Notes on the Keweenawan and other rocks of Lake Nepigon, Canada with some notes on the Keweenawan of Lake Superior: [specimens] 40083-40130. No. 333 1900

Clements, J. Morgan (Julius Morgan), 1869-
[s.l.]: [s.n.], 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. 2.

No. 333.

Notes
on the
Keweenawan and other Rocks
of
Lake Nepigon, Canada
with some notes
on the
Keweenawan of Lake Superior.

1900

J. Morgan Clements.

are exposed. During our trip this afternoon we have been passing the Keweenawan series of interbedded lava flows and sand stones. The lava flows, from the prominence of the cliffs composed of them, seem to predominate, although, not having worked the shore carefully, one cannot make a very accurate quantitative estimate. Camped for the night on the porphyry island in Eagle Nest Channel, just at the mouth of the second stream on the west shore above the lower mouth of Nepigon Narrows.

July 31st. The island on which we were camped is composed of an acid feldspar porphyry
40088 like 40088. On the west shore of the main land, just opposite the island, I find a rock like 40088 cutting a basic rock. This acid rock seems to vary
40088 from a rock like 40088 to such a rock
40083 as is represented in specimen 40083. Possibly this 40083 is the contact rock the result of the metamorphic action of
40088 the red rock 40088. This basic rock varies from a porphyritic rock repres-
40084 ented by specimen 40084, through various
40085 grades of coarseness 40085-6, to a
40087 coarse feldspathic dolerite 40087 which is very nearly an anorthosite. A dike of dolerite about ten feet wide cuts the

dolerite. Going South along the west side of the channel, we pass along exposures of dolerite which continue down to the first point south of the stream opposite the island. Here we find por-
40088 phyritic red rock 40088 occurring along the shore. Back of it, and also running in places down to the shore, we
40089 find a porphyritic dolerite 40089, which is like the specimen near its contact with the red rock, but which grows coarser as we go away from this contact until it becomes such a rock as is
40090 represented in 40090. The fact that this gabbro or dolerite is finer grained on its edge than away from the contact, seems to point to its being intrusive in the red rock. This, however is contrary to the relations which we have found to exist normally where the red rock cuts the dolerite. Even here, just below the surface of the water, there are two narrow dikes of red rock which clearly penetrate the dolerite. One can explain the relations here existing, by premising two red rocks, one older (the main mass) and one younger (represented by the small dikes) than the dolerite. However, instead of sup-

posing two red rocks in order to explain the relations of the basic rock and of the red acid rock, we may suppose two basic rocks. We know we have basic rocks of at least two different ages, and we can readily consider one of them, the older, as cut by red rock, and the second, the younger, as cutting the red rock. However, in the specific instance cited above, we have the dolerite showing a selvage towards the red rock, and the same basic rock cut by dikes of red rock. In this specific instance, the only explanation possible seems to be that of two red rocks.

Passing around this point, there is seen a coarse dike of dolerite with cross columnar parting, represented by
40091 40091, which, though not in actual contact with the gabbro, nevertheless occupies such a position.- Gabbro occurs on both sides of it, with slight topographical break between it and the dolerite - that the presumption is that it cutsthe dolerite, and corrsponds to the small dike which is noted as cutting the dolerite just opposite the island on which we camped. The large island

lying near the entrance of the channel on the west side, and separated from the mainland only by a very narrow channel, is a very coarse dolerite, as is the rock occurring upon the mainland.

Cross channel to the east side,
40092 and take specimen 40092 from the cliff on Fluor Island, just opposite the above island. The same coarse dolerite forms the rocks of this cliff, and can be seen to continue inland both to the east on Fluor island, and west of the channel on the mainland, forming high hills which on the lake charts are shown as reaching a height of 1000 feet. Continue on north and on the islands in the channel Northeast of the one on which we camped, I find the first fine grain-
40093. ed basic rock, specimen 40093, which we have seen in the Narrows. Now cross channel to the Northwest, and goton the
40094 first point an amygdaloid, 40094. Passing along the exposure of amygdaloidal rocks on this west shore, I see one small amygdaloidal basic dike about 18 inches wide, cutting through an amygdaloidal basalt flow. These amygdaloidal rocks continue on up north to the entrance to Nepigan Bay. At the point on the left side of the channel where it opens out into ~~unbroken~~ the bay, I

took a specimen of the amygdaloid,
40095 40095.

The rocks which we have seen to-day seem to correspond to:

First, the Beaver Bay diabase of Irving, including the rocks which I have designated as dolerites, and which occur chiefly at the south end of the Narrows and appear to be of exactly the same character as that forming the heavy sills of the animikie.

Second. Amygdaloidal lavas corresponding to the amygdaloidal lavas of the Beaver Bay group of Irving, with, cutting through them in places, some red
40088. rock as shown in 40088.

The topography of the north shore shows pretty clearly the general character of the rocks, for instance, the Beaver Bay diabase, occurs as massive dolerites + ~~formed the~~ noticeable topographic features which begin in the high hills known as the "Papps" on the point between Black and Nepigon Bays, and, turning east continue through and beyond Fluor Island. To the north, behind this, comes in a topographic area of less elevation, and more gentle outline, which is underlain by the amygdaloidal lavas.

To the north of this comes in again a series of sedimentary rocks with basic sills. The topography of this area is very different from that of the two preceding areas. Here we have prominent hills, ~~underlain by~~ formed of sediments with intercalated basalt sills, ~~nearly~~ very nearly flat lying, ~~basalt masses~~, which drop down to the intervening flat valleys by means of nearly precipitous cliffs. Such topography surrounds Nepigon Bay, and in the course of the Autumn's work we should see the character of the sediments determining whether they are the Keweenawan or the animikie, presumably the first.

August 1st. Leave camp and pass Northwest. Here come outcrops all along the shore of amygdaloidal lavas. Notice at one place a number of fine dike like stringers and irregular patches of brick red rock appearing in the lavas. These become more numerous and larger, and finally I see ~~wide~~ dikes, 12 feet in width, and from this they run on down to mere films. Some of the dikes are shown in the three photographs taken. Examining these dikes closely, I found bedding lines in the rock of the dikes, these bedding planes running at an angle to the verticle extent of the dikes. I

Photograph on page 7.

S. T. R.

Dykes of Red sandstone in Basalt.

even found lines of cross bedding. These dikes are very good cases of
40096 sand stone dikes represented by 40096. These are probably the same dikes described by Irving in Monograph 5, or at least similar th those. Thus Irving, in his descriptions, was years
Cross/ ahead of Crosby and others who have described the so-called sand stone dikes from the rocky mountains. Along the margin of these dikes, the sand stone fills amygdules of the adjacent amygdaloidal lava, as is shown in one of the photographs. At this place the rock has been removed down very close to the dikes, leaving just a skim of basalt with sand stone filled amygdules. A little farther along on the shore, I find red and yellow sand
40097 stone 40097, underlying and in contact
40098 with basalt 40098 which has a scoriaceous border about 18 inches thick. Moreover, at the contact of the basalt and of the sand stone, I could see that in one place the sand stone ran up into cracks in the nearly horizontal lying basalt flows, and also filled the amygdaloidal cavities.

Following the shore to the Northwest, there appears a small anticline

in the sand stone. This anticline as exposed on the shore, extends from Northwest to Southeast, and the axis strikes nearly 10 degrees east, and pitches flat to the South. Above the sand stone lies the basalt with scoriaceous under surface. It is very evident that we are beginning to get here a series of interbeded lavas and sediments.

The same sand stone appears again about 300 feet farther up, that is to the Northwest, along the shore. It is brought up here by a second small roll.

Somewhat farther along the shore the basalt appears back from the water's edge, but from then on along the shore for a long distance, low ground without any exposures, is the rule. ~~which begins and~~ This low ground continues on around the large bay on the west shore of Nepigon Bay where Bayfield has marked on his lake charts 'Supposed cliffs of sand stone'. As a matter of fact, none of the very ancient rocks are exposed around this bay, and the supposed ~~supposed~~ cliffs are really formed of thinly bedded bluish lake clays which continue for several miles along here.

These deposits were evidently formed in Lake Superior when it was at a much higher level.

At the point on the north side of this big bay, a brilliant red sand
40099 stone 40099 is exposed. This has interlaminated with it a few yellowish bands. All of the exposures from here up to the mouth of the river are of this rock, and are brecciated. Owing to the brecciation and contortion of the beds, it is impossible to get the dip upon these exposures. However, from this point, we can see Northeast across Nepigon Bay to the mainland, and on this mainland one of the hills plainly shows very ~~particularly~~ a low southward dip of the sediments. Continue on up ~~on~~ Nepigon Bay and enter the mouth of the river. On the east side there is a very good exposure of sediments in contact with a heavy sill of basalt which overlies them. These sediments
40100 are represented by 40100 and 40101,
40101 and show considerable induration. The wavy character of the contact between the basalt and the sediments can be well seen from near the center of the river on the exposures both on the

east and on the west. On the east cliff one can readily see that the basalt cuts across the beds at a flat angle. On the west side of the river there is an exceptionally good exposure where fresh specimens can be obtained as a result of a C.P.R. Railroad cut through these sediments.

Dontinued on up Nepigon River passing the low alluvial ground at its mouth, and ~~entering~~ passing also just before we reach the railroad bridge, between high banks of alluvial deposits. Camped below the bridge for the night.

August 2nd. Went into Nepigon and made arrangements for getting up the river. Engaged two Indian canoemen with their canoe to help me with supplies up to Lake Nepigon. They are to be at Camp Alexander tomorrow night ready to go on with me the following morning.

August 3rd. Took day off from Geology and went up to Cameron's Pool where I spent the day very enjoyably i in trout fishing.

August 4th. Left Camp Alexander on my way north up the river for Lake Nepigon at 9.00 A.M. Had in the party one white man, Eric Ericson, and two

Indians who were engaged with their canoe and were to help me up as far as the lake. We crossed the first long portage, 2 1/2 miles, from Camp Alexander, up to Lake Jessie, ~~in the course of the day~~. It took all the forenoon to cross this portage. This portage is a good one so far as traveling is concerned, but it passes over drift the entire distance, hence there are no exposures. On the east side of the river at the north end of the portage, I saw a coarse red granite which here cuts through a mica-hornblende schist. This is designated upon Bell's map, published in Irving Monograph 5, Figure 35, page 408. Proceeded on north up Lake Jessie, following the west shore because in this way get favorable wind and eddies. There are no exposures on this side of the stream, although many can be seen across the lake, which can be recognized from this distance as red granite. This will be studied on the way down. This same granite was observed outcropping on the east shore of Lake Maria. Crossed over and touched this east shore at a point projecting north

west into the Lake, almost directly east of the old lumber camp. At this place the rock is a gray schist, which splits into thin laminae. This shows an alternation of bands varying somewhat in grain and also in color. This schist is cut through and through by red granite dikes. This, to judge from Irving's map already referred to, is the patch which Bell has indicated thereon as his Huronian. Continuing on north along this east shore of the lake we pass exposures of this same rock which form fairly high cliffs running down to the water's edge. The same rock continues on up the river for some distance beyond its entrance into Lake Maria. (Note: It may be well to note here that, as a result of studies made on my return, I reached the conclusion that these banded schists are sediments of Huronian Age, probably just immediately preceding the animikie which have been cut through and through by masses of red granite and by this intrusion has been metamorphosed into schists. This Huronian would then continue from a point in the narrows above Lake Maria, south at least as far as the south end of Lake Jessie. For

N. Book 3-34
P. 57

details concerning these rocks and specimens, see notes made on my return at end of the trip). N.B. k

North of the schist, the dolerite begins, known by the people on the river as the gabbro, and continues on up at least as far as the north end of Split Rock Portage. This dolerite is unquestionably the rock which has caused Bell to mark the Keweenawan upon his map as extending over this area. As the result of parting planes into the dolerite, into angular more or less rectangular to rhomboidal blocks. An enormous mass of this dolerite lies in the midst of the river, separating the river into two channels. The water flows ~~which pass~~ on either side of it, in a series of rapids. This necessitates a portage at this point, and the large mass of rock standing in the midst of the channel, split off, as it were, from the walls of the adjacent rock cliffs, has caused the name of "Split Rock" to be given to the portage. This portage we reached at 5.00 P. M., and were compelled to camp here for the night, although the situation was far from a good one. Black flies and sand flies were so

It breaks into

thick that it was impossible to have a moment's peace.

August 5th. Left Camp at 8.00 A. M., going up the river. We passed between high hills of dolerite, From 400 to 500 feet above the level of the river, which, in many places, descend to the river in high vertical cliffs. It is very noticeable that the area which was seen yesterday underlain by granite and mica schist has a very low relief compared to the relief shown here in the area occupied by the Keweenawan dolerite.

Just before reaching the island which is about 3/4 of a mile north of Split Rock Portage, and over which a portage known as the Island Portage must be made, I came to an area which topographically contrasts with that we have just been passing through, in that the banks get lower and the high Keweenawan cliffs recede to the east and the west. There occurs where this change in topography is noticed, a banded fine and coarse mica schist containing garnets and cut by granite veins paralel and perpendicular to the banding, and also full of quartz veins. On the portage across the island, this schist is well

exposed. The same schist forms both sides of the river as we go farther north, and outcrops again at the south end of Pine Portage. (Details concerningthe rocks here and the numbers indicating the specimens which illustrate them can be found in the notes taken on the return). At the south end of the portage some of this granite and staurolite bearing mica schist is exposed. The remainder of the portage, however, is over drift. This portage is about one mile and a half long, and we succeeded in getting our boats and supplies over this so as to leave after having lunch at about 1.30 P.M.

N.B. 334
p. 50

From the north end of the Pine Portage, we go up the river between high hills, descending in places in perpendicular cliffs, which consist of a medium grained dolerite or gabbro as it is called by the explorers who are familiar with the country. Just before we pass across the White Chute Rapids, there is a small fall on the east side of the river which tumbles over a vertical cliff. This is reported as coming from a small lake situated on top of the hill. North of the White Chute, and from there on up both sides

through Lake Emma to camp Victoria, where we camped for the night, we find dolerite as the predominant rock. At one point (see map for location, and later note for description) the mica schists come in. Immediately along the shores of Lake Emma, the rocks have been very deeply eroded, to such an extent, that many of the islands project as low rounded backs, above the water level Usually, however, a short distance back from the shore, and this is especially true on the east side, are the high hills of dolerite proper.

Has rained ever since we left Pine Portage. Reached Camp Victoria and camped there for the night. Failed to catch any fish at Victoria, so supped on bean soup, and afterwards read a greasy copy of the Chicago "Times-Herald about four days later than the last paper I had seen, which was left here by a party composed of Dean Judson, Professor Carpenter and others, of the Chicago University.

August 6th. Broke camp at 7.00 A.M., in the rain. Went west, crossing the river and passing medium grained gabbro exposed on the islands. Ascended small stream and entered Lake

Hannah. This lake is surrounded by shores of flat dolerite exposures. From the west end of Lake Hannah we portaged into Lake Nepigon. This portage is known as Big Flat Rock Portage, and is about 3/4 of a mile long. It goes over a flat bare rock surface of dolerite, grading into basalt for the greater portion of the way. It rises very gradually toward Lake Nepigon. The surface of the exposures is in places very intricately checked by cracks which have been filled with the vein quartz. In some places veins of quartz running parallel with the surface appear now as skims over the rock. No amygdaloidal textures were noted. The rock here very strongly resembles the surface of the basalt on which the Roman Catholic Retreat on McKay's Mountain is built. There the basalt was an intrusive sill in the animikie slates.

Drift is almost entirely absent from this portage. Two little morainial ridges, however, with maximum height where crossed of about four feet, were seen resting on the bare rock. Here and there are scattered also a few drift boulders. (Note: This portage was examined more carefully on the

return, and then I found at one place angular blocks of a dolomite which seemed to be in place, although of this I could not be perfectly sure. It looked very much as though this dolerite is here intrusive as a sill in a series of sediments. These sediments have been removed, with the exception of this one small patch, which I found, down to the surface of the dolerite sill over which the portage passes. There is a gentle rise in the slope from Lake Hannah, as we go Northwest to Lake Nepigon. This gives approximately the dip of the sill and probably the direction of the dip, Southeast).

As soon as the Indians got the boat across the portage, I discharged them, and started them back to Nepigon. Erickson and I then portaged the rest of our outfit and at 10.30 A.M. we started Northeast along the shore of Lake Nepigon. Dolerite similar to that which we have seen at various places as we ascended the river, and on this portage, continues in numerous exposures along the shore. This in general is quite coarse and in this respect might well be classed as the

gabbro.

On the beach in the third little bay about 1 1/2 miles north of the portage, I noticed a large boulder of conglomerate. This conglomerate was made up of pebbles of green stone, vein quartz and red jaspar. In general character it is exactly like the Ogishke Muncie conglomerate of the Vermillion district. This boulder must have come from somewhere to the Northeast, as such is the trend of the glacial striae and here we have good evidence, although I hope to find better, of the existence of a conglomerate lying to the Northeast and which is younger than the iron-beraing formation that probably exists in that region.

40102. Specimen 40102. Took this specimen from a n exposure on the east side of the deep bay south of the first island north of the portage, and distant from it about three miles. This illustrates the normal coarse dolerite or gabbro. Scattered through the dolerite one finds here and there areas and veins even of rock which is coarser grained than that illustrated by this specimen, and in some cases veins which are of finer grain.

The same dolerite continues along the east shore for a long distance. It comes down to the beach in flat exposures which have a very well developed platy parting which dips low to the north. The country back of the shore is low.

On the west side of the point which forms the west side of the deep bay out of which Nepigon River flows, I find exposed about 8 feet of white and greenish banded hard lime stone, 40103 represented by 40103. Theselime stone bands are very nearly horizontal, and they are exposed for about 50 yards. The dip is very slightly to the south, and as a consequence it gradually disappears under the dolerite which overlies it. These bands are very much crumpled in a minor way. The lime stone is overlaid by a great sill of dolerite which follows the irregularities in the lime stone and consequently shows a somewhat wavy undersurface. I could not here get any evidence that the dolerite cut across the beds of the lime stone. This dolerite grows finer grained as the lime stone is approached but it does not become at all vesicular and a contact zone represented by

40104 specimen 40104 lies between what I can recognize on the one hand as the normal dolerite or basalt, and lime stone on the other. This contact is mottled greenish and bluish black. This band varies in thickness from 12 inches up to 2 feet. From the streaky amd irregular character of the mottling it looks as though some of it is the result of secondary action of the water.

The dolerite shows a vertical platy parting instead of the usual parting into hexagonal columns. These plates range from two inches up in width.

At the north end of the point there is another exposure of the lime stone. Here it is about 20 feet thick and shows minor rolls, with the axes of the rolls plunging toward the south. There appear to be from these two exposures which are almost at right angles to each other, both east and west and north and south rolls in these sediments. At this place, the north end of the cliff, the dip of the axes can be ascertained and measured. The fold is here an anticline plunging to the south. The two ex-

posures of lime stone mentioned would very evidently connect under the sill. But for the heavy talis resulting chiefly from the breaking off of the heavy sill of capping dolerite, they probably could be seen to connect.

From this point we laid our course across the bay to the point on the east side. Where we touched the island on our way across and the shore of this long point, we find a coarse dolerite exposed, which, in places, is as coarse and in fact is the same as the normal coarse basal gabbro of Minnesota. This coarse gabbro is very deeply weathered so that it was almost impossible to get a fairly fresh specimen of the
- 40105 coarsest phase. Specimen 40105 is taken from the extreme end of the point just Southeast of the point on which the Indian graves are. This is a coarse phase, but does not represent the coarsest kind of the gabbro.

August 7th. Left camp at 7.30 A.M., and coasted a short distance Southeast along the point west of Bay View Bay, passing numerous exposures of gabbro. ~~At a place where it is nearest to the East shore,~~ Crossed Bay

Trout / View Bay, touching the east shore of the lake, a little to the Northwest of the trappers' houses near ~~Tower~~ Creek. Looking south down the long bay (about 12 miles long) known as Bay View, I see high cliffs which appear to be directly continuous with those at the north end of the Bay, which I have seen to be dolerite. Moreover, I was told by the Hudson Bay men and an explorer, that the rock all around this bay is a gabbro. Followed the east shore of the lake to the north, finding dolerite exposed in a great number of places. This shows good platy parting at a great number of places. Since the parting was developed, the rocks appear to have been slightly folded, and now the plates of dolerite are not flat, but are slightly undulating. This makes the dolerite look as though it were made up of contorted or slightly folded beds. A casual observer might mistake the parting planes for nearly horizontal bedding planes. The reentrants along the shore, when very large, will contain here and there an exposure, but very commonly have well developed sand beaches and no exposures. The dolerite

appears upon practically all of the points as far north as the second prominent point north of the Black River (c. f. map), and about two miles distant from it.

Around this point, that is to the north, there is a narrow east and west bay, which is about 200 yards in width. This bay is continued inland by an area of low ground. On the south side of the bay the dolerite is exposed and also continues east, forming a ridge to the south of the low ground which represents the continuation of this bay. On the north side of the bay, I find the first occurrence of green stone found upon this lake. Specimen 40106 represents a piece of average character. The green stone varies from a medium grained massive to a coarse grained rock and also to schistose forms. The green stone very commonly shows ellipsoidal parting which, in places, is very well developed. Where the schistosity is developed, it is found to strike north 60 to 75 degrees east, magnetic, (no sun), and dips about 40 degrees to the north. In general, the green stone resembles strikingly the Archean (Ely) green stone of the Vermilion district.

40106

N 60° E.

There is a noticeable difference here between the topography of the area underlaid by the Keweenawan and that underlaid by the green stone. The Keweenawan topography is decidedly rugged. The green stone appears in rounded hills lower than the adjacent Keweenawan hills, as a rule. Bare rock is very common, and glacial striae on this are very distinct.

Green stone possessing essentially the same character as that already described continues along the shore to the north. Locally this green stone is exceedingly schistose. For instance there are good exposures of this in the second bay south of Sheboenining Point. This is represented by specimen
40107 40107. The more massive green stone, and especially this schistose green-stone, is cut through by a large number of quartz veins. The green stone is exposed here along the shore in a belt which has a width north and south of about one mile.

North of this green stone, the Keweenawan dolerite is exposed. There is a deep bay between it and the green-stone, so that the relations are not

shown here. This dolerite continues along the shore to the Northeast for about three miles to the point indicated on the map. From this point north, along the shore, there comes in a well developed broad sand beach which merges inland in a sand plain. This beach continues on up to Poplar Lodge River. On the north side of this river, medium grained massive to schistose greenstone is exposed in rounded knobs. With this, cutting the coarser greenstones, there are narrow dikes and stringers of fine aphanitic green stones. Some of these aphanitic dikes have been broken and show slight displacement. I am told that this same green stone occurs inland back of, that is to the east of, the sand plain, and that it also connects to the east of the dolerite which outcrops on and north of Sheboenining Point, and joins the green stone which outcrops south of the above point. (see map upon which the boundary between the dolerite and the green stone is dotted, as it is not known exactly where it does run.) Camped early this afternoon on account of rain, and also because I am to meet here a Mr Mike Ralph, who has promised to guide me in-

land tomorrow to some exposures of the iron-bearing formation.

August 8th. Started at 6.00 A.M. with Ralph and Gilchrist, and the half breeds, six of us in a canoe, to visit the iron formation located by the first named. Paddled for thirty minutes up Poplar Lodge River, going in a direction south of east. Then went by trail for forty minutes brisk walk to the southeast. The location of the iron formation is about two miles inland, and east from the south side of the sand beach south of Poplar Lodge River.

After leaving the river, we ascended a knoll of massive green stone with distinct porphyritic feldspars in places. Characters of this rock were so clearly recognizable that I took no specimen. Passed isolated exposures of green stone. Some few of these had a very rough weathered surface which seemed to be quartzose, and made me think that possibly the rock might be a much metamorphosed massive sediment, although I doubt this. A slight schistosity is developed, but no sedimentary banding could be observed.

40108 Specimen 40108 represents this rock. Exposures of this same kind of rock continued to where the iron formation occurs. Here there appears, lying against this rock, which is presumably green stone (see sec-
40108 tion from specimen 40108), the iron formation. The iron formation con-
40109 sists of good hematite ore 40109,
40110 interbanded with a red jaspar 40110, in very small quantity, these two interbanded with a moderately fine
40111. grained graywhackie, specimen 40111.

The beds of this graywhackie vary in thickness from a fraction of an inch up to two feet and somewhat more. The above specimen shows the graywhackie band to be conglomeratic on the side nearest the ore. Speci-
40112 men 40112 also shows a finely conglomeratic phase of the sediment, taken about 1/4 of a mile distant from the first and on the strike of the ore bearing zone. This ore bearing formation seemed to lie sharply against the green stone on its north side without any intermediate conglomeratic or otherwise clastic material between, although this was looked for, and resembles in this respect the contacts of iron bearing

formation and green stone in vicinity of Otter Track and Jaspar Lakes, along the boundary between Minnesota and Ontario. The strike of the bedding in this zone is nearly 70 degrees east, and the dip is in general to the South, varying from 80 degrees South, to vertical. The ore bearing zone has here an exposed width of about 150 feet, and within this zone the ore predominates over the jaspar and the sediment. To the south of this exposed area there comes a valley about 150 feet below the top of the jaspar exposures, and about 180 feet in width. On the south side of this valley comes a schistose green stone like 40108. Ralph reported that he had followed this iron bearing formation for several miles to the east. He says that he also strikes it after going up the Sturgeon for about 12 miles, and then running south for a half a mile . Sturgeon River is about 3 miles north of Poplar Lodge, and flows into Lake Nepigon from the east (see map). As a result of today's observations, there can be no doubt but what there are well marked clastics closely associated with the

40108

ore and jaspar, so closely, in fact, that, in a description of the iron bearing formation, the clastics will have to be described as forming a part of it. It should be noted, however, that here these clastics are interbedded with the ore and jaspar, and that there is no well marked clastic formation between the green stone and the ore bearing formation.

Near this iron location I found a conglomerate like the Ogishke. It contained granite and green stone pebbles, but the jaspar was wanting. Glacial striae through here trend Northeast and in all probability the conglomerate referred to will, in the future, be found in place at some point Northeast of us, and probably not very far distant.

It would be very interesting, both from a scientific as well as from an economic standpoint, to trace this iron bearing formation to the east. Ralph, who seems to have traveled rather extensively through this country, reports having seen an iron bearing formation which he says is in direct continuation with this one, on Wild-

goose Lake, about 60 miles to the North of East of this point. Furthermore, he says that this formation off to the east swings down forming a half circle and connects with the iron bearing formation lying south, which is very possibly that one north of the Little Pick river.

Returned from this iron bearing location, and came out to shore, and, after having lunch, started north along shore at 1.00 P.M. On the second point, and on the islands north of Poplar Lodge, amygdaloidal green stone occurs. The point north of the second bay, that is, north of the bay, upon whose shores the Indian graves are, is formed by green stone, showing beautifully developed ellipsoidal parting. The long axes of the ellipsoids trend about east and west. One of these ellipsoids was noted, which was ten feet long and two feet broad. The ellipsoids are amygdaloidal, with very large ~~caves~~ pores upon the perriphery. Many of these cavities are of the spike amygdule order, that is, have a very marked long extension which is perpendicular to the perriphery of the ellipsoids, some of the amygdules

being 1 1/2 inches long. These ellipsoids are much smaller near what appears to be the top of the flow. Moreover, on this upper side of the flow, that is on the side towards which the ellipsoids grow smaller, there was noted a tuff of the green stone or a clastic, derived from the green stone, which occurs in a considerable mass. This fragmental material has worked its way down in the interstices between the ellipsoids near the top of the flow. At this part of the flow, one can readily see how, after very far reaching metamorphism, this tuffaceous portion filling the interstices would develop into an imperfectly schistose matrix. Its clastic character might be totally destroyed in one place, although very distinct ~~even~~ at another. In general, the matrix between the ellipsoids is much darker than the rock which forms the ellipsoids. At first I was inclined to think that all of the matrix might be of clastic origin. Later on, I saw some occurrences in which this matrix showed a well defined vesicular character. At other places, I found a matrix which could be seen to

be made up of vesicular fragments lying in the more or less homogenous material constituting the main portion of the matrix. In one instance, while examining a surface carefully, I noted a round patch 3 inches in diameter, of very vesicular basalt lying within one of the ellipsoids. There was a rather strong contrast in the color of the two, hence the fragment stood out clearly. It looks very much now to me as though the matrix between these ellipsoids was originally glass which, in places, has been very much brecciated producing an apparently clastic matrix, and again, in other places, it has not been so ~~distributed~~ brecciated, but has undergone ~~a~~ normal devitrification with subsequent production of schistosity. Although particular search was made for it, I was unable to find upon these exposures a well defined sedimentary banding in any of the clastic material which was associated with the ellipsoids.

The exposures upon this point are not so perfect that one can state absolutely that the following is the relationship of the amygdaloidal, ~~non~~-

S. T. R.

Ellipsoidal Parting

ellipsoidal green stone, and of the ellipsoidal green stone above described which occurs here. It appears, however that the amygdaloidal but non-ellipsoidal green stone occupies a central position with the long direction of its outcrop trending about east and west, and grades, both to the north and to the south, into the amygdaloidal ellipsoidal green stone whichhas associated with it the clastic material. At this place the non-ellipsoidal green stone is very much smaller in quantity than is the ellipsoidal portion. The first has a width of not much more than thirty feet, whereas there is at least 30 feet of the ellipsoidal rock on both sides. (See photographs illustrating ellipsoidal characters). Photo. It seems to me that the non-ellipsoidal green stone represents the central portion of an ancient basalt flow which graded down and up into the ellipsoidal and scoriaceous portions of the flow represented now by the ellipsoidal green stones which lie on both sides of the massive portion.

Continuing north, the first large outcrop in the bay consists of ellip-

soidal green stone. This is here cut by a fine grained red weathering quartz porphyry dike. The green stone all along the shore here, as shown by the exposures, is very fine grained. Upon this particular exposure, there are a number of well defined fine lines which run irregularly through it, and look as though they might be ~~Floyd's~~ flowage/ lines. It seems very likely that many of these fine grained green stones may have been originally ~~chiefly~~ basalt glasses. Some weight is added to this presumption by the presence, especially noticeable here, of large amygdules which are two inches across. But for the color of the rock, indicating the degree of alteration, and the ellipsoidal parting, this green stone here can be compared very closely to the basalt flows of the Keweenawan occurring upon the Lake Superior shore. These ellipsoidal green stones continue to outcrop upon the shore of the bay. Then begins a sand beach which continues north to the Sturgeon River. On the shore north of the mouth of Sturgeon River, there begin exposures of a gray conglomerate. This conglomerate consists of fragments

S. T. R.

* Specimen 40113 shows character of a pebble with some of the fine grained matrix still attached.

40

6—747

of various kinds of green stones and some vein quartz pebbles. The green stones pebbles have been very much solicified. They have been cracked as the result of movement in the rocks, and these cracks are now filled with white vein quartz, forming very intricate patterns upon the surface, and giving to the pebbles an appearance on weathered surface which is very much unlike that of a green stone. These fine lines might, if the pebbles were examined casually, appear as lines of bedding. The true characters of the pebbles show up, however, as soon as they are broken.* Specimen 40114 shows a number of fragments of various green stone pebbles. The fragments in the conglomerate vary in size from boulders two feet in diameter, down to a very fine sand and dust which is the chief constituent of the ~~matrix between the~~ matrix between the finer pebbles. A good bedding was not observed upon the conglomerates here, but a strike was obtained where there appeared to be an imperfectly developed bedding. The strike of these lines was north 30 degrees east, with a dip of 60 degrees

40114

to the Northwest. In general aspect this conglomerate is strikingly like the Moose Lake conglomerate of the Vermillion district. Thus far, however, I have seen no jasper or granite fragments in this conglomerate, although they are common in the Moose Lake conglomerate.

Exposures of this conglomerate continue on around the large point north of the mouth of Sturgeon River to the bay just south of the point east, that is, opposite the Fishing Islands, or Miscabimica. Along this shore there are some very beautiful exposures of the conglomerate. The pebbles and boulders are as a rule well rounded. As we went north along the shore, I found places, however, where the most of the fragments were inclined to be angular, but with the angle sometimes rounded off. Moreover, these fragments show a banding such as is shown in
40115 specimen 40115. I have seen banding similar to this upon the surfaces of some of the greenstones on this shore, and it seems to me very much like the flowage lines which one observes in an Obsidian. At a few places along the shore, I passed areas of amygdaloidal

and massive greenstone which had conglomerates both to the north and to the south. These areas were invariably narrow, and, while it is possible that they were interbedded with the conglomerates, I could also see how they might occur in the relations shown as the result of infolding. I was able to identify pebbles in the conglomerate with this greenstone. Among these greenstones I noted some which were distinctly ellipsoidal, and which had undoubted fragmental material between the ellipsoids. Upon other exposures, near this same place, I could see that the matrix between the ellipsoids was very similar to the massive greenstone forming the ellipsoids themselves, except that it was somewhat finer grained, a little bit more amygdaloidal, and darker colored than that. The amygdules in this matrix still retain their fillings, and the rocks appear to be relatively little mashed. I was ~~therefore~~ led to believe that the greenstones here are infolded in the conglomerate which was partially at least derived from them. At no place along the shore at least up to this point, could I find granite or jaspar

pebbles in the conglomerate, although I searched carefully for them. Specimen
40116 40116 represents a gray to reddish quartz porphyry which was found cutting the conglomerate in dikes up to 30 paces in width. To the north of the conglomerate occurring on the south side of the bay, which is southeast of the Fishing Islands, there occur some banded green and purple schistose rocks repres-
40117 ented by specimen 40117. The banding is very well developed in these rocks. I am not sure, however, whether they are fine sediments higher than the conglomerate, or whether they are extremely schistose greenstones. Am inclined, though, to accept the first interpretation of them.

August 9th. The schistose green
40117 rocks similar to 40117 continue on around the south side of the point opposite, that is, east, of the Fishing Islands. Then begin the massive to schistose non-ellipsoidal and ellipsoidal greenstones. At one place along the shore where these are exposed, I find a narrow band about 20 feet in width, of rock which shows fairly distinct sedimentary characters. An imperfect false bedding was noted for one

thing, and it showed to the eye the rounded character of the grains which we expect in the clastic rocks. Greenstone occurred both North and South of this band of sediment, but I could not tell whether it was infolded with them or interbanded with them. Just after turning into the large bay north of the point east of the Fishing Islands, there was noted a dolerite dike fifty feet wide, which cuts through the ellipsoidal basalt. This dolerite has a well marked cross columnar parting. So far as this parting is concerned it resembles strongly the dikes of Keweenawan dolerite which I have been accustomed to see cutting through the young Huronian rocks. This is very noticeable, however, in that, although it is not schistose, it is still much alterated, and has a greenish tinge that makes it resemble, in general aspect, the old greenstones. As we turned down into the bay east of the northernmost one of the Fishing Islands, this greenstone continues to where the sand beach begins. This continues across the head of the bay. On the north side there begins normal Keweenawan dolerite.

This varies in grain somewhat, although, in general, it has a rather coarse grain. In general, this dolerite seems to resemble very strongly Irving's "black gabbro", but I have seen nothing so far upon Lake Nepigon, which is like the normal lustre mottled "Beaver Bay diabase".

40118 Specimen 40118 is a piece of the normal gabbro taken from the island next to the large point due north of the Fishing Islands. A decided platy parting is noticed upon almost all of the exposures. This dolerite continues on north along the shore, and the point indicated upon the map as forming the south side of the large bay.

After leaving the dolerite, we cross a bay about 100 yards wide, and find upon the north side of this bay, outcrops of a greenstone conglomerate. This conglomerate is very much like that which I studied yesterday, and

40114 to 40117 which is represented by specimens 40114-7, inclusive, except that this is very much sheared, and is now what we would perhaps correctly term a horn-

40119 blende schist. Specimen 40119 is a piece of this conglomerate, showing a

little of the matrix. The strike of the schistosity trends north 70 degrees west. I could not be sure of the direction of bedding. North of this conglomerate belt which is not very wide, comes a greenstone complex made up of fine and coarse greenstones. All of these are very much sheared. These schistose greenstones were cut across by a dike of dolerite, similar to that of Keweenawan age, which is well developed on the lake shore and where it cut the schistose greenstones they were changed to hornblende schist. At least the presumption is that the intrusion of the dike must have aided some in the metamorphism of the schistose greenstone into the hornblende schist, as it is less metamorphosed away from than near the contact with the dike.

40120 Specimen 40120 shows the selvage of the dolerite where it is in contact with the schist.

Continuing farther north along the shore, we pass good exposures which show the coarse green stone which, in places, is very schistose. Upon these exposures one has a magnificent opportunity of studying the intricate manner in which these schistose areas

S. T. R.

Banding in Sediments

Banding in Sediments

6—747

run through the massive rocks. In places upon the exposure a perfectly massive greenstone area was found which was completely surrounded by schistose faces which graded on both sides into the massive greenstone. The coarse greenstones were seen to have been cut by greenstone dikes very much finer in grain.

Farther North and East of the above described exposures, there are bare surfaces showing the interbanded greenstone conglomerates, finer sediments, of graywacke, represented by 40121, and slate represented by 40122, this last with some light cherty bands running through it. The strike of the bedding at this place is North 40 degrees west, the dip 85 degrees to the north. Two photographs were taken to show the character of these exposures. Some of the exposures of the sediments on this shore, show some very marked crumpling, presumably due to the infolding of them in the greenstones from which they have been derived. It is practically impossible to tell from the shore exposures, however, whether the interbanding of the greenstones and sediments are due to infolding or to interbedding

40121
40122

Photos.

as of the sediments and Keweenawan flows.

After passing the area of shore line occupied by the massive to schistose greenstones, which is comparatively narrow, we enter again an area in which exposures of the sediments occur. These various areas are outlined upon the accompanying map of Lake Nepigon. I find at one place a massive broad dike of Keweenawan dolerite with fine selvage, cutting across the Huronian sedi-
40123 ments. Specimen 40123 is taken from an amygdaloidal fragment in the conglomerate which was adjacent to and presumably metamorphosed bythe Keweenawan dike. This particular specimen is now black, instead of having the normal green color of the rest of the greenstones. This change in color is probably due to the fact that, as a result of the metamorphism, black common hornblende has been produced. Away from the dolerite the fragments in the conglomerate are green, and have their normal characters. The sediments continue on to the north up to the next island. To the north of these greenstones with well developed ellipsoidal parting occur. These greenstones have

S. T. R.

Elipsoidal Partings

been very much squeezed, and as a result the ellipsoids are very much contorted, as is shown in the photographs. Photo. The matrix between the ellipsoids has been changed to a very dark hornblende schist. 40124 This is partly due to infiltration of a good deal of iron which shows upon the weathered surface, and aids in darkening the matrix and the rock as well. The greenstones are cut by acid dikes up to 4 inches in width. Quartz veins are numerous. Associated with the ellipsoidal greenstones I find the non-ellipsoidal, as well as non-amygdaloidal basalts. They are all c changed here to what I would speak of as hornblende schists. The lava character of the rocks is still clearly shown in some cases by the preservation of the amygdules. In general, these rocks remind me very strongly of the hornblende schists of the Vermillion district, which have been produced from the greenstone lavas by the intrusion of granites.

As we continue along the shore, 40125 acid dikes composed of rock like 40125 become more numerous. The greenstone appears also to become more and more metamorphosed to hornblende schists,

40126. 40126. The fine and coarse grain of these schists is probably dependent upon the original character of the greenstone from which they were formed.

I was able to note acid dikes of two ages cutting these schists. One, the older, is a grayish granite varying from a very dense rhyolite through fine quartz porphyry~~es~~ to a granite, this latter form occurring in the largest dikes. This gray granite is also cut by a white granite which likewise includes fragments of it. The dikes of both ages contain fragments of the green stone. Moreover the schistosity of the greenstones seems to have been at least partially developed before the intrusion of the dikes, for the fragments in these dikes are schistose. The schistosity of these fragments does not, however, agree with that of the adjacent greenstone walls from which they were ~~drawn~~ derived. Furthermore the acid dikes themselves are not at all schistose.

The relations of these dikes to each other, and to the greenstone, and the characters of the greenstone, can be beautifully seen upon the largest of the group of islands lying off the coast

at this place. Here also one can very plainly see that the ellipsoidal part~~ing~~ of these greenstones grades down into a non-ellipsoidal portion. It seems very probable that this ellipsoidal portion represents the surface of the greenstone, as has been emphasized upon previous occasions (l.c. U.S. Geol. Surv. Mono. Vol. 36.) In some cases where the ellipsoids are very small and gradually go over into the large ellipsoids it looks as though these smaller ellipsoids corresponded to the small slaggy pieces occurring upon the surface portion of the flow, the matrix between them representing the fragments of green stone produced by ~~contraction among themselves after they were sheared~~ friction between, and mixed with ~~one should find~~ also a varying quantity of tuff.

It was noted with some interest, that the massive portion of some of these flows had a structure which simulated the ellipsoidal structure after the flow had been sheared and had become schistose. Such structure is produced in the following way: Joints cutting each other nearly at right angles, broke the rock into rhombs. Shearing subse-

quent to this tended to round these rhombs, producing from them bodies which upon the surface have an oval outline. The main portion remains massive, whereas the schistose portion is developed between the massive parts and corresponds to the matrix in the normal ellipsoids. Such pseudo ellipsoidal structures can be destinguished from the normal ellipsoidal structure by the very narrow schistose matrix which exists between the ~~flows~~ ellipsoids, by the fact that there is a very great regularity in the size of these ~~flows~~ ellipsoids. Furthermore, in no case did I find any amygdules present around the poriphery in these structures, whereas they are very common upon the periphery of the normal ellipsoids.

August 10th. Rained during the early part of the forenoon. Got started at 10.30. Shore to the Northeast of the island has good exposures of rocks upon it. These rocks are black hornblend schists with ellipsoidal parting in them, cut by numbers of granite dikes (see photograph). These dikes increase in quantity as we go to the north, and with this increase there is a corres-

Phot. failed.

ponding diminution in the quantity of the hornbelnde schist. From what I saw yesterday and have seen this morning, it seems to me plain that the hornblende schist has been produced from the green stone by the intrustion of granite.

Continuing still farther north and east along the shore, the hornblende schist is found to be present only as included blocks of various size, and as stringers in the granite complex. This granite complex consists chiefly of a moderately coarse pink to gray granite,
40127 40127, which is cut by later dikes of finer grained gray granite. Both of these granites are very much cracked and veined with quartz, and coarse pegmatite.

Bell begins his Laurentian upon the map a short distance south of where this complex begins, or, in other words, about where the well recognized schistose greenstones end. These schistose greenstones with the associated sediments lying to the south of the Laurentian, he has included in his belt or Huronian schist. Upon the south border of this granitic area we find the rocks as a whole decidedly massive. After continuing about a half a mile north

along the shore, the mica gneisses both
40128 fine and coarse grained (specimen 40128)
begin to appear, and from there on
these gneisses are present along the
shore in considerable quantity. This
gneiss is complexly folded, and is cut
by the gray and red granite, as well as
by ~~the~~ basic dikes. The gneissic por-
tion of this complex does not appear in
the least as though it were derived
from the metamorphism of a sediment.
It has more the appearance of being an
integral portion of the granite mass
with its schistose character produced
as a result of differentiation process-
es, and movements in the granite mass.
In other words, I am inclined to con-
sider this granite and the associated
gneiss as being an intrusive mass of
younger age than the greenstones which
lie to the south and which are cut by
dikes of granite.

When we reached the north side of
the bay, I find, just Northwest of the
last small island, an exposure of pink
40129 sand stone, 40129 which is separated from the
last granite exposure by several hundred
yards. This pink sand stone is massive,
heavy bedded, and, above it, lies thin-
ly bedded brownish sandstone. The

base of this sand stone is concealed under the water. The sandstone strikes upon this exposure North 25 degrees west, and dips 35 degrees to the south-west. Farther west, along this shore, and upon the end of the point, and also in a position that would be above the sand stone, as shown by the dip of the sand stone, there comes in a normal Keweenawan dolerite. This continues and forms a large point which projects off several miles west. The dolerite is exposed practically all along the shore, occurring here and there in high cliffs. This same dolerite continues to show in numerous exposures all around the west end of the point, and upon the south shore. After passing the peculiar shaped peninsula which projects north from this point into Vermillion Bay, we come again upon a granite which lies to the east and under the Keweenawan dolerite.

Reference has already been made to the marked difference in the topography of the areas underlain by the greenstone, and those underlain by the Keweenawan. This same difference exists to a like extent or perhaps even greater extent, between the topography

of the areas underlaid by the granite gneiss complex and the Keweenawan. The Keweenawan dolerite everywhere forms a flat topped hill or ridge which come down to the shore in steep cliffs. Such topography is in strong contrast with the low rounded hills which are developed wherever the granite-gneiss complex exists. Judging from the topography, the Keweenawan which has a gentle slope to the southwest and breaks off with rather steep escarpments to the east, ends, after extending inland for some distance, as indicated upon the map. Back of this, that is, east, the low topography of the granite gneiss area continues. The presumption is that this granite-gneiss area of Vermillion Bay connects with that just south of the point formed by the Keweenawan dolerite.

Continue on east along the south side of Vermillion Bay, as far as the first island where we camped for the night. Up to this point the granite predominates. The gneiss is very scarce.

40130 40130 is a specimen of the coarse gray granite taken from the west end of the island upon which we camped.