Supplementary notes on the Vermilion district of Minnesota: [specimens] 40204-40257. No. 336 1900

U. S. GEOLOGICAL SURVEY

FIELD SECTION BOOK

9-891

LAKE SUPERIOR DIVISION.

INSTRUCTIONS.

1. Ordinarily at least two pages of this book will be devoted to one section. On the left-hand page, place a map of as much of the section as has *actually been seen*. Denote rivers, lakes, marshes, etc., by the usual topographical signs. Denote the ledges of rock, when no structure is made out, by cross-hatching, making the cross-hatching cover as nearly as possible the areas occupied by the exposures. If the rock is a massive one, but still more or less plainly bedded, use the same sign with a dip arrow and number attached, showing the direction and amount of the dip. Denote a shaly or other very plainly bedded ledge by right parallel lines, and a ledge having a secondary structure by wavy parallel lines running in the direction of the strike, with dip arrow and number attached as before. The greatest care must be taken to avoid confusing slaty or schistose structure with bedding, and in all cases where there is the least doubt about the true bedding direction, indicate it by a query. To each exposure on the face of the map attach the number of the specimen representing it. In mapping the section count each of the spaces between the blue lines as 100 paces, and twenty of these spaces to one mile, or 2,000 paces. Usually the southeast corner will be placed at the bottom of the page, or at the first black line above the bottom of the page, and at the right-hand side. If, however, for any reason, it is desirable to show portions of an adjoining section, the southeast corner may be shifted up, or the map may be turned around and the north placed at the left-hand side of the page. The ruling of the left-hand pages is also arranged so that, if desirable, a larger or a smaller scale can be used, eight inches, two inches, one inch, or one-half inch to the mile. With the two-inch scale, the squares outlined in black represent sections, and those in red, quarter sections and "forties," while the space between the blue lines is 200 paces.

2. On the right-hand page place the notes descriptive of the exposures. Begin in each case with the number of the specimen, placing the number on the left-hand side of the red line, after which give in order on the right of the same red line the position of the ledges as reckoned in paces from the southeast corner of the section and the dip and strike when observable, the latter always being expressed from the north; for instance 4025, 250 *N.*, 300 *W.*, *Strike*, *N.* 78° *E.*, *Dip* 50° *S.* Then follow with a full description of the ledge. When topographical maps are used for locations this paragraph applies only in part.

3. Collect a specimen from every ledge, or wherever there is a change of rock on any one ledge, taking care to get fresh material, unless for a special purpose the weathered surface is desired. In case of trips made on foot or in canoes, for long distances, neighboring ledges, unquestionably of one kind of rock, need not be specimened. The position and extent of the ledges not specimened should be marked on the map, with notes that each is of a rock identical with specimen so-and-so. Under the same conditions small-sized specimens, trimmed to a uniform size of 2 x 2½ x ¾ inches will be allowed, but in all other cases *large-sized specimens*, trimmed to a size of 3 x 4 x 1 inches, must be selected, in accordance with section 3, chapter IV, p. 44, Regulations of the U. S. Geological Survey. Specimens should not be placed together without protection in the collecting bag, as the fresh surfaces, important in determining the character of rocks, are thus destroyed. They should be damaged by no temporary mark, but the numbers should be at once marked in at least two places upon the inclosing paper or cloth bags. Specimens may be permanently marked in camp by painting the numbers upon them in white upon a black background, using Silver White and Ivory Black oil tubes for color, with turpentine as a diluent.

4. On the last twenty-five pages of the book give, as may seem desirable, a general account of the examination of the region mapped in the previous pages, correlation of observations, sketches, cross sections, etc.

5. Forward this note book as soon as filled as registered mail matter to C. R. Van Hise, U. S. Geologist, Madison, Wis.

No. 5

#336

Supplementary Notes on the Vermilion District of Minnesota

1900

J. Morgan Clements

1900

SUPPLEMENTARY NOTES ON THE VERMILION DISTRICT OF MINNESOTA.

Sept. 2nd.

Went this morning into Sec. 2-61-15 to hunt for sediments between the jasper and the underlying greenstone. In a dozen places I found masses of jasper of varying size in immediate contact with the greenstone; but in no instance did I find anything that was certainly a sediment between them.

At one place I found a granite like (27110). This cuts the jasper. The granite is considerably
40205 altered. (40205) shows its characters; and near the jasper especially it has developed into a chlor-
40204itic schist (40204). Here and there through this schistose rock there still remains a quartz phenocryst. One can follow in this case with the eye the transition from the red-weathering massive granite through the slightly greenish schistose phase into the green chloritic schist adjacent to the jasper. It appealed to me especially as one can see here the gradation of a massive acid rock into a green very basic-looking schist. It seemed to me

closely comparable to the alteration of the white and associated porphyries of Vermilion Lake, which upon Soudan Hill, especially where they are adjacent to the ore-bodies, have become green chloritic schists. Evidently instead of sericite being developed in the alteration of these quartz-porphyries, sufficient iron has been brought into the rock subsequent to or contemporaneous with the development of the schistosity in them to form the chlorite instead of the sericite.

40204 (40204 and 40205) should be sec-
40205 tioned and studied with especial reference to this process of the development of chlorite in the acid rock instead of sericite.

The greenstones associated with the jasper in this sec. 2 show very well developed ellipsoidal partings. The exposures are very good also; and as this area can readily be reached by the old road shown upon the map it is a good place to go if one wishes to see the characters of such rocks

Spent the afternoon in an examination of the exposure of jasper which occurs north and northwest of the west quarter post of Sec. 3-61-15 W. My special object in going here was to look for sediments in association with the jaspers. I found nothing that I was absolutely sure

was of sedimentary origin. At one place upon the top of the hill immediately northwest of the quarter-post there was found a band of possible sediments which was interbanded with the jasper, and had on the under side of it a layer varying from 6-24 inches in thickness of a conglomerate or a breccia. The fragments of this breccia are of white chert, which lie in a green matrix. The strike of the banding is N. 10 W. The ~~matrix~~ breccia lies on the east side of the band with the fine grained material to the west
40206 (40206) shows the character of the porphyritic greenstone which is here associated with the iron-bearing for-
40207 mation. (40207) was taken from this band of breccia. The greenish material above the breccia varies in thickness from 6-18 inches, and is
40208 represented by (40208 and 40209).
40209

This band is not believed to be of sedimentary origin, although perhaps the microscope will enable this to be determined. It is from the field occurrence judged to be altered greenstone with a brecciated layer at the bottom, the chert fragments having been derived from the adjacent banded cherts and jaspers and the matrix being derived from the greenstone.

Upon the north slope of this hill I found another band of greenish ma-

terial associated with the jaspers. The jasper is exposed in contact with it only upon one side, the east; but presumably this exists also to the west of it. This seems more like a sediment in that it shows some fine ly contorted lines running through it.
40210 (40210) represents a portion of this, showing the fine banding. In general the material making up the band
40211 is massive, as shown in (40211-40212)
40212 Associated with the normal red jasper and white cherts of the iron-bearing formation I noted a band of chert with red spots in it, from which
40213 I took (40213), thinking that examination of it might give some clue to the material from which it was derived.

Sept. 3rd.

Went over to see Ahbe at the Minnesota Co.'s office, and made arrangements for getting drill holes which had been put in since last year, and also arranged for getting mine plats. It rained heavily throughout the day, and I spent all of my time here making a copy of the map of Lake Nepigon as I wanted to get my notes down upon my copy so that I could return the original to Mr. Anderson, of the Hudson Bay Co., the owner. In the evening saw Walsh, and from him obtained some information concerning diamond drill holes put down on his property by the Oliver Mining Co. The location of the first hole is 500 ft west, 400 ft. north of the S. E. corner of the N. W. 1/4, Sec. 4-61-15. It was put in about 800 ft. north of the southern greenstone outcrop, and runs south at an angle of 48°. The log is as follows:

~~125 ft. surface drift~~.
125 ft. glacial drift.
80 ft. rock designated by Walsh as a green rock, but which he describes as being coarse grained and containing eyes. I am quite sure this is a coarse grained quartz-porphyry similar to that which outcrops about due N. W.

of the location of the drill and which is found cutting through the greenstones in various places. I consider~~ed~~ it the same porphyry as (27107).

117 ft. graphitic rock, as shown by the drill. This is usually very soft. In places however it is harder, and such phase is shown in
40214 (40214) This graphitic rock is reported to harden somewhat upon exposure. It looks very much indeed like some of the fine grained slates which occur in the series overlying the greenstone and jasper. A section should show whether or not it is of fragmental origin or merely an exceedingly schistose phase of greenstone.

28 ft. green rock was found below the above mentioned slaty rock, and after penetrating this far drilling ceased and the drill was withdrawn.

40214 If (40214) turns out to be a clastic then it would seem to indicate that at least a part of the low ground lying north of the southernmost greenstone-jasper bluffs in Secs. 3 and 4-61-15 is underlain by the upper sediments.

The second drill hole was put down in the middle of the swamp, at the center of the N. W. 1/4 of Sec. 4-61-15. He could not give me the direction of the hole nor the dip The following is the log which he reported:

116 ft. drift.

200 ft. same coarse greenstone which occurring to the west has large quartz eyes, and which I interpreted to be quartz-porphyry like (27107)

40215 25 ft. grayish slaty rock, represented by (40215), was passed through below the greenstone.

The drilling ceased after the drill had enter to the above depth. Presumably this belongs to the same series to which(40214) belongs, and if this as well as the other (40214) is sediment it would show the presence of these sediments in this basin.

Walsh also told me that jasper has been found by diamond drill in the N. W. 1/4 of the N. W. 1/4 Sec. 3-61-15. He said the drill had been put in about 300 ft. south of the north corner post between Secs. 3 and 4, and that the drilling was done by the Mahoning Co.

Sept. 4th, 5th, and 6th.

It rained almost continuously on Sept. 4th and 5th and the forenoon of the 6th. In the afternoon of the 6th I visited the North Lee mine, in order to search for the conglomerate which has been mentioned by Merriam as occurring upon the south side of the jasper between it and the greenschists. I had in the course of previous years' work visited this pit and found nothing that I was sure was a conglomerate, although I saw some material that I had interpreted as a breccia. Again saw on the south side of the pit and at the west end of the pit a very well developed fragmental rock which is without question
40216 a breccia of the jasper. (40216) is a breccia of the jasper which near the greenstone has some of the greenstone which has been mixed with it and forms the matrix for the jasper and chert fragments. The iron-bearing formation in the vicinity of this jasper has been extremely contorted and is traversed by numerous cracks which are filled with vein quartz. It is also interesting to note that great nembers of the
fractures ~~fragments~~ in the jasper have been healed by the infiltration of hematite, and that irregular masses of hematite occur in such a position in the brecciated jasper as to show

that they have been formed subsequent to the brecciation of the rock. It is also clear that they owe their origin to the process of infiltration of the ore similar to that which has produced the fine veins filled with hematite.

Upon the ~~outcrop~~ dump from this North Lee mine one can get fairly fresh specimens of the breccia. I searched this carefully and took (40217 and 40218) from the breccia which showed a rounding of the fragments and might be taken for a conglomerate, although I believe it to be merely pseudo-conglomerate.

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(40219) is a chip from a boulder which looks somewhat more like a conglomerate than any of the other coarse grained clastics. This boulder has in it besides the greenschist, paint rock, ore, chert, and jasper, which occurs in the normal breccia, ~~and~~ rock ~~represented in the specimen~~ with whose character I am not acquainted. I can notice in it here and there large quartz eyes, and these may indicate that the rock is a quartz porphyry, although the eyes may be secondarily infiltrated quartz which has filled amygdules or even secondary cavities.

40219

Upon further search I found an angular block of rock which shows a certain banding and looks more like a banded sediment than any I have yet seen upon this North Lee ~~outcrop~~ dump.

40220 (40220) shows the character of the rock. This block is too fresh and too angular to be an erratic block Its occurrence moreover on the top of the outcrop might indicate that it came from deep down in the pit.

I walked ~~from~~ the east end of Lee Hill, again visiting the South Lee pit and the jasper and green-schist
40221 exposures along that slope. (40221) was taken from the exposure near the east end of the ridge about 400 yds. west of the railroad. This schist is somewhat acid looking and may possibly show up under the microscope as a sheared quartz-porphyry. The easternmost exposure along this ridge, the one just west of the new wagon road to Soudan, shows an imperfect ellipsoidal parting and traces of amygdules and appears without any doubt to be an altered greenstone.

Took the night train to Ely.

Sept. 7th.

Took train from Ely to Robinson Lake, and from the quarter-post on the south side of Sec. 7 ran north to the exposures of fragmental rocks which occur just south of the north quarter-post of Sec. 7-62-13. I examined these fragmentals closely and there can be no question but that they are of sedimentary origin. I find a conglomerate interbanded with and grading into graywacke and slate. I could not make a trustworthy estimate of the thickness of the rocks here exposed. At one place where the exposures were favorable I found jasper and chert (iron formation) covering an area about 10 paces in width; this is followed by about 15 paces of sediments; and then 18 inches of jasper; and then sediments were again exposed for a short distance. The jasper is presumably interbedded with the sediments. (40222 to 40227) represent various kinds of sediments, from the relatively coarse conglomerate up to the slaty phases. I could not get a hand specimen which would show the character of the coarsest conglomerate; the pebbles of this are of greenstone and of chert. The ore associated with the jasper and chert is very nearly all magnetite. These sediments with the jasper are exposed on the north side of a valley. Back

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of these, that is, to the north, massive greenstones occur. To the south of the valley similar greenstones are also found. It was absolutely impossible from the occurrence here to state whether the sediments were interbedded with the greenstones or infolded in them. The fact that greenstone pebbles occur in the conglomerate is clearly indicative that the sediments are younger than some of the greenstones.

The greenstone at N. 800, W. 75 paces from the south quarter-post, Sec. 7-62-13 is cut by a granite dike which trends northwest and in this direction finally thins out. This granite is similar to that seen in previous years southwest of Robinson Lake.

Returned now to the southern belt of iron-bearing formation, which is fairly well exposed about a quarter of a mile north of Robinson Lake. Followed this jasper west to the west section line of Sec. 7-62-13. The formation is well exposed over almost the entire distance. The large number of exposures enable one to see the extremely contorted character of the formation and the alternation of the jasper, chert, and iron-ore bands which make up the formation. In general however in spite of the contortion the strike of the bands corresponds with the strike of the belt, which is about N. 80° W. The iron-ore of this

iron formation is magnetite. Interbanded with the materials already described as forming the iron-bearing formation there occurs a greenish material in bands varying in width, rarely exceeding a couple of inches. 40228 (40228 and 40229) show the character 40229 of this material. These specimens were taken with the view to examining them to see whether they are of fragmental origin or not In places along the iron formation belt the green stone appears on the south side in contact with the formation.

Just before reaching the west section line of Sec. 7, I found a green rock in contact with the jasper, which is sometimes very fine grained and shows an imperfect banding. This 40230 phase is represented by (40230). Again this same rock is coarser and appears more like a graywacke. This phase 40231 is represented by (40231). It is possible that this may also be a greenstone.

I examined the exposures of iron formation on the south-facing hill where the west line of Sec. 7 cuts across it. I again saw here a band about three feet in width which looked decidedly conglomeratic, having pebbles in it which I took for pebbles of amygdaloidal basalt, and containing some lenses of jasper. It is barely possible that these may be fragmental, but from their regular lenticular

shape I would judge them to be of
40232 secondary origin. (40232) was taken from this rock. As a result of my studies on this belt of iron formation I do not hesitate to say that there is sediment in small quantity associated with it. Here as elsewhere I am unable to state with certainty the relations which exist between the formation and the adjacent greenstone. It would be more natural for me to consider them as interbedded, but I can readily see how extremely close infolding might get the two rocks in the positions which they now occupy.

Sept. 8th.

Spent the forenoon putting in the dolerite dikes which cut the ellipsoidal greenstones in the vicinity of Ely, and in correcting the granite dikes and other details of the map on the 4-inch scale in this vicinity. The dikes which cut the ellipsoidal dolerite and occur northeast of the Methodist church have a somewhat different appearance from the normal dol-
40233 erite, and (40233) was taken so that it could be examined and their true character ascertained

In the afternoon got my camp equipment packed up and got all supplies, so that we would be ready to start on our canoe trip Monday.

Sept. 9th.

Went today(Sunday) to Saturday or Mud Lake to check up the boundaries between the greenstone and the Fall Lake belt of sediments. These boundaries were corrected, as indicated upon the map. The conglomerate is very well exposed in a number of places, especially on the bare knobs just south of the landing at the east end of Fall Lake. The rock is made up apprently exclusively of fragments of greenstone which lie in a green matrix of detrital material derived from the greenstones. Good exposures can be seen between Fall Lake and Mud Lake. just north of Mud Lake at the west end of the portage leading from that lake into Annie Hall lake on the east there is a cut which was made for a logging railroad Here conglomerate has been exposed. At this place the conglomerate consists of pebbles of greenstone and of granite. A fine grained form of the conglomerate
40234 is shown in (40234). The granite
40235 in the pebbles is represented by (40235). I was unable to find any distinct bedding on any of the exposures. During the afternoon heavy rain again set in, which continued through the afternoon and all night.

Sept. 10th.

It has been storming heavily since yesterday; and as the rain continues, am unable to get off.

Sept. 11th.

Leave this morning in spite of the fact that it rains occasionally. Wind from the northwest seems to indicate that it will clear in the course of the day.

Reached Sullivan's Bay with supplies in the morning, but did not get the canoe up from Fall Lake and get ready to start until noon. When the canoe is loaded with our supplies and with ourselves she is very nearly overloaded; gives us only about 4 inches of freeboard. Went up through Garden Lake, through the Kawishwi. Saw the sediments on the north side of the river again, and am more than ever convinced that they are true sediments. The banding is sharp, and there is a very rapid alternation of the bands of different grain. Leaving the Kawishwi at the deep bay which extends southeast into the S. E. 1/4 of Sec. 30-63 N.-10 W., we followed the portage southeast to Clearwater Lake. Upon this portage there are exposed in a number of places mica and hornblende-schists. These are

cut by dikes of the White Iron Lake granite. These schists show the same good banding that has been noted in a few cases upon the rocks bordering the Kawishwi river. Moreover at one place about midway the portage I found a few exposures of fine grained conglomerate. This conglomerate has a a very similar appearance to that much metamorphosed conglomerate which occurs on the east side of the Duluth and Iron Range Ry. south of Tower, near mile-post 92. The pebbles in this conglomerate are of granite, chert, and ferruginous chert. They are small and I could not readily distinguish the varieties. There may be other kinds of rocks present, but I was unable to recognize them.

The granite dikes seem to become more numerous as we continue farther south and at the south end of the portage, near Clearwater Lake, the granite dikes are even more numerous and of larger size. Here there is an exceedingly good example of an eruptive breccia. The breccia consists of dark gray and black schist fragments in a matrix of grayish to pink granite. The White Iron granite has here intruded the sediments, metamorphosing them to schists and producing the brecciation. The granite is exposed along the north shore and upon the islands of Clearwater Lake. We camped upon the first large island we reached after leaving the portage.

Sept. 12th.

Traveled south from Clearwater Lake through the South Kawishwi passing numerous normal granite exposures at intervals on the route. From South Kawishwi portaged into Gabbro Lake. On the south side of this portage, that is on the shore of Gabbro Lake, the first exposures of gabbro were observed. The contact between the gabbro and the granite must have been passed somewhere on the portage, but no exposures were observed in contact which would enable the relations to be seen. Moreover since I know from previous work northeast of here that the gabbro is younger than the granite and cuts it I did not spend much time in looking for a contact. Where seen on Gabbro Lake the gabbro appears to have its normal characters. We crossed Gabbro Lake, and making two short portages, entered Bald Eagle Lake. Upon the portages a phase of the gabbro is exposed which is practically an anorthosite. It is not quite as coarse grained as the greater portion of that observed south of here on Lake Superior, but so far as the composition is concerned it is the same. A small quantity of magnetite is present in it, and possibly the microscope would show some bisilicates; but these do not show macroscopically.

Continued across Bald Eagle Lake,

noting occasional exposures of the gabbro on the ~~section~~ shore, but did not take the time to examine these closely. My objective point was an exposure of banded gabbro whose location about a mile up the first branch which enters Isabel river after we enter it from Bald Eagle Lake is given by Grant. (17th Ann. rept. Minn. Geol. Surv., p. 164) He described the exposure as being of gabbro which has "a gneissic structure, which is practically vertical and runs N. 15° W. making the rock break more readily in this direction than any other. In some places the gabbro lies in horizontal beds from 2 to 4 inches thick. The rock seems to be almost entirely composed of a feldspar (probably labradorite) and a mineral which is probably olivine; this when not decayed is af a yellowish green color."
40236 (40236) represents this gabbro, and upon the specimen the imperfect banding can be seen. The exposures here are poor, but I consider the rock to be merely a differentiation phase of the gabbro and that the banding in the rock is due to movements in the magma. The occurrence is very similar to the banded facies seen upon the St. Paul and Duluth RR., between Shortline Park and Smithville, and also seen upon the shore of Lake Superior. For description and photograph see notebook 332 p. 8.....

Returned to South Kawishwi, having made a good long day's trip.

Sept. 13th.

Went up the South Kawishwi which flows (from the) northeast. There is a spendid eruptive breccia of granite and greenstone at the south end of the portage from the South Kawishwi into South Twin Lake. Crossed this portage and went through the Twin Lakes to Moose Lake where we camped.

Sept. 14th.

Went south of Moose Lake; followed the trail down to the southeast corner of Sec. 32-64-9. The sediments near this corner are cut by north and south trending basic dikes from 12-24 inches in width.

The dolerite dike south of this corner noted before, and for which the strike and width were not given, is found to be about 20 ft. wide and to strike N. 30° W. From the corner above mentioned I worked in southwest to get the relations between the sediments and the quartz-porphyry which is outlined upon our map. I found that there is a great deal of greenstone in the area which upon our map is now marked as a ~~slaty~~ quartz-porphyry, and it will be necessary to change these boundaries considerably. The relations between the two are clear, as I find unquestionable quartz-porphyry dikes in the greenstone.

I also found at one place a very good conglomerate between the greenstone-quartz-porphyry complex and the sediments. In this conglomerate there were pebbles of the greenstone and quartz-porphyry which shows ~~more~~ clearly that the conglomerate is younger than and overlies them. There are eruptives here of several ages, as is shown by the fact that a quartz-feldspar-porphyry was found which appears in dikes cutting both the greenstone and quartz-porphyry as well as the slates.

Furthermore the quartz-porphyry is found to be cut by dikes of dolerite which presumably represent the youngest rocks in the region.

Returned to camp at noon. In the afternoon was detained in camp by the rain.

Sept. 15th.

The rain continued. Sent Erick into Ely to get provisions so that we could continue on through to Gunflint without having to send in again.

Sept. 16th.

Rain continued.

Sept. 17th.

Clear this morning; but having only the one canoe, which Erick had, was unable to leave camp to do any work. At noon Erick returned.

Spent the afternoon in checking up the boundaries between the slate and the greenstone upon the islands and south shore of Moose Lake.

Sept. 18th.

Moved to east side of Snowbank Lake; after leaving our supplies, continued on to Disappointment Lake and checked up the boundary of the Animikie iron formation.

The gabbro which lies to the south of the iron formation south of Disappointment Lake is imperfectly banded, and these bands strike about parallel to the boundary of the gabbro mass. They dip 70° S.E. The gabbro here is very biotitic, as is shown by (40237).

40237

Sept. 19th.

Started this morning in the rain and moved through Basswood and Ensign lakes to Little Bass Lake. Rain continued all day, and upon reaching this place we camped.

Sept. 20th.

Went to Jordan Lake southeast of Ensign Lake and corrected the boundary between the gabbro and the slate. Started to rain before we returned and continued all the rest of the day.

Sept. 21st.

Left Little Bass Lake and moved to the easternmost island on Knife Lake where we cached our supplies and then with enough for a couple of days went on up to the small lake in Secs. 25 and 26-66-6. Here we camped.

Sept. 22nd.

Started in this morning to make a run east across the sediments in order to locate the boundaries of the conglomerate anticline. (See map.) This conglomerate belt is only about 500 yards wide on an east and west line which was run from the east shore of the lake just south of the southernmost island in the lake, which lies in a small bay. On the east side of the conglomerate belt the slate has a strike of N. 10° W., with a dip of 80° W. This apparently indicates very closely the general trend of the axis of the anticline. After continuing in the slate for some distance, going about a little over half a mile east of the starting point on the lake, I turned north and went about 800 paces north. The slates and interbanded graywackes are well exposed and the banding shows very plainly. The strike of this bedding was taken in several cases and it was noted that as we went north the strike varied, becoming more nearly east and west, changing from N. 20° W. with a dip of 80° W. to a strike of N. 65° W. with a dip of 85° S.W. Some of the graywackes interbedded with the slates show exceptionally well their fragmental
40238 characters, and (40238) taken from the N. E. 1/4 of Sec. 26-66-6 is a good sample of such a fairly coarse grained

graywacke. This change in strike of the sediments is evidently due to the fact that they are bending around this conglomerate anticline; and also it must be borne in mind that they bend so as to follow approximately the strike of the boundary of the Saganaga granite massif which lies to the east of the area in which work was done today and around which these sediments wrap. Dip & W. near anticline is due to overturn.

Went up into Oak and Saganaga lakes and corrected the boundary between the slate, conglomerate and granite on the west bay of Saganaga. Made an east run from ~~about~~ 5/8 mile north of the shortest portage into the lake, between Secs. 25 and 30-66-5 and 6. This enabled me to make a cross section from the sediments into the granite and to observe the changes which take place. In the direction opposite to that from which we went, i.e. from the Saganaga granite into the sediments, one observes the following: At first the normal Saganaga granite-porphyry with the large phenocrysts of quartz scattered through it occupies a number of bare knobs; west of these knobs and in contact with the porphyry of these knobs at places there is found a rock that is made up to a great extent of the large quartz eyes, ~~containing~~ from three containing these quartzes in far greater abundance than

does the normal granite. Moreover this rock in places shows a banding, some of the bands being those which are practically very nearly clean quartz and others in which there is somewhat more finer grained material, with less of the quartz eyes. This extends over a belt about 100 paces in width. This material is evidently a product which has been derived from the disintegration of the granite, and has evidently been worked over not a great deal, for the quartzes are not very well rounded or very fine. Moreover there is no very well marked banding. presumably disintegration had advanced so that there was a considerable thickness of this disintegrated material which was presumably worked over by the water and deposited with relative rapidity near the shore and in rather quiet waters. There is no true boulder conglomerate present at this part of the contact between the granite and the sediments, although such a boulder cgl. is present somewhat farther north on Cache Bay.

After passing over this belt of arkose we come into well banded reddish weathering graywackes with an occasional coarse arkose, like that described above. The graywackes predominate very much over the arkose. Interbanded with the graywackes we find grayish to greenish slates, but

these are also subordinate to the graywackes. The strike of these beds is N. 20° W. This belt of sediments in which the coarse graywacke predominates is from 500-700 paces in width, and upon the map this with the belt of very coarse arkose which lies to the east of it will be shown with the same color as is used for the conglomerate, as it corresponds to the conglomerates which occur elsewhere along the border especially to the north.

West of this belt the normal greenish graywackes and slates which make up the Knife Lake slate formation occurs and continues out to the west, as shown on the maps. The color of these graywackes is of course due to some extent to the alteration of materials derived from the Saganaga granite. It must not be overlooked however that associated with these slates there are some dark greenish bands of rock varying from fine greenish slates to greenish conglomerates in which the fragments, and this is especially noticeable in the case of the conglomerates of course, are of basic igneous rocks. Associated with the fragments of the rocks there occurs in these sediments considerable quantity of fragments of crystals of augite, hornblende, and feldspar. The presumption is that these green colored sediments represent volcanic materials which were ejected from some

volcanic centers and were worked over by the water and deposited with the non-volcanic sediments which were being formed in the adjacent seas. Of course somewhat similar sediments might be derived from the disintegration of the Archean greenstones which lie to the north and to the south of Lake Saganaga. The minerals and rocks composing these pyroclastics are however altogether too fresh to lead us to the belief that all of the materials were derived from the Archean. It appears highly probable that they owe their origin to contemporaneous volcanic outburst. Grant finds fragments of rhyolite in these sediments. (See Grant's notes, 24th Ann. rept. Minn. Geol. Surv.) It is well to note here while speaking of these green rocks associated with the Knife Lake slates that the graywackes and arkosas lying to the east near the granite are formed almost exclusively from the granite debris, practically no greenstone being mixed with them.

Had arranged everything this morning so that while I was inland the portage would be cut out and I could have gotten to Oak Lake, finished the work there, and returned to our camp and reached Knife Lake before night. However instead of following instructions and cutting along the line indicated the man tried to find a better portage route, and did not get the

portage cut over. Was compelled to take that in hand after returning from the run this morning. Got the portage cut and finished the afternoon's work in the rain. Returned to camp too late to attempt to reach Knife Lake tonight.

Sept. 23rd.

Moved from our last night's camp south to Epsilon Lake; picked up our supplies on the way, and reached the south side of Epsilon Lake portage where we had lunch. Then proceeded southwest of Epsilon Lake to study the hornblende-porphyry which occurs upon that side of the lake. I corrected the boundaries between it and the slates, as well as the dolerite dike which cuts through the porphyrite Made section across the porphyrite to reach its contact on the south side with the sediments. Upon the south side of Epsilon Lake there is a contact described by Grant (24th Ann. Rept. Minn. Surv., p. 105) which was visited. The absolute edge of the contact was not visible, but there was certainly no great thickness of conglomerate present between the two rocks even if there was any at all, which I could not find. I now made a section across the porphyrite and hunted for the contacts on its southern side with the sediment. At the south

side of the porphyrite massif, between Beta and Epsilon lakes (c.f. Grant, 24th Ann. Minn. Surv., p. 106) I saw at several places the actual contacts of the porphyrite and the slates; but at no point could I find a well marked conglomerate. The following facts noted by Grant and also observed by myself seem to me to ~~be negative of the fact~~ show that the contact between the sediments and the greenstone indicates an unconformity, i.e. the sediments derived from the greenstone, rather than an eruptive breccia. The porphyrite which usually has a purplish color has, as noted by Grant, near the contact with the slates a very noticeable green color, showing that it is more or less decayed. Moreover it is here very much fissured. This green color, decayed condition, and the fissuring, which contrasts with the massive character and purple color of the rest of the porphyrite, seem to me to be due to the fact that this outer zone is the decayed portion of the porphyrite from which the sediments were partially at least derived. The porphyrite, lying as it does in the midst of a great mass of slates, could hardly be expected to be overlaid by a thick bed of conglomerate lying between it and the slates; but rather one should find as here a zone of rotten disintegrated discolored and schistose porphyrite, grading on the one hand into slates and graywackes and on the other into the nor-

mal eruptive rock.

I was not able to satisfy myself on one further point that Grant notes. He says that this outer zone is of a distinctly finer grain than the remainder of the porphyrite. I was not sure of this.

If my recollection holds good I have found pebbles of porphyrite exactly like that forming this massif in the conglomerates which lie at the base of the Knife Lake series. If such is the case there can be absolutely no question of the relative ages of the porphyrite and the sediments.

in previous field seasons

Returned to the portage, and after getting our supplies loaded moved on to Fox Lake where we camped.

Sept. 24th.

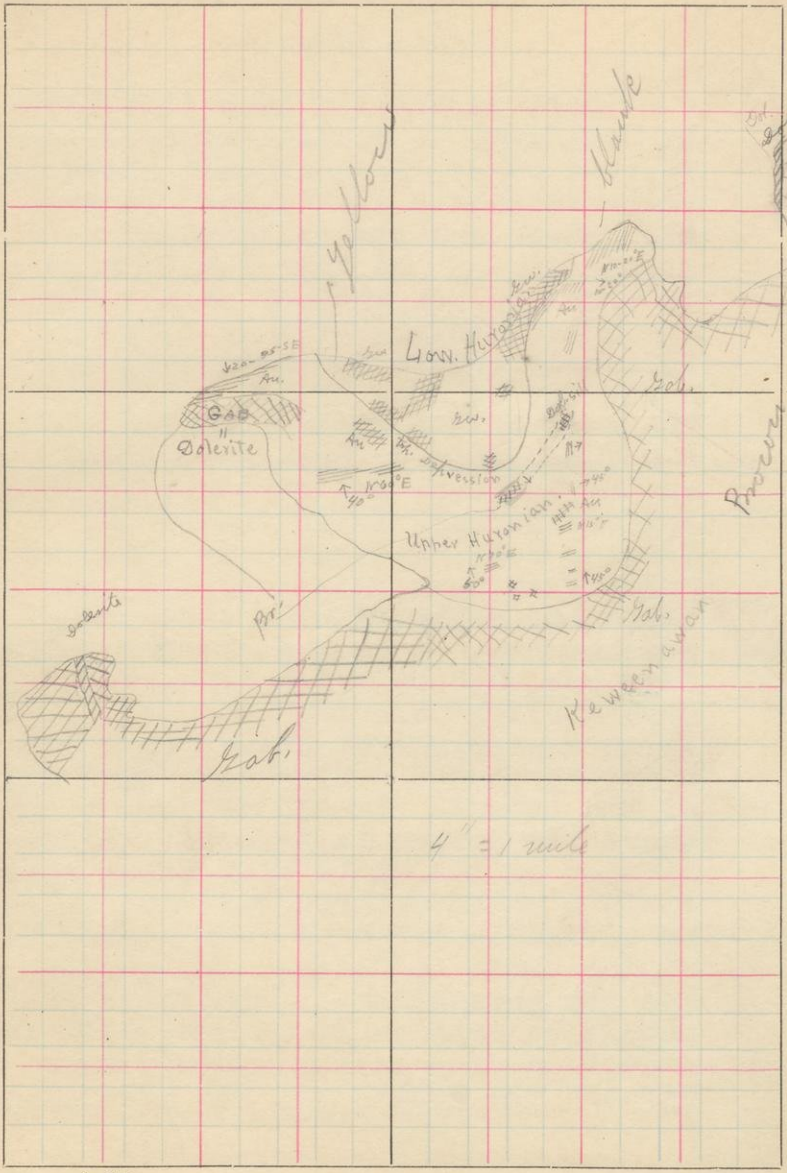
Today went up Frog Rock Lake and corrected the boundaries between the conglomerate and the greenstone in that vicinity. Upon our old map the greenstone is made to cover too large an area upon this lake. Nearly all of the southeast shore is of greenstone conglomerate; consequently the color for this should be extended over this portion of the lake.

40239 (40239) taken from the shore east of the large prominent south-projecting point just in front of the portage from Townline Lake is believed to be a greenstone and not a fine tuff. Should this prove to be a fine tuff, this would be included in the fragmental belt.

Sept. 25th.

Left campon Fox Lake this morning and went to Gobbemichigamok Lake. Visited first the southwest shore and cross-sectioned the contact between the gabbro and the ellipsoidal greenstone of the Twin Peaks Range in order to see whether or not there was a sedimentary belt in between. This belt exists farther west, but I could not be sure of its existence her The most of the rocks observed were the fine grained granular rocks weathering dark and having a brownish appearance upon fresh fractur e. Similar rocks collected in previous years from near this locality show tht these are metamorphosed ellipsoidal
40240 greenstones. I took a specimen 40240 from one outcrop which appeared to have a slight banding upon it. This is an exposure that seemed more like a metamprphosed sedimentary than any of the others. Immediately upon the shore the gabbro is exposed. If a section of the above rock shows that it is a metamorphosed sediment it will be advisable to put a very narrow belt of the slate in between the gabbro and the greenstone ; otherwise it should be left as it is now, with the exception of a narrow contact zone between the gabbro and the greenstone.

S. T. R.


Yellow
Lower Huronian
Gab.
Dolerite
Upper Huronian
Gab.
Dolerite
Gab.
Keweenawan
Gab.
Dolerite
4" = 1 mile

Crossed the bay to the south and observed upon the northward projecting point a thick dike of dolerite with basalt selvage cutting through the gabbro. Gabbro forms the southwastern shore of the bay up to a deep eastward trending bay. The continuation of this bay eastward shows as marked topographic depression in which there are no outcrops. Coasted now northwest along this shore and observed numerous outcrops of the animike rocks. Upon the point just before leaving the bay the dolerite is exposed and around this point the animikie again occurs. Landed on the shore near where this animikie is exposed and went inland working over the area within which the animikie lies with the results as shown upon the opposite page. We have here lying to the east and to the south of the animikie the normal gabbro. The animikie occupies a "V" shaped area with the opening of the V pointing to the northwest. At the extreme southeast edge the animikie dips approximately north with a dip of 50°, strikes north 70° east. When followed around to the northeast the strike changes to an approximately north and south strike N. 20° E. with a dip of about 20° east. On the northwest limit of the V the strike is N 60° E, with a dip of 40° to the N. Upon the extreme

northwest edge of the west limit of the V near where the dolerite cuts through the animikie the strike is there approximately east and west with a dip of 20° to 25° south. The area within the opening of the V is occupied by the so-called Muscovada of Winchell, which appears to be an extremely metamorphosed
40241 sediment. Specimen 40241 is a specimen taken from this muscovada. In order to reassure myself upon a later date, Sept. 30th, I returned from Gunflint to this place and traced the contact between the muscovada and the animikie in order to get the relations. These notes at this place are embodied in the notes given here. I could in places get the two rocks within about 2 feet of each other but no absolutely basal contact was observed because both of them weather quite readily and seem to weather most
40249. readily at the contact. Specimen 40249 In some places the muscovada appears to be quite massive. In fact at no place did I find any distinct bedding. Specimen 40249 represents a phase of this rather massive micaceous rock which is very common especially so near the center of the area. This appears to be an intermediate phase between the very quartzose rock represented by specimen
40241 40241 and the gabbro. Possibly this is to be looked upon as a contact phase of the sediment.

At several places in the Animikie iron formation exposures of dolerite

were observed. This when connected up indicate the presence of a sill following approximately parallel with the bands of the animikie. A second sill of dolerite was observed upon the northwest point of the V. This is of smaller extent than the other.

As a result of the mapping upon this area it looks as though the Animikie lies here in a Northwest-Southeast trending anticline, the crest of which has been removed so that the underlying rock, the muscovada (G. H.) appears in the center. There are minor cross ~~coarse~~ rolls with approximate northeast southwest trending axes. From Gobbemichigamax, moved southeast and camped for the night on the first lake after leaving this one.

Continued this morning on the route to Little Saganaga. Followed the usual canoe route and from Gobbemichigamak until we had coasted well around the west side of Little Saganaga, the little exposures seen were of the gabbro varying from the normal coarse grained variety to forms with rather a fine grain. This normally coarse and fine gabbros occur all around the northwest side of the lake. We were compelled on account of high wind to follow the shore very closely until we came to the fir st large east and west trending bay. At this point, the wind having gone down sufficiently, we were able to lighten canoe and making two trips got across ~~XXXX~~ open water. Upon the west side of the lake the rock is very feldspathic. This richness in feldspar increases to such an extent that the rock is a normal anorthosite. This anorthosite
40242 is represented by specimen 40242-3.
40243. I was unable to recognize a contact between the gabbros which occur chiefly upon the northwest shore and these anorthosites which occur prominently upon the west shore. In examining the anorthosite masses which are beautifully exposed upon the bare islands one finds scattered through it irregular to roundish ares of what
40244 appears to be a normal gabbro 40244
which appears to grade into the anorthosite as shown in specimen 40244

There also occurs 39 a finer grained facies in rounded areas in the anorthosite

and which appears also to grade into surrounding anorthosite. Specimen
40245 40245 represents this finer grained form. It thus appears that the anorthosite grades into the normal gabbro of coarse grain and also into a normal gabbro of fine grain, thus showing both a mineralogical and a textural gradation. The more basic areas which are scattered through the anorthosite range in size from 1 1/2 inches in diameter to those 4 or 5 inches in diameter. The anorthosite between these masses covers much larger areas than does the more basic portions. These more basic portions weather more readily than the anorthosite producing a pitted surface in the rock. When disintegration proceeds much farther the anorthosite is apt to break down into rounded boulder like masses. Anorthosite showing essentially these same characters and showing the same change into the associated basic gabbro, can be seen in the vicinity of Duluth.

The anorthosite continues on around the south shore of Little
40246 Saganaga. Specimen 40246–7 represent
40247 pieces of fresh anorthosite showing t the small basic areas which occur in

them. These basic areas are fairly sharply outlined on the surface but when they are examined closely it will be seen that there is a gradation. This gradation should be especially noticeable when sections of the anorthosite are examined under the microscope. This will without question in many cases show that the anorthosite contains varying quantities of dark minerals.

In passing to-day from the normal gabbro on the northwest shore of the lake to the anorthosite occupying chiefly the west shore, there was no sharp line observable between these two rocks and everything indicates a gradual transition . Moreover upon th the anorthosite exposures one can readily find the basic masses which unquestionably show gradations into the surrounding anorthosite. These facts seem to me to indicate that the anorthosite is but a phase of the great gabbro mass and certainly cannot be looked upon as an igneous rock differing essentially in age from the gabbro.

It will be recalled that upon the shore of Lke Superior large masses of anorthosite are found enclosed in the

so-called Beaver Bay diabase (a fresh gabbro). These masses are cut by this same gabbro. Moreover between the gabbro and the anorthosite there is a sharp contact line the gabbro not uncommonly being of considerable finer grain near the very large masses of anorthosite than elsewhere. The anorthosite occurring upon the shore of Lake Superior is essentially similar to that found in the interior as for instance upon Little Saganaga and elsewhere. It seems almost certain that this anorthosite masses for instance at Carlton Peak, Split Rock (Castle Dangerous) Beaver Bay, and elsewhere are but inclusions in the Beaver Bay diabase and it further seems that these inclusions were derived fro anorthosite masses contemporaneous with the great gabbro anorthosite mass which has its distribution just southeast of the Vermilion range.

Continued from Saganaga through East and West Lake and north along North and South Lake through Greenwood Island Lake, Little Round lake and Big Round Lake. Camped at the east end of Big Round Lake. Through all of these lakes the rock exposed upon the shore is predominantly the normal gabbro with

which is associated some anorthosite, this last occurring especially in East and West Lakes.

Sept. 27th.

Started out from Big Round Lake in the rain early in the morning. We were working our way toward Gunflint through Little Copper, Snipe Lake, etc. The first portage from Round lake into the small one east was very good for a part of the way but not having been used formsometime finally became very blind and we lost it in the midst of a big marsh. Were turned off by an old homesteader's trail and spent the greater part of the forenoon in recovering the trail an and getting to the small lake. Snowed today for the first time this season. From the small lake we entered Little Copper Lake and through that into Snipe Lake and thence down the creek from Snipe Lake into Cross River. Reached Cross river at 5.00 and camped upon the island opposite the bay into which the creek from Snipe Lake enters. Our route today has led us over the gabbro without any exceptional facies showing Just where the portage from Snipe Lake ends at Cross River Bay a dike of dolerite was observed which cut the gabbro. Upon the island on the east

side of the river just opposite this bay there is also a granite dike 3 ft in width which cuts through the gabbro. This dike trends approximately north
40248 and south. Specimen 40248 illustrates the rock of this dike.

Sept. 28th.

Left camp here and made flying trip to Gunflint intending to get mail and additional supplies. Reached there shortly before noon and found instructions with reference to further work upon the Animikie. Remained with Dowman over night and sent the men back to move camp to vicinity of Paulson's mine.

Sept. 29th.

Men moved the camp this morning to the place indicated. Starting at the valley which extends north and south through the east side of section 27 - 65 - 4, I followed the iron formation to the west as far as Fay Lake. Beyond this we know as a result of numerous cross sections and traverses under the strike that this is practically a continuous formation.

I also visited again the various places where in the previous year in company with Professors Van Hise and Grant we had seen the supposed conglomerate under the iron formation. I also continued west along the boundary between the iron formation and the main mass of greenstone conglomerate to Fay Lake, but could get absolutely no evidence which would enable me to separate a conglomerate immediately below the iron formation and belonging with it from the main greenstone conglomerate. In general I could get no new evidence which bore on the relation of the animikie and of the Ogishkie conglomerate. Was able to correct the distribution of the dolerite sills to a certain extent. In addition to the large sills that make fairly prominent topographic features, one was noted in the cut at the head of the valley just east of Paulson's which is only about 3 feet thick and lies in the animikie sediments. This is only about 30 feet from the main mass of the gabbro. East of this point along the railroad track shortly after crossing the trestle there is a small area in which very much contorted animikie is exposed. This animikie has gabbro lying both to the

north and to the south of it. This mass has been described by Grant as an inclusion in the gabbro. It has seemed to me that if the exposures were sufficiently good some of these sills might be traced out until their connection with the gabbro was obtained. It looks here somewhat as though this mass of slate lies in the angle between the main mass of gabbro and such an offshoot or sill from the main mass. Near this the sill appears absolutely identical in every respect with the main mass of the gabbro and impresses upon me again the impracticability of separating the sills from the gabbro that is in point of age. In mapping of course they should be mapped where possible but we should use the same color and symbol as that used for the gabbro.

Sept. 30th.

Spent today in going west to Gobbemichigamak and studying the Animikie there and returning to camp. Started out 6.45 AM, and got back to camp at 6.00 PM. having been traveling practically all the time. Collected
40249 specimen 40249, and the description of this and the notes taken during the

day will be found embodied in the work done at a previous date, Sept. 25th, upon this same area (see page _____, Sept. 25th.).

Oct. 1st.

Started this morning near Dowman's homestead in the southeast 1/4 of section 22, and followed the iron formation from this point to the east. The rock on the east side of the valley is absolutely identical in appearance with that upon the west side of the valley where we began tracing the iron formation day before yesterday. The continuity of the formation across a distance of about 1/4 of a mile is interrupted by a valley, but the lithological identity of the rocks clearly shows that they belong together. Specimens taken last year illustrate the kinds of rock which occur here. The iron formation here consists chiefly of interlaminated bands of greenish actinolite schist and quartzose bands with some bands of magnetitic ore. Going east along the belt we find this same actinolite schist to con-

tinue for a considerable distance. Finally we find associated with them banded cherty rocks represented by
40250 specimen 40250, and these finally make up the greater portion of the formation. Still farther east I find associated with the above mentioned cherty bands a spotted rock
40251 (40251) which evidently corresponds to the brilliant spotted jasper like that collected at the east end of Gunflint Lake in previous years. Presumably this rock (40251) represents a rock which has been metamorphosed by the gabbro and in which consequently the iron is changed to the magnetite. It is not then a stage in the change to the brilliant red spotted jasper above referred to, but represents an analogous change, but one which has followed a somewhat different course, both rocks having been originally derived from some of the glauconitic sands. As we continue farther east along the range the ferruginous carbonates with the overlying slates come in in greater abundance. These ferruginous carbonaceous slates are exposed along the railroad cut west of the Customs House.

There is in my mind absolutely no question but what the iron formation observed at Paulson's is the metamorphosed lower portion of the sediments which occur in the vicinity of Gunflint, and are well exposed upon the hill ranges to the northwest of Gunflint. In the afternoon rain prevented my starting off on a trip south into the Keweenawan.

Oct. 2nd.

Rained this forenoon but in the afternoon moved south up Cross River to Lake south of Sucker Lake.

Oct. 3rd.

Rained this forenoon but continued south in the afternoon through Kiskadinna to Narrow Lake where we camped. Eric Ericson my canoe man reports that at the east end of Kiskadinna Lake the bright red rock (the red granite or redrock of the Minn. Survey) comes down to the lake shore and that this redrock is cut by narrow dikes of a black rock (presumably basalt dikes). Gabbro is the only rock seen since we have been traveling south.

Oct. 4th.

Started down Narrow Lake. Gabbro is exposed on the first point in the lake but a red granite outcrops on the third point on the west side counting from the north end of the lake. Near the south end of the lake the gabbro i

is cut by a number of fine veins of redrock. Presumably these fine dikes of fedrock are offshoots from the larger mass previously observed but s which showed no relations to the gabbro Continuing south now the gabbro with occasionally red Syanite dike in it appears along the shore. This gabbro continues on to the hill overlooking the first lake at the east end of the portage from Ida Belle into Found Lake. The portage follows along near the crest of this hill for a distance and then goes down into the above lake. The hill is made up of gabbro repres-
40252 ented by specimen 40252 which occurs upon the north side of the hill. This gabbro is cut and included in a reddish
40253 weathering feldspathic porphyry (40253) One dike like mass of gabbro about 10 feet wide was seen but upon close examination this mass was found to have the same grain throughout its extent whereas the porphyry adjacent to this mass is finer grained than elsewhere. Evidently the porphyry is an intrusive in the gabbro. Both of these rocks are cut by dikes usually only a few inches in width but ranging up to 10 feet in
40254c width, of a reddish rock (40254). This rock (40254) seems to be but a

40255 phase of the more normal red cyanite (40255) which makes up the outcrops on the northeast shore of Found Lake. The gabbro and the cyanite come very close together upon Surveyor's Lake and at one place the gabbro was found cut by a dike of the cyanite so that the relations between them are definite ly shown.

Upon the southeast side of Surveyor's Lake outcrops were observed of a find grained dense basic rock which was cut by red cyanite. No relations between this dense basic rock and the gabbro were seen however. At a later date the same place was revisited and a specimen (40269) was taken from it. I now crossed the portage between Surveyor's Lake and Lake Georgia upon which gabbro is exposed and skirted the north side of this lake for some distance. Gabbro is exposed along the shore as far as it was touched. Then entering the river we ascended to Brule Lake. The portage into Brule Lake is very short and is for the most part very bare rock which is a porphyritic amygdaloidal basalt varying from very fine grained to a rock which

is somewhat coarser grained and which is also non porphyritic. Specimen
40256 40256 shows the porphyritic amygda-
40257 loidal facies and 40257 is a specimen of the finer grained less amygdaloidal facies with only an occasional phenocryst. These rocks are cut by very fine grained, in fact afenitic basalt dikes, but none of these rocks were seen in relation to the gabbro or the red cyanite. As it was getting late we paddled straight over to the second prominent point east of the portage and upon the north shore of the lake where we camped. At this place rock like 40256 is well exposed.