a mile below Rapid No. 12 is a bank of clay which contains boulders and is cut through by the river. The drift hills are higher here, and on the north side of the river this bank is 12 or 15 feet high. It contains limestone pebbles and clay concretions. No. 85 (H.)

Less than half a mile below this is Rapid No. 13 which descends about seven feet in a few rods. Here there is a large outcrop of very interesting rock. It is composed of coarse crystals of orthoclase running mostly all in the same general direction, mica, hornblende and a a little quartz, and contains garnets.

There is a long smooth-topped outcrop on the north side of the river, the general direction of which, as well as of the feldspar crystals in it is E 50° S. The only evidence of bedding is the direction of the majority of the crystals and also the direction of inclusions of fine mica schist which are numerous in the hard surface of the rock. These inclusions are softer than the rest of the rock and so the surface presents concavities where they lie.

Some of the crystals of orthoclase are nearly two inches long and are generally quite narrow. The rock has veins of granite running through it. The mica schist inclusions seem to stand with their bedding vertical; and the rock itself presents some appearance of it also. Boulders of this peculiar porphyritic rock had been seen in the river S. E. of this place. See No. 86 (H).

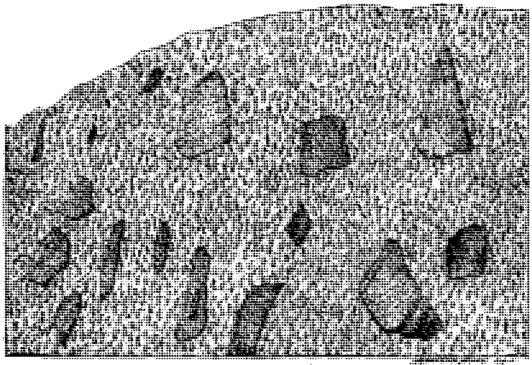


Fig. 2.—*Porphyritic Breccia. Rapid No.* 13, *Little Fork river.*

About a mile further down is Rapid No. 14 over boulders as far as could be seen. The principal rock is like 86 (H) but finer.

Half a mile below a large river enters on the south. It is called Sturgeon river by the Indians. Below this is a high ridge on the north side of the river.

About a mile further is Rapid No. 15, where the river cuts through drift hills 60 or 75 feet high. The rapid is 15 or 20 rods long, and the river falls about three feet.

A mile below the last is Rapid No. 16, about 5 rods long over boulders. Small pieces of limestone are seen in most all of the drift ridges now; and there is more sand mixed with the clay.

There is very little large timber growing here. Dead stumps of trees reaching up above the smaller growth of late years give evidence of what a fine forest existed here before fires ran over the country and destroyed the vegetation. There are good-sized elm, ash, birch, balm of Gilead and aspens along the river, and enormous spruces and cedars occasionally; but the valuable timber is ruined.

A little more than a mile further down is Rapid No. 17, a small rapid. A few limestone boulders here are a foot in diameter. See No. 87 (H).

About quarter of a mile further is Rapid No. 18, a short rapid over boulders and gravel. Just before reaching it is a clay bank on the west side of the river over 50 feet high.

Two miles further is an exposure of syenite gneiss just above Rapid No. 19. This gneiss has the same general character as that at Rapid No. 13, except that it contains much less mica, some of it none at all. There are garnets in it as in the other and also a few of the mica or hornblende schist inclusions. The rock at the south side of the outcrop is greenish schist containing mica and hornblende and but little feldspar.

This rapidly graduates into syenite poor in quartz, and further north this contains more feldspar than any other mineral. This syenite gneiss seems to be vertically bedded and to strike N. 10° E. No. 88 (H).

About two miles below the last is Rapid No. 20, where the river falls 8 feet in 100 yards or less. There are numerous large boulders here and a low exposure of fine green schist that looks like fine diabase. It is polished wonderfully smooth on the surface by glaciation. The direction of the striations is N. 10° E. Bedding is vertical; strike E. and W. It is full of joints, and a hand sample of regulation size can with difficulty be obtained. It is cut by a dyke of light-colored rock composed of quartz, feldspar, mica, hornblende, and garnets. It narrows down from six feet to one foot in 15 feet, going N. 20° E. It does not appear in abrupt contact with the green schist. Nos. 89 (H), 90 (H).

Forty rods farther is Rapid No 21, where there is a fall of two feet over boulders. Half or three-quarters of a mile below is Rapid No. 22. Just above this is an exposure on the south side of the river. It is a greenish mica schist that has a striking resemblance to that at Rapid No. 20; but contains much mica in fine scales. Bedding is vertical; strike N. 70° E; glacial marks N. 10° E.

Included in this mica schist are patches of a different kind of mica schist, also with vertical bedding and same strike. The schist contains quartz veins. Nos. 91 (H), 91 A (H).

Half a mile farther is Rapid No. 23, about four rods long with a fall of 4½ feet. The rock is mica schist similar to the last and containing quartz veins. Strike N. 80° E. Dip S. 70°. About a mile below a river enters on the east.

About two miles below the mouth of this river is Rapid No. 24, over boulders for a few rods. Two miles further on a good-sized stream comes in on the south, and 1¼ miles farther a large creek enters on the east.

Very few boulders and no solid rock is seen for several miles along here. The river-banks are of clay. Just below the mouth of the river on the N. E. side is a clay bank 20 feet high. It is horizontally stratified and contains a few small pebbles. It is gray and somewhat sandy and appears to be of lacustrine or river deposit; but may be Cretaceous.

About half a mile farther is Rapid No. 25, about a quarter of a mile long over boulders. A short distance below, a creek enters from the S. W., and at the mouth of it is Rapid No. 26—a short rapid formed by boulders.

A little below this is a rapid 40 rods long or more over a bed of boulders. This is Rapid No. 27. Below this rapid for some distance the water is almost continually rapid and boulders are numerous. There is a sand and gravel bed here of which limestone pebbles constitute about one-half. Below this on the other side is a bank of boulders in which are some of limestone three or four feet in diameter. No. 92 (H).

Just around the bend a creek comes in on the east side, which has washed out a large bed of pebbles, most of which are limestone. The banks of this creek are lined and covered and fairly white with limestone. Lignite in a mass eight inches long, six inches wide and three inches thick, was found here. No. 93 (H). The banks of the creek are formed of very fine, sticky, horizontally stratified clay, which becomes hardened shale on drying. This clay is fine, soft, bluish-gray Cretaceous, in strata of from one to three inches thick. The banks of the creek for one-fourth mile back from the river are 20 to 25 feet high and formed of this shale. A total thickness of at least 40 feet can be seen at this place. A few cycloid fish scales and other fossiliferous remains were found in this shale.* Some gravel was seen in the clay in one or two places; also aggregations of fibrous yellow needles of aragonite. Nos. 94 (H), 95 (H), 96 (H), 97 (H), 98 (H) are from here.

It is remarkable to see the variety and number of boulders and pebbles that are in this creek bed. Limestone masses five feet thick occur; also pieces of a very peculiar conglomerate as well as of a fine, pink sandstone that looks like the Potsdam.

Half a mile farther down is a hill apparently composed of till which rises 50 or 60 feet above the river. A short distance below this is a

* Microscopic examination of this shale by Messrs. Woodward & Thomas reveals characteristic Cretaceous foraminifers.

bluff, 40 feet high, of shale. It is all very slippery and fine, with here and there a pebble. No fossils were found here. On the east side of the river below here the clay hills are 80 feet high.

Nothing worthy of note is seen for the next six miles; boulders are few and no solid rock is visible. At six miles a stream which has been used for driving logs comes in from the south, and forms a large bed of gravel and sand at its mouth. The banks of this stream are formed of the same muddy shale. The hills in this vicinity are 75 feet or even 100 feet high; and seem to be horizontally stratified to the very top. A few fragments of lignite were found here.

About two and one-half miles below this stream is Rapid No 28, over some large boulders in the stream. There are some large flat masses of siliceous mica schist that do not appear to have traveled far; but the covering of drift and Cretaceous is too thick for the solid rock to be exposed.

About two and a half miles down the stream is seen the first meander corner. It is between sections 22 and 23, T. 65-24. A little below here a small stream enters from the S. E., and there is an old logging camp, "Seller's Camp."

About a mile below this camp, in the N. E. ¼ sec. 22, 65-24, is Oak Rapids (Rapid No. 29). At the top of these rapids is an outcrop of mica schist in the bed of the river. Strike is E. 10°S.; dip S. 20°. This schist may not be in its original position, although it appears to be. No. 100 (H). This rapid produces a fall of five or six feet in less than one-quarter mile. Considerable mica schist is exposed on the N. E. side. It is interbedded with gneiss. No. 101 (H). The schist near the foot of the rapids contains much quartz in veins, and many small garnets or grains of rose quartz. No. 102 (H).

At the west line of sec. 7, T. 65-24, is Rapid No. 30, over boulders for about five rods.

Just below the place where the river leaves T. 65-24 is Rapid No. 31, called "*Dead Man's Rapid.*" The rapid is over mica schist interbedded with gneiss, and the river falls ten or fifteen feet in about eighty rods. The schist dips south 72°. Strike is N. 80°E. It is very siliceous and also contains quartz veins. The beds of granite or gneiss are of all thicknesses up to three or four feet. Some of the schist weathers red on the surface, and some contains much hornblende. Part of the gneiss contains a bright green mineral near the surface. The outcrop is low and only rises a few feet above the water. No. 104 (H).

Around the point just below this rapid is a low exposure of massive syenite or dioryte. There are two sets of glacial striæ; one N. 20° E., the other E. 10° S. They are both well defined; but it could not be told which was of later date. This rock extends for two or three rods along the north bank. No. 105 (H).

A short distance below, on the other bank, is the ordinary mica schist cut by granite; so the dioryte is not very extensive, but may be in a dyke. It is very hard and massive; hardly a joint or crack being seen in the whole of it. Several very large granite boulders lie in the river near here, some 15 or 20 feet in diameter.

Half a mile below "Dead Man's rapid" is Rapid No. 32 over an ugly barrier of boulders.

A mile below this is Rapid No. 33, about 15 rods long over boulders. The river falls about 2 feet.

Half a mile farther is Rapid No. 34. Here there is an outcrop of mica schist, fine, biotitic and ferruginous, interbedded closely and strikingly with biotite-muscovite gneiss.

The gneiss and schist are in nearly vertical strata; dip S. 32°W. 75° and strike N. 58°E.

Less than one-quarter mile below is Rapid No. 35, a short rapid over boulders. The banks along here are higher than have been seen for some time.

About 2 miles farther is a meander corner between sections 19 and 24, Twps. 66–24 and 66–25.

The hills below for several miles seem to be composed principally of till containing small boulders with which there is mixed considerable limestone.

Six miles from the last rapid is Rapid No. 36, having a fall of about a foot in a few rods. No rock but boulders was seen here.

About 1¾ miles farther down is a low outcrop of interbedded mica schist and granulyte, exposed for about 5 rods along the N. W. bank of the stream. The schist is vertically bedded; strike is N. 70° E. There are indications along the banks of the river of water in the river 12 feet higher than at the time these notes were taken, (July 5th.)

Two and a half miles farther, about in the N. E. ¼, T. 67–25, is an outcrop of doleryte less than a foot above the water. It is apparently a dyke running across the river N. and S. Glacial marks are long and deep, N. 42° E. No. 106 (H.)

Just below, around the point is an outcrop of mica schist interbedded with thin beds of gneiss. Strike is E. and W. Dip N. 65°. It is quite thin-bedded and is the characteristic rock of this whole region. In places it is hard to say which is schist and which is gneiss, or where one bed stops and the other commences, and again they are separated quite distinctly. It will be noticed that the dip has changed to the north. This schist causes Rapid No. 37, short and not steep. About a mile below a good sized stream enters on the south side.

Two miles further down is a low exposure of inter-bedded gneiss and mica schist. Glacial striæ are N. 40°E. Dip N. 50°. Strike E and W. The beds are very thin, fifteen alternating beds in a thickness of one foot being counted in one place.

About five miles farther down is Rapid No. 38 over boulders which probably rest on mica schist, as that is the material of which most of them are composed. There seem to be very few boulders in the till here. Small white pine and tamarack trees are beginning to be abundant. Box-elder is plentiful and soft maples are seen here and there.

Two miles farther down is a bank of Cretaceous shale on the west side of the river. It is sub-jacent to a mass of till and gravel. The latter contains many limestone pebbles. A few of these pebbles seem to be in the shale too. The bank consists of 20 feet of shale, and 10 feet of drift on top. The water from the surface filters down through the till and not being able to get through the shale forms springs of cold water coming out in the bank at many places. The shale is always wet and slippery and in thin beds. By a bed is meant a layer of clay with a line of fine sand or sandy clay at the bottom of it. The shale separates easiest at the line of sand.

Half a mile further is a low outcrop of mica schist and gneiss, and near it two immense granite boulders that look as if they were once one piece.

Three miles farther down the stream is a large, slightly elevated exposure in the middle of the river. It is nearly round and about 100 feet in diameter. It is composed of mica schist interbedded with and cut in all conceivable directions by coarse gneiss. This gneiss runs principally with the schist, but there are large and small veins that run straight across and twist through the schist in such a manner as to make a very rough and irregular surface where the gneiss stands above the weathered and washed out schist. The gneiss is very coarse; the crystals of feldspar and mica, both biotite and muscovite, being four and sometimes six inches on a side. The mica and quartz are often blood-red. The gneiss also contains garnets and tourmaline crystals four inches long, besides a green mineral that resembles beryl. Beds of rock composed mainly of biotite and augite occur in the schist.

The south side of this outcrop has a south dip; then comes a hard, wide bed of fine schist on the other side of which the dip is north at an indefinite angle. The general strike is about E. 20°S. Glacial striæ N. 22°E. Most of the feldspar is orthoclase, but there is also a light bluish-green feldspar in parts of it. Nos. 107 (H), 107A (H), 107B (H) and 108 (H) are samples from here. The large crystals of mica, as well as the biotite-augite (?) inclusions or beds, stand on edge.

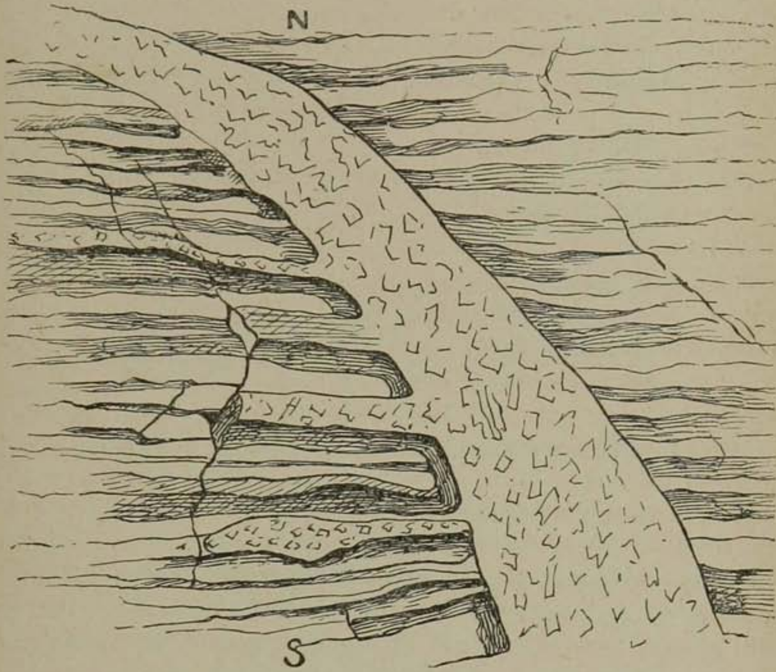


Fig. 3.—*Mica schist cut by granite, Little Fork river.*

The large intrusion of granite seen in the sketch to run across the beds seems to lie on the beds and not cut them much. It is very coarse. This is rapid No. 39 (Kabemabegetchiwak, "where the water goes round"). The river falls about three feet in the course of a few rods.

About a mile and a half below are three more outcrops of mica schist and gneiss. Strike is E. and W.; there is a high dip to the north.

About 3 miles farther on the west side of the river is a bank 18 or 20 feet high that has in the top of it about 10 feet of horizontally stratified clay of a light color and containing limestone, schist and other pebbles as large as 4 inches in diameter. No. 109 (H). This is probably in the bed of lake Agassiz.

Just below this is a low exposure of mica schist and gneiss in thin beds dipping north at a high angle and running east and west.

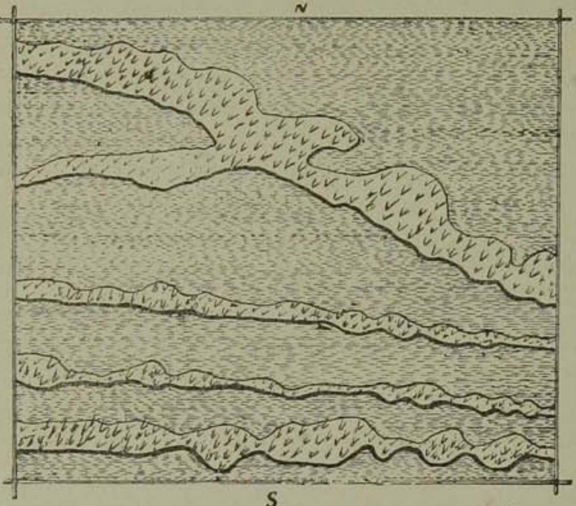


Fig. IV—*Mica Schist and Interbedded Gneiss, Little Fork river.*

About a mile below this is Rapid No. 40, over boulders for 20 rods. The river falls about 2½ feet.

Two miles below is a rapid fall of 6 feet over boulders. There is a clearing of 40 acres or more on a drift bluff 50 feet above the river. The Indians have come here each spring from time immemorial to catch sturgeon. Their name for it is *Onakaiamis* ("where the sturgeon run.") This rapid is No. 41 and is about 19 miles above Rainy Lake river.

About two miles below, Little Fork creek comes in on the east side. The drift hills and banks are 20 feet to 30 feet high here and are stratified at the top and perhaps all through.

About two and one-half miles further down is a layer of black gravel in the northeast bank of the river. It contains some magnetite. No. 110 (H).

RAINY LAKE RIVER.

Nothing particularly noteworthy is seen for the next fifteen miles, when Rainy Lake river is reached. The water in this river is much cooler and cleaner than that in the Little Fork, which is red and muddy. The banks are not more than 20 feet high and are more or less stratified. There seems to be an occasional exposure of Cretaceous shale. For eight and one-half miles up Rainy Lake river from the mouth of the Little Fork there is no rock to be seen in place. The banks are from five to fifty feet high and seem to be composed of till; but that cannot be positively ascertained as they are so rounded and covered with vegetation. There are numerous limestone boulders lying along the water's edge. There are settlers all along the British side and a few on the American. Oak trees are common and poplars are numerous.

About 3½ miles below Fort Francis is an exposure of mica schist in the middle of the river. Strike is N. 82° E.: dip N. 80°. Glaciation N. 32° E. This schist is quite fine and very fissile in places. It has a wavy, schistose structure running in the same general direction as the bedding. There are a few small beds of feldspathic material running through it. A couple of pieces lying on the surface which seem to belong here contain chlorite and pyrite and some other mineral. Nos 111 (H) and 112 (H).

About a mile and a half below Fort Francis is a long exposure of green hydro-micaceous schist on the British side. Strike is N. 40° E. Dip at a high angle to the north or vertical. There are a few scales of unaltered mica in the schist and some dolomite in the veins and seams. No 113 (H). There are some beds that are very siliceous with fine grains of quartz that crumble and separate with a slight blow of a hammer. They resemble the quartz beds in the jasper schists north of Tower. No. 114 (H).

There is a bed of green schist or rock possessing a schistose structure that runs so as to slightly cut the bedding of the schist. It is about two feet wide and continues for several rods. It seems to be a little softer that the other schist and has about the same composition. No. 115 (H). It looks as though it may have been of a dyke-like nature and had its schistosity formed at a later period by lateral pressure. The character of its constituents has also been changed.

A little further up the river on the same side is an exposure that rises 15 feet above the water. Here the schist contains twisted beds of quartz stained with iron which have a marked resemblance to those in the Vermilion lake rocks. No. 116 (H). See figs. 5 and 6.

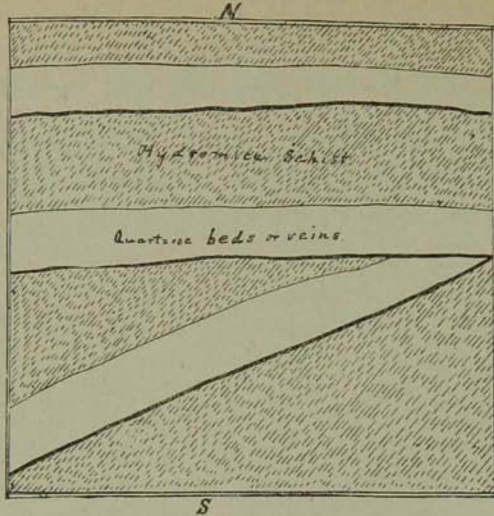


Fig. 5.—*Rainy Lake river.*

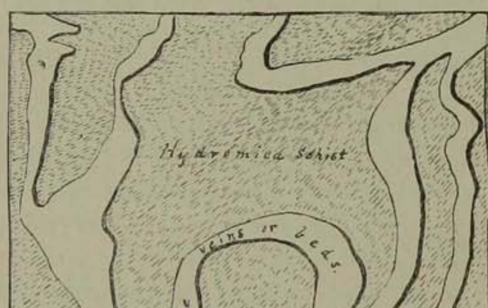


Fig. 6.—*Rainy Lake river.*

On the south end of a small island in the middle of the river is a small, massive outcrop of porphyritic granite. It is exceedingly porous but tough. Crystals of feldspar less than an inch in length stand out all over the surface The rock also contains mica and hornblende or chlorite and a very little quartz. Going east a short distance nodules of hardened mica schist are seen enclosed in the other rock. Soon the porphyry* begins to have more and more of the green minerals in it; and finally it becomes fine, hard mica schist. Along the strike there is a gradual transition from porphyry to schist; but in one or two spots they have an abrupt contact. Some of the nodules are porphyritic. Nos. 117 (H), 117 A (H), 117 B (H), 117 C (H), 117 D (H), 117 E (H) and 117 F (H) are from here.

The island just east of this one is composed of the same porphyritic rock with beds (for it certainly is bedded in places) of a fine crystalline greenstone. It is astonishing how quickly an apparently massive igneous rock can become gneissoid and then schistose. There seems to be no choice between hornblende and mica; of two specimens taken out of the solid rock less than three feet from each other, one is micaceous and the other hornblendic. Nos. 118 (H), 118 A (H), 119 (H) and 120 (H).

The same porphyritic rock forms the American shore for a long way up the river. It contains masses of mica schist in it, entirely surrounded by the porphyry and merging into it. There are straight, well-defined bands of greenstone in it that seem to be dykes. The first one met with was hard trap at the west end, and schistose rock ten feet farther east. Nos. 121 (H) and 121 A (H).

Further along is a dike six feet wide cutting right through the porphyry. Its direction is N. 72° E. Dip S. 62°. On the surface, portions of this dyke look much like the porphyry, but of finer composition. The edges, however, are well marked and the contact abrupt. Nos. 122 (H) and 122A (H).

Sometimes the green mineral in the porphyry is like chlorite and the feldspar is pink instead of cream-colored or white as in most of it. No. 123 (H).

Just beyond the dyke last mentioned the porphyry contains masses of greenstone several feet in diameter, and winds and twists al around them. The most of this greenstone is similar to the dyke rock No. 122 (H), but on one side of one of the inclusions is regular mica schist which grades into the "greenstone." No. 124 (H).

---

*This rock has a semi-crystalline groundmass but is called porphyry here for convenience.

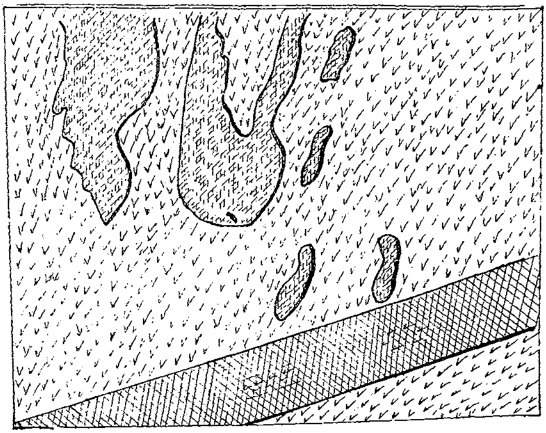


Fig. 7.—*Dyke cutting porphyritic breccia, Rainy Lake river.*

This porphyritic gneiss continues up to Fort Francis, where it forms a waterfall twenty-five feet high. At this place the rock has been blasted out to a depth of thirty feet to make a lock. The entire rock is shown by this means to contain the rounded lumps of dark schist of all sizes up to several feet in diameter, to a depth of at least thirty feet. No. 125 (H). There seems to have been some mighty metamorphosing agent at work, which uplifted and changed a belt of mica schist into porphyritic gneiss. The general direction of this ridge or belt of altered schist is from N. W. to S. E., i. e., if the similar rock at the west end of Pelican lake be, as seems probable, a continuation of this same rock.

Half a mile above the falls, on the American side, is a low outcrop of syenite, porphyritic with red and green feldspar. The red is very decidedly red, but seems to be orthoclase. No. 126 (H).

About a mile further is an outcrop of mica schist in vertical strata, with a strike N. 48°E. It appears the same as usual, and has nothing to show that it is so near an extensive belt of metamorphism. The shores of the sluggish stream conform to the strike of this schist all the way to Rainy lake. Some of it is exceedingly soft and fine, and crumbles easily.

The second rapid below the lake is over mica schist which contains many small quarts veins. Strike is N. 54° E ; dip north at a high angle.

The rock on the Canadian side at the Agency is hard and jointed and bears evidence of considerable baking. No. 127 (H).

RAINY LAKE.

Mica schist, much jointed and with fine veins of quartz and gneiss, is seen in a low outcrop on the point in N. W. ¼ sec. 29, 71-23. On the east side of this point the schist seems to be of two kinds; one siliceous and granular crystalline, the other soft and fine, both mixed and twisted up together. No. 128 (H) shows the two kinds in contact. In the small bay around this point are many large boulders of gneiss, schist and greenstone.

The point in the N. E. ¼ sec. 29, 71-23, is a low exposure of mica schist. The general strike is N. 70° E. There are beds of a semi-crystalline, grayish-green rock in the schist and running in the same general direction, but sometimes cutting the beds. This rock weathers faster than the schist and the surface is white from the feldspar in it. It contains also pyrite, hornblende and a soft green mineral, probably chlorite. There are three of these beds on this point. No. 129 (H). The dip of the schists is north at a high angle. There are small veins of quartz and granite in the schist.

The point in the N. W. ¼ sec. 28, 71-23, is composed of mica schist. Dip. is N. 72°. Strike N. 70° E. The strata of schist vary in different parts. One side, presumably that which was originally at the bottom, is coarser and darker than the other. When therefore the coarse side of one stratum comes in contact with fine upper side of another stratum they do not look like the same rock. The finer side of the beds is the north side at this locality. No limestone boulders have been seen since reaching the lake. The schist at this place contains veins of dark red quartz. No. 130 (H).

Around the point the rock becomes coarser and contains grains of siliceo-feldspathic material. Glaciation N. 32° E. No. 131 (H).

In the center of sec. 28, 71-23, the rock is a very fine, hard, green schist. The mica which it contains is exceedingly fine. No. 132 (H). The surface of this schist is sometimes covered with long slender crystals of hornblende. No. 133 (H).

Along the shore in the N. E. ¼, sec. 28, 71–23, the schist contains many very ferruginous quartz veins. Some of the beds of schist are quite decayed and jointed on account of the iron in them.

In this locality there is a trap dyke nearly 3 feet wide running E. 60° S. across and through the beds of schist. It does not seem to incline any from vertical. The surface of the rock is covered with small, green crystals that look like epidote, but seem too soft. Nos. 134 (H) and 134A (H.)

A little farther east is much more of the ferruginous schist in large, soft beds. No. 135 (H.) The general dip here is N. 45°. Small, crooked beds of granulyte occur in the schist and appear to become more numerous toward the east. The strike has changed to E. 10° S. Boulders of gneiss and mica schist interstratified with each other are becoming very numerous. The schist is occasionally quite hard and contains some hornblende. Dip is N. 40°. No. 136 (H.)

On one of the numerous sand beaches is a deposit of very green sand. It looks like the mineral seen on the surface of the dyke rock. No. 134 A (H.)

There is another small dyke a little coarser than the last a little farther east. Its direction is N. 60° E. It is about 2 feet wide and weathers light green on the surface. No. 138 (H).

The beds of schist begin to be very different from each other and contain much quartz and feldspar besides an undetermined green mineral. No. 139 (H). A little further along, still in sec. 28, 71-23, the schist becomes very thin, bedded and fine-grained and lies in long parallel beds. Strike is N. 72° E., No. 140 (H). Some beds in the schist here are quite hydro-micaceous. No. 141 (H).

The south side of the small island in N. E. ¼ sec. 28, 71-23, is formed of mica schist. Lying against it upon the north is white granite or gneiss. The contact is abrupt and distinct; but the granite has sent out branches that cut the schist, and has also enclosed a few pieces of schist in it. The granite is cut by intrusions of granulyte and granite containing but a little mica. The only evidence of gneissoid structure is the arrangement of the minerals in parallel lines. These have about the same general direction as the schist, viz. N. 60° E. The masses of schist that are enclosed in the gneiss are unaltered and seem to have retained their strike and dip. Nos. 142 (H) and 143 A (H). The larger island at this same place is composed almost entirely of granite. In one place only a few short beds of schist were seen. The middle of the island rises 25 feet above the water. There are small masses of schist enclosed in the granite in various places. No. 144 (H).

In the N. E. ¼ sec. 27, 71-23, the schist lies against the gneiss all along the coast. They are mixed and cut and twisted up together in a remarkable fashion. Long feelers of the gneiss or granite stretch off through and across the beds of schist, and from them branch out smaller winding, twisting veins in all directions. The general line of contact seems to be in the direction of the bedding of the schist.

In the N. E. ¼, of N. E. ¼, sec. 27, 71-23, is a dyke which is 35 paces from one side of it to where it goes under the water and disappears. On the west side it is a fine diabase. This becomes coarser and coarser toward the middle of the dyke. The rock on the west side of it is fine, hard mica schist. The line of the west side of the dyke runs E. 60° S. Glacial marks are N. 40° E. Nos. 145 (H), 145A (H), 145B (H), 145C (H), 145D (H), 145E (H) and 145F (H), show the change in the rock in crossing the dyke.

The coarsest side of this dyke which is naturally supposed to be the middle, is at the water's edge, and it can not be determined where the rest of it has gone or whether there is any more. If the coarsest part is the middle, the dyke is 210 feet across.

Jack pine trees are numerous in this region. Not one was seen on the Little Fork.

The dyke mentioned above continues to form the shores of the islands and main-land for a long distance going E. 50° S. Its edges are irregular and sometimes penetrate a long distance into the schist; but the line of contact is always distinct. This dyke probably contains magnetite; as the compass is disturbed by its proximity. Some of it contains epidote. No. 146 (H).

The long point in sec. 26, 71-23, is composed of micaceous and hydromicaceous schist containing quartz in veins.

A round polished knob of the dyke rock sticks up in the middle of the bay south of the east end of the point mentioned above. This is very finely marked by glaciation. The augite crystals are arranged in long rows which run at about right angles to the glacial marks. There is so much disturbance of the needle here that direction can not be determined by the compass.

On the south side of the bay in sec. 26, 71-23, is what appears to be the continuation of the dyke. It contains beds of coarse, dark schist running N. 70° E. No. 148 (H). In some places this very trap rock has a bedded structure and almost becomes schist with a strike similar to that of all the schists in this region, and apparently in vertical beds. Nos. 149 (H) and 149 A (H).

In the S. W. ¼, sec. 25, same township, this diabase has all graduated into a rock that is very plainly gneiss; and going a little farther south across the strike it is still further changed into thin-bedded gneiss and finally into mica schist with the ordinary strike and dip.

In the S. E ¼ of S. W. ¼, sec. 25, 71-23, is a high bare knob of mica schist. It contains a quartz vein three or four feet thick running across the beds. There are also beds containing an unknown, heavy, black mineral. No. 150 (H).

In the S. E. ¼ of S. E. ¼, sec. 25, 71-23, the shore is composed of dioryte (?). This becomes finer toward the south until it graduates into doleryte or trap. Then comes a fine-grained, thin-bedded, green schist dipping north at a high angle and with a strike N. 80° E. Its contact with the doleryte is abrupt and irregular. The hills rise 75 feet above the lake and are almost bare. The schist is quite siliceous and finely micaceous. No. 151 (H). This dyke seems to be the continuation of the large one mentioned above, but is narrower here.

In the S. W. ¼, sec. 30, 71-22, the mica schist is conglomeritic, containing innumerable flattened pebbles and boulders all changed into rock very similar to the schist. No. 152 (H). There is also a greenish mica schist here that is very smooth and even in its composition and seems to be in thicker beds than the rest. No. 153 (H).

A little farther east in sec. 30, 71-22, the schist assumes the appearance of a decided conglomerate, containing pebbles of granite, quartzyte and schist as large as eight inches in diameter. On a smooth surface they show very plainly. No. 154 (H). Some of the beds of schist are light-colored and are more like gneiss. No. 155 (H). Some of the schist also contains hydromica in place of mica.

In the S. E. ¼, sec. 30, 71-22, the schist contains less and less mica until it becomes almost a fine granulyte or quartzyte. Nos 156 (H), 156 A (H) and 156 B (H). Near the east side of sec. 29, 71-22, the glaciation is N. 60° E.

There is a great deal of hydromica schist on an island in the N. E. ¼ sec. 32, 71-22. For a mile or two west of here the bluffs 40 feet high are composed of light-colored siliceous schist. At this place the schist is very fine and hydromicaceous, and contains beds of the light-colored schist. Dip is N. 45°. No. 157 (H).

The point in the north half of sec. 33, 71-22, is composed of mica schist that rises 50 feet above the lake. It stands in vertical strata.

The point in S. E. ¼ of N. W. ¼. sec. 33, 71-22, contains two or three quartz veins, one three feet thick, running with the bedding N. 48° E. The schist stands on edge. It contains beds of hard gneissoid rock.

In the S. W. ¼ of S. W. ¼. sec 34, 71-22, the strike of the schist is east and west. Some of it is beautifully fine and soft; and some is folded and wrinkled in parallel beds. The dip is north at a high angle.

Along the west side of sec. 3, 70-22, the schist is in thin, straight beds dipping north at a lower angle than usual. There are also beds of gneiss in it and numerous quartz veins. The general strike is about E; dip is N. 50°.

In the N. E. ¼ of N. W. ¼, sec. 10, 70-22, is an outcrop of gneiss showing for several rods along the shore. It contains irregular patches of hard, coarse, hornblendic mica schist. The gneiss has an irregular contact with the schist and encloses some of it. The schist on the east side of the gneiss dips N. 40°—50°. No. 158 (H). Strike is E. 40° S. In the east half of sec. 10, the strike veers around until it is E. 70° S. and even E. 80° S. This schist is thick-bedded and dips N. E. 40°.

The round point in the S. ½ sec. 10, 70-22, is composed of a gneissoid mica schist very much jointed. Strike is E. 40° S.

Mica schist is exposed in S. W. ¼ sec. 13, 70-22. It is quite feldspathic, soft and crumbling. There are very few exposures in this bay which is called Black Bay by the white settlers of the region, and Wazushkatabiwi, or *Rat Root* lake by the Indians. Most of its shores are marshy and the bay itself is full of rushes and rice.

Near the east side of sec. 13, 70-22, the schistose gneiss strikes east and dips N. 48°. A good portage of about a mile connects Black Bay with Kabetogamak (*the lake that lies along the side*). On the portage in sec. 19,70-21, ridges of gneissoid mica schist are crossed which trend N. 70° to N. 80° E. No. 160 (H).

In the N. W. ¼ of S. E. ¼ of the same section mica schist occurs interbedded with coarse gneiss. Strike N. 70° E. Dip N. 58°.

In the S. E. ¼ of S. W. ¼ sec. 27, 70-18 the beds of schist have a dip S. 80°; strike is N. 84° E. The point near the center of S. W. ¼ sec. 27, 70-18 is made of perfectly straight parallel beds of schist standing nearly vertical. There are also a few beds of gneiss. Some of the beds have a high dip to the south. No. 176 (H) from this place contains green muscovite.

Biotite, muscovite schist is found in N. W. ¼ of N. E ¼, sec. 28, 70-18, dipping S. 76°. Strike is E. There are narrow beds of gneiss, granite intrusions and quartz veins in the schist here.

In the S. E. ¼ of S. W. ¼ sec. 21, 70-18, the schist dips S. 73°. It contains a few thin beds of gneiss. Glaciation is N. 40° E. Strike is N. 88° E. Boulders are numerous here. No. 178 (H). A little way north is a granite intrusion that cuts the beds of schist considerably. It is four feet thick and contains coarse orthoclase and muscovite like the regular beds of gneiss. A few rods further north is another intrusion of granite having a general direction N. 50° E. It is quite coarse and is porphyritic in places. There is a gneissoid structure running directly across the intrusion, the minerals and the weathering both showing it plainly. No. 179 (H).

The schists north of this for some distance are not so regular, but are more thickly bedded. They weather into irregular lumps and not into thin sheets as usual. There are occasional narrow, winding intrusions of granite about six inches thick, that seem to be filled with muscovite in plates half an inch to an inch in length.

In the N. W. ¼ of S. W. ¼, sec. 21, 70-18, are numerous intrusions, all having a general trend of N. 50°E.—N. 60°E. They generally have a dip similar to the schist. They frequently contain large orthoclase crystals which have quartz in them, thus forming a graphic granite. No. 180A (H). Some of the schist contains red beds in which all of the ingredients have a reddish tinge.

Occasionally the intrusions are quite gneissic. No. 182 (H) is a sample from one of them that winds around and cuts across the beds of schist, and is finally pinched down from thirty inches to two inches in thickness. Some of these intrusions are garnetiferous. No. 183 (H).

There is a small rock island in the S. E. ¼ of S. W. ¼, sec. 21, 70-18, that seems to form part of a very large granite intrusion. It runs across to the north end of the larger island east of it, where it is about 70 feet wide. It trends N. 55°E. It is composed mainly of graphic granite, which contains coarse muscovite and garnets and becomes gneissoid in places. No. 184 (H). There are also large and small masses and bunches of silvery or light-greenish quartz and mica in fine grains and scales, arranged in fibrous rays. It occurs in considerable quantities in this locality. No. 184A (H). Perhaps the term "greisen" might be applied to this rock.

Beds of gneiss are seen in S. E. ¼ sec. 20, 70-18, having a very gneissoid appearance and striking N. 60° E. They also contain the peculiar masses of quartz and muscovite. No. 186 (H).

Just east of the last the schist is remarkably straight and smooth. Strike is N. 83° E. Dip S. 80°.

On the point in the S. E. corner of S. W. ¼ of S. W. ¼, sec. 20, 70-18 is a curious example of the way in which the granite intrusions cut the schist and twist about in it.

The beds of gneiss are quite coarse and contain considerable quartz and muscovite. The orthoclase is yellow. The schist aboutas usual. Strike N. 84° E.

In the N. W. ¼ S. E. ¼, sec. 19, 70-18, are more large and small beds of gneiss. Some of them conform with the strike of the schist here.

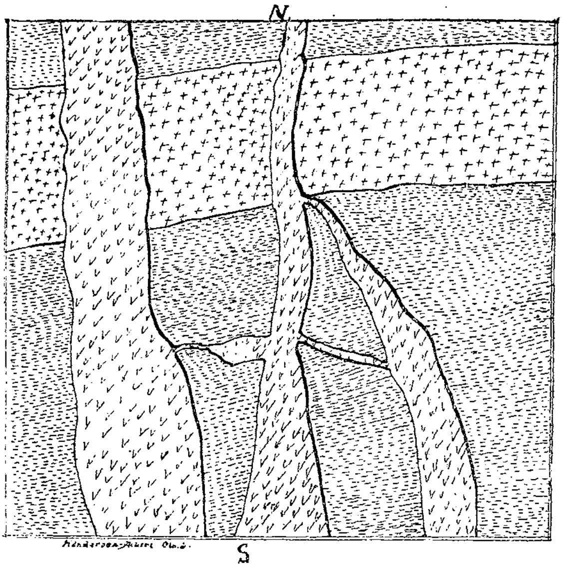


Fig. 8. *Gneiss and mica schist cut by granite, L. Kabetogamak, S. E. ¼ sec.* 31, 70-21.

The beds of gneiss are quite coarse and contain considerable quartz and muscovite. The orthoclase is yellow. The schist about as usual. Strike N. 84° E.

In the N. W. ¼, S. E. ¼, sec. 19, 70-18, are more large and small beds of gneiss. Some of them conform with the strike of the schist here. It is a little singular that all the intrusions observed for several miles east of here have a general trend N. 60° E. and the schist N. 80° E. Here the schist strikes N. 74° E. and dips S. 80°. The beds or intrusions of gneiss still contain considerable quantities of the above mentioned radiated quartz and muscovite.

At this place is a bed of gneiss that cuts across the schist for some distance, then comes into conformity with it and all at once splits up into thin beds an inch or two thick and becomes lost in the schist. It was over two feet wide at the start and maintained its thickness until it divided. These intrusions or beds of gneiss—for either name seems to fit at times,—frequently enclose long strips of schist which sometimes maintain their usual strike and sometimes take that of the surrounding and enclosing rock. Glaciation is N. 44° E. Some of the grooves in the schist are half an inch deep and an inch wide.

Sometimes the gneiss laps over and lies upon the edges of a good many beds of schist as if it had been squeezed up and out, and had flowed over. Most of it is porphyritic.

In the S. W. ¼ of S. W. ¼ sec. 19, 70-18, the schist occurs in beds which average about two feet thick and strike N. 74° E, with a dip S. 82°. It is uniform and regular. There are large intrusions of granite running through it, N. 40° E. Part of the west side of a bluff has fallen into the lake and left a fresh break showing graphic granite containing muscovite. Each individual crystal of orthoclase seems to contain quartz grains running in the same direction through it according to some cleavage or other natural tendency in the feldspar. Two crystals of orthoclase are never seen side by side with the quartz running the same way in both; but in each individual however large the quartz "characters" are all parallel or at right angles to each other. No. 187 (H).

In the S. E. ¼ sec. 24, 70-19, the schist rises in bluffs twenty-five feet above the lake. There is also much gneiss here. Some of it contains large quantities of immense biotite scales. The strike of the schist here is N. 74° E, dip is S. 74°. The schist here is regular and uninterrupted in perfectly even, thick beds for one hundred feet at a time. Glacial striations N. 46° E.

The point at the south line of S. E. ¼, sec. 23, 70-19, is composed of gneiss containing much of the quartz and mica masses and graphic granite. No. 188 (H) is from a mass of the former two feet long.

The N. E. ¼ of N. E. ¼, sec. 27, 70-19, is composed of mica schist, with a strike N. 76°E and dip S. 80°, and large beds of gneiss. Glaciation is north 50°E. A little east of here the straight walls of mica schist and, in one place of gneiss, rise up thirty feet from the water's edge, covered with moss and lichens. The trees are mostly a thick growth of small spruce and Jack pine.

The point in the S. W. ¼ of sec. 23, 70-19, is composed of mica schist and gneiss. The latter is full of radiated masses of quartz and mica in fine, glistening scales. It seems to have been pushed over the beds of schist in a plastic condition and to have a sort of horizontal gneissoid structure. It is quite coarse, and is porphyritic in places. The strike of the schist is N. 84°E.

Fine-grained patches are often seen in these intrusions or beds of gneiss. The fine parts are often porphyritic, with perfect orthoclase crystals six to ten inches across. Frequently there are beds of pebbles and accumulations of boulders on a point or in some recess where there is a large bed of gneiss. These pebbles and boulders are principally of the same rock as that directly beneath and around them; and seem to have been formed right there by the action of frost and waves of the lake. No. 190 (H).

The rock in N. W. ¼ sec. 20, 70-19, is principally mica schist. Strike is N. 70° E. Dip S. 80°, in thick beds. No. 191 (H). There are hard nodules in it, as there are most everywhere, that stand out in knobs and sheets and all sorts of odd shapes on weathered surfaces. It also seems to be cut by hard veins of matter which cross themselves and make a net-work of little ridges on the weathered surfaces. They do not seem to have any influence on the cleavage of the rock.

In the S. E. ¼ sec. 19, 70-19, there is a bed of chloritic (?) mica schist in the other schist. It is four or five feet thick and contains much black mica in scales. It is cut off by an intrusion of granite which crosses the east end of it; and hidden by the lake on the west. Its general trend is N. 80° E. No. 192 (H). There are hard veins running through it that seem to have been gneissoid, but now contain hornblende or chlorite and but little mica.

The point of the island in S. E. ¼ of N. E. ¼, sec. 24, 70-20, is composed of garnetiferous gneiss, porphyritic with very large orthoclase, and containing quantities of the masses of mica scales and quartz grains. All of the large orthoclase crystals are pegmatitic.

The mica schist in the S. W. ¼ of N. E. ¼, sec. 23, 70-20, strikes E. 40°S ; dips S. W. 78°; and has glacial marks N. 46°E. It is in thick beds, and the mica is biotite. There are beds of porphyritic gneiss here as everywhere in this region, only this has more of the radiated accumulations of mica and quartz. There is often a decidedly gneissic structure in these beds, but they are generally without it.

The schist in the N. E. ¼ of S. E. ¼, sec. 16, 70-20, is quite thick-bedded in nearly vertical strata. Strike, N. 80°E. Glaciation, N. 45°E. There are but few granite intrusions in this region, and the shores are lower and frequently covered with vegetation down to the water's edge. The lake at this time was unusually high. Streams of water were pouring into it on all sides from places where usually there is no stream at all. There was a cascade over each bluff, and a roaring little torrent down each ravine.

In the N. E. ¼ of N. W. ¼, sec. 15, 70-20, the schist lies flat, in thin laminæ or plates. For several rods along the water's edge the flat schist lies piled up six or eight feet above the water, like slabs in a wood pile. No. 193 (H). This continues around the point for some distance, becoming thicker and coarser. From here it goes on to the S. E. ¼ of S. W. ¼, sec. 10 in a rather confused and disturbed way, now dipping north, now south and now lying flat. This seems to be the middle of an anticlinal,—and, in fact, the dip soon becomes permanently to the north. Beds of gneiss are still seen in the schist, but here they too are broken and discontinuous. Around the point farther, beds of schist two and three feet thick dip N. 40° to N. 60°.

Strike is N. 80°E. Some of the schist here is very rich in garnets. Nos. 194 (H) and 194A (H).

On the N. E. ¼ of N. E. ¼ sec. 16, and S. E. ¼ of S. E ¼ sec. 9, 70-20, the schist is flat again. It rises twenty feet above the lake. There is a bed of gneiss which has come up through with a dip N. 60°; and there are other small granite intrusions that lie flat and cut through the gneiss for several rods.

In the S. W. ¼ of S. E. ¼ sec. 9, 70-20 is a bed of gneiss three feet thick that lies on the top of flat beds of schist all the way around the point.

In the S. W. ¼, of S. W. ¼ sec. 9, 70-20 the schist is still distorted and contains garnets and considerable biotite. The granite intrusions run more irregularly than usual through the schist in this supposed middle of an anticlinal. The shores are all much lower here than further east; and are inclined to be marshy. Veins of white quartz two or three feet thick are common in this locality.

The schist in the S. ½ of sec. 7, 70-20 has a north dip varying from 60° to 80°. The strike is E. It is a little harder here than usual and contains quartz veins and garnets. The bedding is wavy. No. 197 (H).

In the N. E. ¼ of N. E. ¼ of sec. 12, 70-21, is the first large bed of gneiss that occurs along here for several miles. It embraces several masses of schist. It is porphyritic and quite gneissic and contains much peculiar green mica, especially near the contact with the schist. It also contains a few garnets and has quartz veins penetrating it. The schist near it has a strike N. 80°, and a low dip to the north. Nos. 198 (H) and 198A (H).

In the N. E. ¼ of N. W. ¼, sec. 12, 70-21 the schist rises about thirty-five feet above the lake. It strikes N. 70° E. Long, grayish-blue crystals of cyanite are found in some quartzose veins near the water's edge. Some of the blades of this mineral are six inches long. No. 199 (H).

The schist in the S. E. ¼ of S. W. ¼, sec. 1, 70-21, contains many quartzose beds and one or two veins of quartz. There are numerous garnets in these beds. No. 200 (H.)

The walls of schist on the north side of the bay, in sec. 1, 70-21, have glacial scratches along the smooth, perpendicular sides in all directions, but the majority are nearly horizontal. Sometimes the mark curves around a point or corner of the rock and continues on the other side as if the ice conformed to the outlines of the rocky surface and walls.

The mica schist in the N. E. ¼, sec. 6, 70-20, is in thick beds that strike N. 70°E and dip N. 35° to 38°. Long, low reefs of this rock run out into the lake, and the shores are low. Few or no granite or gneiss beds are to be seen in this region. The schist is exceedingly uniform in the appearance and composition of its strata.

The south side of the point in sections 31, 32 and 33, 71-20, is composed of mica schist in beds of different degrees of hardness and amount of mica, but which have a general sameness of appearance. At the end of the point is some porphyritic gneiss in beds running about N. 50°E. The general strike of the schist is N. 70°E; the dip N. 35°. In places there is a jointage structure that crosses the bedding and divides the schist into angular plates and prismatic forms. The south side of this point presents the long beds broken off in a succession of rows that resemble walls of masonry slanting a little to the north. The schist on the north side of the point in S. E. ¼ of N. W. ¼, sec. 33, 71-20, strikes N. 80°E., and dips N. 52°. No. 201 (H). Small quartz veins occur in it, running with the strike. The mica in some of the schist is in spots, and gives the rock a mottled appearance.

No. 203 (H) is hard mica schist from S. W. ¼, sec. 29, 71-20. It strikes N. 76°E. and dips N. 60°, more or less. The schist here has some appearance of being conglomeritic. It is in very thick masses that do not show any banded structure, as some of the schist does. A little further west, in the N. W. ¼ of S. W. ¼, sec. 29, 71-20, there are beds of schist that are hydro-micaceous, and have a wavy structure running with the bedding. No. 204 (H).

Some of the beds in the mica schist in the S. W. ¼ of S. E. ¼, sec. 26, 71-21, are quite siliceous, with finely granular quartz. No. 205 (H). The beds here are vertical, or have a high dip to the north, and the strike is about N. 80° E., but is becoming irregular and broken. No beds of gneiss are seen in the schist here. Quartz veins are numerous.

On the point in the S. E. ¼ of N. W. ¼, sec. 35, 71-21, the mica schist changes gradually into a rock composed principally of augite (?). It has no apparent bedding and is quite massive for a short distance. The continuation of it is lost in the water. This change takes place in going across the strike from north to south, the strike being about E. Some of this massive rock contains glassy quartz in veins. The schist here is finely banded and dips N. 72°. Nos. 206 (H) to 206 F (H) are from this place.

The point in the S. W. ¼ of N. E. ¼, sec. 34, 71-21, is composed of evenly-bedded mica schist. Strike N. 86° E. dip N. 74°. Glaciation N. 64° E. There are no beds of gneiss here; but quartz veins eight inches to two feet thick, running with the bedding are frequent. These veins are sometimes connected by cross-veins.

The schist in the S. W. ¼ of the N. W. ¼, sec. 34, 71-21, contains both mica and hydromica. Strike is N. 84° E. Many of the strata have reddish veins of quartz running with the strike and scattered all through the bed. The schist is also garnetiferous. No. 207 (H).

Some beds in the schist on the point in the S. W. ¼ of N. W. ¼, sec. 33, 71-21, are lighter colored and more siliceous than usual. Strike is N. 80° E.; dip is about vertical. No. 208 (H). The schist in this immediate vicinity is very thin bedded; and where the sheets have fallen over into the lake overlapping each other they look like shingles on a roof. These siliceous beds became felsitic in the N. W. ¼ of N. E. ¼, sec. 32, 71-21. Strike is N. 74° E., dip S. 60°. No. 209 (H).

No. 210 (H) is a sample of mica schist from the S. E. ¼ of N. W. ¼, sec. 32, 71-21. The beds here are about vertical; strike N. 74° E. Quartz veins are numerous, and boulders, of which we have seen very few if any in the last three townships, are becoming more plentiful.

In the N. E. ¼ of N. W. ¼, sec. 31, 71-21, the schist is cut slightly by a greenstone dyke six inches thick. The direction of the schist is about E. 10° S. and that of the dyke is E., although it curves. No. 211 (H). This is the first greenstone dyke seen since coming into this lake from Kabetogamak.

In the N. E. ¼ of N. W. ¼, sec. 31, 71-21, the schist contains several beds of a light color that seem to be composed of small rounded quartz grains, biotite scales and larger scales of some opaque mineral, probably feldspar. The strike here is N. 74° E. The schist is also hydromicaceous. These light colored beds vary from an inch to two feet in thickness. Nos. 212 (H), 212A (H) and 212B (H). In the N. E. ¼ sec. 36, 71-22, there are more of these siliceous beds in the schist; some of them are felsitic and some sericitic.

The schist in the S. E. ¼ of S. E. ¼, sec. 24, 71-22, contains both mica and hydromica. It becomes more fissile and wavy in its structure toward the west, and in the S. W. ¼ of S. W. ¼, sec. 26, 71-22, it is very schistose. Here there are many quartz veins in it, and little streaks of lighter-colored feldspathic beds. The dip at this place is north; while a short distance east of here it is distinctly to the south. Strike is about N. 74° E. There are numerous thin felsitic beds in the schist here.

A light-colored, siliceous schist is found on an island in the S. E. ¼, sec. 28, 71-22. It is quite hard, and does not weather easily. Strike is N. 84° E. Glaciation, N. 52° E.

The south side of the island, in the N. E. ¼ of S. W. ¼, sec. 28, 71–22, is composed of siliceous schist that strikes east, and stands in vertical beds.

The east end of the island, in the S. E. ¼, sec. 19, 71–22, is composed of hydromica schist, varying to graywacke, and even to a harder, semi-crystalline rock, containing chalcedonic quartz, opaque feldspar and pyrites. The general strike is about east; dip is north to vertical. Some of the schist is very fissile, and some has almost lost its schistose appearance. Some of it seems to be chloritic; and all of it contains considerable carbonate of lime in the seams, and to a certain extent in the rock itself. No. 216 (H).

In the N. E. ¼ of S. E. ¼, sec. 19, 71–22, on the south side of the large island, the schist is diabasic, and assumes a jointed structure; but the schistose structure is still everywhere apparent. Strike is N. 74° E.; dip north at a high angle. No. 217 (H).

No. 218 (H) is from the south side of the island, about a quarter of a mile west of last. It is hydromica schist, that dips north, and forms the highest part of the coast in this place. It is quite schistose, and contains many small veins of quartz. Strike is about N. 76° E.

Mica schist is again found in the S. W. ¼ of S. E. ¼, sec. 24, 71–23. It contains also a little hydrated mica. Strike is about N. 70° E.; dip at a high angle to the north. Light-colored, feldspathic mica schist, somewhat stained with iron rust, is found in the S. E ¼ of S. W. ¼ of the same section.

In the S. W. ¼ of S. W. ¼, sec 24, 71-23, is a ridge of doleryte that becomes very coarse near the top and middle of the ridge. It has an irregular, abrupt contact with the mica schist on the north. The general direction of the contact is N. 80°E. It rises thirty-five feet above the lake, and is very solid and massive. Glaciation is N. 60°E. No. 220 (H).

On the point of the S. E. ¼ of S. E. ¼, sec. 23, 71-23, this doleryte rises in hills at least eighty feet above the water. It is an exceedingly tough rock, and causes the needle to point south. It seems to be cut by veins or "dykelets" of fine trap in places. There is a coarse jointage structure running about north. This structure is also seen in the hardened mica schist which lies at the east side of the dyke. Nos. 221 (H) and 222 (H).

No. 223 (H) is from the S. W. ¼ of S. W. ¼, sec. 23, 71-22. It is hard, greenish schist, which strikes N. 75°E. It appears to be semi-crystallized. It lies between mica schist on the south and hydromica schist on the north.

KABETOGAMAK

On the portage in sec. 19, 70-21, ridges of gneissoid mica schist are crossed which trend N. 70°E. to N. 80°E. In the N. W. ¼ of S. E. ¼, sec. 30, 70-21, is mica schist mixed with coarse gneiss. Strike is N. 70°E; dip N. 58°.

The small island in the S. W. ¼ of S. E. ¼, sec. 30, 70-21, is composed of interbedded mica schist and gneiss. The gneiss is quite coarse, is muscovitic and lies in thick beds. It contains also a little biotite. No. 161 (H).

The mica schist in this region is often cut by beds or veins of black mica schist that weathers sooner than the rest of the schist. The gneiss contains pyrite and some small crystals of a black mineral like tourmaline. It also contains irregular patches of the schist.

The point in the N. E. ¼, sec. 31, 70-21, is composed of interbedded gneiss and mica schist. The gneiss is often very coarse, containing mica crystals four inches long, and orthoclase six inches across. No. 165 (H). Both schist and gneiss are cut by intrusions of granite running in all directions. The general strike is N. 70°E; dip N. 45° to 50°.

The S. E. ¼ of sec. 31, 70-21, contains a point nearly bare of vegetation, composed of rounded knobs of gneiss and mica schist cut by granite intrusions. Some of the orthoclase crystals in the gneiss measure ten inches in length. The strike of the gneiss and schist is N. 80°E. The following diagram shows how the granite cuts the mica schist.

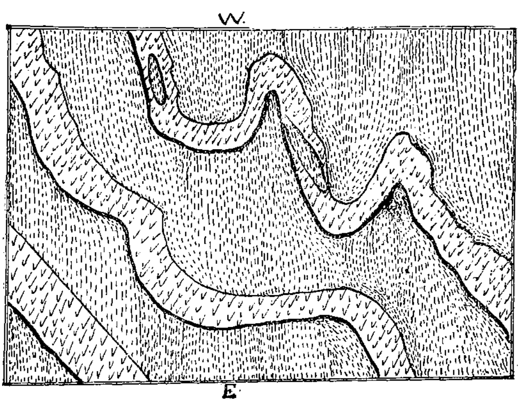


Fig. 9. *Mica schist cut by granite. Rainy lake, S. W. ¼, sec. 20, 70-18.*

In the N. E. ¼ of N. W. ¼, sec 6, 69–21, is a bold bluff of gneiss, containing some mica schist. It is pegmatitic also. No. 162 (H). The gneiss is very coarse, and contains large crystals of muscovite. It is a little peculiar that the mica schist, which is found in patches all through this gneiss, contains chiefly biotite mica; while the gneiss contains muscovite. There is some muscovite, however, in the schist, and a little biotite in the gneiss. No 163 (H). The graphic granite here seems to be crystals of orthoclase, two feet or more in length, containing quartz. The surface of each mass of feldspar has one common cleavage, and reflects the sun as if it were one flat surface.

Mica schist and gneiss are seen in the N. E. ¼ of N. W. ¼, sec. 8, 69-21. Strike is N 80° E. There seems to be a tendency in all of this gneiss for the different constituents to separate from each other, and to collect as much as possible by themselves.

Gneiss and schist are found in the N. E. ¼ of the N. W. ¼, sec. 17, 69-21. Strike is N. 80° E. Dip is north, at a high angle. When the beds of gneiss are thin the crystals are smaller than in the thick beds.

Where the line between secs. 20 and 21, 69-21, crosses the shore-line there is a round hill of gneiss and mica schist that rises at least fifty feet above the lake. The feldspar weathers white on the surface, and makes the rock quite dazzling in the sun. There is less mica in the gneiss here; but the beds and included masses of mica schist are quite common. The strike is N. 70° to N. 80° E. Dip still to the north. No boulders are seen at the west end of this lake.

Gneiss and mica schist, with an east and west strike and a dip N. 16° to 30°, occurs in the N E. ¼ of N. W. ¼, sec. 27, 69-21. A few boulders lie along the shore here; but no drift covers the rock hills. Mountain ash trees are first noticed at this place.

In the S. W. ¼, sec. 25, 69-21, the gneiss and schist still have a low north dip, 15°-30°. The gneiss is sometimes porphyritic, and contains very black biotite No. 164 (H).

In the N W. ¼ of N. W. ¼, sec. 30, 69-20, gneiss and mica schist occur in interbedded, thin, wavy or folded strata. Strike is E. 50° S. to E. 80° S., and with a low dip of less than 45° to the east. The character of the rock remains unchanged for a long distance east of here. It is always gneiss and mica schist in more or less distorted beds. Much of the gneiss is porphyritic, and contains large scales of both biotite and muscovite. The quartz is often chalcedonic. Most all of the large orthoclase crystals contain quartz, being thus pegmatitic. The beds become too much bent and twisted for any general strike or dip to be noted. The country is more wooded and hilly, and the rock comes down close to the water in perpendicular bluffs, over twenty-five feet high.

There is such a mixture in the rocks that beds of any considerable length are not to be seen. Masses round, square, oblong, irregular, thin, thick and in fact all shapes and sizes of mica schist are seen in the gneiss where the gneiss predominates, and of gneiss in the schist where the schist is the main rock.

Sometimes the strata lie in wavy, horizontal beds, and sometimes they stand nearly vertical. The gneiss is frequently porphyritic, and occasionally rock that approximates mica schist rather than gneiss is porphyritic with feldspar crystals two or three inches long. The trees are Norway pine, white pine, Bank's pine, spruce, balsam-fir, birch, aspen, great-toothed poplar, mountain ash, white cedar, willow, ash and elm.

In the N. E. ¼, sec. 30, 69-19, there are beds of schist and gneiss that seem to be more regular. and have the usual strike and high dip to the north. The country through here is much wilder than that farther west. There is considerable good pine on the shores of the lake. The rock hills generally rise to a hight of fifty feet or more above the lake.

Mr. Trussell examined the north shore of Kabetogamak, through Twp. 69-20, up to Namekan, in Twp. 69-19. The formation is all the same—gneiss and mica schist in irregular beds. One specimen from the north side containing much biotite is No. 166 (H).

NAMEKAN LAKE.

The west end of Namekan or Sturgeon lake is very beautiful. There are numerous points and islands, all heavily wooded down to the water's edge. The hills rise higher, too, in this region, and the bluffs have a bolder aspect. The rock is the usual gneiss and mica schist, the latter generally quite soft and crumbling, so that the gneiss is the rock that is most seen in all exposures.

In the S. E. ¼ of S. W. ¼, sec. 26, 69-19, the gneiss and schist rises seventy-five feet in perpendicular bluffs, from which many large pieces have fallen down into the lake and left overhanging crags that have quite a picturesque appearance. There are pine and spruce trees growing in every available crack and crevice of the solid rock.

In the S. W. ¼ of S W. ¼, sec. 28, 69-19, the rock is more gneissoid than usual, and contains but little schist. It rises twenty-five feet to fifty feet above the lake on the islands and points in this locality. It is cut and re-cut by granite intrusions, but no trap or dioryte dykes are seen on this lake. Nos. 167 (H) and 168 (H). The strike in N. W. ¼ of S. E. ¼, sec. 30, 69-18, is E. 70° S.; dip E. 45° to 60°.

In the S. E. ¼ of S. W. ¼, sec. 28, 69-18, the strike is more regular and has returned to its general direction, N. 70°—N. 80°E., with a high dip N. Many mica schist beds occur in the gneiss, and serve to show the strike and dip better than the gneiss does.

The gneiss in the S. W. ¼, sec. 26, 69-18, is fine and red, and contains very few beds of mica schist. There is a coarse, schistose structure running E. 60°S No. 169 (H).

In the N. W. ¼, sec. 31, 69-17, the rock is almost pure mica schist. There are a few beds of gneiss, but the rock is largely schist, in thin, straight beds. Some of the strata are nearly horizontal, and some dip 60° or more to the east. The flat beds are folded and bent considerably.

In the S. W. ¼, sec. 28, 69-17, the gneiss begins to appear again in thick beds, but the schist still predominates. The strike of the gneiss is about east and west, with a dip N. 40°.

On the west side of the island, in the S. E. ¼ of N. W. ¼, sec. 29, 69-17, is a bed or dyke of dioryte about twenty feet thick. No. 170 (H).

The channel of the stream which flows from Sand Points lake into Namekan lake is one of the most picturesque spots seen in this region. The stream is deep and narrow, and runs between rugged bluffs of mica schist. The hills are covered with pine and the rocks with a luxuriant growth of lichens. The rocky walls are almost continuous enough to deserve the name of "dalles." They are all of mica schist having a general strike about east and west, and dipping about N. 45°. There are occasional beds of gneiss and veins of quartz.

The rock on the island in the S. E. ¼ of N. W. ¼, sec. 21, 69-18, is gneiss and mica schist. The gneiss is fine-grained, and contains irregular masses of the schist. It is only slightly foliated. No. 171 (H).

The entrance to Rainy lake is quite intricate, and is hard to find, as well as hard to keep when found. The plats do not follow the regular canoe route for the boundary, but take the north channel between Namekan and Rainy lakes, where a canoe seldom goes, because of the longer portage.

There are two falls between these lakes. The southern one is a chute of about nine feet, over mica schist. There is a good portage of about two hundred paces on the south side.

The rock in this region is mica schist, with beds of gneiss. It is quite regular in bedding, strike and dip. Strike is N. 80° E. Dip about N. 80°. The beds of gneiss are quite generally in conformity with the schist; but sometimes cut it a little. No. 172 (H).

The north fall is about the same hight in one *chute* as the south fall. It is over fine, hard, brittle mica schist. No. 173 (H.) The schist is very evenly bedded, and stands nearly on edge. Strike is N. 86° E. Dip, N. 84°. Glaciation, N. 30° E. The gneiss beds are very uniform, and are conformable with the schist. It is generally coarse, and contains garnets. Some of it, however, is quite fine, and shows the gneissic structure well. The mica in the schist is mostly biotite; that in the gneiss is muscovite. Some of the schist is hydromicaceous. No. 175 (H).

BIG FORK RIVER.

This river should really be called Bowstring river, inasmuch as the Indian name *Pisachabani* signifies that, and it comes from Bowstring lake.

No rock is seen on Rainy Lake river between the mouths of the Little Fork and Big Fork rivers, which are only six miles apart. Stratified, sandy clay is seen in the banks ten and even twenty feet above the river. A few limestone boulders are to be seen.

The banks of the Big Fork for the first three miles up the stream are not more than five feet high. No rock in place nor boulders are seen. Then the banks become higher and in places are twelve feet to fifteen feet high, composed of stratified sand and clay. The water is dark and the river has a smaller volume than the Little Fork.

The stratified clay banks have in them beds containing pebbles of gneiss and other rocks; they also contain very fine clayey layers. On top is generally a few inches of loose sand or soil. About seven miles up the river the clay banks are seen to contain quantities of fresh-water shells. No. 224 (H) is clay in which these shells are imbedded. It was taken out of a bank about fifteen feet above the water in the river and five feet from the top of the bank. The whole bank is made of the stratified clay; and as far as could be seen contained fragments of shells, as well as boulders and pebbles.

There is a very swift current in this river. Boulders begin to be numerous at about two miles up the river, and pieces of Cretaceous shale are seen on the bank. Small fragments of limestone too, are frequently seen. The trees noticed in the first ten miles are as follows: Plenty of large hardwood timber of all the varieties mentioned, basswood, soft maple, elm, black ash, white ash, white oak, aspen, white birch, balm of Gilead, box elder, three varieties of willow, ironwood, cottonwood, spruce, white cedar, Norway pine, Jack pine, mountain maple, dogwood, cherry, alder and June berry. The banks become higher in the next ten miles, and groves of fine Norway pine are seen at intervals. The water was so high that no short rapids were noticed; it was all one long rapid.

The neighboring country is quite flat and a good share of it is swampy. There are chances for many fine farms along this stream. The river bed seems to be paved with boulders, and there is much gravel in the banks, which are all composed of stratified drift. They are covered with vegetation, part of which was overflowed by the high water.

About 27 miles above the mouth of the river the first rapid is encountered. At this place a large mass of gneiss and mica schist protrudes from the water. It may not be in place. Boulders are very numerous The banks are lower, being seldom more than ten or twelve feet high. They are all, so far as could be seen, composed of stratified sandy clay containing pebbles and boulders. There are many fragments of limestone and Cretaceous shale. No large masses of limestone were seen; but there may be plenty of them which would be exposed in the bed of the river at times of low water. Much fine pine has been stolen along this river, and still a great deal remains.

Passing two or three quite rapid places in the river, the first exposure of rock was found at a rapid which flows between banks 30 feet high on the east side of the river, and 40 feet high on the west. This is about 33 miles up the river. The rock is trap; and no other rock can be found on either side of it. It is seen only on the east bank of the river where there is a large exposure of it about 12 feet across and 6 feet above the river. No. 226 (H).

The banks contain gravel and sandy clay and appear to be stratified. The many springs which issue from the banks near the bottom indicate that the Cretaceous underlies them. Pieces of this shale are seen in the banks up to the top.

Several tall trees were ascended for the purpose of viewing the surrounding country. It was seen to be all of one gėneral level.

Opimabonowin river enters on the west side, about thirty-seven miles up the river. There is a rapid over boulders up this river a short distance. Above the mouth of this river, on the Big Fork, rapids are of frequent occurrence for four miles, when the "Big Falls" are reached. This is not one perpendicular fall, but consists of rapids and one or two steep *chutes*. It was so hemmed in and covered by a "jam" of logs that it could not be measured, but it was estimated that the fall is not more than twenty feet in one-eighth mile.

The rock is gneiss and mica schist, which is cut at the head of the falls by a trap dyke at least twenty feet wide. A quarter of a mile below the falls mica schist and gneiss are seen to outcrop in the river. The strike is N. 68°E; dip south at a high angle. No. 227 (H). At the falls the rock is so much disturbed that no strike or dip can be ascertained. The general direction of the dyke seems to be N. 10°E. Nos. 228 (H) to 230 (H).

The falls are about forty-one miles up the river, in sec. 36, or sec. 35, 155-25. The water above the falls is quiet for five or six miles.

The banks and surrounding country for a short distance above are low and flat. Then the banks become higher and are occasionally thirty feet high; whether stratified or not could not be ascertained.

Less than a mile above the falls is an outcrop in the river of gneiss and mica schist. The strike appears to be E. 50° S. Dip S. W. at a high angle. No. 231 (H).

For the next nine miles the river is still with a moderately strong current. The banks are not over fifteen feet high; generally less than ten. They consist of stratified clay containing pebbles. A meander corner at the south side of sec. 34, 65–26, shows this place to be thirty-two miles, in a straight line, south of the mouth of the river. It is estimated at fifty-five miles by river.

In one or two places large masses of gneiss and mica schist are seen in the river just under the water. They may be in place. Limestone and Cretaceous shale are seen in small pieces in the banks. There is much good hard-wood timber, plenty of immense poplar and some large pine along the river. It is a good country for farming.

About eight miles farther is a bank where the clay beds are exposed. They consist of fine hard clay containing pebbles and a few boulders. The bank rises fifteen feet above the stream. Fragments of limestone and bluish-gray shale are seen in it. No. 232 (H). A meander corner is seen at the east line sec. 1, 152-25, which is sixty-four miles up the river. Very few boulders were seen in the banks for ten or fifteen miles along here. The river is remarkably straight, much more so than the Little Fork. A stream enters on the east side at about sixty-two miles.

For the next few miles (about seven) there is more current and the stream is more crooked than below. A stream enters on the west side at about 67 miles. No rock in place has been seen for miles.

The banks are all stratified clay containing gravel. Boulders begin to be more frequent. The banks are low and heavily wooded, and contain limestone and shale.

About five miles farther is a rapid and an outcrop of fine mica schist projecting a few inches above the water in the stream. This is about 72 miles up the river. The schist is scratched and smoothed in various directions, the main part of them being N. 10° E and N. 30° W. One or two small veins of gneiss cut the schist. This broad smooth exposure would be hidden if the water were a few inches higher, as the river is so muddy that nothing can be seen four inches below the surface. No. 233 (H). The course of the river along here is considerably east of south and much more crooked than before. A short distance above the last is much more mica schist. It has a strike N. 68° E. and very marked glacial scratches N. 60° W. It is quite hard in places and contains hornblende and chlorite, also garnets. The dip is N. W. at a high angle.

A little farther up the river on the east side the strike changes to N. 40° E. A dyke is then seen which is about ten feet wide and runs nearly north and south. The schist is hard, fine, siliceous and brittle next the dyke. Nos. 234 (H) and 235 (H).

On the right (west) side of the river is a bed of light-colored crystalline rock, with the constituents of granite. Only a few feet of it were visible; but it seemed to be three or four feet wide and to cut the schist. Nos. 236 (H) and 237 (H).

The banks continue to be low. They contain but little gravel and few boulders though the presence of quantities of both in the bed of the stream is evidenced by the frequent collisions between them and our paddles. The clay banks are about ten feet high, of hard clay, with pebbles scattered through it. In some of the banks there is a stratum a few inches thick of gravel and boulders about three feet from the top of the bank.

About five and a half or six miles farther up the stream is a rapid and at the head of it is a low outcrop of hard greenish rock. No strike or dip can be ascertained from the small amount visible. No. 238 (H). This is about 78 miles up stream, and 42 miles above the falls. The river is very crooked and still tends eastward. About a mile farther is a rapid in which no rock was seen but boulders.

About a mile and a half farther, in which distance there is considerable rapid water and a large number of boulders, is seen a fall in the river of about five feet. The rock is a hard, tough greenstone that has the appearance of trap. Portions of it have been moved on other parts and produced a slickensides and faint lines of schistosity. There are quartz veins in it, and also veins of light-colored siliceous rock and of calcite. The rock exposure is a hundred feet wide at least in any direction. Its longest outcrop is across the river about N. 80°E. Nos. 239 (H) to 239D (H).

About 40 rods above the falls south is an outcrop of a hard green rock similar to that at the falls. It might be called very fine diabase, but looks like the fine graywacke of Vermilion lake. No strike or general structure of any kind could be observed. No. 240 (H).

A sharp lookout was kept in the next seven or eight miles for Norwood's "ridge of gneiss",* sixty feet high, crossing the river. No ridge of any sort can be seen from the river, and no banks over twenty feet high. Few boulders are seen in this distance.

At the end of seven and a half miles, the foot of a rapid nearly one half a mile long is reached. At the foot of it is a bank of gravel and sand. It is a very different sort of bank from those seen below here. It is stratified, or partially so, but not horizontally nor all in the same direction. It looks like a stratified river deposit. Under it crops out a little fine bluish-gray clay, of which only a foot or two can be seen. This is supposed to be Cretaceous. No. 241 (H). There are many limestone pebbles in the bank, above the clay, but no shale is seen in it.

This rapid is over an immense number of boulders. Most of them are hornblendic gneiss, but other rocks are frequent. Many of the boulders are large and stick up several feet above the water. A short distance up the rapid is a small island which seems to be made of boulders and is covered with trees and bushes. All the rock that could be found on or around the edges of this island was boulders. This may be the "rock island" mentioned by Norwood.* A specimen from one of the syenite boulders 17 feet long, 7 feet wide and 4 feet thick, is No. 242 (H).

Above the rapids quantities of boulders are seen; while below only a few were encountered. The country does not seem to be of one general level as before, but is knolly. The banks are of sand and gravel and contain much more gravel than those below the rapids. This is about 95 miles up the river, probably in Twp. 62-25. It seems probable that the rapid mentioned above is on the boundary or shore of he glacial lake Agassiz, and that all of the river below this rapid is included in the ancient basin.

---

* D. D. Owen's Geol. Sur. Wis. and Minn., 1852.

Five miles farther up is an Indian clearing and house. This is on what is called *Baskokagin* Indian reservation. Twp. 62-25.

The country appears to consist of knolls of till. Quantities of boulders obstruct the stream and form rapids at every bend.

Deer river enters the Big Fork just above the Indian's clearing. Four or five miles up Deer river is a dam and logging camp. The bed of Deer river contains hard, polished beds of stratified clay. The banks are somewhat clayey, but mostly gravel and sand.

The drift knolls rise thirty to fifty feet in the country away from the river and are covered with large pine. The drift contains many limestone pebbles.

In the bed of Deer river at a dam about half a mile from the Big Fork bed rock was seen. It is hard, green schist, that looks like greenstone. Some of it contains mica in very fine scales. The rock seen right at the dam did not contain any mica; that farther east did. Strike N. 36°—N. 40° E. Dip about vertical. Glacial scratches N. 80° W. to W. No. 243 (H).

About three miles up the Big Fork from the mouth of Deer river is a hard round exposure of green rock on the east side of the river. It contains pyrite in cubes. It also contains nodules of a light-yellowish color, some of them two inches in diameter. They seem to be feldspathic, and this may be the rock that Norwood calls "porphyritic greenstone."* No island such as he describes containing "hornblende slate" has been seen. Glaciation here is east and west, No. 244 (H). This is about 104 miles up the river. This rock much resembles the slates and greenstones at Thomson south of Duluth. The country is well covered with drift here—the river bluffs rising fifty or sixty feet above this outcrop of rock.

About two and one-half miles farther is an exposure of rock in a small island on the west side of the river. It is hard, jointed, green rock, much like the last. It contains considerable calcite in seams. No. 245 (H.)

Less than a mile above the last is a quantity of large, broken fragments of rock which seem to have been broken by blasting. It is trap or dioryte and varies in texture in going from north to south.

About five miles farther is a small exposure of a peculiar greenish rock. It is at the foot of Rice River rapids, three and one-half miles below Rice river, which enters the Big Fork on the east about fifteen miles above the mouth of Deer river.

This rock looks almost like a metamorphosed conglomerate. It is

* D. D. Owen's Geol. Sur. Wis. and Minn. 1852.

feldspathic and becomes felsitic a little farther south. It shows only at the edge of the river, and specimens had to be obtained from under water.

About fifteen rods up, on the east side, is another small outcrop of rock. This is hornblendic, epidotic rock that varies to syenite or dioryte and then to amphibolyte. It is quite a remarkable change from green schist to syenite. Nos. 247 (H), 248 (H), 248A (H) and 248B (H) illustrate this transition which takes place going south. At this place a portage of three-quarters of a mile was made around a log jam in the river.

A short distance farther up the river, on the same side, is another small exposure. This is feldspatic greenstone, quite jointed and hard to get at. No. 249 (H).

About seven miles farther up the river, 120 miles above Rainy Lake river, is a ridge of quartz dioryte on the N. W. side of the stream. It looks much like the rock into which the greenstone grades below here. No. 250 (H).

The river banks along here are lower and are swampy and marshy. Boulders are plentiful. This is at the west side of section 30, 61–26. A short distance above the last locality, which is N. 40° to N. 60° E. of this, is more similar rock on both sides of the river. This is in the east side of section 25, 61–27. The exposures rise but a little above the water. The feldspar is green and red.

About four miles farther are some large angular pieces projecting from the water and some rock in the bed of the stream which seems to be solid rock. This is a peculiar porphyritic rock that is almost wholly made of feldspar; but contains a little green material, perhaps chlorite or sericite. No. 251 (H).

About three miles above this is an outcropping of dioryte (?) on both sides of the river. It rises four or five feet out of water and extends nearly across the stream. It is No. 252 (H), quite similar to 250 (H). It is very siliceous and contains quartz geodes. No. 252 A (H). Glaciation N. 52° W. Twenty-four rods east in the woods the rock is finer grained and looks more like syenite. No. 253 (H).

Around the next bend in the river is a large exposure of rock which rises 15 feet or more above the water. Some of it is syenite and some looks more like dioryte. No. 254 (H). This a large outcrop of massive feldspathic rock that thus appears to be the direct product of alteration or metamorphism from the hardened green schists seen north of here. These schists become gradually feldspathic, hornblendic and siliceous, and develop into regular syenite. This is the last rock observed in ascending the Big Fork river.

About two miles above is a rapid over boulders. The river is winding and runs through swampy country most of the way. About a mile farther, 142 miles from Rainy Lake river, is a meander corner between secs. 4 and 5, 149–25. The land is flat and marshy, and the stream is nearly filled with manomin or wild rice. The river here is named Bowstring river on the goverment plats. It expands into a shallow lake filled with rice, in Twp. 149-27. Much splendid pine is seen on the shores of this lake.

No boulders or solid rock are seen along the shores. A few miles further is Kashebushkag (grass-spots) lake, so called from the large, round bunches of tall grass that grow in it. Just west of this lake is Round lake (Kawaie-gamak). After crossing this lake and searching for some time, a first-class portage is found three-fourths of a mile long, leading into a small lake whose outlet is to the south. This creek is very crooked and full of rice, but has much excellent pine along its banks, as has also Round Lake river and Kashebushkag lake.

Boulders are seen in this creek, which flows south, through one or two small lakes, into Winibigoshish. Limestone fragments are seen in the bed of this creek, and in the bottom of the deep pools are beds of extremely hard, bluish clay. The water was so deep that no specimens could be procured.

LAKE WINIBIGOSHISH.

The shores of this lake are low and marshy or sandy, with a few boulders. Some limestone pebbles are mixed with the rest.

At the dam at the lower end of the lake the shores are twenty-five feet high, of stratified sand.

MISSISSIPPI RIVER.

The banks of the river below lake Winibigoshish are of sand, sometimes twenty-five feet high, and sustaining a good growth of pine. A few large boulders of granite are seen in the river. Probably most of them were taken up to be used in the dams above here.

It is about 55 miles by river to the mouth of Pokegama lake. The river banks are generally of fine sand not over ten or fifteen feet high. The river valley varies in width from half a mile or less to two miles. Few boulders or pebbles are seen.

POKEGAMA—(*The lake that lies with one end in the river*).

The shores of this lake are of reddish till five feet to thirty feet high, containing very few limestone pebbles. Many boulders are seen around the islands and on some of the points.

A trip was made to the south end of the lake and up on to the ridge in sections 22 and 27, 54-26. This ridge is covered with fine hardwood timber, oak, elm, yellow birch of immense size, sugar maple, etc. Boulders and pebbles are numerous all the way up the sides and on top of the ridge which is probably 175 feet above Pokegama lake. No rock in place could be seen. The ridge has the appearance of a moraine, the trees that have fallen having torn up boulders and pebbles and disclosed nothing but till below. Still the solid rock may be underneath at no great distance.

A few large pieces of limestone are seen on an island in the lake. The till is quite sandy and generally of a reddish-brown color, though some of it is decidedly yellowish. Pebbles of all ordinary kinds of rock are seen, and some peculiar varieties such as porphyritic greenstones and diorytes.

MISSISSIPPI RIVER.

A short distance before reaching Pokegama falls in the N. E. ¼ of N. W. ¼ sec. 13, 55–26, a ridge of quartzyte is seen on the south side of the river. It is twenty or twenty-five feet high and has been blasted out some to furnish rock for the dams.

This rock varies in color from white and yellow to green, red and almost black; and in texture from aphanitic quartzyte to coarsely granular sandstone. The general direction of the ridge is between N. 60° E. and N. 80° E. The top of it is thinly covered by drift and is on about the same level as the land south of it.

Pokegama falls are over this rock. The water here falls about seven feet in a slanting *chute*. It is said that the falls were formerly much higher and have been much worn down in the last twenty years. The Indians call them Kakabikag, (rocky falls). They sometimes add a diminutive and call them the "Little Rocky falls." This rock is No. 256 (H). There are round nodules of iron sesqui-oxide in many of the pieces that have been blasted out at the falls. They are half an inch to an inch in diameter, and are more or less hard and siliceous. No. 257 (H). Some of the rock at the falls is exceedingly soft and will crumble in a person's hands. Most of it is quite ferriferous and the bands or lines of iron rust give an appearance of stratification in places. It appears to lie nearly flat with a low dip to the southeast especially noticeable where the water has decomposed it considerably. No. 258 (H).

Portions of it contain a fine red clay supposed to be Catlinite. This occurs sometimes in thin scales or sheets, sometimes in round or angular lumps that evidently bear some relation to the ferruginous nodules mentioned above. Specimens of the quartzyte containing Catlinite (?) are No. 259 (H).

The drift below the falls contains many boulders. Grand rapids is over boulders that have been so much removed and cleared out that there is not much of a rapid there now. The upper part of the banks is composed of sand. This rests on hard clay beds. Springs of cold water come out on top of this clay.

PRAIRIE RIVER.

This stream enters the Mississippi three miles below Grand Rapids. About a mile up this river is a long rapid over small boulders. No solid rock is seen until the first fall is reached five miles above the rapids.

The river has a sluggish current between the rapid and the falls, and but few boulders are seen until nearly at the foot of the falls. Here there are many boulders of gneiss of all sizes. One boulder of limestone was noted. The fall is a long rapid, which descends about nineteen feet. There is one *chute* near the top, of about five feet. This fall is in the S. E. ¼, sec. 34, 56-25.

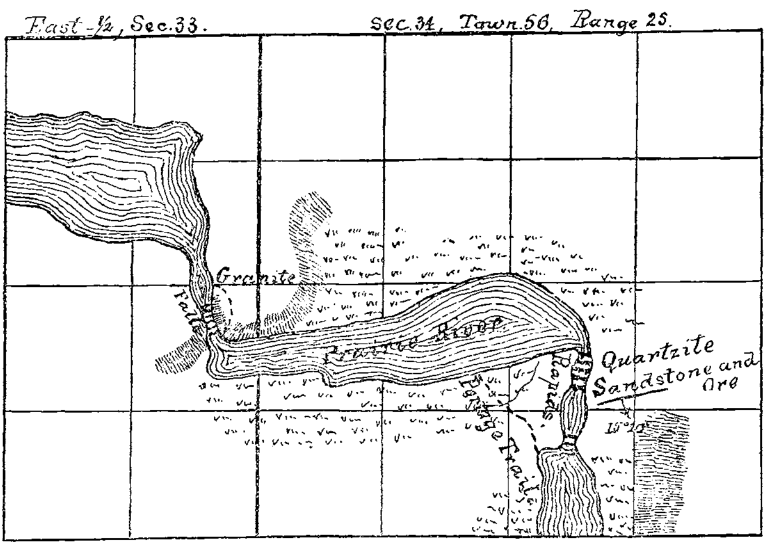


Fig. 10.—*Falls of Prairie river.*

Solid rock is exposed on the banks and in the bed of the river all the way up the rapid, and in the lake above, a distance of about one half mile. At the foot of the rapid the rock is red or reddish and more or less rusted with a quantity of iron oxide. Some of the rock is very good hematite. An analysis of ore [No. 260A (H)] from here, made by Prof. J. A. Dodge, resulted as follows:

Silica	8.25 per cent.
Alumina	Traces.
Peroxide of iron	92.08
Lime	Traces.
Magnesia	Traces.
Phosphorus	.09
Sulphur	.01
Manganese	None.
Titanium	None.
	100.43
Metallic iron	64.45

thus "making a first-class ore, just above the lower limit of the Bessemer grade." These red ferruginous beds are not exposed for a thickness of more than two or three feet. Some of the rock is fine enough to be called jasper.

Above this the rock resembles that at Pokegama falls. It is seen most of the way up the rapids, and in the woods on both sides. It is in horizontal beds, which have occasional slopes in all directions, but have a general low dip to the southeast. Where the rock is decomposed it has the same appearance as at Pokegama falls. There are long scratches in the polished rock in the bed of the river that were probably caused by floating ice, log jams, etc.* Their direction is about north and south.

About two-thirds of the way up the rapid is a thin bed of fine conglomerate exposed on the surface for a space of several feet. It contains quartz, jasper, and greenstone pebbles, mostly less than half an inch in diameter. No. 262 (H). Some jaspery, hematitic rock, found about half way up the rapid, which contains chalcedonic quartz, is No. 263 (H).

There is no doubt that there is a limited quantity of good hematite here; but it is probably only in thin, horizontal strata, perhaps separated from each other by non-ferruginous beds, and of course would

*At a subsequent visit, in October, 1888, the rock was exposed much better than at the time of the first examination, and the scratches were seen to cover the whole surface of the rock in a nearly uniform direction, and are undoubtedly glacial marks.

in that case be valueless. The true state of affairs could be determined by a shaft or test-pit.

The quartzyte and hematite weather almost black. The ferruginous rock at the foot of the rapids weathers red. At the upper end of the rapid in the lake the quartzyte contains the iron ore disseminated through it in small spots. No. 265 (H). Several large, irregular shaped masses of gneiss at this fall have the appearance of being not far transported. No. 266 (H). This was found to be the rock which forms the "Upper Falls."

About a mile west of the upper end of the "Lower Falls" is the south end of the "Upper Falls." This rapid is about a quarter of a mile long and has rock walls on each side rising in places thirty or forty feet and only twenty or twenty-five feet apart in one place. This fall is in the east side of section 33, 56–25.

The rock at the foot of the rapid is a fine-grained, gray gneiss containing comparatively little mica and orthoclase. It is nearly horizontally stratified and varies from white to reddish in color. It changes in ascending the rapid, becoming coarser and containing more mica and feldspar. Some of it contains a very red feldspar; and small particles of sesquioxide of iron are seen in places. The mica is biotite. The horizontal gneissoid structure is very evident. Nos. 267 (H.) and 268 (H).

Veins of all thicknesses up to six inches of coarse, reddish granite cut the gneiss and run in crooked lines through it. It contains both muscovite and biotite and occasionally garnets. No. 269 (H).

There are many cracks or joints running in different directions but principally north and south. They appear to have been caused by pressure and slight movements of the rock upon itself. No. 270 (H). Calcite and gypsum are found in some of the seams.

The ridges that produce these falls run for some distance on each side of them in a general direction of about N. 70° E. They are more or less covered with a glacial drift containing many boulders and supporting a heavy growth of forest trees.

There is a lake about a mile long from east to west between the two falls. The land between the two ridges at each end of the lake is low, and no solid rock is visible. The quartzyte ridge can be traced for some distance on each side of the Lower Fall.

Going northeast from the Upper Fall through the N. W. ¼, sec. 34 into the S. E. ¼ sec. 27, 56-25, some variety is noticed in the rock.

About half a mile from the falls the gneiss has the same general appearance as at the falls, No. 271 (H).

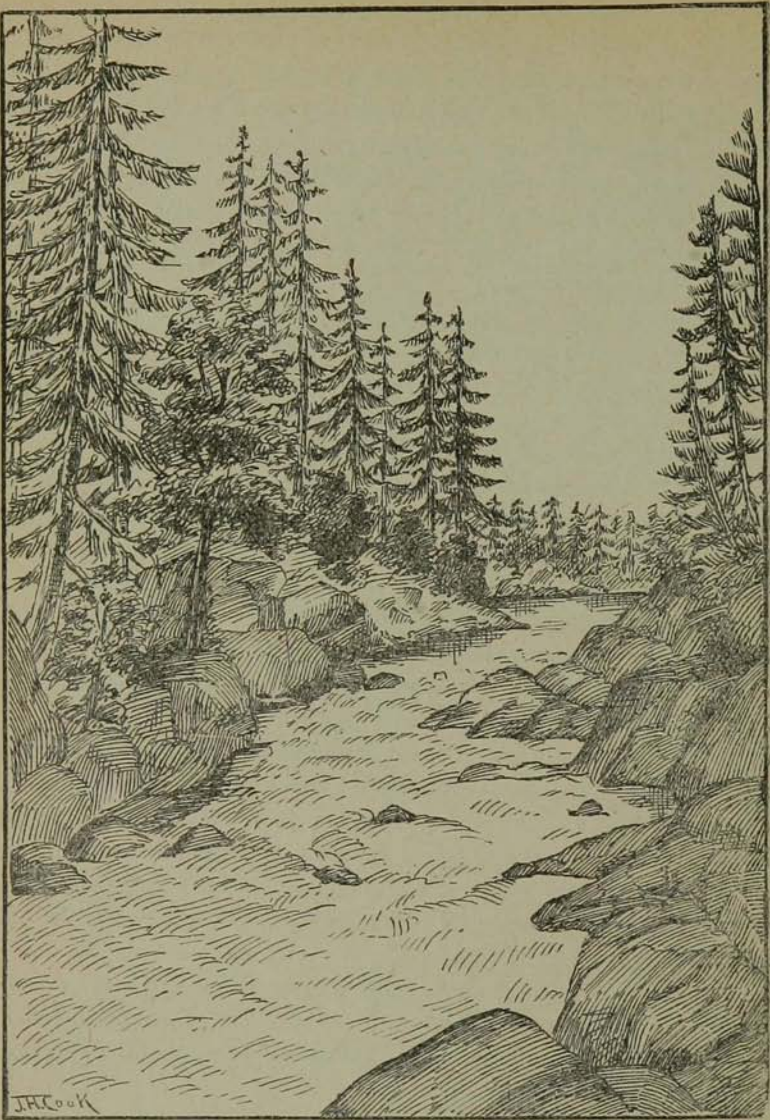


Fig. 11.—*Sketch of Upper Falls Prairie river. By H. W. Fairbanks.*

There is found a round knoll or part of a ridge of rock containing less quartz and some hornblende with only a little mica. This rock is pale greenish in color. It is in nearly horizontal beds and approximates syenite gneiss rather than true gneiss. No. 272 (H.) This rock has the same red veins penetrating it. Only a few feet from the last, the intervening space being obscured, is a small exposure of a dark green rock looking almost like doleryte, but hardly compact enough, and containing small lumps of fine dark rock like argillyte. No. 274 (H.)

In the S. E. ¼, sec. 27, 56-25, is found a low ridge of slightly porphyritic hornblendic gneiss. It is in mostly swampy land, with a thick carpet of moss. The rock is horizontally stratified, or nearly so. No. 275 (H.) It is cut by red, coarse muscovite granite. This rock all seems to have a low dip to the S. E. Whether the dip is sufficient to carry it under the quartzyte or whether it extends any farther south could not be ascertained. Much time was spent in trying to trace the rock continuously from the quartzyte to the gneiss. But there is a depression between the two ridges which is occupied in part by the lake, by a swamp at the east end of the lake and a covering of till at the west end. Both of these rocks, the quartzyte and the gneiss, are nearly horizontally stratified, both contain more or less sesquioxide of iron, and both seem to have a dip which would bring the quartzyte on top of the gneiss where it would naturally belong.

At the upper side of the "Upper Falls" the rock contains some beds that are quite hornblendic. Other beds at the same place consist of hornblende schist containing more or less mica. These beds are cut by red granite veins and generally lie nearly flat, but sometimes cut the gneiss almost vertically. The line of separation between the gneiss and hornblende schist is usually quite distinct. Nos. 276 (H), 277 (H) and 278 (H).

At the upper end of the Upper Falls, on the east side near the dam, the gneiss changes into a jointed, coarsely schistose rock that contains much red feldspar and a greenish-black mineral, perhaps chlorite. This rock seems in places to constitute a bed cutting or running through the gneiss, but the conclusion reached after careful examination is that it is in flat beds, and is a belt harder than the rest and therefore standing above it. The gneiss itself at this point contains considerable quartz and white and red feldspar. No. 283 (H).

It is noticeable that this gneiss here at Prairie River falls does not have the appearance of uniform gneiss. It looks lumpy and as if made from various materials. It seems as though it could easily become mica schist, hornblende schist, graywacke, quartzyte or iron ore. Tendencies toward all these rocks are visible in it. The most permanent and generally prominent feature is the nearly flat gneissic structure.* The gneiss is much coarser at the head of the Upper Falls than at the foot.

Above the falls the banks of Prairie river are composed of sand containing more or less gravel. Boulders are numerous and produce rapids in the river. The drift does not seem to contain any limestone. Some of the banks are of sand, fifteen or twenty feet high. There are many springs of cold water issuing near the bottom of these banks.

In the S. E. ¼ of N. E. ¼ sec. 5, 56-24, gneiss protrudes through the moss and soil in a swamp. It is in very many rough angular pieces of all sizes that seem to have been split up by the action of frost. It is all of about the same nature, fine biotite, muscovite gneiss. No. 279 (H).

Quite a ridge of gneiss similar to the last is seen in the S. W. ¼ of S. W. ¼ sec. 4, 56-24. It is found in large masses that have been split apart to a depth of ten feet, in places, by the action of frost. They are somewhat rounded and smoothed on top. No. 280 (H). This locality may be in the N. W. ¼ of N. W. ¼ sec. 9, 56-24. This rock is near the surface for a quarter of a mile or more south of here. The ground is high and covered with a good forest. Knobs of granite project here and there. No trap rock was seen, though it is marked on the government plats.

No 281 (H) is from the S. W. ¼, sec. 33, 57-23. It is gneiss; the rock lies in regular masses on the surface. It appears to be closely connected with the bed rock.

In the bed of Sucker brook, in sec. 27, 57-24, is found some fine, bluish-gray clay in beds of unknown depth. No. 282 (H). Much of this section of the country seems to be underlain by clay beds, as springs of cold water are very numerous.

MISSISSIPPI RIVER.

In Twp. 54-24 the banks of the river are 25 feet high or more. They are composed of sand for 15 feet from the surface. The rest of them is composed of fine, hard clay, red and blue, in thin beds. The top beds of this clay are red, and there are also thin, red layers in the blue strata all the way down. No. 284 (H).

This clay continues to form part of the banks where they are over ten feet high for twenty or thirty miles farther down the river (ten miles below the mouth of Swan river, in township 52-23). Most of it is bluish-gray clay and is more sandy than the red layers. A thin

*Mr. Bailey Willis in vol. xv, 10th Census, p. 460, describes this gneiss as being without bedding.

layer of fine sand separates each stratum of clay from the ones next to it. This clay forms the bed of the river in many places. It is so hard that one can hardly stick a knife into it. It is not in perfectly horizontal layers everywhere, but the strata undulate and have a wavy appearance in places, and again are flat or slightly inclined.

A short distance, perhaps ten miles, above Sand lake is the first rapid and first accumulation of boulders seen below Grand Rapids. From here down boulders are quite numerous. Below Sand lake the clay strata appear only occasionally and have a slightly different aspect, containing more sand. The banks are lower and all seem to be alluvial.

There were reports circulated at Grand Rapids of silver ore found in township 61-23. The locality was not visited, but a sample of the rock from there was obtained of the postmaster at Grand Rapids. This was assayed by Mr. C. F. Sidener, who reported "no gold or silver."

TRIP TO PELICAN LAKE.

The rock in the N. E. ¼ of the S. W. ¼, sec. 4, 63-18, is gneissic mica schist. It is cut by intrusions of gneiss and syenite gneiss. It rises forty of fifty feet above the stream connecting Hoodoo lake with Partridge lake, and above Hoodoo lake. There is no fall in the stream between these lakes, which is wide and dead water all the way. No. 286 (H) is from the above mentioned locality. There is very little rock exposed on the shore of Hoodoo lake. The schist in this region has a very gneissic appearance and might be called fine gneiss rather than schist. It contains both muscovite and biotite as well as hydromica.

In the N. E. ¼ of S. E. ¼, sec 5, 63-18, the rock is schist containing mica that is partly hydrated. It also contains some hornblende and is very siliceous. Small veins of quartz run all through the rock in the direction of the strike. There are also lenticular masses of quartz in the schist. Strike is about E. 20° S. Dip is S. 70° to vertical. There are intrusions of granite in the schist. Fine particles of pyrite are scattered through the rock. No. 287 (H).

A few rods west of the last, along the strike, the rock assumes a more perpendicular dip and contains much chlorite which gives place to hornblende a little farther west.

The schist here is much jointed and is composed almost wholly of hornblende. It is quite ferruginous and heavy in places, and disturbs the needle. Samples are No. 288 (H).

A little further west along the strike, which is in a general east and west direction, the schist becomes like syenite gneiss, and is finer grained. It rises in perpendicular beds sixty feet above the lake. Some of the thin beds are much more hornblendic than others; some contain both mica and hornblende. The whole hill is cut by intrusions of granite, intricately crossing and re-crossing each other. No. 289 (H). The intrusions contain thin veins of a hard, green mineral, probably epidote. There are small cavities in the hard crystalline rock, filled with a soft white substance, like kaolin. Parts of these intrusions are also felsitic.

Soft, red mica schist is seen at the portage near the west end of Hoodoo lake, N. W. ¼ of S. E. ¼, sec. 5, 63–18. Fine-grained siliceous mica schist is seen on the portage from Hoodoo lake to Susan lake, which lies just north of it.

No. 291 (H) is from a small island in the north side of Susan lake, in sec. 32, 64–18. It is fine mica schist, which assumes a gneissic texture on the same island. This schist dips S. W. 50°, and strikes E. 70° S. It is mostly quite solid and firm, and contains fine particles of pyrite. The features of the rock in this lake are the strike and dip. The latter is generally, at a low angle, W. S. W. The schist contains many wavy sheets or beds of gneiss. In one place there is a mass of hornblende schist, inclosed in the mica schist and cut by the same granite intrusions. It has the same strike as the mica schist. The continuation of it is covered on both sides, but later it can be traced for five rods, sometimes a foot thick, sometimes only an inch, running through the mica schist. This rock seems to be composed almost wholly of hornblende and biotite, with some feldspar. No. 292 (H). Some of it seems to contain graphite. No. 292A (H).

No. 293 (H) is from the S. E. ¼ of S. E. ¼, sec. 32, 64-18. It is mica schist, with thin sheets of green mica. The schist itself has a rosy or pink tinge. The rock in the southeast end of Susan lake is gneiss interbedded with schist. No. 294 (H).

ELBOW LAKE.

On the north side of the Portage from Susan lake to Elbow lake—probably in the N. E. ¼, sec. 32, 64-18—is a round point of mica schist and gneiss that projects into the lake a short distance. The strike is east and west. Glaciation is N. 26°E.

Twisting, winding veins of granite run all over the surface of this point. One intrusion about four inches wide (No. 1 in the sketch) runs with the bedding nearly straight for several feet, and cuts through a bed of gneiss (No. 2) two feet wide that cuts the schist into an irregularly shaped mass. The thin intrusion (No. 1) after conforming with the schist for a distance, turns off and splits up into thin threads, cutting the schist as well as the feelers from the gneiss bed (No. 2). No. 2 is also cut by a fine dark vein of granite (No. 3) that also runs across the beds of schist. No. 1 cuts both No. 2 and No. 3. It is pinker than the others, and is coarser at the edges than in the middle. No. 2 is coarser than Nos. 1 and 3.

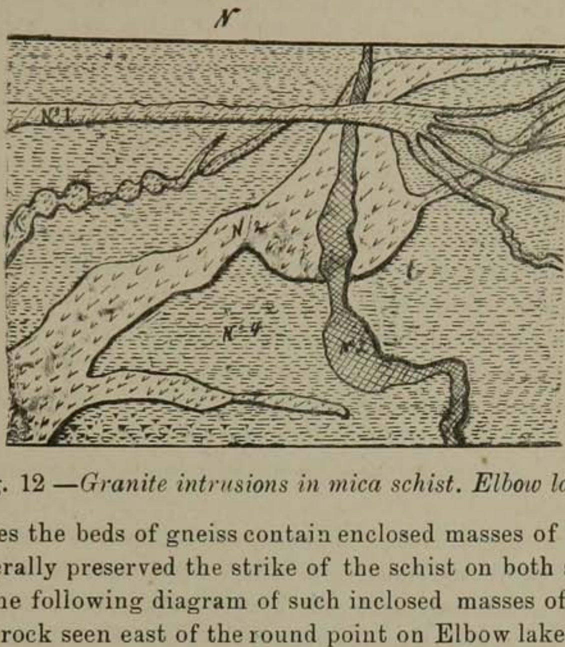


Fig. 12 —*Granite intrusions in mica schist. Elbow lake.*

Sometimes the beds of gneiss contain enclosed masses of mica schist which generally preserved the strike of the schist on both sides of the gneiss. The following diagram of such inclosed masses of schist was made from rock seen east of the round point on Elbow lake illustrated in the last figure.

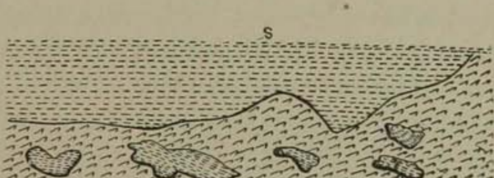


Fig. 13.—*Gneiss containing masses of mica schist interbedded with mica schist. Elbow lake.*

The dip is about vertical; sometimes a little one way, and sometimes the other. Many of the thin beds of schist are hornblendic as well as micaceous;—the hornblende crystals standing out on the surface and giving a black color to those beds. The rock is quite generally covered by moss and lichens when not obscured from view by overlying soil.

A sample of the mica schist from the south-east bay of Elbow lake is No. 295 (H).

A little north of the last the rock is a regular alternation of gneiss and mica schist in beds of variable thickness. The general trend is N. 80° E, and the prevailing dip is to the south, sometimes as low as 45°. There are also granite intrusions cutting gneiss and schist alike. The strike changes a little in going farther east, becoming about N. 60° E. Much more intrusive granite is seen. In some places it has flowed over the schist and lies unconformably upon its upturned edges. Much of the gneiss is fine and very micaceous; none of it is very coarse.

At the east side and end of the lake the gneiss lies nearly flat—quite so in places. It has been folded and bent in large waves so that it dips in all directions; now are seen the crumpled edges and again the convex tops of the distorted strata.

At the northeast end of the lake the strike of the gneiss and schist has changed to N. 20° E. Here it is impossible to tell which is bedded gneiss and which intrusive granite: it all seems to cut the schist in one place or another. Gneiss that seems to have flowed over on the upturned strata of mica schist is cut by granite intrusions that also cut the schist.

The flatness of the schist beds around the east and north end of Elbow lake is quite striking. The rock rises in bluffs forty feet above the lake; and granite intrusions can be seen cutting the schist and beds of gneiss at all angles from horizontal to vertical. Some of it is a fine breccia; but the most noticeable feature is the general horizontal position of the strata.

The gneiss and schist in the hills east of the northeast end of the lake are stirred and mixed most thoroughly. Gneiss and schist alike are bent and doubled on themselves as a piece of paper crumpled in one's hand would be. The gneiss is mainly composed of feldspar in very angular crystals, some an inch and a half long and of a red color. Much of the schist is hornblendic.

There is a dyke (?) of rock, similar to No. 292 (H), six inches wide running through the schist and gneiss uninterruptedly for a good many feet. Its course is N. 80° E. It is composed chiefly of hornblende, mica and feldspar. No. 297 (H.)

On the point which projects into the lake from the north side of the lake the rock is the usual mixture of micaceous and hornblendic schist and gneiss. The gneiss being harder it is slower in submitting to the erosive action of the lake and the elements, and so it appears to predominate largely; but there is a fair proportion of schist with it. The schist lies in all possible positions and relations to the gneiss; over it and under it, twisted around it and enclosed in it. The usual intrusions of granite cut it in all directions. These are much more regular in their course and shape than the beds of gneiss. There are two or three series of them, crossing and cutting each other in various directions. There is no uniform strike or dip to the strata here; but the apparent tendency is to assume a north dip. The rock becomes more gneissic as we go north, and does not seem to be penetrated by so many granite intrusions.

A little southwest of the last the solid rock rises up nearly 100 feet above the lake. It is mostly gneiss of different colors and degrees of coarseness; some lying flat and some on edge cut by other beds in all sorts of ways. Some of the main body of the rock is fine, gray biotite gneiss in flat strata. It resembles the gneiss at the Upper Falls of Prairie river. No. 300 (H). Some of it is coarsely granular, containing pink and white feldspar and mixed with mica schist. No. 301 (H).

No. 302 (H) is from a bay near the west end of the lake. It is the dark, fine, heavy rock composed mostly of mica and hornblende which has already been labelled No. 292 (H) and 297 (H). It is interbedded in vertical strata with mica schist and gneiss; strike is N. 80° E. Just west of this the rock is similar but contains more feldspar. It is in beds with gneiss and schist that contain both mica and hornblende, but the mica predominates. Glaciation here is N. 28° E. The hills north of the west end of Elbow lake consist of gneiss and hornblendic mica schist. They are immense rounded knobs of rock almost destitute of vegetation and half covered with loose fragments of boulders and *debris* from the hillside. They rise 150 feet above the lake.

ELBOW RIVER.

A small stream leaves Elbow lake, and after tumbling down a winding glen around boulders and over solid rock for about a quarter of a mile becomes a small river with no apparent current most of the way to Pelican river, into which it flows. This is Elbow river. There is a high ridge of hills south of it and considerable high rocky ground north of it. When any large amount of the rock in this region has a uniform strike it is about east and west. All of the rock around Elbow lake contains

56

more or less hornblende, and most of it is decidedly acidic. The south shore of Elbow Lake follows the changing strike of the rock quite closely.

Going down Elbow river the first rapid is just at the outlet of the lake. The next is 2½ or 3 miles below. The hills here rise about 200 feet above the river on each side. They are almost bare knobs of gneiss, containing more or less schist interbedded with it. The hill on the north side of the rapid is called Bald mountain.

The country for a few miles around, as seen from the top of Bald Mt., is rough and hilly and probably all composed of this same formation. There is generally a strip of swamp along the river. The river bed is remarkably level for such a hilly country. Elbow river flows into Pelican river about two miles south of the east bay of Pelican lake—probably in sec. 18, 64-19. Samples of the gneiss from the top of Bald Mt. are No. 304 (H). The mica schist from the same place is No. 305 (H). The gneiss is hornblendic or chloritic, and is a fine-grained, siliceous rock with fine veins of a light green mineral running through it.

PELICAN LAKE.

The shores of this lake are not very high nor rocky, i. e., with solid rock. Most of the coast is either sandy or boulder-bound.

Pink gneiss is found in the N. E. ¼ of S. W. ¼, sec. 2, 64-20 It grades into mica schist in the immediate vicinity. The apparent dip here is south, but there is so little continuity in strike or dip that the general direction cannot be determined. Nos. 306 (H) and 307 (H). The south side of the point at the same place consists of beds of mica schist and gneiss that dip west and strike north and south. The schist is hard and fine-grained; the gneiss, gray and fine. No. 308 (H).

The island in the N. E. ¼ of S. E. ¼, sec. 3, 64-20, is composed of gneiss and schist and granite intrusions. The schist is both micaceous and hornblendic. The general strike is north and south, with a high dip to the west. The surface of the rock presents a most intricate commixture of veins, dykes, beds of schist and gneiss and granite intrusions. The last thing to come in was a small dyke of greenstone about three inches wide, running N. 30°E. It cut all the rest, but has been faulted off two or three feet since, and thus been changed in its direction.

Samples from the dyke are No. 309 (H.). It was traced for about three rods. Glaciation here is N. 36° E. At the same place there is a

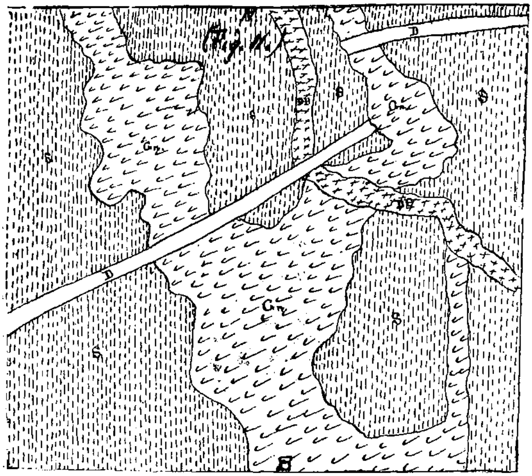


Fig. 14.—*Pelican Lake. Gn., gneiss. S., mica and hornblende schist. D. B., granite intrusion. D., small dyke of greenstone.*

band of greenish rock composed of mica, hornblende, feldspar and perhaps quartz, running through the rock in an east and west direction. Streaks or threads of gneiss run all through and across it, and give it a mottled appearance. It is about six inches wide and can be traced in a straight course for five or six rods. It maintains about the same thickness during this distance. Where it passes through schist there is generally a line of granite to separate it from the schist. Where it cuts gneiss there is no distinct line of separation, but the gneiss runs right down into it in the threads spoken of above. The dark parts of this band of rock have a kind of schistosity in the direction of the vein.

The island near the centre of sec. 3, 64-20, is composed of the same mixture of gneiss and schist and rises 50 feet above the lake. There are long, smooth beds of rock which is half gneiss, half schist, on the west side of the island. These beds strike north and south and dip W. 64°. Much of the schist contains both hornblende and mica, and some of the gneiss is syenite gneiss. Occasionally dark, hornblendic rock is seen, just as much bedded as the rest and evidently part of the formation, but looking much more like eruptive rock. Some of it contains round grains and feldspar that look like amygdules. Nos. 310 (H) and 310A (H).

In the N. E. ¼, sec. 12, 64-21, the rock is massive gneiss. The only signs of mica schist are a few small lenticular masses of it, four to six inches long which are enclosed in the gneiss. The rock is in low, flat outcrops. It contains hornblende and is somewhat porphyritic. No. 311 (H). It does not exhibit any granite intrusions nor other rock cutting it in any way. The same rock appears on the next point to the west, and here contains masses of mica schist, 12 to 14 inches long. It is also more porphyritic, containing orthoclase crystals 1½ inches long.

The point in the N. E. ¼ of N. W. ¼, sec. 12, 64-21, is composed of this same rock. It contains a few masses of hardened mica schist two or three feet in diameter.

No. 312 (H). This rock is very similar to that which forms the falls at Fort Francis; the points of resemblance being its porphyritic nature, the presence of hornblende crystals as well as mica, no gneissic structure apparent, enclosed masses of mica schist, and position to the west of a disturbed region of gneiss and mica schist. It is probably the continuation of the same belt of rock as that at Chaudière falls. Immense, rounded pieces of this rock lie on the surface, some of them twenty feet in diameter.

No. 313 (H). is siliceous gneiss, coarse, granular and white. It occurs in thin beds in the mica schist on a point in the N. E. ¼ sec. 35, 65–20. On one side of it is mica schist with the biotite in round spots. The strike of the gneiss and schist here is north and south; dip at a high angle to the west. The gneiss predominates and is largely in thick beds. Both gneiss and schist are penetrated by granite intrusions that run for the most part east and west. These are very siliceous, contain white orthoclase and have an indistinct gneissic arrangement of the mica. No. 314 (H).

A small island supposed to be about in the S. E. ¼ sec. 26, 65–20 is composed of gneiss and hornblendic mica schist. Strike is N. 30° E., dip N. W. 75° more or less. Glaciation N. 30° E.

The beds of hornblendic mica schist are more decomposed than the rest of the schist.

One of these beds of schist cuts into the mica schist proper in some of its curves, for it is not quite straight though it follows closely the bedding of the mica schist, and is cut by the same granite intrusions as the mica schist. No. 316 (H). The specimens are from the hardest part of the bed, which is about six inches thick and has a gneissic arrangement of the minerals.

The next point to the northwest, about a quarter of a mile, is composed of gneiss and schist; the latter containing more or less hornblende all through it. The strike varies from N. 30° E. to N. 50° E. There is a high dip to the N. W. Glaciation N. 24° E. The schist is dark, hornblendic rock containing vitreous quartz grains and apparently but little feldspar. No. 317 (H). Some of the schist is harder and finer and less schistose than the samples. Much of it contains fine particles of pyrites.

The extremity of the point consists almost wholly of gneiss enclosing large masses of schist. Some of the gneiss is quite coarse, containing feldspar crystals over two inches long. Much of it looks like the coarse gneiss seen on Rainy lake, and some of it is pegmatitic. The finer gneiss contains hornblende as well as mica.

On one point in section 26, 65–20, the gneiss contains pockets of amphibolyte (?). They are round or irregularly shaped masses that have no resemblance to the gneiss and no visible connection with the schist beds or any other beds. They are simply enclosed in the gneiss. No sample could be obtained.

Just across the bay from the last point, to the north, the rock of the point is half way between mica schist and gneiss, but looks on the whole more like schist. It contains and lies along-side of beds of hornblendic mica schist such as is commonly found imbedded with gneiss in all this region. They are both cut by intrusions of granite. Thus we have here, instead of gneiss proper folded around mica schist or squeezed into it in a plastic state, mica schist—for it is that rather than anything else—enclosing and interbedded with irregular masses and strata of entirely different mica schist. No. 318 (H). This is somewhere near the N. W. ¼, sec. 26, 65-20. The general strike is about N. 20° E.

In the bay north of the last is a small rock island composed principally of gneiss. The enclosed mica schist is like No. 318 (H) and not like the more schistose schist with which that is associated. The schist and gneiss on this island are cut by an irregular intrusion varying in width from four to ten inches. It is noticeable that the intrusions which seem to have been latest and have cut all the rest are generally pinkish or reddish; while the bedded gneiss is white or but slightly pinkish, as a rule; though some of it is red rather than pink.

On this same small island the gneiss that conforms with the beds of schist for a short distance and is cut by the granite intrusion mentioned above, in its turn strikes off in a mass two feet and more in thickness, cutting through the schist—or at least across the strata, and constituting what might be termed a "dyke-bed" without being paradoxical.

The south side of the small island just west of the last is composed for the most part of handsome gray gneiss, slightly porphyritic. It is cut by the usual granite intrusions. No. 319 (H) is a sample.

On the shore of the mainland about 100 paces north of the island the rock rises 30 feet above the lake. It is mica schist and syenite gneiss with granite intrusions. It contains varying amounts of hornblende and grades in places from syenite to a dark, heavy, fine-grained rock almost all hornblende. It seems to contain some epidote. No. 320 (H).

For some distance along the shore to the west the rock is syenitic gneiss and mica schist. A little farther along some immense masses of schist and gneiss stand up in the water near the shore, fifteen feet above the surface. They seem to have constituted one enormous boulder, now split and broken into several irregular, jagged masses.

The large island southwest of the last-mentioned locality presents an appearance similar to that of the coarse gneiss at the east end of Rainy lake. It is a mixture of coarse gneiss and mica schist. The schist predominates at the southwest end of the island. The strike is N. 20° E. Dip, W. N. W. 70°. The backbone of the island is principally gneiss, containing a little mica and hornblende schist in irregular masses and short beds. This gneiss is very siliceous, the coarse, vitreous quartz lying in it in masses several inches across. The feldspar is pink or white orthoclase, and is also very coarse; the largest crystals being over six inches long The mica is muscovite; and scales two inches square can be obtained.

The gneiss incloses masses of hornblende schist. Samples are No. 321 (H). The mixture of mica in fine scales, and quartz in small grains, such as seen at the east end of Rainy lake, is found here, too. Perhaps this may be called greisen, but it does not seem massive enough to answer the usual definition. Some of the large feldspar crystals here contain quartz arranged in such a way as to form graphic granite. At the northeast end of the island there are siliceous beds in the schist containing pyrite, hornblende, malachite, chalcopyrite and a greenish-yellow mineral that was not determined. No. 322 (H). These beds are a foot or two feet wide, and continue for some distance, disappearing under the lake. The coarse gneiss here contains some biotite, as well as muscovite.

On the large point west of here is found the usual mixture of gneiss and mica schist both containing more or less hornblende. Strike is N. 35° E. Some of the schist enclosed in the gneiss has been so much changed and resembles the gneiss so closely that one is hardly able to discern the outlines of the former schist masses. Much of it is exceedingly hornblendic.

On the hill north of the point there is a breccia. It is a gneissic schist containing angular masses of hornblendic schist of all sizes up to two or three feet in diameter. Many of them have their longest direction across the schist beds. They seem to be much metamorphosed. The breccia also contains pieces of gneiss a foot long.

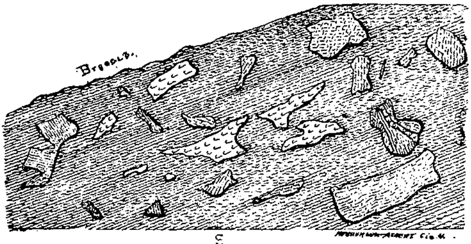


Fig. 15.—*Breccia. Pelican Lake.*

There are also in this breccia pieces of schist with gneiss running through them. There is a schistose or flowage structure running N. 35° E., and conforming somewhat to the shapes of the enclosed masses. This breccia extends nearly to the south end of the point.

The island just west of this point is composed mostly of micaceous, porphyritic syenite very poor in silica. It is massive and contains large irregular masses of mica and hornblende schist and gneiss. It has a contact with rocks similar to those enclosed in it, on the east side The direction of this contact is N. 20° to N. 24° E. In some places this rock resembles a coarse breccia, and elsewhere a conglomerate, the faint outline of formerly enclosed masses being visible. It has the appearance on the surface of having been heated to a boiling condition, and the uneven surface covered with curved lines and half-broken bubbles reminds one of oat-meal when cooking. It is cut by one or two narrow granite or rather granulyte intrusions. It also contains a few masses of red granulyte wholly enclosed in it. When it has been washed and weathered by the lake a schistose structure or something similar appears, the rock weathering in wavy lines and sheets.

The small island nearly a mile west of the last consists of pyritiferous, micaceous, garnitiferous, chloritic (?) syenite gneiss. The rock that lies to the west of this and is similar to the Fort Francis rock grades into this and into rock more hornblendic than this. This rock is all laminated in thin sheets having a low dip to the north. Nos. 325 (H) and 325A (H).

In section 36, 65-21, the whole shore, where it is high, is formed of the Fort Francis rock and its variations. The main part of it is quite similar to that which forms the falls at Fort Francis, but much of it is similar to No. 325 (H). It contains masses of pure, unchanged mica schist ten, twelve and even forty feet across. This schist is cut by granite intrusions and stands for the most part in vertical beds. Some of the mica schist inclusions are very much smaller, only six inches wide and two feet long or less. The schist has a very abrupt contact with the rock in which it lies. There are also inclosed in this rock numerous rounded and irregular pieces of rock quite similar in appearance to the main part of the rock, but generally more hornblendic. The inclusions are porphyritic and in other ways have a close resemblance to the rock which contains them, and yet they are decidedly different and probably were much more so formerly. The granite intrusions may be, and probably are, stringers from the main mass of the rock. The mica schist which is contained in this rock has small round "geodules" on the surface. They are little geodes having a quartz crust with garnets inside. One enclosed mass of schist is cut by a small dyke of trap which has a slight schistose structure. The glaciation here is finely marked N. 28°E.

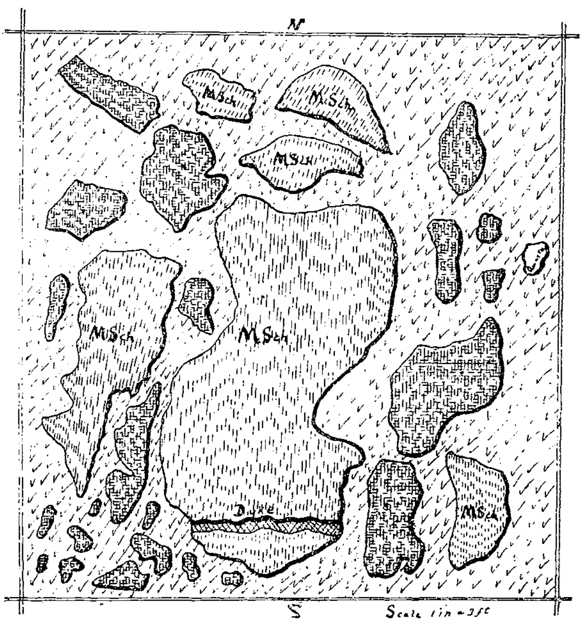


Fig. 16--*Breccia. Pelican lake.*

In the N. E. $\frac{1}{4}$ sec. 35 (?) 65–20, the gneiss and mica schist are cut by granite intrusions. Some of them are garnetiferous. Tourmaline crystals were found in the gneiss which is interbedded with the schist at this point. The rock is mostly fine gneiss. One of the large granite intrusions on the east side of the point consists largely of pegmatyte. This looks much like the coarse gneiss seen at Rainy lake. The trend of the graphic granite intrusion is N. 25° E ; width, feet; length of exposure, 150 feet. It contains muscovite crystals $2\frac{1}{2}$ inches across. No. 331 (H.)

In the N. W. $\frac{1}{4}$ sec. 36 (?) 65–20, the rock is principally mica schist and interbedded gneiss. Irregular masses of a greenish, heavy rock, consisting mostly of hornblende, are contained in the gneiss. These masses are not over two feet long, and have an abrupt contact with the gneiss.

In the N. E. $\frac{1}{4}$ sec. 36 (?) 65–20, the rock is principally mica schist containing some very even beds of gneiss and cut by granite intrusions running directly across the strata.

NET LAKE.

This lake is reached by making a four-mile portage from Pelican lake and descending a small stream nearly to the lake. The name of this lake, *Sabikweness*, signifies a fish-net; hence this name should be spelled with but one *t*, *Net*. The lake is almost entirely surrounded by swamps and is shallow so that a landing place is hard to find.

In only one place near the lake was any considerable exposure of rock seen. This is on a small island near the east side of the lake, just west of the Indian village. This island is composed of mica schist and interbedded gneiss cut by granite intrusions. The whole is then cut by a large dyke of greenstone from which stringers have been sent out across and through the other rock.

The west and north sides of the island are beautifully polished by glacial action, the striations running N. 20° E. to N. 24° E. The strike of the schist is N. 58° E. The direction of the dyke is about north and south. The dip of the schist is about S. 70°. There is much magnetite in the dyke-rock. This dyke cuts the granite intrusions and contains a few feet of one of them in it lengthwise.

The first solid ground south of where the river enters the lake on the east side is now cultivated by the Indians for a potato-patch. It was formerly the site of an Indian village; and many chips of flint and quartz as well as broken pottery and fragments of copper are to be found there. A few scrapers and imperfect arrow-points and knives were found here. The Indian who owns the potato patch says that he has seen quantities of arrow-points, but has never preserved any.

The portage from Pelican lake is about four and a quarter miles long. It is a good trail and leads to a small stream about two miles from Net lake. There is not much difference in the elevation of the two lakes, Net lake being a little lower if anything. The country between them is covered with drift for the most part; many large boulders and much gravel and sand are seen, but little or no solid rock. The hills north and northeast of Net lake contain much rock and so probably do the hills south of the lake, though they are said to consist only of boulders and drift material. Solid rock crops out in the midst of the Indian village at Net lake. It is mostly mica schist containing round or lenticular masses of gneissic rock.

TROUT LAKE.

The stream from this lake into Vermilion lake is a short one. It is quite rapid and is full of boulders and loose fragments of rock. The remains of an old water-wheel and stamp-mill are visible at the foot of the rapids. Angular masses of white quartz lie around. They contain pyrite and siderite. No. 333 (H).

The rock in the river channel is a mixture of mica and hornblende schist and gneiss. There are fine veins of red feldspar penetrating the rock in all directions. Most of the gneiss contains both orthoclase and plagioclase and more or less pyrites. The general strike seems to be east and west. Nos. 334 (H) to 337 (H).

The point in the S. W. ¼ of N. W. ¼ sec. 19, 63-15 is composed almost wholly of mica schist. There are a few narrow veins or stringers of gneiss running through it in various directions, and one or two granite intrusions of considerable thickness. The mica schist here does not seem to contain any hornblende.

In the N. W. ¼ of N. W. ¼ sec. 19, 63-15, the rock is mostly a fine, gray, biotite gneiss, slightly prophyritic and containing irregular inclusions of mica schist. No. 338 (H). On the north side of the point at the same place the rock is syenite gneiss in nearly flat beds. No. 340 (H). The schist with which it is bedded and into which it graduates is also hornblendic. The gneiss is pyritiferous. There is a heavy covering of drift here and many boulders lie around.

In the S. E. ¼ of N. E. ¼ sec. 13, 63-16, there is an exposure 200 feet long of flat bedded gneiss and mica schist. It is in bluffs 15 feet to 20 feet high. The gneiss and schist grade into each other and alternate in beds of all thicknesses up to three feet. Most of it is fine-grained and more or less decomposed. No. 341 (H). These horizontal beds of gneiss and schist are cut by one or two nearly vertical granite intrusions. No. 342 (H). The feldspar in both the gneiss and granite is yellowish-white, and some of it is iron-stained. They both contain more or less hornblende.

In the S. W. ¼ of S. W. ¼ sec. 13, 63-16, is a large, low exposure of gneiss and mica schist interbedded in vertical strata, and cut by vertical granite intrusions from an inch to four feet thick, running in all directions through and across the beds. Strike is E. 54° S. The schist is typical, biotite mica schist. The gneiss is fine-grained yellow rock, similar to most of that in this region. Following this along the shore in a southeasterly direction we soon come upon a perpendicular wall of rock with a smooth face twenty feet high and one hundred feet long. This looks like a wall of masonry made of thin slabs laid horizontally. On careful inspection it appears that most of the gneissic structure and the arrangement of the minerals in lines and bands is vertical, and the beds are laminæ or sheets instead of strata. In much of it there is no gneissic structure evident. In places the gneissic structure dips S. W. 45°. This rock is hornblendic as well as micaceous and contains granitic veins. No. 343 (H). The direction of the face of this wall is E. 70° S., and the general direction of the gneissic vertical beds in it is about the same, some being however E. 40° S. At the edge of the water this appearance of laminæ disappears and the rock seems to be as usual in vertical strata. Quantities of boulders and pieces of the adjacent rock line the shores of this lake.

The rock on the point in the S. W. ¼ of the S. E. ¼ sec. 14, 63-16, is gneiss and syenite gneiss containing a little schist, both mica and hornblende. It seems to be in vertical strata. The syenite gneiss contains rounded or lenticular lumps or nodules of actinolite mixed with a little mica. These nodules are four inches long, on an average, and vary from light, grayish-green to greenish-black in color. They are much softer on the exterior than a short distance within. The hornblende on the exterior is altered from some softer mineral. Nos. 345 (H) and 345A (H).

In the N. W. ¼ of S. E. ¼ sec. 14, 63-16, the shore rises up almost perpendicularly for forty feet. It is mica schist containing a little gneiss. It is all pervaded by more or less hornblende. The strata are much disturbed here, and have no permanent dip. The strike is E. 40° S.

In the N. W. ¼ sec. 14, 63-16, the rock is principally a reddish, biotite gneiss, some of it quite coarse and containing pyrite. It lies across the mica schist beds, which are vertical for the most part, but have been much distorted in places. No. 346 (H). This reddish gneiss is itself cut by thin, light yellow or white granite veins.

Red chlorite gneiss is found in the S E. ¼ of S. W. ¼ sec. 15, 63-16. It occurs in vertical beds with strata of micaceous, hornblendic schist. Some of the beds are bent considerably and have a low dip to the north.

Near the centre of sec. 15, 63-16, the bluffs rise 60 feet or more vertically or in overhanging masses. It is principally mica-schist with some gneiss and a few veins of pyritiferous quartz. The schist itself is gneissic and almost massive; it is in such thick beds. Where there is any bedding structure visible it is wavy and distorted.

In the N. E. ¼ of S. E. ¼ sec. 10, 63-16, the granite shores rise 40 feet above the lake in smooth, sloping ridges. Hornblende and a few other accessory minerals are present. In places the granite is quite coarse, orthoclase crystals four inches long being noticed. Some of it is pegmatitic. In some of this coarse granite the muscovite scales are set in or surrounded by quartz. Nos. 348 (H) and 349 (H).

From here north the shores seem to be wholly granite, no schist being mixed with it. It is all decidedly acidic and does not contain much mica. The feldspar is orthoclase. It is jointed in various directions. Sometimes it seems to lie nearly flat, sheets of it lying over each other, dipping to the southeast. Granite from the S. E. ¼ sec. 11, 63-16, is No. 350 (H).

Syenite is found in the N. E. ¼ of N. W. ¼ sec. 11, 63-16. It contains red orthoclase, dark hornblende, and but little quartz. Epidote is a common ingredient. It has much the same appearance and manner of occurrence as the granite. It is inclined to be porphyritic in places. No. 351 (H).

Across the bay in N. E. ¼ sec. 11, 63-16, the rock appears to lie in flat beds. It is gneiss with about equal amounts of mica and hornblende. Some of it is almost schist, and some is granulyte. It is cut by intrusions of granite. No. 352 (H).

In the S. E. ¼ of N. E. ¼ sec. 11, 63-16, the rock is fine, gray, biotite gneiss, containing plagioclase feldspar. It is quite firm and solid, but contains mica schist beds and lumps in which the strata run nearly north and south. Glaciation is N. 16°E. No. 353 (H). Portions of this same gneiss are very coarse, and the feldspar is orthoclase with the pegmatitic character.

Low, flat exposures of granite or gneiss are seen in the N. E. ¼ of sec. 2, 63-16. It is mostly fine-grained rock similar to 353 (H). It has bands of coarse granite running through it or lying on the surface. The line of contact or of separation from them is indistinct. Most of it has the appearance of being in beds dipping to the southeast at an angle of 30° or less. But in some of it there is an indistinct gneissoid structure which is about vertical. The shores are piled up for about ten or fifteen feet back from the lake, by the action of the elements, with masses of the subjacent rock and with boulders of granite. The gneiss contains a little hardened schist, and sometimes approaches the fineness of schist itself; but generally it is coarse, firm and compact.

Low exposures of porphyritic, micaceous gneiss are seen on the point in the N. W. ¼ of N. E. ¼ sec. 35, 64-16. In places it assumes the character of a breccia, and contains angular masses of hornblendic rock similar to that at the west side of Pelican lake.

Much fine pine grows around this lake. The water is clear and the lake shores and islands are beautiful. In many places, however, low reefs of rock extend out into the lake but a short distance below the surface of the water; thus making it difficult as well as dangerous for a canoe to land. In fact all of the shores have a very gradual slope into the lake.

A large exposure has been caused by fire in the S. E. ¼ of S. W. ¼ sec. 26, 64-16. It is gneiss, partly fine and partly coarse. Part of it is mica schist and part half-way between schist and gneiss. Coarse masses of iron-stained quartz are seen here; also some coarse feldspar. In all this region there is a more or less striking appearance of horizontal lamination in the rock. In almost every place careful examination reveals the fact that the rock has a gneissic texture that is vertical or nearly so. Also when any schist beds lie in the gneiss they seem to be in vertical strata.

The point in the west half of N. W. ¼ sec. 30, 64-15, is composed of gneiss and mica schist rising about 40 feet above the lake. At this place there is also a good display of the horizontal laminæ and vertical gneissic structure. The thin beds of schist which are in the gneiss are bent and doubled up like a letter *S*. The general strike is east and west.

There is a most enormous pile of "cobblestones" here. Just to the southeast of the long sand beach in the S. E. ¼ of S. E. ¼ sec. 24, 64-16, is a pile of them 20 feet or more in hight and extending for 200 or 300 paces along the shore. They are rounded and polished nicely and are from four inches to a foot in diameter.

At the north end of the lake the rock becomes more regular in its bedding and dip. The latter is north, at a high angle. At the very end it is mostly gneiss; but contains more schist or gneissic schist than the gneiss a mile or two south. Glaciation in the N. E. ¼ of S. E. ¼ sec. 18, 64–15, is N. 36° E.

Coming south through secs. 30 and 31, 64–15, the beds of gneiss and schist gradually become more and more distorted and irregular. The dip gradually goes from vertical to horizontal, and the strike is extremely variable. The beds are about horizontal in the S. W. ¼ of of N. E. ¼ sec. 31, 64–15. They are cut by vertical granite intrusions. In the N. E. ¼ sec. 32, 64–15, there is considerable mica schist, quite regularly interbedded with gneiss, having a strike E. 60° S.; dip, N. 60°.

In general. This lake lies on an anticlinal. The flat-lying beds are in the middle or on the top of this anticlinal, and the strata dip north at the north end and south at the south end of the lake. The bays and general contour of the lake do not conform with the general strike of the formation, showing that the rock is very irregular in its bedding and dip.

Much hornblendic rock is seen on the west side of the lake and hardly any on the east side. Much fine pine grows around the lake. Most of it is taken by pre-emption. The shores, as said above, are wretched for landing, large piles of boulders and loose masses of rock extending far out into the lake from nearly every part of the shore.

ELEVATIONS FURNISHED BY MR. WARREN UPHAM.

	Ft above the sea.
Rainy lake,* low and high water, approximately 1115–1120; mean	1117
Rainy river, rapids ½ mile long, just below Rainy lake	1117–1114
Rainy river, Chaudière falls, at Fort Francis, descending 23 feet	1114–1091
Lake of the Woods, low and high water, 1057–1063; mean.	1060
Bowstring lake, determined by U. S. engineers	1321

*Hinds' *Narrative of the Canadian Exploring Expeditions*, London, 1860, vol. ii, pp. 399-402. Corrected by Upham through comparison with survey of C. P. R. R.

On Bowstring river.

	Miles from mouth of Bowstring river. (Whittlesey.)	
Head† of "fall of 6 feet over trappose rock" estimated about 70 ft. above the mouth of this stream.	82	1240
"Rapid of 4 feet over hornblende slate"	75	1225
"Fall of 29 feet over gneiss and mica slate"	45	1179–1150
Mouth of Opimabonowin river	40	1140
Junction with Rainy Lake river	0	1085
Red lake, approximately	..	1150

†Whittlesey's *Report of Explorations in the Mineral Regions of Minnesota*, 1866. Corrected by comparison with leveling observations.

LIST OF SPECIMENS COLLECTED BY H. V. WINCHELL DURING THE SUMMER OF 1887.

LITTLE FORK RIVER.

No. 75 (H). Massive, green dioryte with a little biotite (?).

On north side of river about two miles below Wakemaup's portage.

No. 76 (H). Siliceous mica schist containing dolomite or calcite. From Rapid No. 1 three miles below last.

No. 76A (H). Biotite granite containing masses of muscovite granite, also containing calcite. Same locality.

No. 76B (H). Sample of schist similar to 76 (H); but containing grains of vitreous quartz. A little south of last.

No. 77 (H). Tough, massive, crystalline rock, containing magnetite. Underlies Rapid No. 1.

No. 78 (H). Mica schist containing also hydromica. From Rapid No. 2, four miles below last; three-quarters of a mile above the mouth of Rice river.

No. 79 (H). Siliceous schist. From Rapid No. 3, just below the confluence of Little Fork and Rice rivers.

No. 80 (H). Mica schist cut by gneiss. South side of river, three miles below Rapid No. 6.

No. 81 (H). Greenish mica schist containing pyrite. North side of river, four miles below last.

No. 82 (H). From "Big Falls" of Little Fork, about a mile below last. Fine-grained, compact, green schist; much jointed and presenting many different aspects in different strata.

No. 82A (H). A greenish-black mineral found in seams and joints of last.

No. 83 (H). Micaceous syenite gneiss containing lumps of a green material. Two miles below last.

No. 84 (H). Drift limestone from a gravel bank about a mile and a half below Rapid No. 10.

No. 85 (H). Clay concretions from clay bank on north side of river about three-quarters of a mile below Rapid No. 12.

No. 86 (H). Pophyritic garnetiferous, micaceous syenite. From Rapid No. 13, half a mile below last.

No. 87 (H). Fossiliferous drift limestone. From Rapid No. 17, about three miles and a half below the mouth of Sturgeon river.

No. 88 (H). Syenite gneiss. Just above Rapid No. 19. Graduates into greenish, hornblendic mica schist containing little quartz.

No. 89 (H). Fine, green schist, hardened and jointed. From Rapid No. 20.

No. 90 (H). Fine, light-colored dyke rock, cutting last; composed of quartz, feldspar, mica, hornblende and garnets.

No. 91 (H). Mica schist. From south side of river just above Rapid No. 22.

No. 91A (H). Mica schist, different from last and enclosed in it.

No. 92 (H). Fossiliferous drift limestone from below Rapid No. 27.

No. 93 (H). Lignite. From bed of a creek that enters on the east side of the Little Fork a short distance below Rapid No. 27.

No. 94 (H). Cretaceous shale. From same locality.

No. 95 (H). Shale containing fossils. Same locality.

No. 96 (H). Shale containing gravel. Same locality.

No. 97 (H). Shale containing crystallized aragonite.

No. 98 (H). Drift conglomerate from the same creek-bed.

No. 99 (H). Red sandstone. From drift in same creek-bed.

No. 100 (H). Mica schist from Oak rapids, half a mile below Seller's camp.

No. 101 (H). Granite, interbedded with mica schist at same place.

No. 102 (H). Mica schist containing numerous garnets. From foot of Oak rapids.

No. 103 (H). Drift conglomerate, Rapid No. 30, west line of sec. 7, 65–24.

No. 104 (H). Mica schist, interbedded with gneiss and containing more or less hornblende. From Rapid No. 31, just below the place where the river leaves Twp. 65–24.

No. 105 (H). Syenite or dioryte, hard, massive and not at all jointed. From the next point below Rapid No. 31.

No. 106 (H). Doleryte, from dyke just above Rapid No. 37.

No. 107 (H). Mica schist, cut by gneiss. Rapid No. 39.

No. 107A (H). Same gneiss containing garnets, beryl (?) and tourmaline

No. 107B (H). Tourmaline; same locality.

No. 108 (H). Samples of inclusions in 107 (H) composed of biotite and augite (?)

No. 109 (H). Boulder clay. From west bank of river about four miles and a half below Rapid No. 39.

No. 110 (H). Black gravel and sand. From northeast side of river about four and a half miles below Rapid No. 40. (*Onakaiamis bachtik*).

RAINY LAKE RIVER.

No. 111 (H). Pyritous, chloritic mica schist. From a small island in the river three miles and a half below Fort Francis.

No. 112 (H). Mica schist. Same place as last.

No. 113 (H). Green hydromica schist, British side of river, a mile and a half below Fort Francis.

No. 114 (H). Siliceous schist containing mica more or less hydrated. Same locality as last.

No. 115 (H). Dyke rock with superinduced schistosity. Same place.

No. 116 (H). Quartzose beds in mica schist. A short distance up the river from last.

Nos. 117 (H), 117A (H), 117B (H), 117C (H) and 117D (H) illustrate a gradual transition from massive porphyry to mica schist. From a small island in the river about a mile below Fort Francis.

No. 117E (H) shows an abrupt contact between the two.

No. 117F (H). A porphyritic nodule or inclusion in the mica schist. Same locality.

Nos. 118 (H) and 118A (H). Specimens of rock similar in appearance and from contiguous strata; one containing mica, the other hornblende. From a small island just east of the last.

No. 119 (H). Showing contact between the schist inclusions and the porphyry which contains them. Same locality.

No. 120 (H). Porphyritic schist containing both mica and hornblende. Same locality.

No. 121 (H). Greenstone having the appearance of trap, from the west end of a dyke (?) on the American bank a short distance above last locality.

No. 121A (H). A specimen from the same dyke (?) ten feet farther east, having a schistose structure.

No. 122 (H). Doleryte (?). From a dyke a little farther up stream than the last.

No. 122A (H). Specimen from the same dyke resembling the porphyry which it cuts.

No. 123 (H). Porphyry containing chlorite and pink feldspar. Near last.

No. 124 (H). Mica schist grading into diabase. Same locality.

No. 125 (H). Porphyritic gneiss. From the falls at Fort Francis.

No. 126 (H). Porphyritic syenite, containing red and green feldspar. N. W. ¼ sec. 35, 71-24.

No. 127 (H). Fine, jointed mica schist. Canadian side of the river at the Indian agency.

RAINY LAKE.

No. 128 (H). Mica schist and siliceous schist in fine beds, twisted and folded together. East side of point in N. W. ¼ sec. 29, 71–23.

No. 129 (H). Semi-crystalline rock in dyke-like beds, generally, but not always, conformable to the schist. From N. E. ¼ sec. 29, 71–23.

No. 130 (H). Mica schist, containing veins of quartz stained very dark red. N. W. ¼ sec. 28, 71–23.

No. 131 (H). Felsitic mica schist. Same locality.

No. 132 (H). Fine, hard, green mica schist. Center of sec. 28, 71–23.

No. 133 (H). Mica schist, with long, slender crystals of hornblende on the surface. Same locality.

No. 134 (H). Trap rock. From a dyke in N. E. ¼ sec. 28, 71-23.

No. 134A (H). Same rock, with crystals of epidote (?) on weathered surface.

No. 135 (H). Soft, ferruginous schist in mica schist. A little east of last.

No. 136 (H). Hard, micaceous, hornblende schist. A little east of last.

No. 137 (H). Heavy, black mineral, occurring in veins in the rock at last locality.

No. 138 (H). Dyke rock from a small dyke just east of last.

No. 139 (H). Variegated schist, containing much quartz and feldspar and a green mineral.

No. 140 (H). Fine, thin-bedded mica schist. N. E. ¼ sec. 28, 71–23.

No. 141 (H). Hydromica schist. East of last.

No. 142 (H). Gneiss cutting mica schist. South end of island in N. E. ¼ sec. 28, 71-23.

No. 143 (H). Granulyte veins cutting 142 (H).

No. 143A (H). Mica schist in small beds enclosed in 142 (H) and 143 (H).

No. 144 (H). Mica schist in irregular masses enclosed in 142 (H).

Nos. 145 (H), 145A (H), 145B (H), 145C (H), 145D (H), 145E (H) and 145F (H) show the change in the character of a dyke from the edge toward the middle. N. E. ¼ N. E. ¼ sec 27, 71-23.

No. 146 (H). Epidote found in connection with the same dyke farther southeast.

No. 147 (H). Sample from same dyke from an island south of the point in N. W. ¼ sec. 26, 71-23.

No. 148. (H). Coarse dark schist contained in the dyke in S. E. ¼ sec. 26, 71-23.

Nos. 149 (H) and 149A (H) are samples showing a schistose aspect of this dyke-rock.

No. 150 (H). Heavy, black mineral from mica schist in S. E. ¼ S. W. ¼ sec. 25, 71-23.

No. 151 (H). Siliceous mica schist from S. E. ¼ S. E. ¼ sec. 25, 71-23.

No. 152 (H). Conglomeritic mica schist. S. W. ¼ sec. 30, 71-22.

No. 153 (H). Soft, fine, green mica schist. Same locality.

No. 154 (H). Pebbles from conglomeritic schist, east of last, in sec. 30, 71-22.

No. 155 (H). Gneissic mica schist: Same place as last.

Nos. 156 (H), 156A (H) and 156B (H) show a change from mica schist to fine granulyte.

No. 157 (H). Hydromica schist. From an island in N. E. ¼ sec. 32, 71-22.

No. 158 (H). Gneiss. N. E. ¼ N. W. ¼ sec. 10, 70–22.

No. 159 (H). Soft and crumbling mica schist. From "Black bay," S. W. ¼ sec. 13, 70-22.

KABETOGAMAK.

No. 160 (H). Mica schist with the biotite in circular aggregations and spots. N. E. ¼ N. W. ¼ section 30, 70-21.

No. 161 (H). Coarse muscovite gneiss interbedded with mica schist. From the small island in S. W. ¼ S. E. ¼ sec. 30, 70-21.

No. 162 (H). Graphic granite. N. E. ¼ N. W. ¼ sec. 6, 69-21.

No. 163 (H). Coarse gneiss. Same locality, contains scales which are half biotite and half muscovite.

No. 164 (H). Porphyritic, biotite gneiss. S. W. ¼ sec. 25, 69-21.

No. 165 (H). Mica. Sec. 31, 70-21.

No. 166 (H). Gneiss, containing much biotite. North side of lake in T. 69-20.

NAMEKAN LAKE.

No. 167 (H). Gneiss. S. W. ¼ S. W. ¼ sec. 28, 69-19.

No. 168 (H). Gneiss, containing much muscovite. N. W. ¼ S. E. ¼ sec. 30, 69-18.

No. 169 (H). Gneiss. S. W. ¼ sec. 26, 69-18.

No. 170 (H). Dioryte. S. E. ¼ N. W. ¼ sec. 29, 69-17.

No. 171 (H). Gneiss. S. E. ¼ N. W. ¼ sec. 21, 69-18.

No. 172 (H). Garnetiferous gneiss. Foot of Kettle falls.

RAINY LAKE.

No. 173 (H). Hard, fine, brittle mica schist. The rock at the American or North Kettle fall.

No. 174 (H). Coarse gneiss, garnetiferous. Same locality.

No. 174A (H). Mica from 174 (H).

No. 175 (H). Hydromica schist. Same locality.

No. 176 (H). Gneiss containing green muscovite. From the point near the centre of S. W. ¼ sec. 27, 70-18.

No. 177 (H). Nodule of hard mica schist Same locality.

No. 178 (H). Conglomeritic boulder of mica schist. S. E. ¼ S. W. ¼ sec. 21, 70-18.

No. 179 (H). Porphyritic, coarse gneiss. Just north of last.

No. 180 (H). Coarse gneiss. N. W. ¼ S. W. ¼ sec. 21, 70-18.

No. 180A (H). Pegmatyte. From last.

No. 181 (H). Red mica schist. Same locality.

No. 182 (H). Gneiss from an intrusion. Same locality.

No. 183 (H). Garnetiferous gneiss. Same place.

No. 184. (H). Coarse, garnetiferous gneiss. From a small island in S. E. ¼ S. W. ¼ sec. 21, 70-18.

No. 184A (H). Radiated masses of quartz and mica in fine grains and scales (greisen ?). Same locality.

No. 184B (H). Muscovite from 184 (H).

No. 185 (H). Mica schist lying on east side of 184 (H).

No. 186 (H). Gneiss. S. E. ¼ sec. 20, 70-18.

No. 187 (H). Graphic granite. S. W. ¼ S. W. ¼ sec. 19, 70-18.

No. 188 (H). Same as 184A (H). From the point on the south line of S. E. ¼ sec. 23, 70–19.

No. 189 (H). Garnetiferous gneiss containing green muscovite and in contact with mica schist, N. W. ¼ S. W. ¼ sec. 23, 70–19.

No. 189A (H). Same as 184A (H). Same locality as last.

No. 190 (H). Pebbles from a recess in the shore, S. W. ¼ N. W. ¼ sec. 21, 70–19.

No. 191 (H). Mica schist. N. W. ¼ sec. 20, 70–19.

No. 192 (H). Chloritic mica schist. S. E. ¼ sec. 19, 70–19.

No. 192A (H). Hornblendic rock from veins in last.

No. 193 (H). Horizontally stratified mica schist. N. E. ¼ N. W. ¼ sec. 15, 70–20.

No. 194 (H). Mica schist. S. E. ¼ S. W. ¼ sec. 10, 70–20.

No 194A (H). Garnetiferous mica schist. Same locality.

No. 195 (H). Gneiss. S. W. ¼ S. W. ¼ sec. 9, 70–20.

No. 196 (H). Average specimen of mica schist from N. W. ¼ S. W. ¼ sec. 8, 70–20

No. 197 (H). Hard mica schist. S. ½ sec. 7, 70–20.

No. 197A (H). Quartz vein in last.

No. 198 (H). Coarse gneiss containing green mica. N. E. ¼ N. E. ¼ sec. 12, 70–21.

No. 198A (H). Fine gneiss. Same place.

No. 199 (H). Cyanite. N. E. ¼ N. W. ¼ sec. 12, 70-21.

No. 200 (H). Garnetiferous mica schist. S E. ¼ S. W. ¼ sec. 1, 70–21.

No. 201 (H). Mica schist. S. E. ¼ N. W. ¼ sec. 33, 71–20.

No. 202 (H). Mica schist with the biotite in spots. N. E. ¼ sec. 32, 71–20.

No. 203 (H). Hard, thick-bedded mica schist S. W. ¼ sec. 29, 71–20.

No. 204 (H). Hydromica schist. N. W. ¼ S. W. ¼ sec 29, 71–20.

No. 205 (H). Siliceous mica schist. S. W. ¼ S. E. ¼ sec. 26, 71–21.

Nos. 206 (H), 206A (H), 206B (H), 206C (H), 206D (H) and 206E (H) represent a transition from mica schist to amphibolyte. S. E. ¼ N. W. ¼ sec. 35, 71–21.

No. 206F (H). Same as 206E (H), (amphibolyte) containing much quartz in veins.

No. 207 (H). Hydromica schist, garnetiferous. S. W. ¼ N. W. ¼ sec. 14, 71–21.

No. 208 (H). Light-colored, siliceous mica schist. S. W. ¼ N. W. ¼ sec. 33, 71-21.

No. 209 (H). Felsitic schist. N. W. ¼ N. E. ¼ sec. 32, 71–21.

No. 210 (H). Mica schist. S. E. ¼ N. W. ¼ sec. 32, 71–21.

No. 211 (H). Greenstone. N. E. ¼ N. W. ¼ sec. 31, 71–21.

No. 212 (H). Mica schist. N. E. ¼ N. W. ¼ sec. 31, 71–21.

No. 212A (H). Schist just north of last.

No. 212B (H). Light-colored schist on both sides of 212 (H).

No 213 (H). Hydromica schist. S. E. ¼ S. E. ¼ sec. 24, 71–22.

No. 214 (H.) Light-colored, siliceous schist. On an island in S. E. ¼ S. E. ¼ sec. 28, 71–22.

No. 215 (H). Siliceous schist. South side of the island in N. E. $\frac{1}{4}$ S. W. $\frac{1}{4}$ sec. 28, 71–22.

No. 216 (H). Hydromica schist and graywacke. On the east end of the island in S. E. $\frac{1}{4}$ sec. 19, 71-22.

No. 217 (H). Diabasic schist. N. E. $\frac{1}{4}$ S. E. $\frac{1}{4}$ sec. 19, 71–22.

No. 218 (H). Hydromica schist. South side of an island about a quarter of a mile west of last.

No. 219 (H). Light-colored, feldspathic mica schist stained with iron rust. S. E. $\frac{1}{4}$ S. W. $\frac{1}{4}$ sec. 24, 71–23.

No. 221 (H). Doleryte containing much magnetite. On the point in S. E. $\frac{1}{4}$ S. E. $\frac{1}{4}$ sec. 23, 71-23.

No. 222 (H). Hardened mica schist lying on east side of last.

No. 223 (H). Hard, green schist lying between mica schist on the south and hydromica schist on the north. S. W. $\frac{1}{4}$ S. W. $\frac{1}{4}$, sec. 23, 71-22.

BIG FORK RIVER.

No. 224 (H). Clay containing fresh water shells. From banks fifteen feet high, about seven miles up the river.

No. 225 (H). Mica schist containing large garnets. From drift at same place.

No. 226 (H). Greenstone. East bank of river, about thirty-three miles above Rainy Lake river.

No. 227 (H). Mica schist and gneiss. Just below the "Big falls," about forty-one miles up the river.

No. 227A (H). Dyke rock cutting No. 227 (H).

No. 228 (H). Trap. From dyke at head of "Big falls."

No. 229 (H). Gneiss and mica schist from immediate contact with the dyke.

No. 230 (H). Samples of the gneiss and schist which underlie the principal part of the falls. (The last four numbers are from sec. 36 or sec. 35, 155-25).

No. 231 (H). Gneiss. In the river, about a mile above the falls.

No. 232 (H). Limestone pebbles and Cretaceous shale from a clay bank about sixty-three miles up the river, near sec. 1, 152-25.

No 233 (H). Fine mica schist. About seventy-seven miles above the mouth.

No. 234 (H). Trap from dyke a little above last.

No. 235 (H). Schist from edge of the same dyke.

No. 236 (H). Dyke-rock, light-colored and having the composition of granite. Same locality.

No. 237 (H). Schist; fine, micaceous. Same place.

No. 238 (H). Fine, green, diabasic schist, about eighty-three miles above the mouth of the river at the head of a rapid.

No. 239 (H). Dyke-rock. From the "Little falls"; about eighty-five and one-half miles up the river.

No. 239A (H). Samples of green veins seen in the dyke.

No. 239B (H). Specimen from dyke showing apparent schistosity.

No. 239C (H). "Slickensides" from same dyke.

No. 239D (H). From a vein of quartz and calcite in the dyke.

No. 240 (H). Diabase, about forty rods above the falls.

No. 241 (H). Cretaceous (?) clay. About ninety-three miles up the Big Fork at the foot of a rapid.

No. 242 (H). Syenite from a large boulder. Same place.

No. 243 (H). Green schist containing a little mica. At the dam on Deer river, about half a mile from the Big Fork.

No. 244 (H). Porphyritic greenstone. About three miles above the mouth of Deer river, one hundred and four miles above the mouth of the Big Fork.

No. 244A (H). Same as 244 (H): but containing pyrites.

No. 245 (H). Hard, jointed, green rock similar to 244 (H). About two and one-half miles farther up stream, contains calcite.

Nos. 246 (H), 246A (H) and 246B (H) are specimens of dioryte of different grades of coarseness. About a mile above last.

No. 247 (H). Feldspathic greenstone. Foot of Rice River rapids; about one hundred and eleven miles above Rainy Lake river.

No. 247A (H). A felsitic variety of the same rock.

Nos. 248 (H), 248A (H) and 248B (H) illustrate the change from greenstone schist to dioryte or syenite. 248B (H) is very hornblendic.

No. 249 (H). Feldspathic greenstone. A little south of last

No. 250 (H). Quartz dioryte. About 120 miles up the Big Fork, at the west side of sec. 30, 61–26.

No. 250A (H). Rock similar to 250 (H). From east side sec. 25, 61–27.

No. 251 (H). Chloritic, porphyritic granulyte. About four miles above the last.

No. 252 (H). Siliceous dioryte (?). About three miles above last.

No. 252A (H). Quartz crystals from a geode in 252 (H).

No. 253 (H). Syenite. In the woods 24 rods east of 252 (H).

No. 254 (H). Syenite. From the next bend in the river above 253 (H).

No. 255 (H). Limestone fragments from the bed of the creek leading into lake Winibigoshish in T. 147–27.

MISSISSIPPI RIVER.

No. 256 (H). Quartzyte. N. E. ¼ N. W. ¼ sec. 13, 55–26.

No. 257 (H). Nodules of sesquioxide of iron. From the quartzyte at Pokegama falls.

No. 258 (H). Quartzyte showing decomposition and bedding structure. Pokegama falls.

No. 259 (H). Quartzyte containing catlinite (?). Same locality.

PRAIRIE RIVER.

No. 260 (H). Ferruginous quartzyte. Foot of "Lower falls" of Prairie river.

No. 260 A (H). Hematite. Same place.

No. 261 (H). Quartzyte. Lower part of Lower fall.

No. 262 (H). Fine conglomerate. About two-thirds of the way from the foot to the head of the Lower fall.

No. 263 (H). Jaspery, ferruginous quartzyte containing chalcedonic quartz. Same place.

No. 264 (H). Quartzyte; showing rusty ferruginous spots. Same locality.

No. 265 (H). Quartzyte from upper end of Lower fall.

No. 266 (H). Gneiss, from a large, irregular-shaped mass, at foot of Lower fall.

No. 267 (H). Fine, gray gneiss. From foot of "Upper fall," east side sec. 33, 55–25.

No. 268 (H). Different varieties of gneiss seen in going from the foot to the head of the Upper fall.

No. 268A (H). Gypsum. Upper falls, Prairie river.

No. 269 (H). Garnetiferous granite Same place.

No. 270 (H). Gneiss, containing red feldspar. Locality the same.

No. 271 (H). Gneiss, similar to that at the Upper fall. N. W. ¼ sec. 34, 56–25.

No. 272 (H). Micaceous syenite gneiss. Northeast of last.

No. 273 (H). Gneiss, containing veins of dark-red feldspar. Same place.

No. 274 (H). Dark, green rock, like doleryte. Locality the same.

No. 275 (H). Porphyritic, hornblendic gneiss. S. E. ¼ sec. 27, 56–25.

No. 275A (H). Coarse, red, muscovite granite; cutting last.

No. 276 (H). Hornblende schist, containing mica. Upper end of Upper fall.

No. 276A (H). Same as last; cut by a vein of red feldspar

No. 277 (H). Fine hornblende schist cutting the gneiss.

No. 277A (H). Showing the contact between the gneiss and No. 277 (H).

No. 278 (H). Fine hornblende gneiss. Same locality.

No. 279 (H). Fine, biotite, muscovite gneiss. S. E. ¼ N. E. ¼ sec. 5, 56–24.

No. 280 (H), Gneiss. N. W. ¼ N. W. ¼ sec. 9, 56–24.

No. 281 (H). Gneiss. S. W. ¼ sec. 33, 57–23.

No. 282 (H). Bluish-gray clay. From the bed of Sucker brook, in sec. 27, 57–24.

No. 283 (H). Coarse, jointed, chloritic gneiss. Upper end of Upper fall.

MISSISSIPPI RIVER.

No. 284 (H). Blue and red clay. From the river banks in T. 54–24.

No. 285 (H). "Silver ore," so-called. T. 61–23. (Upon analysis, this rock was found to contain no traces of either gold or silver).

HOODOO LAKE.

No. 286 (H). Gneissic mica schist. N. E. ¼ S. W. ¼ sec. 4, 63-18.

No. 286A (H). Gneiss. North side of Hoodoo lake.

No. 287 (H). Hydromica schist, very siliceous. N. E. ¼ S. E. ¼ sec. 5, 63-18.

No. 288 (H). Ferruginous hornblende schist. West of last.

No. 289 (H). Fine syenite gneiss. West of last.

No. 290 (H). Soft, red mica schist. At portage in N. W. ¼ S. E. ¼ sec. 5, 63-18.

SUSAN LAKE.

No. 291 (H). Fine mica schist. On a small island in sec. 32, 64-18.

No. 292 (H). Rock composed of hornblende and biotite, with a little feldspar. Same locality.

No. 292A (H). Same as last with graphite(?).

No. 293 (H). Pink mica schist containing green mica. S. E. ¼ S. E. ¼ sec. 32, 64-18.

No. 294 (H). Gneiss. From a small island in southeast end of the lake.

ELBOW LAKE.

No. 295 (H). Mica schist. From the bay east of the one to which the portage from Susan lake leads.

No. 296 (H). Gneiss. From same bay, north of last.

No. 297 (H). Rock similar to 292 (H). From northeast end of Elbow lake.

No. 298 (H). Chloritic gneiss. Same locality.

No. 299 (H). Fine, red syenite gneiss. From the deep bay directly north of the portage from Susan lake, on the opposite side of Elbow lake.

No. 300 (H). Fine, gray biotite gneiss. Southwest of last.

No. 301 (H). Coarse granular gneiss containing pink and white feldspar. Same locality.

No. 302 (H). Rock similar to 292 (H). From a bay on the north side of the lake near the west end.

No. 303 (H). Similar to last but containing more feldspar. From a point west of last.

No. 304 (H). Gneiss from the top of Bald Mt. North of Elbow river, in south part of T. 64-19.

No. 305 (H). Mica schist. From same place.

PELICAN LAKE.

No. 306 (H). Pink gneiss. N. E. ¼ S. W. ¼ sec. 2, 64-20.

No. 307 (H). Mica schist. Same locality.

No. 308 (H). Fine gray gneiss. From south side of point in N. E. ¼ S. W. ¼ sec. 2, 64-20.

No. 309 (H). Dyke rock from an island in N. E. ¼ S. E. ¼ sec. 3, 64-20.

No. 310 (H). Hornblendic mica schist. From an island near the centre of sec. 3, 64-20.

No. 310A (H). Heavy, dark, hornblendic rock containing round grains of feldspar that resemble amygdules. Interbedded with last.

No. 311 (H). Hornblendic porphyritic gneiss. N. E. ¼ sec. 12, 64-21.

No. 312 (H). Mica schist enclosed in gneiss. From point in N. E. ¼ N. W. ¼ sec. 12, 64-21.

No. 313 (H). Coarse, granular, white, siliceous gneiss. N. E. ¼ sec. 35, 65-20.*

No. 314 (H). Siliceous granite. Same locality.

No. 315 (H). Mica schist containing a vein of granite. From small island near S. E. ¼ sec. 26, 65-20.*

No. 316 (H). Micaceous hornblende schist. Same island.

No. 317 (H). Dark rock similar to last, but more schistose, and containing vitreous quartz grains. About a quarter of a mile northwest of last.

No. 318 (H). Gneissic mica schist. Near N. W. ¼ sec. 26, 65–20.

No. 318A (H). Mica schist, interbedded with hornblendic mica schist. Same locality.

No. 319 (H). Handsome gray gneiss. Just west of last.

No. 320 (H). Syenite. A short distance north of last.

No. 321 (H). Hornblende schist enclosed in gneiss. From the island in N. W. ¼ sec. 26, 65–20.

No. 321A (H). Samples of mica and radiations of mica scales and quartz grains (greisen?). Same island.

No. 322 (H). Siliceous mica schist containing pyrite, hornblende, malachite, chalcopyrite and a greenish-yellow mineral. Same island.

No. 323 (H). Breccia. Point near S. W. ¼ sec. 29, 65–20.

No. 324 (H). Micaceous, porphyritic syenite. From an island in N. E. ¼ sec. 31, 65–20.

No. 325 (H). Pyritous, garnetiferous, micaceous syenite gneiss. From the small island in N. W. ¼ sec. 31, 65–20.

No. 325A (H). Fine, hornblendic gneiss. Same locality.

NET LAKE.

No. 326 (H). Mica schist. From a small island near the east side of the lake, west of the Indian village.

No. 326A (H). Rock composed of feldspar, quartz and some greenish-brown mineral. Same island.

No. 327 (H). Trap, cutting 326 (H).

PELICAN LAKE.

Samples of the rock on the point in sec. 35, 65–21, and illustrated in figure No. 16 are

No. 328 (H). Mica schist.

No. 329 (H). Hornblendic inclusions.

No. 330 (H). Porphyritic gneiss.

* All locations given in Twp. 65-20 are only approximately correct, as the township is unsurveyed.

No. 330A (H). Mica schist in contact with the gneiss.

No. 330B (H). Contact of gneiss with hornblendic inclusions.

No. 330C (H). Dyke of fine diabase cutting enclosed mica schist.

No. 330D (H). Mica schist containing "geodules" of garnets.

No. 330E (H). Sample of granite intrusion or "stringer" from the main mass.

No. 331 (H). Pegmatyte. N. E. ¼ sec. 30, 65-20.

No. 332 (H). Heavy, green rock, mostly composed of hornblende, in contact with gneiss. N. W. ¼ sec. 36, 65-20.

No. 332A (H). Same rock near its contact with mica schist.

TROUT LAKE.

No. 333 (H). Siderite. On masses of quartz at the old "stamp mill" on the stream between Trout lake and Vermilion lake.

No. 334 (H). Mica schist. In the river channel, between the two lakes.

No. 335 (H). Hornblende schist containing red feldspar. Same place.

No. 336 (H). Gneiss, more or less hornblendic. Same locality.

No. 337 (H). Showing contact between mica schist and red gneiss. Same locality.

No. 338 (H). Fine, gray, porphyritic gneiss. N. W. ¼ N. W. ¼ sec. 19, 63-15.

No. 339 (H). Gneissic schist with the mica partly hydrated. Same locality.

No. 340 (H). Syenite gneiss. North side of point at last place.

No. 341 (H). Gneiss. S. E. ¼ N. E. ¼ sec. 13, 63-16.

No. 342 (H). Granite intrusion cutting mica schist. Same locality.

No. 343 (H). Hornblendic mica schist. S. W. ¼ S. W. ¼ sec. 13, 63–16.

No. 344 (H). Mica schist. Same place.

No. 345 (H). Porphyritic syenite gneiss. S. W. ¼ S E. ¼ sec. 14, 63–16.

No. 345A (H). Nodules of amphibolyte and actinolite. Same place.

No. 346 (H). Reddish biotite gneiss, N. W. ¼ sec. 14, 63–16.

No. 347 (H). Red chlorite gneiss. S. E. ¼ S W. ¼ sec. 15, 63–16.

No. 348 (H). Fine, pinkish granite. N. E. ¼ S. E. ¼ sec. 10, 63-16.

No. 449 (H). Muscovite in quartz. Same locality.

No. 349A (H). Coarse orthoclase. Same place.

No. 350 (H). Granite. S E. ¼ N. W. ¼ sec. 11, 63–16.

No. 351 (H). Porphyritic syenite. N. E. ¼ N. W. ¼ sec. 11, 63–16.

No. 352 (H). Hornblendic gneiss. N. E. ¼ sec. 11, 63–26.

No. 353 (H). Fine, gray, biotite gneiss containing plagioclase. S. E. ¼ N. E. ¼ sec. 11, 63–16.

NOTES

ON

THE MOLLUSCAN FAUNA OF MINNESOTA

ULY. S. GRANT.

NOTES ON THE MOLLUSCAN FAUNA OF MINNESOTA.

By Uly. S. Grant.

Since the publication, in the Fourteenth (1885) Annual Report, of a list of the mollusca in the University museum, a few species and a larger number of specimens have been collected. These specimens are mostly from the three north-eastern counties of the state, St. Louis, Lake and Cook, and were collected by the writer during the last two summers, while with a party of the Geological Survey. The lack of good transporting accommodations and press of other duties prevented a very careful and thorough search being made, and as yet not more than half of the material so collected has been examined and classified. The following very incomplete list is published with the hope that it will throw a small degree of light on the fauna of a part of the state yet unexplored. The writer soon hopes to make the list more complete; probably twice as many species have been found in that region as are here given. The lakes of the country passed over contained only one species of *Unio*, i. e., *Unio luteolus*, Lamarck, and one or two of *Anodonta*. The Gasteropoda are represented by a very limited number of species, and by far less individuals than are found in the central or southern portion of the state. The water forms are not abundant, but where found are of rather larger size than the same species found elsewhere. The land forms are small, thick shelled, and possess the characteristics of a northern fauna.

So far the survey has not received many shells from different parts of the state, but it is hoped that this will not long be the case. Prof. John M. Holzinger, of the Winona Normal school has kindly contributed a good number of specimens from that county, and has also sent the subjoined list of Winona county mollusca.

The localities given below are additional to those given in the former list; and the species marked (*) are not found in that list.

LIMACIDÆ.

**Zonites nitidus*, Müller.—Rather common in damp woods near Minneapolis, easily confused with *Z. arboreus*, Say, but *nitidus* is a larger shell, and the last whorl is disproportionately large. 2101.†

**Zonites indentatus*, Say.—Winona county. Only three specimens are in the museum, and these are rather below the average size. 1894.

**Zonites fulvus*, Draparnaud.—Tower, St. Louis county, and Minneapolis; quite common; a very pretty small shining brown shell. 1950, 2093.

**Vitrina limpida*, Gould.—Tower, St. Louis county. Two specimens were found, but after long and careful search no more could be discovered. This is a very fragile, transparent shell, with the last whorl proportionately very large. 1951.

HELICIDÆ.

Patula alternata, Say.—Winona and Tower. Only three specimens were found at the latter place, and they were much below the average size. The shells from Winona are subcarinate and quite small. 1897, 1952.

Patula striatella, Anthony.—Winona and Tower. Quite common at Tower, where this shell has very prominent ribs. 1886, 1953.

Helicodiscus lineatus, Say.—Traverse county, Tower, Winona. Some of the specimens in the museum have three distinct pairs of teeth. 1895, 1954, 2098.

Strobila labyrinthica, Say.—Tower and Winona. This shell has three parallel revolving laminæ on the inner wall. The specimens from Tower are much smaller than those from other localities. 1893, 2055

Stenotrema hirsutum, Say.—Winona. 1870.

Stenotrema monodon, Rackett.—Winona and Minneapolis. The specimens found at the latter place are large and strong. 2102.

* *Mesodon albolabris*, Say.—Winona. This species sometimes has a small parietal tooth, and then it is easily confounded with *M. exoletus*, Binney, but the latter shell is not found in Minnesota. 1905.

Mesodon multilineata, Say.—Winona. The specimens from this locality are much smaller than those found at Minneapolis. 1983.

* *Mesodon profundus*, Say.—Winona. This species is often found crawling along the trunks of trees. Individuals without the revolving band are common. 1904.

† These numbers refer to the Zoological Register of the University museum.

* *Acanthuinla harpa,* Say.—Tower. This species is thought to be circumpolar; it is a very small umbilicated shell with heavy ribs on the last two whorls. 1956.

Vallonia pulchella, Müller.—Tower, Winona and Big Stone county. 1896, 1897, 2096.

PUPIDÆ.

**Pupa fallax,* Say.—Winona. 1890.

STENOGYRIDÆ.

Ferussacia subcylindrica, Linnæus. Tower and Winona. Rather rare at Tower. 1889, 1959.

AURICULIDÆ.

Carychium exiguum, Say.—Tower. Rather common in the moss in tamarack swamps. 1964.

LIMNÆIDÆ.

Limnœa stagnalis, Linnæus.—Winona, Tower and Lake county. Not very common in the northeastern part of the state, but when found there the shell is usually quite fragile and of large size. 1880, 1965, 2020.

Bulimnea megasoma, Say. Vermilion lake and other lakes in St. Louis and Lake counties. Rather rare, only a few specimens being found in the same locality. The animal is quite sluggish in its movements, and is found clinging to aquatic plants in still water around the mouths of streams. 1966, 2021, 2022.

**Limnophysa emarginata,* Say.—Found along the boundary waters in Lake county. The specimens collected vary much in size; on a few the corrugations of the body whorl near the aperture are very distinct. 1970.

**Acella gracilis,* Jay.—Vermilion lakė. But one specimen was found, and this is only a little over half an inch long, but the length is about six times the diameter; this is by far the most slender and fragile of our Limnæidæ, and is quite rare. 1976.

Physa gyrina, Say.—Common in Vermilion lake. 2026.

Bulinus hypnorum, Linnæus.—A few specimens were found in a swamp near Tower, but these are only about one half the size of those found at Minneapolis, and the epidermis is rougher and less brilliant. 1982.

**Planorbella campanulata*, Say. — Wright county, Winona, and Cook, Lake and St. Louis counties. This is the most common shell of the northern lakes of Minnesota; it varies from two-eighths to five-eighths of an inch in diameter, according to locality. 1875, 1876, 1983-6.

Helisoma corpulenta, Say.—Vermilion lake and all over St. Louis and Lake counties. This shell seems to be quite distinct from *H. trivolvis*, Say; it is much heavier and much higher in proportion to its diameter, and is also distinctly carinated,—always on one side and frequently on both,—and the aperture is much higher than the penultimate whorl. It is found clinging to rocky shores and reefs, and seems to seek places where the water is quite rough. 1988, 2029.

Helisoma bicarinata, Say.—Vermilion lake, Winona, Lake county, and various places in St. Louis county. This shell varies greatly in size, and is always found associated with *Planorbella campanulata*, Say, which, however, is the more common. 1878, 1991-4.

**Menetus exacutus*, Say.—A few specimens were found in Vermilion lake; one has the body whorl deflected for the last half of its length. 1995, 1996.

Gyraulus deflectus, Say.—Very common in all of the lakes of St. Louis, Lake and Cook counties,—in fact, it is the only shell that can be said to be at all abundant in that part of the state; it is found in large numbers clinging to the rocky shores of the lakes.

**Segmentina armigera*, Say.—Rather common on the shores of a small island in Vermilion lake. It is a solid little shell and is easily recognized by the five teeth far within the mouth. The specimens collected are less than a fourth of an inch in diameter. One or two of the teeth may be sometimes lacking, and rarely all of them are. 1987.

VALVATIDÆ.

Valvata tricarinata, Say.—Wright, Lake and St. Louis counties. The specimens from Wright county are quite large, while those from St. Louis county are much smaller and rarer. 1593, 2005, 2006.

VIVIPARIDÆ.

Vivipara intertexta, Say.—Winona, 1901.

NOTES ON THE MOLLUSCA OF WINONA COUNTY.

BY JOHN M. HOLZINGER.

Much of the material which is the basis of these notes has been collected the last two years by the zoology classes of the Winona Normal School. The students were encouraged in thus combining field work and observation with text-book work, with the conviction on the part of the teacher that this plan is more likely to result in an active love of the things of nature. A number of the students have sent in from several counties collections of mollusca, thus aiding in a modest way in the determination of geographical distribution. All the shells noted are in the Winona Normal School museum. It should be stated that Dr. J. Lindahl of Rock Island, Ill., and Mr. Wm. Marsh of Aledo, Ill., have aided in determining most of the Unionidæ.

LAMELLIBRANCHIATA.

UNIONIDÆ.

Anodonta corpulenta, Cooper.—Four specimens from Straight slough, two to five miles above Winona.* The largest specimen is 6½ inches long, and 4⅝ in. high. This shell is difficult to preserve, breaking up on drying. Nacre reddish.

Anodonta imbecillis, Say.—Three specimens found; 1 in. high, 2 in. long. Color outside, greenish; inside, lighter; frail.

Margaritana complanata, Barnes.—Five specimens secured. Largest: 5¼ in. long, 4⅝ in. high.

Margaritana marginata, Say.—Only three specimens were found; largest: 4 in. long, 2⅜ in. high, 2⅛ in. wide,—probably a female; smallest: 1 in. long, ⅝ in. high.

Unio æsopus, Green.—Five specimens found; largest: 4 in. long, 3 in. high.

*All the bivalves here noted are from Straight slough, unless otherwise stated.

Unio alatus, Say.—Six specimens found; $4\frac{1}{2}$ in. long, $3\frac{1}{2}$ in. high.

Unio anodontoides, Lea.—Six specimens found; largest: 3 in. long, $1\frac{3}{8}$ in. high; smallest: $1\frac{3}{4}$ in long, $\frac{7}{8}$ in. high.

Unio asperrimus, Lea.—Seven specimens found. A pretty and firm shell, easily confounded with *U. metanever*, Raf.; in fact, I fail to see any material difference between these two shells, except that the latter has the lower posterior lobe of the shell a trifle longer; color of the epidermis the same in both shells.

Unio capax, Green.—Twelve specimens found; largest: 5 in. long, 4 in. high, 3 in. wide. Epidermis yellowish brown with rays on the young, which disappear in old shells. Nacre white. This shell has much the form of *U. occidens*, Lea, but is wider, as its name implies, and also firmer. Another closely related shell is *U. subovatus*, Lea; I can distinguish the latter from *U. capax*, only by the nacre,—*subovatus* having the posterior half of the inside covered with a beautiful peach-blow colored nacre.

Unio coccineus, Hild.—Two specimens were brought in by Miss Lewena Gallup, from near St. Charles, Winona county. Largest: $1\frac{1}{4}$ in. long, $1\frac{1}{8}$ in. high.

Unio cornutus, Barnes.—Four specimens found; largest: $2\frac{1}{2}$ in. long, 2 in. high. This shell in firmness of build and general outline stands near *asperrimus* and *metanever*.

Unio crassidens, Lam.—One specimen found, $3\frac{3}{4}$ in. long, $2\frac{3}{8}$ in. high. This shell is of the same form and has the same nacre as *U. nigrinus*, Lea, but it is a more solid shell. It resembles a shortened *U. gibbosus*, the nacre being the same in both.

Unio ebenus, Lea.—Thirty or more specimens were collected, ranging from the smallest, hardly an inch long, to the largest: $3\frac{3}{8}$ in. long, 3 in. wide. This shell, as to firmness, average size and general outline, reminds one of *U. ellipsis*, Lea, and *U. trigonus*, Lea. Two shells of the lot are apparently hybrids,—one, *ebenus* x *ellipsis*, the other, *ebenus* x *trigonus*,—showing the affinity between these three so-called species.

Unio elegans, Lea.—Eight specimens found. The pretty marking, of especially the younger shells, justifies the specific name *elegans*. Largest: $1\frac{3}{4}$ in. long. $1\frac{1}{2}$ in. high.

Unio ellipsis, Lea.—About twenty-five specimens were collected; a number of these are quite small—less than an inch long; the epidermis of these is handsomely marked with rays, which become obscure with age. Largest: $3\frac{1}{8}$ in. long, $2\frac{1}{2}$ in. high. See *U. ebenus* above.

Unio gibbosus, Barnes.—Five specimens collected; largest: 4⅛ in. long, 1⅝ in. wide. In firmness and nacre like *U. crassidens*,—in fact one shell collected stands between these two species in relative length and hight;

crassidens 3¾x2⅝;
gibbosus 4⅛x1⅝;
hybrid 3x1½:

Epidermis, nacre and build are the same in the three shells.

Unio gracilis, Barnes.—Six specimens collected; largest: 3½ in. long, 2½ in. high. I fail to see the slightest difference between this species and *U. lævissimus*, Lea.

Unio lævissimus, Lea.—One specimen.

Unio ligamentinus, Lam.—Three large shells were collected, one with white nacre, the other with peach-blow inside. Largest: 5 in. long, 3¼ in. high. Obscure rays on epidermis.

Unio luteolus, Lam.—Some fifteen specimens were collected. Those of middle size, 2½x1½ in., I have difficulty in distinguishing from *U radiatus*, Lam.; the epidermis at that age is yellowish or light green crossed by a number of dark bluish rays. Largest: 4½ in. long, 2⅛ in. high.

Unio metanever, Raf.—Eight shells collected; largest: 3⅛ in. long, 2¾ in. high. See *U. asperrimus*.

Unio occidens, Lea.—Six specimens collected; largest: 4x3 in. See *U. capax*.

Unio parvus, Barnes.—Seven specimens collected; largest: 1⅝ in. long.

Unio plicatus, Le Sueur.—The most common and abundant species; over 75 specimens were collected, including some less than an inch long and the largest, 5 in. long, 3½. high.

Unio pressus, Lea.—One specimen was found, 1⅞ in. long, 1 in. high.

Unio pustulosus, Lea.—Sixteen specimens were collected; largest: 2⅞ in. long, 2⅞ in. high. One specimen with fewer warts or postules seems to be *pustulosus* x *trigonus*.

Unio radiatus, Lam.—One specimen from Mr. Manuel, Odessa, Big Stone Co,, Minn.

Unio rectus, Lam.—Five specimens were collected; nacre lighter colored than in *U. gibbosus*; largest shell; 6⅛ in. long, 2½ in. high.

Unio securis, Lea.—Two specimens found; largest: 3¾ in. long, 3 in. high.

Unio subovatus, Lea.—Three specimens found; $3\frac{1}{2}$ in. long, $2\frac{1}{4}$ in. high. See *U. capax* and *occidens.*

Unio trigonus, Lea.—Quite common; over 50 specimens were collected, ranging from the quite young, $1\frac{1}{2}$ in. long, to the largest, $2\frac{3}{4}$ in. long, $2\frac{1}{2}$ in. high. A firm shell. The animal is frequently of a saffron color.

Unio tuberculatus, Barnes.—Five were collected; largest: $5\frac{1}{4}$ in. long, $2\frac{3}{4}$ in. high.

Unio undulatus, Barnes.—One specimen was found near St. Charles, Winona county, by Miss L. Gallup. This is $1\frac{1}{4}$ in. long, 1 in. high.

Unio zigzag, Lea.—Two specimens were found; the larger is $1\frac{1}{2}$ in. long, $\frac{7}{8}$ in. high.

CORBICULADÆ.

Sphærium transversum, Say.—A few dead shells were found in the river bottom.

Sphærium striatinum, Lam.—Was found in abundance in the same situations as *S. transversum.* Miss Lillian Miller brought dead shells of this species from Goodhue county.

Sphærium rhomboideum, Say.—Occurs in lake Winona in abundance. The largest of these bivalves are $\frac{1}{2}$ in. long. Young ones measuring over $\frac{1}{8}$ in. in length have been taken out of the females; these are more compressed than the adults and might be mistaken for another species, resembling more the *S. occidentale.*

Sphærium solidulum, Prime.—One was taken in lake Winona; length $\frac{5}{8}$ in., hight $\frac{7}{16}$ in. A number of dead shells were brought from Goodhue county by Miss Lillian Miller.

Sphærium partumeium, Say.—In lake Winona.

Sphærium fabale, Prime.—None have been found near Winona, but Miss Lewena Gallup brought in ten fresh specimens from near St. Charles, Winona county.

Pisidium compressum, Prime.—These minute bivalves were found creeping over the muddy creek bottom near Laird's flouring mill. About thirty specimens were collected.

Pisidium abditum, Hald.—This bivalve, a trifle larger than the preceding, was found in lake Winona, in muddy places, crawling over submerged weeds. Twelve specimens were collected.

Pisidium variabile, Prime, and

Pisidium rotundatum, Prime, have both been found recently in lake Winona, with *P. abditum*, Hald, and have been determined by Mr. Marsh, Aledo, Ill.

GASTEROPODA.

LIMACIDÆ.

Limax campestris, Binney.—Common in moist meadows.

Zonites nitidus, Müller.—After the spring flood of 1888, eight specimens were picked up alive along the shore of lake Winona, under bark that had been washed ashore; identically the same shells were found near Madison, Wis., the year before, and determined by Mr. W. Marsh.

Zonites arboreus, Say.—Abundant. This species was found alive under logs and boards, south of lake Winona.

Zonites viridulus, Menke.—Some ten specimens were collected near Stockton, Winona county. Shell more translucent than that of *Z. arboreus*; slightly smaller; outer whorl relatively larger.

Zonites minusculus, Binney.—A few dead shells were found in the meadow south of lake Winona. Determined by Dr. Sterki.

Zonites fulvus, Drap.—Only about twelve specimens have been found, half of them alive. To the naked eye this shell has much the shape and color of *Strobila labyrinthica*, Say; but under the lens the external striæ and internal laminæ of *Strobila* are absent.

HELICIDÆ.

Patula striatella, Anth.—This species was found with *Zonites arboreus*, and rather more abundant.

Helicodiscus lineatus, Say.—Dead shells of this species are found in abundance on the bluffs under stones; comparatively few live specimens have been found.

Strobila labyrinthica, Say.—Abundant in a moist meadow south of lake Winona; often found gregarious.

Stenotrema hirsutum, Say.—Some thirty specimens, mostly alive, were collected near Stockton and Winona.

Stenotrema monodon, Rack.—Only four specimens were found near Stockton, Winona county.

Mesodon albolabris, Say.—A few live shells have so far been found on the bluffs; dead shells are common.

Mesodon multilineatus, Say.—Abundant in the meadows with *Strobila labyrinthica*. It is a small variety.

Mesodon clausus, Say.—Two specimens were brought in by Miss S. Buck from bluffs south of lake Winona.

Mesodon profundus, Say.—On the bluffs; slightly more abundant than *M. albolabris*.

Vallonia pulchella, Müller.—Under logs and stones on the bluffs; more shells are found dead than alive.

PUPIDÆ.

Pupa pentodon, Say.—Occurs in a wet meadow.

Pupa fallax, Say.—In moist meadows; rare.

Pupa armifera, Say.—Our largest species of *Pupa;* common along the bluffs and in moist meadows.

Pupa contracta, Say.—Rather rare.

Pupa corticaria, Say.—Under stones on the bluffs.

SUCCINIDÆ.

Succinea ovalis, Gld.—Abundant on rushes along the Mississippi. Two sets, one collected in June, the other in September, showed an increase, in the latter set, to nearly double the size in June.

Succinea avara, Say.—Along the Mississippi. Rare.

Succinea obliqua, Say.—A few specimens from Root river, south, brought by Miss Laura Wright, are evidently of this species.

AURICULIDÆ

Carychium exiguum, Say.—Found in goodly numbers in wet places south of lake Winona, under chips and boards in water.

LIMNÆIDÆ.

Limnæa stagnalis, Linn.—A few specimens were found in lake Winona. Abundant in the fall of 1888.

Limnæa palustris, Müller. — In abundance in pools along lake Winona.

Limnæa humilis, Say.—On muddy flats in the Mississippi; especially in Straight slough.

Probably one or two more species of Limnæa may be found in the collected material, some of which is not yet worked up.

Physa ancillaria, Say.

Physa heterostropha, Say.

Physa wolffiana, Say.

Physa elliptica, Lea.—All these species of Physa, and probably several more, have been collected in the springs and brooks in this county. I take the species commonly found on watercress to be *P. elliptica*, Lea.

Planorbis campanulatus, Say.—Common. This and the following species of *Planorbis* have been collected in lake Winona.

Planorbis trivolvis, Say.—Common.

Planorbis bicarinatus, Say.—Abundant.

Planorbis exacutus, Say.—Rather rare.

Planorbis deflectus, Say.—Common.

Planorbis parvus, Say.—Rare.

Segmentina armigera, Say.—Quite common.

VALVATIDÆ.

Valvata sincera, Say.—Lake Winona. Not common.

VIVIPARIDÆ.

Vivipara intertexta, Say.—In Mississippi river. Rare.

Melantho subsolida, Say.—In abundance in the Mississippi river.

RISSOIDÆ.

Somatogyrus subglobosus, Say.—In Mississippi river.

Amnicola limosa, Say. In lake Winona. Not very common.

HELICINIDÆ.

Helicina occulta, Say.—Dead shells have been found for two years, but in the cold, wet spring of 1888 about a dozen live shells of this species were found, some near Stockton and some near Winona.

GENERAL INDEX

Across the country from Gunflint to Ogishke Muncie lake 79
Act extending the work of the survey........ 10
Agamok lake.....................95, 338, 345, 359
Agassiz lake.........................396, 408, 434
Alpha lake..........................100, 326, 344
Ambiguous greenstone..................108, 112
Amygdaloidal appearance at Thessalon...15, 149
Amygdaloidal porphyry..................... 825
Analysis of iron ores...............80, 83, 93, 113
Animike and Kewatin in contact, on Gunflint lake, 69, 254-6, 264; on Epsilon lake..322, 323
Animike bay, 77, 233, 244, 245, 246, 247, 250, 355, 362
Animike series, 64, 352, 365; distribution of, 352; lithological characters of, 84, 353; thickness of, 356; magnetitic beds of, 68, 80, 82, 354; unconformities of, 69, 73, 87, 357, 358, 365; relics of, 358; not inclosing Ogishke conglomerate, 359; contrary evidence, 91, 360; jaspilyte beds in, 73; possible organic remains in, 78; relation to the Pewabic quartzyte 87
Animike series on Gunflint lake, 66, 235, 238, 243, 352
Animike series on Gabimichigama lake.....89-95
Animike slate, 38, 105, 108, 135, 146; in Plummer, Can., 30, 38, 159, 167; near Negaunee, 178; in Gogebic range, 58, 188; in Penokee gap, 191; on Knife lake......... 200
Animike island............................ 105
Ancient mining............................ 284
Ansonia, Canada............23, 154, 155, 167, 168
Anthracitic matter.......................... 355
Aragonite, on the Little Fork................ 403
Archæan geology unsettled................ 329
Argillyte, black, near Negaunee............ 178
Argillyte, gritty............................ 317
Argillyte as member of Kewatin, 339; as basis of Ogishke conglomerate.......... 345
Argillyte, Plummer............159, 160, 165, 166
Arrow lake................................ 275
Arthur, Prof. J. C.......................... 11
Ascutney, Vt............................. 334
Ashawiwisigaton lake...................... 273
Aurora mine, 56, 186; section near, 187; granite at, more recent than the slates... 59

Banding and schistosity.....................322, 323
Basaltiform gabbro......................246, 361
Bashitanakueb lake......................... 89
Basin lake................................ 228
Basswood granite.....................330, 331, 332
Basswood lake....110, 133, 135, 196, 330, 331, 336
Bat.. 188
Batrachoides nidificans..................... 239
Bayley, W. S., cited....................... 292
Bear....................................... 138
Bearings................................... 142
Bear narrows, Knife lake..................204, 208
Bell, Robert, cited...................143, 269, 352
Bessemer, Mich............................ 186
Beta lake...............................326, 344
Big Fork river............................ 430
Birch lake................................ 276
"Birch ridge".............................. 60
Black bay................................. 417
Black-fly bay 73, 81, 233, 239, 240, 241, 243, 254, 271, 353
Black belt, so-called, the.................... 75
Blind river, Canada........................32, 161
Blueberries............................... 232
Blueberry cascade and portage............. 232
Blueberry, distinct form of................. 136
Blueberry island........................... 213
Boulders, 28, 62, 63, 64, 78, 89; formed by frost..................................... 204
Boundary river, 135; described, 229; disappearance of, 230; source of.............. 270
Bowstring river............................ 437
Breccia in Saganaga syenite................ 223
Breccia, porphyritic........................ 401
Brecciated terrane, 200, 251, 258, 263, 276, 281, 354
Brooks, Major T. B.....................42, 47 f.n.
Bruce limestone.........................147, 168
Bruce mines.........................13, 145, 164
Brule mountains, 61, 62; river.............. 62
Buddle, statement of......................247, 266
Buffalo mine, Negaunee...................41, 178
Burntside lake....133, 195, 330, 331, 334, 3:6, 363

Calcitic rock, Canada...................... 155
Cap-rock, defined.......................... 59
Cascade, Mich.............................. 43
Cambrian.................................. 170
Cambria mine...........................43, 140

Campement d'ours.... 170
Camper's island. 316, 347, 348
Canada Pacific R. R. 153. 161, 162, 167
Carbonaceons matter......................71, 355
Carbonate of iron...................252, 262, 306
Caribon.......................... 138
Caribou narrows............................ 216
Carp, lake, 334. 386; river.................. 359
Chert and limestone of Logan.......155, 158, 169
Chalcedonic quartz...............44, 73, 55, 440
Chalcopyrite.............................. 15
Cherty limestone, Canada.................. 158
Chemically deposited limestone...........49, 95
Chester, Prof. A. H....................... 80
Chipmnck................................. 138
Chlorite rock, so-called.................. 175
Chlorite slate of Logan............147, 148, 150
Chloritic schist as member of Kewatin, 341; not eruptive 351
Chub (or Akeley) lake.................. ... 82
Classification of rocks.................... 366
Clearwater lake........................... 61
Cleveland mine............................ 197
Climate.............................. 139
Colby mine .... .54, 185, 187, 188
Colnmnar diabase, 20, 285; gabbro.......246, 361
Conclnsions respecting the original Hnronian 36
Concretions......... ....317, 318
Conditions of exploration.................. 134
Conglomerate, at Bruce mines, 147; at Thessalon, Ont., 15; slate at Ottertail, 157; red jasper of Logan, 166; at Saginaw mine, 45, 172, 177; near Deer lake, 47, 175, 176; at Bessemer, Mich., 55; in the granite at the Aurora mine, 57; on Knife lake, 199; on Wonder island, 219, 334, 368 note, and reflections on 219; on Seagull lake, 293, 298; on Frog-rock lake, 307, 313; on Ogishke-mnncie lake, 96, 317; 337; on Gabemichigama lake, 91; on Kekekebic lake, 102; diabasic, 317; on Crab lake, 320, 321; on Zeta lake, 321; on Rainy lake, 416; in gneiss in New England, 334; same in Germany.....368 note
Conglomerate, unconformable on the magnetic quartz schist...................44, 46
Contact of Animike and Kewatin........... 357
Conglomeritic strnctnre in various formations..................................... 78
Contortions in Gunflint slate......... 241
Crab lake, 344—described................... 318
Cretaceous on the Little Fork river, 403; on the Big Fork.......................431, 434
Crocodile lake............................ 64
Crooked lake 332, 333
Cupriferons veins, Wellington mines........ 146
Cyanite, Rainy lake....................... 422

Daniel's lake 276, 277
Dead Man's rapids 404
Deer lake, near Ishpeming 47, 175
Deer river................................ 435
Delessite filling cavities.................. 15
Delta lake............ 324
Devil's Track river........................ 60
Diabase, at Bruce mines, 13, 145; included in quartz vein, 147; at Thessalon, 14, 148; its slaty character, 16, 148; near Thessalon, 19, 151, 152, 154, 155; at Macbeth's creek, 153; on quartzyte, 20, 153; speckled, 14, 156; near Blind river, Canada, 32, 161, near Missisagui river, 34, 163; Columnar, 33, 285
Diabasic landscape........................ 162
Diabase rocks.......................... 363
Diabase schist........................164, 199
Diabasic rock, with pebbles................ 317
Dike crossing Kekekebic lake................ 101
Dike in quartzyte, Canada....... ....19, 151
Dike lake............................342, 344, 348
Dike of basaltic greenstone................ 92
Dioryte, so-called, Michigamme..........49, 177
Dioritic group of Dr. Rominger.............. 48
Discontinuity, horizon of.................. 364
Distribution of terranes..... 330
Divergence of views....................... 329
Dodge, Prof. James A., Analysis by......113, 440
Dolomyte on Ogishke-mnncie................ 344
Dore river................................ 350
Dncks..................................... 139
Duff's valley, Canada...................... 156
Dump, The, Canada....................154, 155
Duncan's lake 275

Eagle-Nest lakes......... ....336, 343, 348
East Twin mountain......................... 99
Eldridge mine............................48, 180
Emmons, E., cited.......................... 359
Ensign lake..........................339, 347, 348
Epidote in amygdaloid, Thessalon.........15, 149
Epochs evidenced at Marquette...........53, 183
Epsilon lake, 347, 349, 359, 363; described, 326; rapids from...................... 199
Eruptives, 360, not including Kawasachong rock, 351, nor hæmatites and jaspilytes............................... 367
Exchanges........ 11
Expansion or swell in Gunflint lake.....237, 239

Fall lake..................111, 135, 195, 327, 339
Fairbanks, H. W........................... 395
Farm lake................................. 336
Faults, Canada, 37, 160, 167; system of in Minnesota 278
Faulted quartz vein......................... 257
Felsitic argillyte,.......................... 41
Felsitic sericitic schist,..................... 341
Felsyte, Ottertail, 27, 156, 157; in Plummer, Canada, 30, 159; position of, discussed, 168, 169
Felsyte schist, ...309, 312, 341
Field work in 1887 9
Fires, effects of...........136, 234, 279, 282, 314
First National Mine.......................60, 188
Fishes, ... 139
Flint beds in Animike.................67, 261
Flint Lake,............................... 236
Flowage lines in porphyry.................. 325
Ford, S. W............... 10
Flying Cloud lake............................ 86

Forest, character of........................ 136
Foraminifera, Cretaceous, on the Little Fork river.................................. 403
Fort Charlotte............................... 291
Fort Francis................................. 109
Fox lake 338, 345
Frazer lake 362
Frog-rock lake, 98, 337, 343, 345, 348; described................................ 306

Gabbro 29, 61, 85, 87, 90
Gabbro dike..............................291, 363
Gabbro flood................................ 361
Gabbroloid rock, Canada, 158; Minnesota, 355, 361
Gabbro, on Knife lake, 206, 207, 209; on Gunflint lake, 237, 242, 243, 246, 248, 249, 259, 260, 261, 262; on North lake, 271; on South lake, 273; on Rove lake, 275; on Mountain lake, 280; on Moose lake, 281; on North Fowl lake, 283; porphyritic on Loon lake, 301, 302, 304, fine, same, 301, granular, 302, 303, on Iron lake,...................... 305
Gabbro ranges, 135, 165, 272, 279, 280, 281, 284,..................................285
Gabimichigama lake, 89, 321, 331, 337, 355, 356,...................................... 359
Garden lake, 133; re-examined............111, 327
Gateway mountain,........................ 286
Giant's range, 82, 104, 134, 135, 136, 224, 230, 234 235, 239, 238, 248, 266, 271.......... 296
Giessbach, American,....................199, 203
Glaciation, 14, 21, 23, 35, 113, 147, 150, 398, 402, 405, 406, 407, 409, 413, 415, 416, 417, 419, 420, 421, 422, 423, 424, 425, 430, 433, 436, 440
Glacial river,................................ 86
Glanville shaft, Wellington mine............ 146
Gneiss, where found, 367, overlain by gabbro, 86
Gogebic iron belt 54, 185, 359; comparisons with Vermilion and Marquette,......188, 191
Gradations, to crystalline rocks, 76, 263. 266, 265, 264, 306, 309, 310, 335, 351; to graywacke, 211, 351, in granite, 333; between Animike and gabbro,................... 355
Grain on slaty sheets,.............. 253, 257, 322
Granby, Vt.,................................ 334
Grand Marais,.......................60, 135, 277
Grand Portage...................135, 291, 352, 362
Grand Portage Indians...................... 287
Grand Rapids............................... 439
Granite lake, 135, 213, 331; described........ 226
Granite Lake falls........................... 227
Granite, so-called, at Michigamme........... 177
Granitoid and gneissoid rocks.............. 330
Grant, Uly S., 10, on the molluscan fauna... 479
Grant's peak, 326.......................... 363
Graphite near Tower 113, 328
Graywacke, in Kewatin....................77, 338
Green chlorite slate of Logan.....16, 36, 150, 164
Green rock...............................346, 347
Green schists.............................. 108
Greenstone ..83, 33, 98, 102, 309-11, 313, 314, 325
Greenwood mountains...................... 62
Greisen.................................. 418, 420
Gunflint falls,...........................233, 331
Gunflint lake, 65, 74, 135, 167, 331, 335, 336, 337, 342, 348, 352, 358; described, 233; map of, 236; geology of generalized, 268; other notices of................................. 269
Gunflint lake, the expansion of, 237; west and south shores of, 241; north side of, 65, 250, excursions from, 262; first traverse from, 68, 262; Stacy's first traverse from, 75, 265; Stacy's second traverse from, 76, 266; excursion to iron deposits........78, 266
Gunflint narrows,...................233, 239, 244
Gunflint river, ...262, 270, 331

Hæmatitic schist and hæmatite, 26, 31, 71, 325, 353
Hæmatites not eruptive,..................... 367
Hall, Capt of Ishpeming, aid from,......... 172
Hare, northern,............................. 138
Hartford mine...........................43, 180
Hatch, Dr. P. L.,............................ 11
Herrick, Prof. C. L......................... 11
Historical statements....................79, 142
Hitchcock, E. cited......................57, 334
Holzinger, Prof. John M., mollusca of Winona county................................ 485
Hornfels, ... 339
Horizons of geologic discontinuity,.......... 364
Houghton, D. quoted,..............142; cited 359
Hoyt, Wis., slates near..................... 189
Hudson's Bay Co.,........................... 283
Hunt, T S., cited,.......................343, 352
Hunter's Island............................. 109
Huronian rocks, characteristic features of, 169; Canadian opinions on, 364..........note
Huronian region visited 13, 145; generalization on.....................................36, 164
Huronian System,........................... 366

Ice-house, natural,....................... 286
Illusion lake,............................... 355
Ima lake...............................331, 362
Interlaminated schists,..............70, 263, 295
Intermixture of rocks,.......................295
Iron-bearing rocks at Marquette,............ 40
Iron Cliffs mine......................40, 42, 179
Iron deposits, Gunflint lake, 68. 73, 266-8; North lake, 270; Rove lake, 278; Iron lake, 78, 305; Garden lake, 111, 327, at Chub lake, 82; on the north shore of Mud lake, 112
Iron King mine..........................59, 188
Iron lake of the west........................ 144
Iron ore, Canada............................ 160
Iron ores, 68, 71, 72, 77, 80, 82, 83, 86, 112, 113, 440
Iron or Mayhew lake, 78, 355, 362; described, 304
Iron range of the Vermilion................. 110
Ironwood, Mich 56, 186
Irving at Michigamme...................... 179
Irving, R. D., cited, 79, 144, 191, 193, 269, 287, 291, 352, 357, 358; important work of, 144 note
Ishpeming 44

Jasper, at Cambria mine, 181; at Iron King mine 188
Jaspilitic schist, 54, 198, 359; not eruptive, 42, 367; on Gunflint lake, 73, 242, 353; fragment of, near Epsilon lake..........325, 359

Jaspilyte 111, 113
John lake.................................... 284
Junction of gabbro and Animike slates, 66. 72, 250, 251, 302, 303; Kewatin and Animike 69, 257-9, 322, 323

Kabetogamak lake 417, 426
Kawasachong rock, 198; described, 308, 309. 341; not eruptive 311, 351
Kekequabic lake, 100, 324, 326, 331, 333, 337, 341, 345, 346, 359
Kewatin bay.................................. 259
Kewatin rocks, 62, 67, 69, 108, 194, 210, 224, 349, 365; on Saganaga lake. 224; on Gunflint lake, 253; on Range 3 east.......... 284
Kewatin semi-crystalline schists described, 336; distribution of, 361; lithological characters of 338
Kewatin stuff......................310, 312, 343
Knife lake, 109, 133, 135, 144, 196, 235, 310, 339, 342, 348, 358; survey of, continued.. 197
Knife lake, Arm IV , 198, 363: Arm III., 203; Arm I., 204; body of................204, 208

Laurentian rocks................76, 170, 366
Labradorite...... 89
Lawson, Mr. A. C., cited..................67, 76
Lefroy, Canada...... ....23, 156
Lichens of bright colors........................ 292
Light House, Marquette.................181, 182
Lignite, Cretaceous, in fragments............ 403
Lily lakes.................................... 281
Lily mine....... 181
Limestone, at Bruce, 147; at Ansonia, 155, 167; at Ogishke-muncie lake............ 344
Limonite..................................42, 71
Lindahl, Dr. J...................... 485
Little Bear creek, Canada.................... 164
Little Fork river............................ 396
Little Rapids, Canada 21, 154
Little Saganaga lake 356
Little Thessalon, Canada.................... 154
Lithographic rock.....................23, 28, 38
Localities particularized..................... 141
Lodes, iron, in Marquette region..........172, 173
Logan, Sir William, cited..................36, 350
Long lake.........................334, 336, 339, 348
Loon lake, 234, 249, 362; described........... 299
Luxuriance of vegetation.................... 137
Lower slate conglomerate.................31, 37

Macbeth's creek, Canada........... 20, 153
Magnetic belt, Wisconsin.............. 194
Magnetite, at Penokee Gap, 192, 193: on Knife lake. 209; on Gunflint lake, 235, 237, 238, 241, 244, 245, 250; near Gunflint lake, 266, North lake, 271; Moose lake, 282, 283; Iron lake, 305; Garden lake............ 327
Magnetic schists, 237, 241, 245, 247, 271, 276, 303, 327, 354
Mallmann's peak.......................326, 101
Marble 95
Marquette city..... 181
Marquette iron rocks, age of, 171, 184; compared with Vermilion, 184; not Huronian, 185; belong to an unrecognized system... 185
Marquette region, observations in........50. 171
Marquettian system 365
Marsh, William 485
Martite, Negaunee........................... 177
Mayhew, Henry............................... 80
Mayhew cabins..... 277
Mayhew or Iron lake, described..........78, 304
McFarland lake.............................. 284
McMinn, Herman S........................... 113
Mellen, Wis., slates near.................... 189
Mesabi range........ ....134, 234, 219, 300
Metamorphism of pebbles.... 346
Method of operation......................... 140
Michigamme mine......................49, 177
Millar, Mr. J. M............................ 80
Miranda lake................................ 284
Mississippi river.......................437, 438
Mississagni quartzyte...............38, 168, 170
Misquah Hills............................... 62
Mokoman island......................... 198
Molluscan fauna, Grant. 481
Moose 138
Moose lake, described........................ 281
Moose lake of the west..............339, 347, 363
Morton, Vermilion group at.................. 79
Mountain lake described...................... 279
Mountain lake of Norwood.................. 274
Mount Reunion............................... 64
Mud creek bay 336
Mud lake...................... .... .112, 195
Mud lake of the east, see "Rose lake."
Murray's corners, Canada........30, 159, 160, 166
Murray's Hill... 30
Muscovado, 73, 88, 93, 253, 267, 355, 360; on Iron lake................................ 305
Muscovado lake.............................. 88

Namekan lake............................ 428
Nameless lake............................... 340
Nascent mica schist.....................190, 195
Negaunee................... ....40, 179, 359
New-found lake.......................339, 347
Newton lake 111, 195, 335
Norrie mine 186
Northern Light lake.................65, 270, 271
North-Fowl lake...................... 283
North lake, 65, 234, 335, 337, 338; described, 270; Norwood on........................ 271
Norwood, J. G , cited, 143, 236, 269, 273, 274, 276, 277, 291, 292, 434, 435
Noryte....... ....167, 200, 301, 324, 363

Oak lake, 210, 331, 336; rapids............ 404
Oestlund, O. W................ 11
Ogishke conglomerate, in bowlders, 147; appearance of in diabase, 96, 149; on Frog-rock lake, 98, 313; on Ogishke-muncie lake, 318; underlaid by argillytes, 322; as member of Kewatin group, 344, 347; not enclosed in Animike, 359; evidence that it is so included......................91, 97, 330
Ogishke-muncie lake, 95, 331, 339; described. 315
Olivine knob..... 288

Operations, method of.......................... 139
Opimabonowin river.......................... 431
Opin island 110
Opinions, divergence of.. 329
Organic remains in the Animike (?)......... 78
Orthoclase gabbro......................... 62
Orange hall, Canada....................... 159
Original Huronian.........................13, 36
Ottertail, Canada................26, 156, 157, 158
Ottertail lake, Canada.................. 26, 156
Ottertail quartzyte 37, 43
Ottertail limestone.......................167, 168
Ottertrack lake.........................210, 336
Owen, D D., cited...................143, 434, 435
Owen, R., cited........................... 292

Paint rock..................................54, 188
Parophyte..................................205, 313
Partridge.................................... 138
Partridge falls, 290, 356; portage........... 289
Passage from argillyte to graywacke........ 211
See "Gradations."
Pebbles, in diabase, 96, 97, 149; in syenite, 56, 104, 73, 216, 223, 226, 298, 299, 324; in schist, 106, 313; in diabasic rock, 317; in Ogishke conglomerate, 345, 346, 347; metamorphosed 346
Pegmatyte, structure of.................... 420
Penokee gap, 187; age of rocks at........... 191
Peridotyte.................................. 111
Petrography, functions of.................. 368
Pewabic lake................................ 362
Pewabic quartzyte....................86, 91, 93
Physical aspects............................ 134
Pickle lake................................. 348
Pigeon Point................................ 292
Pigeon river, 275, 281, 283; described, 288, 356, 362
Pigeon river gateway 285
Pigeon river valley......................... 291
Pine, unlawful cutting of................396, 431
Pine lake..................................229, 331
Pine mountain............................... 61
Pinite...................................... 313
Pipestone rapids 111, 196, 333
Plan, of operations, 9, 140; of report.. 140
Plats, erroneous.....................228 318, 321
Plum lake................................... 348
Plummer argillytes 165, 166, 168, 170
Plummer, Canada.....................29, 156, 159
Pokegama lake............................... 438
Porcupine................................... 138
Porcupine mountains......................... 359
Poroditic rock..................205, 263, 265, 324
Porodyte..................................343, 113
Porphyrel, at Ishpeming, 175; on Knife lake, 201; on Gunflint lake, 257; Frog-rock lake, 307; Town-line lake, 315; Crab lake 320
Porphyrel explained, 104 f.n., 342; evidences of sedimentary origin of.................. 344
Porphyrelloid graywacke...... 307
Porphyrelloid schist.....................190, 201
Porphyrellyte, 204, 205, 206, 248, 257, 328; defined, 205; as member of Kewatin, 341; growth of conception of, 341, 342; evidences of sedimentary origin of.......... 344
Porphyry, on Rainy Lake river............... 411
Porphyry proper 344, 325, 326, 363
Portage from Mud to Burntside lake 195
Portages made, 134; on the national boundary 388
Potholes 86
Potato lake.................................. 197
Prairie river, and falls..................... 439
Primitive geology............................ 367
Promontory, Knife lake, 208; gabbro on..209, 235
Prospect mountain............................ 326
Pseudomesser lake 109, 196, 341
Pulpit rock, noryte.......................... 200
Purgatories.................................. 105

Quadrupeds................................ 138
Quartz, free in schists...................... 340
Quartz on island in Saganaga lake........... 215
Quartz-porphyry 53
Quartzose schist, Deer lake, 176; Garden lake, 112, 327
Quartz schist, inclosed in gneiss..........58, 187
Quartz veins, 364: in diabase, 148; in schists. 156
Quartzyte, near Thessalon, 18, 150, 152, 153, 154, 155, 156, 165; at Little rapids, 21: at Ottertail, 26, 157; near Blind river, 32, 161, 162; flinty at Missisagui river, 34, 163; at Deer lake, 176; at Ishpeming, 45; at Michigamme, 49, 178; at Negaunee, 41, 178, 179, 180; at Cascade, 43; at Aurora mine, 58, 187; at the Colby mine, 55; on Garden lake.........................111, 327
Quartzyte, thickness of...................42, 155
Quartzyte, white, vitreous, Ottertail..26, 156, 158

Rabbit, so-called.......................... 138
Rainy lake................................... 413
Rainy Lake river............................. 408
Rat lake..................................... 274
Rattle and Nye, analysis by..............80, 82
"Red rock"................................... 62
Red-rock lake, 213, 331; described........... 292
Red felsyte.. ....19, 28, 34, 38
Regions surveyed in 1887, 9, 133, 395; in 1886. 144
Report, plan of.............................. 140
Reunion Mt.............................64, 277, 356
Riddlebank P. O., Ont........................ 31
Robin.. 139
Rock lake, Canada............................ 159
Rock identifications......................... 142
Rock numbers, 141; catalogue of....464, 114, 369
Rock samples collected...............464, 114, 369
Rominger, C., cited..........42, 47, 48, 50, 67, 343
Ropes gold mine.......................48, 172, 176
Rose, Canada 156
Rose lake described.......................... 274
Rose lake mountain 275
Rosenbusch, as authority..................... 142
Round lake................................... 64
Rove lake, 356; described.................... 276
Roy lake..................................... 284

Saganaga falls............................. 227
Saddle-bags lake 98
Saganaga lake, 135, 333; described, 211; great middle arm of, 214; body of........ 217

Saganaga syenite or gneiss, 76, 215, 217, 227, 340; described....330, 331, 332
Saginaw mine, Ishpeming....47, 172, 177
Sam Mitchell mine....41, 179
Sand lake....340, 348
Saw-teeth configuration.... 361
Schistosity and bedding....322, 323
Schists at Ottertail, Canada.... 158
Sea-gull lake, 135, 213, 217, 331, 333, 349, 357; described, 295; map of, 297; conglomerate on, 222; river....216, 299
Sedgwick and Brotherton's location....70, 262
Sericitic argillyte.... 256
Sericitic felsite-schist....308, 313, 314
Sericitic schist, Deer lake, Mich, 47, 176; Frog-rock lake, 312; Town-line lake, 315; Ogishke-muncie lake....97, 316
Sericitic schist, granular, 312, 315; is it ever eruptive?.... 351
Serpentine group.... 50, 343
Serpentine in diabase.... 146
Shrubs of the region.... 137
Siderite....42, 71
Siliceous schists, Knife lake....204, 340
Siliceous slates....198, 199, 208, 211, 353, 359
Silver city....111, 327
Silver location.... 284
Slate conglomerate, 31, 39, 161, 356. See "Animike."
Slate, black, near Ishpeming, 174; near Negaunee, 179, 359; near Iron King mine, 59, 188; at Penokee gap, 191, 194; at Knife lake.... 202
Slate, diabasic....161, 164-5
Snowbank lake....331, 335, 337
Soap-rock....175, 180
Sodergren, aid from.... 179
Soil under Animike.... 262
South Fowl lake....284, 356
South lake.... 272
Spalding, William P.... 284
Spoon lake.... 109
Stacy, Frank, cited....75, 99, 222, 254
Stacy island....102, 344, 346, 347
Stair portage....275, 276
Ste. Marie's river.... 170
St. Joseph's island.... 176
Strawberry blossom.... 202
Striæ observed.... 113
Striæ, glacial, peculiar.... 150
Structure at Ishpeming....44, 175
Stuntz conglomerate, Deer lake, 47, 98, 175, 176; Knife lake, 199, 200, 201, 203, 348; described.... 350
Sturtevant of Ishpeming, aid from.... 172
Sucker lake....196, 335, 336, 347, 358
Sulphur island, lake Huron.... 170
Summary of facts.... 329
Summary statement.... 9
Surface geology, Thessalon....19, 171
Swan mine, Mich....42, 178
Syenite range.... 73
i c c results.... 364
c o nio, position of.... 176

Talc, crystalline....49, 176
Talcose slate, so-called....175, 195
Taft, chemist, Negaunee, 175, 177; analysis by 177
Teal lake....42, 180
Terms used.... 142
Test-pits for iron....354, 356
Thessalon, valley of....19, 147, 164
Thessalon quartzyte.... 27
Thickness of Huronian terranes, 168, 169; of other terranes.... 366
Thunder bay....252, 253
Titaniferous iron ore....205, 362
Todd, Prof J. E....23, f. n
Tower blasts.... 199
Tower iron mines....113, 328
Tower to Pseudomesser lake.... 195
Town-line lake, 337, 348; described.... 314
Tourmaline, Little Fork river.... 406
Transition from Kewatin to Ogishke conglomerate, 314. See "Gradation;" from felsyte to quartzyte, 28, 35; of conglomerate to granite, 57, 58; of schists, 70; of Animike, 71, 74, 91, 94; of the Kewatin... 76
Triangle lake....335, 336
Trussell, W. F....395, 428
Tucker lake.... 362
Twin bay portage.... 229
Twin mountain....100, 326
Twisted beds....69, 263
Two Harbors.... 331

Ulrich, E. O.... 116
Unconformity, at Thessalon, 40; near Negaunee, 40, 44, 179, 185; at Ishpeming, 46; in Penokee gap, 191, 193; on Gunflint lake, 69, 81, 73, 253, 264, 268, 357; on Epsilon lake, 322, 323
United States Survey....144, 236
Uralitic gneiss.... 264
Uralitic schist.... 264

Vaccinium, distinct form of,....136, 137
Valley mine,....55, 186
Vegetation,.... 135
Vein rocks,.... 364
Veins metalliferous,.... 156
Veins, of quartz, 148, 156; of Calcite,.... 149
Vermilion group, 69, 74, 77, 95, 112, 310, 311, 350, 366; described,.... 334
Vermilion iron series.... 175
Vermilion iron mines.... 328
Vermilion lake,....144, 331, 334, 336, 343, 348
Vertical attitude of beds, 330; of Kewatin, 338, 348, 357

Wadsworth, M. E., cited 47, f. n.... 343
Watab lake,.... 276
Weasel,.... 139
Webster-Ashburton treaty,.... 109
Wellington mine, Canada,....13, 146
West Seagull lake, 135, 310, 331, 333; described,.... 298
White-iron granite,....330, 331, 332, 335
White-iron lake,....104, 111, 328, 333, 336
Whitney and Wadsworth cited,.... 329

Winchell, A., report of, 133, 269; cited 10, 133, 74, 81, 357
Winchell, H. V., cited 10, 78, 338, 358; report of, ... 395
Winchell, N. H., cited, 143, 144, 170, 230, 235, 236, 269, 272, 274, 284, 287, 291, 292, 352, 357; report of, ... 13
Winibigoshish lake 437
Wisacode river, ... 276
Winona County, Mollusca of 485
Wolf, ... 138
Woodward and Thomas, cited, ... 403
Wonder Island, 217; conglomerate at, 219, 296, 349, 368, note

Zeta lake, 257, 322, 342, 344, 347, 348; described, ... 321

Corrections and additions for the report for 1886.

Page 27. Second line from bottom, for "62-15" read "62-14."

Page 37. Halt 69. For "sec. 25" read "sec. 35."

Page 39. After Halt 75, add:

HALT 76. N. W. ¼ S. W. ¼ sec. 32, T. 63-13. Base of point, south shore of Burntside lake. Rock very fine-grained mica schist, bluish and hard, and intersected by granitic veins. Rocks 63 and 64 are from this locality.

Page 47. Halt 361. For "Fig. 17" read "Fig. 18."

Page 50. For "Rock 177" read "Rock 170."

Page 56. Halt 336. For "sec. 2" read "sec. 21."

Page 57. Halt 341. For "sec 29" read "sec 20."

Page 60. For "Halt 134" read "Halt 144"; and for "Rock 146" read "Rock 140."

Page 62. Halt 309. For "T. 64-11" read "T. 63-11"; and the same under Halt 315.

Page 68. Halt 148. For "T. 63-13" read "T. 63-11."

Page 74. For "Rock 103" read "103 bis"; and in next line read "Halt 178."

Page 79. Halt 216. For "63-11" read "62-11."

Page 80. Halt 223. For "62-11" read "63-11."

Page 88. Before Halt 236 add:

HALT 234. S. E. ¼ S. E. ¼, sec. 34, T. 63-11. Coarse syenite. Low outcrop.

HALT 235. S. E. ¼ S. E. ¼, sec. 34, T. 63-11. Porphyritic syenite in two portions separated by 20 feet of fine syenite.

Expected to pass into the southern one of the long arms of Farm lake, but the outlet mapped as broad as a river is not passable for a canoe.

Page 88. Halt 236. For "73-11" read "63-11."

Page 90. For "Halt 354" read "Halt 254."

Page 91. Halt 257. For "62-11" read "63-11."

Page 95. Halt 411. For "65-10" read "64-10"; and for "Rock 169" read "Rock 179."

Page 96. Halt 419. For "S. 1¼" read "S. 16."

Page 98. For "Halt 225" read "Halt 425"; and under "Halt 432 bis," for "64-19" read "64-10."

Page 99. Halt 439. For "64-19" read "64-10"; and before "Rock 187" add:

HALT 442. S. E. ¼ S. E. ¼ sec. 33, T. 65-9. Went ashore to examine the fragments. They are mostly as heretofore, of syenite having whitish feldspar. But here are some with masses of hornblende rock; and I saved one piece in which prisms of hornblende are pretty well preserved.

Page 100. Halt 444. For "S. 30" read "S. 34"; Halt 446, for "S 25" read "S. 35"; and Halt 448, for "S. 39" read "S. 35."

Page 107. Halt 649. For "S. 64-11" read "S. 14, T. 64-11."

Page 109. Halt 672. For "S. 3" read "S. 30."

Page 115. Halt 698. For "65-11" read "66-11."

Page 117. For "Halt 792" read "Halt 712."

Page 126. For "*Rock* 203" read "*Rock* 203 bis."

Page 136. Halt 566. For "65-8" read "64-8."

Page 145. Halt 741. For "S. 44" read "S. 24"; and for "Halt 774" read "Halt 744."

Page 263. Second line from bottom, for "their" read thin.
Page 263. Fifth line from the bottom, for "luminated" read laminated.
Page 381. Twenty-fourth line from the bottom, for "it" read It.
Page 391. Eighteenth line, after "of" read last gabbro.
Page 396. Fifteenth line from the bottom, for "conglomerate" read carbonate.
Page 149. Halt 754. For "61-7" read "64-7"; and before Halt 756 add:

HALT 873. N. E. ¼ N. W. ¼ sec. 2, T. 64-7. Chlorite gneiss—that is, composed of chlorite, feldspar and quartz. Seems to be of the same constituents as Rock 379, but they are well stirred together, same as at Halt 756.

Rock 380. Chlorite gneiss.

HALT 874. N. W. ¼ S. W. ¼ sec. 36, T, 65-7. West end of island.

Rock 381. Porphyrel.

Page 153. For "Rock 363" read "Rock 363 bis."
Page 160. For "Rock 324" read "Rock 325."
Page 167. Dele "Halt 820. S. W. ⅜ S. E. ¼ sec 26, T. 65-6."
Page 170. Halt 830. For "S. 30" read "S. 36."

Errata for the report of 1887.

Page 23. Sixth line from the bottom, for "southwestern" read southeastern.
Page 37. Seventh line, for "number" read "member."
Page 70. Second line from the bottom, for "65-1 and 65-2" read 65-2 and 65-3.
Page 77. Second line, insert than before "there."
Page 82. At the bottom, for "Little" read Rattle.
Page 107. Fifth line from the bottom, for "the same" read some.
Page 168. Twenty-third line, for "if" read of.
Page 176. Twentieth from the bottom, strike out "(1069)."
Page 188. Nineteenth line from the bottom, strike out "(1104)."
Page 207. Third line from the bottom, for "latitude" read altitude.
Page 215. Third line, strike out "1177."
Page 222. Sixth line from the bottom, for "Seagull" read West Seagull.
Page 252. Thirteenth line from the bottom, for "conceded" read concealed.
Page 253. Eighth line from the bottom, for "structure" read whatever.
Page 258. Eighth line from the bottom, for "leans" read bears.
Page 260. Last line, after "65-3" insert as of Minn.
Page 270. Ninth line from the bottom, after "rock" insert (743).
Page 294. Line 23, for "(502)" read (582).
Page 294. Eleventh line from the bottom, for "573," read 593.
Page 313. Tenth line from the bottom, for "65-6" read 65-5.
Page 321. Twelfth line, before "Obscurely" insert Rock 915.
Pages 384 and 385. In the heading, for "Report, 1886" read Report, 1887.

PUBLICATIONS OF THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.

I. ANNUAL REPORTS.

THE FIRST ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1872. 112 pp., 8vo.; with a colored map of the State. By *N. H. Winchell*. Published in the Regents' Report for 1872. Out of print.

THE SECOND ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1873. 145 pp., 8vo.; with illustrations. By *N. H. Winchell* and *S. F. Peckham* Published in the Regents' Report for 1873. Out of print.

THE THIRD ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1874. 42 pp., 8vo.; with two county maps. By *N. H. Winchell*. Published in the Regents' Report for 1874. Out of print.

THE FOURTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1875. 162 pp., 8vo.; with four county maps and a number of other illustrations. By *N H. Winchell*, assisted by *M. W. Harrington*. Also in the Regents' Report for 1875. Out of print.

THE FIFTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1876. 248 pp , 8vo.; four colored maps and several other illustrations. By *N. H. Winchell*, with reports on Chemistry by *S. F. Peckham*, Ornithology by *P. L. Hatch*, Entomology by *Allen Whitman*, and on Fungi by *A. E. Johnson*. Also in the Regents' Report for 1876. Out of print.

THE SIXTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1877. 226 pp., 8vo.; three geological maps and several other illustrations. By *N. H. Winchell*, with reports on Chemical Analyses by *S. F. Peckham*, on Ornithology by *P. L. Hatch*, on Entomology by *Allen Whitman*, and on Geology of Rice county by *L. B. Sperry*. Also in the Regents' Report for 1877. Out of print.

THE SEVENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1878. 123 pp., 8vo.; with twenty-one plates. By *N. H. Winchell*, with a Field Report by *C. W Hall*, Chemical Analyses by *S. F. Peckham*, Ornithology by *P. L Hatch*, a list of the Plants of the north shore of Lake Superior by *B. Juni*, and an Appendix by *C. L. Herrick* on the Microscopic Entomostraca of Minnesota (twenty-one plates). Also in the Regents' Report for 1878.

THE EIGHTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1879. 183 pp., 8vo ; one plate (Castoroides). By *N. H. Winchell*. Containing a statement of the methods of Microscopic Lithology, a discussion of the Cupriferous Series in Minnesota, and descriptions of new species of brachiopoda from the Trenton and Hudson River formations; with reports on the Geology of Central and Western Minnesota, by *Warren Upham*; on the Lake Superior region, by *C. W. Hall*; lists of Birds and of Plants from Lake Superior, by *Thomas S Roberts;* Chemical Analyses by *S F. Peckham;* report by *P. L Hatch;* and four Appendices. Also in the Regents' Report for 1879 and 1880. Out of print.

THE NINTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1880. 392 pp., 8vo.; three appendices, two wood-cut illustrations and six plates. By *N. H. Winchell*. Containing field descriptions of 442 crystalline rock samples, and notes on their geological relations, from the northern part of the state; new brachiopoda; the water supply of the Red River Valley, and simple tests of the qualities of water; with reports on the Upper Mississippi region, by *O. E. Garrison;* on the Hydrology of Minnesota, by *C. M Terry;* on the Glacial Drift and its Terminal Moraines, by *Warren Upham;* Chemical Analyses by *J. A. Dodge;* a list of the Birds of Minnesota, by *P. L. Hatch;* and of the Winter Birds, by *Thomas S. Roberts.* Also in the Regents' Report for 1879 and 1880

THE TENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1881. 254 pp., 8vo.; with ten wood cut illustrations and fifteen plates. By *N H Winchell.* Containing field descriptions of about four hundred rock samples, and notes on their geological relations, continued from the last report; the potsdam sandstone; typical thin sections of the rocks of the Cupriferous series; and the deep well at the "C" Washburn mill, Minneapolis; with Geological notes, by *J. H. Kloos;* Chemical Analyses, by *J. A Dodge;* and papers on the Crustacea of the fresh waters of Minnesota (eleven plates), by *C. L. Herrick.* Also in the Regents' Report for 1881 and 1882.

THE ELEVENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1882. 219 pp., 8vo.; with three wood cut illustrations and one plate. By *N. H. Winchell.* Containing a report on the Mineralogy of Minnesota, and a note on the age of the rocks of the Mesabi and Vermilion iron districts; with papers on the crystalline rocks of Minnesota, by *A. Streng* and *J. H. Kloos;* on rock outcrops in Central Minnesota and on Lake Agassiz, by *Warren Upham;* on the iron region of Northern Minnesota, by *Albert H. Chester;* Chemical Analyses, by *J. A. Dodge;* and an Appendix containing Minnesota Laws relating to Mines and Mining, abstracted by *C. L Herrick.* Also in the Regents' Report for 1881 and 1882.

THE TWELFTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1883 Summary report, containing palæontological notes, and a paper on the comparative strength of Minnesota and New England granites, twenty-six pages, by *N. H. Winchell;* final report on the Crustacea of Minnesota included in the orders Cladocera and Copepoda. 192 pages and 30 plates, by *C. L. Herrick;* and a catalogue of the flora of Minnesota, 193 pages with one map showing the forest distribution, by *Warren Upham.* Also in the Regents' Report for 1883 and 1884.

THE THIRTEENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1884. 196 pages. Geological reconnoissances, the Vermilion iron ores, the crystalline rocks of Minnesota and of the Northwest, the Humboldt salt-well in Kittson county, records of various deep wells in the State, fossils from the red quartzyte at Pipestone, reports on the New Orleans Exposition and on the General Museum, by *N. H. Winchell;* Geology of Minnehaha county, Dakota, by *Warren Upham;* Chemical report, by *Prof. Jas. A. Dodge;* Minnesota geographical names derived from the Dakota language, by *Prof. A. W. Williamson;* insects injurious to the cabbage, by *O. W. Oestlund;* Geological notes in Blue Earth county, by *Prof. A. F. Bechdolt;* and on a fossil elephant from Stockton, by *Prof. John Holzinger;* papers on the Cretaceous fossils in the boulder clays in the Northwest, by *George M Dawson* and by *Woodward* and *Thomas;* and notes on the Mammals of Big Stone lake and vicinity, by *C. L. Herrick.*

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. 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 Aphididæ of Minnesota, with descriptions of some new species, by *O. W. Oestlund;* Report on the Lower Silurian 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* Also supplement II of the Regents' Report for 1885-1886.

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.

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 auditors' 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 *Dr. 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.
9. CIRCULAR No. 5. To Builders and Quarrymen. Relating to the collection of two-inch cubes of building stones for physical tests of strength, and for chemical examination, and samples of clay and brick for the General Museum. 1880.
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*. In preparation.

No. 2. Preliminary Description of the Peridoytes, Gabbros, Diabases and Andesytes of Minnesota By *M. E. Wadsworth*.

No. 3. Report of work done in Botany in the year 1886. By *J. C. Arthur*.

No. 4. A Synopsis of the Aphididæ of Minnesota. By *O. W. Oestlund*.

No. 5. Natural Gas in Minnesota. By *N. H. Winchell*.