Conclusions drawn from work on Lake Nepigon, Canada, and supplementary notes on Keweenawan of Minnesota: [specimens] 40252-40270. No. 335 1900

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1900

J. Morgan Clements.

Conclusions.

As a result of the reconnoissance made of Nepigon Lake area, I find it possible to make the following division of the rocks occurring upon that lake, and reach the conclusions which will be mentioned concerning their relative ages: -

The brief description of these divisions which follows is given in order from the oldest to the youngest:

1. Fairly massive greenstone which very commonly shows a well developed ellipsoidal parting.
2. With this massive greenstone there are associated schistose phases. Upon the map these kinds of rock are indicated by different symbols, but the field work was not done in sufficient detail to enable me to separate in mapping these different phases of the greenstone. The symbols are hence to be understood as used merely to indicate the presence of these varieties but not to give the proportions in which they occur, or the exact locations upon the map.
3. Derived from the greenstones, hence stratigraphically overlying

them, comes a series of sediments consisting of interbedded conglomerates, graywackes and slates. Of these sediments the first two kinds predominate.

4. With the above mentioned sediments there are associated at one locality bands of hematite and jasper forming an iron-bearing formation. These ferruginous rocks are reported to extend for a long distance to the eastward and presumably somewhere within this belt there occur iron deposits of economic value.

The above four divisions are very closely related and since they resemble in such a striking degree the rocks of the Vermilion District of Minnesota which have been included under the head of Archean, they are also classed under this head. These rocks have on the whole a green color and in general are more or less schistose, as was to be expected of rocks of their extreme age. These are the ones which Bell has designated upon his map as green schists, and has concluded are of Huronian age.

5. The foregoing rocks are cut throu by numerous dikes of granite which are

certainly in some cases and are presumed in most cases to be offshoots from some one of the granites so extensively developed in certain of the areas shown upon the map. These areas are marked as underlain by a granite gneiss complex for the reason that we find that there is not a single granite constituting such an area but a complex of granites of at least two different ages, and that with these granites there are associated, apparently playing a subordinate role, gneissose rocks. Granite offshoots from the massives ~~border~~ the adjacent greenstone and sediment areas. They are more abundant near ~~the~~ their contact than further away; moreover near the contacts the intruded rocks are altered to hornblende and mica schists. The gradual increase in the number of dikes as we approach the granite massive and the corresponding increase in the stage of metamorphism as we go in that direction is very plainly shown upon the exposures. Since the relation of the granite to the Arehean so clearly shows the relative ages of the two, I have given them their proper position in the legend upon the accompanying map.

6. At one place upon the south side of the point forming the south side of Vermillion Bay, I find a series of sediments, slates, graywackes and conglomerates, which are well bedded and now stand on edge with an approximately east and west strike. These sediments overly and are youhger than a greenstone which is adjacent to them. They contain fragments of hornblende schist and granite. These fragments a are presumably derived from the greenstones of Archean age which are cut and metamorphosed by the granite and from the granite which cuts these Archean rocks. Containing fragments of said rocks, the sediments above referred to are of course younger than the Archean and the granite. They were not observed to be cut in any place by the granite. These sediments are very limited in their occurrence.

7. In ascending and descending the Nepigon River there was observed a series of mica schists bearing in places garnet and staurolite, and showing very excellent banding. These rocks did not show anything which would give absolute proof of their original characters. I am convinced however from the examination in the

field, and from their banding and from their petrographical character that they were originally sediments and that their present condition is due to extreme metamorphism occasioned by mountain making movements (they now stand on edge or else are very steeply inclined) and the intrusion of granite. The granite occurs in numerous dikes in them. The dikes seem to grow more numerous as one goes to the south and with this increase in quanti ty of the granite associated with the schists there seems to be a corresponding increase in the degree of metamorphism which they show.

These rocks are cut by a few dikes of dol erite presumed to be of Keweenawan age.

The relations of these schists to other rocks are not shown, hence I can only state definitely that they are older than the Keweenawan and a granite. If this granite is the same as the one cutting the rocks upon Nepigon Lake, then presumably these schists are like those upon Nepigon Lake, of Archean age. This I could not prove however in the limited time which I had at my disposal for the study of these particular rocks.

The youngest rocks of the Nepigon Lake region are those of Keweenawan age. These Keweenawan rocks cover ~~the~~ a greater area than do all the ~~areas of the~~ other rocks of the region combined. They may be divided into the sediments, the basic rocks (dolorites) and the acid rocks.

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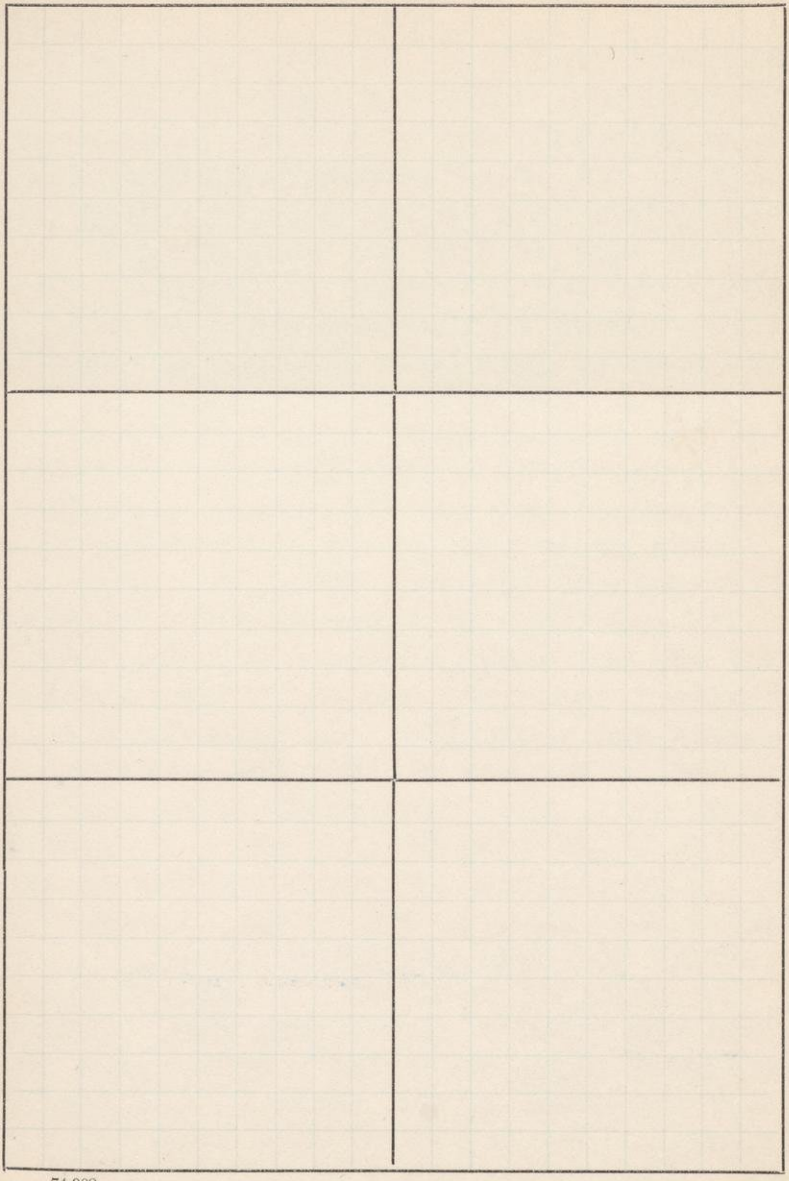

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8. The sediments are exposed in very small quantity upon the shores of the lake, but since they are not nearly so resistant as the other kinds of rocks with which they are associated the presumption is that many of the reentrants along the lake shore are really indicative of their presence and that they probably underlie very considerable areas of country. This is especially probable where we find the Keweenawan rocks - dolerite associated with the sediments - exposed, and where the topography is only very slightly marked as for example upon the southwest shore of the lake, particularly on Chief's Bay, and also on the south shore between the head of Nepigon River and Flat Rock Bay, for usually where the dolerite is alone we get very marked topographic features developed, such as flat topped plateaus rising with sheer precipices from the adjacent low ground, or else great ridges bordered by cliffs or very steep slopes.

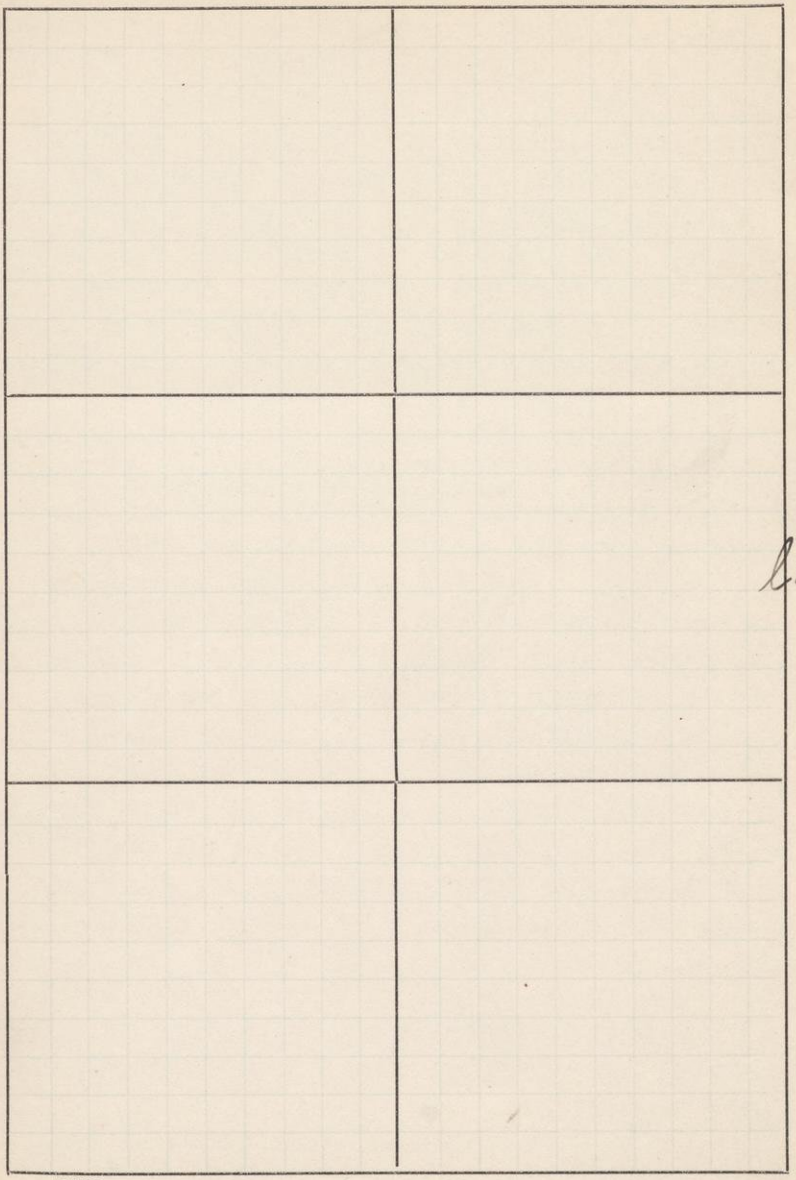
The sediments above mentioned are sandstones and dolomites. The sandstones are light pink to brownish and show their best exposures (although even at their best the exposures are small) at the northeast side of the lake, especially on the lakeward side of the great point forming the southwest side of Obabica Bay. Dolomite occurs in Chief's Bay, on Flat Rock Portage, and on the point west of the bay out of which Nepigon River flows.

9. The Keweenawan basic rocks (dolerite or

gabbro) cover an enormous extent of territory and have the greatest developement of any single kind of rock in the Nepigon area. The areas underlain by the dolerite (gabbro) stand out with their rugged topography in marked contrast to the adjacent areas underlain by the granite, greenstone, and associated very ancient sediments, in which the topographic features are rounded and show in general only slight relief. The Keweenawan basic igneous rocks range from the fine grained aphanitic basalt to coarse gabbro. Very rarely a slight developement of amygdaloidal facies was observed. All of these however are but phases of essentially the same magma. The intermediate to coarse grained forms of rocks (dolerites and gabbros are those most commonly exposed. These rocks are found associated with the sediments described under division 8. They appear to intrude them as sills, as where they appear in contact there is a dense selvage developed in the igneous rocks, such as would not be the case were the rocks interbanded surface flows and sediments. If these igneous rocks are sills there must, of course, be dikes of the same rocks cutting through the sediments. The dolerites were found in dikes cutting through the Archean rocks and through the granite complex.

10. This division includes certain acid rocks which are found intrusive in the Keweenawan dolorites and are hence the youngest of

S. T. R.



Lake

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the very ancient rocks of the region. Their bright red to brick red color contrasts strongly with the dark colors of the dolerites with which rocks they were alone found in relation and hence they are very conspicuous. They range from quartz porphyries to fine grained granite. They apparently correspond in age to the "redrocks" of the Keweenawan of the shore of Lake Superior and presumably are also of essentially the same petrographical character.

No attempt will be made to described the glacial deposits, but I wish to call attention to the extensive developement of horizontally bedded sands upon the northwest of the shore from Sandy River east. The waters of the lake working against the sandy shores have produced very extensive sand beaches along here which offer very favorable spawning grounds. These beaches are well known to the Indians as the Big Spawning Grounds. These sands occur near the shore, where they are dissected by the streams draining into Lake Nepigon, in hills 100 feet in height. They apparently run back inland maintaining about that uniform height. These are I judge beds deposited during the glacial times when the water of the glacial lake Nepigon was at a much higher level than the water of the present lake. No other similar deposits were observed upon the shores of the lake.

MAP. 9

Accompanying this report there is a Geological map based upon the topographic map of Nepigon Lake which was made by McGinnis and Dowling, of the Canadian Geol. Surv. in 1898–99. This map not having been published at the time I went into the region, was not known to me, and it was only by mere good chance that I obtained a manuscript copy from one of the Hudson Bay company's men.

The Geological map is only a reconnoissance map made as a result of 2 1/2 weeks spent in coasting the lake shores, and hence does not claim to be very correct in its details. For instance the schistose greenstones have not been separated from the massive ones, and the areas shown upon the map are merely put in to show the presence of these kinds of greenstones without intending to locate their exact locations or relative quantities. The boundaries between large divisions ~~whose upon the legend~~, as for example the boundaries between the Keweenawan and between the granite gneiss complex, etc. may be relied upon.

In every case where the colors have been brought down to the lake shores, these shores have been personally examined. The extent of the rocks inland can only be guessed at, although in many cases where the color has been carried for several miles inland I was practially sure of the continuation of the rocks indicated by the color up to that

point because the topography was so characteristic. It will be noticed that the shores of the extrem ends of several of the bays on the west southwest and south sides of the lake are left uncolored. This is so for the reason that they were not touched and hence the characters of the rocks occupying these shores were not accurately determined. In every instance however where the shores are left blank the topography indicated the presence of the Keweenawan dolerite, so that I felt perfectly safe in not visiting these portions of the lake shore. And I would now feel justified in coloring this portion with the Keweenawan color. It was observed that occasionally the older rocks appeared just along the shore whereas immediately back of the shore the Keweenawan was in its usual topographic developement. It may be possible that some such small areas underlain by the older rocks occur along these portions of the lake shore which were untouched. In order, however, to avoid the possibility of error I have left these untouched portions of the shore uncolored.

The following supplementary notes upon the Reconnaissance made in Northeastern Minnesota were ~~taken~~ near the close of the season and after the main work upon Lake Superior and Lake Neipigon was completed:

~~38~~

Continued this morning on the route to Little Saganaga. Followed the usual canoe route and from Gobbe-michgamog until we had coasted well around the west side of Little Saginaga, 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 appears to be a normal gabbro, 40244
40244 which appears to grade into the anorthosite as shown in specimen 40244

and which appears also to grade into surrounding anorthosite. Specimen
40245 40245 represents this fine 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 seem 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.

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 redrock (the red syenite 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 is cut by a number of fine veins of redrock. Presumably these fine dikes of redrock are offshoots from the larger mass previously observed but which showed no relations to the gabbro . Continuing south now the gabbro with occasionally red syenite 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
40252 gabbro represented by specimen 40252 which occurs upon the north side of the hill. This gabbro is cut and included in a reddish weathering feld-
40253 spathic 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
40254 width, of a reddish rock (40254.)

This rock '40254) seems to be but a phase of the more normal red Syenite
40255 40255 which makes up the outcrops on the northeast shore of Found Lake. The gabbro and the Syenite come very close together upon Surveyor's Lake and at one place the gabbro was found cut by a dike of the Syenite so that the relations between them are definitely shown.

Upon the southeast side of Surveyor's Lake outcrops were observed of a fine grained dense basic rock which was cut by red Syenite. 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.

40256 Specimen 40256 shows the porphyritic
40257 amygdaloidal 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 aphanitic basalt dikes, but none of these rocks were seen in relation to the gabbro or the red syenite. 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.

Oct. 5th.

Starting this morning to coast around Brule Lake intending to get an idea of the character of the Keweenawan in this vicinity. Heavy fog lay over the lake and did not rise until late in the day and after that it was misty or drizzling for the entire time. Again coasting the lake shore from a point on the south shore just east of the section line between sections 19 and 20 T. 63 R. 3. From this point I traveled east. Found red rock like 40255 predominating as far east as the large bay in sections 13 and 24. Associated with this there is a more porphyritic facies represented by 40258. 40258

From here on black fine grained rock like 40259 seemed to be more common. In the above mentioned bay 40259 40260 an amygdaloidal basalt 40260 was also found. With this there is associated a coarse dolerite with some redrock. The redrock cuts the dolerite but no relations could be observed between the dolerite and the fine grained basalts.

These same rocks continue on

around the east end and the northeast shore of Brule Lake. With them is associated a great deal of a coarse
40261 porphyritic rock like 40261 in which the feldspar phenocryst not uncommonly attain a length of 2 inches. Some of this rock has a very bright red color upon the weathered surface. This por-
4 phyry grades into a more evenly granu-
40262 lar rock like 40262 in which however there are occasionally centered phenocrysts. This rock weathers very much like the gabbro. The question seems to me warranted: "Are not these dikes or sills which are offshoots from the gabbro and are intrusive in the adjacent rocks?" Specimen 40261 was taken from the point on the east side of the bay from which the portage rout leaves going north into Winchell's lake. The more granular gabbro like form of the rock 40262 is very abundant along the shore in sections 11 and 12 - 63 - 3. Farther west in section 10 an amygdaloidal basalt like 40260 appears and near it although no relations between them were seen, occurs the red cyanite like 40255. Th This same redrock continues along the shore to the west for some distance.

Near the meander corner between sections 9 and 10 - 63 - 3, a fine
40263 grained basalt 40263 appears and continues on across section 8 to the large North and south bay on the west side of that section.

Oct. 6th.

Rained steadily all day. Was unable to do any work.

Oct. 7th.

It continued raining part of this forenoon, ceasing about 11.30 when I managed to get to work. Went up the bay of Brule Lake which projects north into sections 17 and 18, T. 63, R. 3. Both sides of the entrance to this bay there are exposures of fine grained dense black basalt like 40263. To the north of this comes then the red-
40264 rock specimen 40264 which is exposed in large outcrops occurring on the steep slopes of the high hills which occur on both sides of the bay. This redrock continues on north on both sides of this bay, and also north and on both sides of the lake lying to the north of this bay, and emptying by a stream into it. We approached.

from this bay of Brule into this little lake and then continued on north up the stream which flows into the northernmost bay of this lake. We continued as far up the stream as to the point where a fair sized water fall occurs on a tributary stream flowing from the west into this. The waterfalls in a series of steps down the hill side of redrock. Ascended this hill very nearly to the crest following along side the stream and then turned going due north over this high hill of redrock to the steep clif which marks its northern boundary. From the top of this cliff I get a splendid view to the north. At the foot of this cliff there is a small lake upon whose shores are exposed the same redrock over which I have been crossing. As far to the east and west as I can see there is a high ridge upon the cliffs of which one can see the bright red color of the redrock. The area underlain by this redrock exhibits wherever seen these strong topographic features. To the north of this I can see for a considerable distance an area of irregular topography but several hundred feet lower than the area underlain by the

redrock. To the north of this comes the characteristic topography of the animikie sediments with intruded sills Descending this cliff I continue north around the west side of the lake but remaining well upon the hills. At a point about even with the north shore of this lake I find a dark colored coarse grained rock represented by
40265 specimen 40265, which is much darker colored than the normal redrock. It has a great deal of black hornblende in it. This redrock continues to the north for about 200 paces when the normal gabbro begins. This presumably underlies the low area above referred to and continues on to the north up to the animikie sediments. In this gabbro I noted two narrow dikes of fine grained redrock. The zone underlain by rock like 40265 I consider a contact phase of the redrock on the gabbro. From the presence of the dikes of redrock in the gabbro it is clear that the redrock is the younger of the two. I could not notice however any marked diminution in grain of the redrock as I approached its contact line with the gabbro. The gabbro is coarse grained and of normal character as soon as the contact zone is

passed.

Now turned and followed southwest along the contact zone for a short distance seeing nothing different. Then turned back and returned to the canoe and on back into camp. As the result of today's observations and those made on the 4th inst., and also judging from the evidence presented by Grant in the annual reports of the Minn. Survey, it seems to be clearly established that the relation of the redrock to the gabbro is that of an intrusive the redrock being younger than the gabbro and being found in dikes cutting it.

Oct. 8th.

Coasted the northwest shore of Brule lake from camp to the river which is the westernoutlet of this lake. Along this shore there occur amygdaloidal rocks like 40260 and also a porphyritic rock similar to 40262. Portaged into the river and started down stream. At the portage the porphyritic amygdaloidal rock 40256 occurs. About 150 yards down the river I find upon the north shore of

the stream gabbro represented by
40266 40266 exposed. Got out at this exposure and went inland to try and get the relations of the gabbro and the adjacent amygdaloidal rocks. Going north I crossed about 100 paces of this gabbro. To the north of the last exposure there lies a depression now filled with water. Beyond this to the north lies the amygdaloidal lava like 40256. Turning I now followed the gabbro which trends about Northeast-Southwest to the east, and found that it narrowed quite rapidly. Within about 100 paces it has narrowed to a width of about 23 paces with amygdaloidal rocks on both sides of it. As the gabbro is followed still farther northeast it is found to run down in a depression in which there is no exposure. At one place upon the south side the amygdaloidal lava is only about 12 inches distant from it. At no point was the basal contact between them observed. As the gabbro is followed to the east it was seen that as the width of the wedge diminished the grain of the gabbro correspondingly finer and the rock also became porphyritic. Where the

gabbro wedge was narrow and the amygdaloidal lavas occurred on both sides it was noticed that the rock got finer away from the center of the wedge showing the development of a
40267 saalband. Specimen 40267 shows a rather fine grained porphyritic ophitic phase of the dolerite. At one place not far from the contact of this dolerite with the amygdaloidal lava, it was found to be cut by a narrow two inch dike of redrock.
40268 Specimen 40268 shows the two rocks in contact. Followed out to the west the gabbro is found to widen and across the river upon a point similar gabbro was observed. This point is separated by another body of water on the west from the main gabbro mass.
Without question this gabbro wedge above described is but a wedge shaped offshoot projecting northeast from the main gabbro and partly surrounded by the amygdaloidal lavas. The relations indicate that it is intrusive of these lavas. Moreover the increasing fineness of the rock from the center toward the edges is further evidence of its intrusive character.

Elfman has indicated upon his map (Amer. Geologist, Vol.22, Pl.7) certain basic dikes known as his "Later Diabase member" which are younger than the redrock of the northeastern Minnesota. This mapping of Elfman is certainly correct to a certain extent as my own observations have shown. One might possibly be inclined to place the wedge of gabbro grading into dolerite above described with this later dikes. It must be remembered however that the presence of the redrock dike in this basic mass clearly shows the relations of these two rocks. There seems to be no escape from the conclusion that this wedge is a continuation of the main gabbro mass and of younger age than the lavas which partially surround it. Continuing west down the river after passing the gabbro w wedge we pass an area underlaid by the amygdaloids and then another gabbro which, but for a small area on the northeast side where these amygdaloidal rocks occur, completely surrounds Lake Georgia. Have portaged into Surveyor's lake from Lake Georgia. Gabbro occurs along the portage and

part way around the southeast shore of Surveyor's lake. Just before reaching the extreme end of the southeasternmost bay there begins a
40269 very fine grained basalt 40269 which in places is amygdaloidal. This basalt was found to continue across to Lake Georgia where it appears at several places upon the shore of the northeast bay as above stated. On the west shore of this southeastern most bay of Surveyor's lake, just opposite a small corky island, there is a dike 3 feet in width of fine grained redrock with a trend about north and south, which cuts the basalt 40269. ~~XX~~ I went inland following this basalt across the land to Lake Georgia. At one place in a depression I found an exposure of a rock varying from fine basalt to medium grained dolerite with the basalt like 40269 occurring both to the north and south of it. No contact was observed. I could not connect ~~this~~ with the main mass of the gabbro which lies only a short distance to the west, but it seems highly probable that it is an offshoot from this mass. I attempted to follow the contact between the

basalt like 40269 and the main gabbro mass, but was unable to get absolute contacts there on account of the intervening depression, or else because everything between was covered with soil. I was able to get them within about 10 paces of each other, and found the gabbro then fairly fine grained in fact almost a basalt. Indeed all along the side next the amygdaloidal lava 40269 the gabbro is decidedly finer grained than it is farther away from this. This would seem to indicate thatthe gabbro was intrusive in the amygdaloidal rocks and tends to confirm my view with reference to the gabbro wedge above described.

Another interpretation of the gradation from the gabbro into a finer grained rock and the occurrence then of the amygdaloidal lavas adjacent to it is possible, but it does not seem to me to be probable. This interpretation would be that the amygdaloidal lavas are the surface flows directly connected with and grading into the gabbro by an intermediate fine grained facies of the gabbro which has already been mentioned.

A serious objection to this view would be that the gabbro changes apparently at one place into an amygdaloidal like 40256 and at another into a rock like 40269. This objection would be hard to overcome unless the said amygdaloids proved to be essentially the same rock and chemically and essentially similar in composition to the gabbro.

The normal coarse grained gabbro occupies the southwest shore and Surveyor's lake. At the west side of this lake there is a long east and west trending bay about 150 yards in width and into the west end of which the portage from Found lake enters. This bay seems to run along the contact between the gabbro on the south
40270 and the redrock 40270 which forms the north shore of this bay. I followed along the gabbro hills hunting for intrusive dikes of the redrock in the gabbro, but was able to find only one such. This occurs on the hill just to the south of the west end of the bay. Upon this hill I found a very large gabbro boulder cut through by a 3 inche dike of fine grained red rock. This block does not seem to be in place. It occurs on the south edge

of the redrock area but whether the block is one of disintegration or an erratic from the norther border of the redrock area is immaterial. It still shows clearly the relations between these two rocks. This is confirmation of the facts already seen and described by myself in previous pages, and also those mentioned by Grant which all tend to show that the redrock is intrusive in, therefore younger than the gabbro.

I now coast back to the east following along the north shore of this bay upon which only redrock is exposed. On the first point on the west shore of Surveyor Lake north of the island on the north side of the mouth of this bay, I find an 8 inch dike of basalt cutting the redrock. Eric Ericson my canoeman, reports that redrock occurs in high hills east of the east end of Long Island (Kiskadinna lake), also coming downto the shore. He says he has there seen cutting this redrock on the hillside sloping down to the lake a narrow band 4 inches in width of black rock. Moreover this band comes down to the lake. He followed it thinkint it was

black iron (magnetite) as he says. Evidently this is another dike of basalt cutting the redrock.

The redrock continues on up the west side of this northernmost bay of Surveyor's lake, and was also seen upon the east side of the stream entering this bay. Just to the north of the mouth of this stream a contact of the redrock with the black dolerite was seen. Only a very small area about 1 foot in length of this contact was exposed by digging with a rotten log. I could not be absolutely sure that the dolerite grew finer grained toward the redrock, although such seemed to me to be the case. The redrock occurs on the north side of Surveyor Lake, and upon the islands in this lake. At one place upon the north side of one of these islands ne near the north end a thin mass of dolerite lies against the redrock. This is presumably a remnant of a dolerite dike. The redrock continues part way down the east side of the lake and then the gabbro begins and continues on down to the southeasternmost bay where the tongue of amygdaloidal rock like 40269 occurs.

I now returned to Brule By way

S. T. R.

For map see

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of Lake Georgia, and the river, and coasted along the southwest side of Brule over that portion of the shore which I had not yet touched. Near the outlet amygdaloidal rock occurs along the shore but back of it lies the gabbro which is finer grained near the amygdaloids. Continuing east along the shore the gabbro is exposed up to a point about south of the east end of the first small island near the south shore of the lake about up to the place where the north and south section line between sections 19 and 20, T.63 R. 3, touches the lake shore. Here the fine grained gabbro with the coarser grained phase farther inland is cut by ramifying dikes of redrock. To the east along the shore as shown by previous work, the redrock comes in in full force just across a small bay which marks the contact between the main mass of gabbro and the main mass of redrock. The map opposite gives in a rough way the limits of the various kinds of rocks observed on the west end of Brule. From the facts observed and noted above, it seems to me that the following conclusions are warranted

concerning the relations of the amygdaloidal lavas the gabbro and the redrock. The oldest rocks around the lake at the west end of the lake are the amygdaloidal lavas. They were intruded by the gabbro which at least in one place as shown by my studies has sent a tongue of gabbro into the amygdaloids, this tongue getting finer grained away from the gabbro and also along its sides both as it is followed away from the main mass of gabbro and as one goes from the center toward its sides. Since the intrusion of the gabbro the redrock has been erupted and is now found cutting through the amygdaloidal lavas and also the gabbro. No attempt has been made to trace out the gabbro beyond the immediate vicinity of the west end of the lake. Presumably however the portion now occurring northwest of Brule Lake originally connected with the main mass of the gabbro from which it is now separated by the hills of redrock. The redrock in some places followed approximately along the contact between the amygdaloidal lavas and the gabbro, that being presumably the line of least resistance. Near the

west end of the lake it gradually left this line of contact and from there on has a trend more slightly to the north of west. Upon the south side of the lake the re rock also followed the line of contact between the amygdaloids and the gabbro but it there runs out to a wedge shaped mass which finally di appears as it is followed to the west.

It is somewhat difficult to explain the presence of the amygdaloidal lavas so far inland and so widely separated from the main mass of the Keweenawan lavas which occur to the south along the lake shore. Presumably this mass which is in reality of relatively limited extent represents a great mass included in and bodily uplifted by the gabbro mass. It is presumed to lie upon this gabbro. The lavas are not sufficiently well bedded to enable one to distinguish with any certainty the various flows and still less to determine the dip of these flows. I am strongly inclined to think, however, that the general structure is a synclinal one and that Brule is essentially a structural lake lying in a syncline of lavas.

This synclinal structure has been emphasized by the fact that the lavas more readily alter than the surrounding gabbro, and redrock, so that erosion has still further emphasized the basic character of the Brule area by removing the lavas leaving the prominent hills of gabbro and redrock surrounding it.

Oct. 9th.

It rained last evening just as I got in from work, and this morning there was a heavy fog. Having finished the work on Brule Lake I broke camp and started east along the shore of the lake en route for Grand Portage, about 75 miles distant. Going north from Brule over the regular route we pass redrock which is exposed along the portage trails and on the small lakes. At the north end of Sham lake (see Gunflint lake, Plate ,Geology of Minnesota, Plate 82) gabbro comes in just north of the redrock. This continues to be exposed on along the south shore of Winchell lake the large lake immediately north of Sham la e. This gabbro weathers somewhat reddish and

is very coarse grained. This reddish weathering may be due to the fact that it has been affected by the contact of the redrock and that there is here produced an orthoclase gabbro similar to that described by Irving and which from studies made this summer upon Lake Superior appears to be the result of contact action of the acid redrock upon the basic gabbro.

No relations were seen between the gabbro and the redrock but it is known elsewhere that the redrock cuts the gabbro and is presumed also to cut it here. We go east through Winchell lake to the portage on the north side at the east end. This gabbro continues to be exposed across this portage and also through Gaskanas Lake (Since the last few years this lake has been known as Johnson's lake after the man who has done some diamond drill exploring through this country.) Gabbro continues on through North Bruce and through Caribou Lake. Camped at the end of the portage on the north side of Caribou Lake at 5.15.