Vermilion district of Minnesota, with Clements, Grant + Leith: [specimens] 29462-29490. No. 320 Summer of 1899

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.

Sp. 29462-29490

Summer of 1899.

Vermilion district of Minn.
with Clements & Leith.

Notebook 370

September 9th.

With Clements and Leith visited the Agamok slates and greenstone conglomerates N. of Paul lake. Here the Agamok slates are less finely banded and coarser grained on the whole than they are on Fox lake and Ogishke lake. A noticeable feature in them are the graywacke bands. Clements called attension also to similar masses in the Agamok slates at the N. end of the portage between Agamok and Fox lakes.

The greenstone conglomerate also bears narrow bands of graywacke. No evidence of any structural break between the two formations was observed. For detailed facts see Leith's notes.

In the afternoon examined the contact of the Animikie and gabbro at the S. E. shore of Gabbemichigomok lake. Here the iron formation appears on two points; one just E. of the section line, the E. line of Sec. 6. T. 46. N. R. 5 W., and the other a third of a mile to the S. W. in Sec. 1. T. 46. R. 6.

At the first point is a vertical cliff in places 30 feet high. As examined ~~along~~ along the faces of the cliff, the major part of the rock seemed to me to be clearly gabbro although within this gabbro are bands more or less

discontinuous and some of them cut off sharply, which resemble the Animikie. At only one place were the relations perfectly clear. Here a mass appeared over 8 feet long, over which was gabbro. Between the band of supposed Animikie represented by the peculiar greenish quartzitic material and other bands rich in iron were ~~these~~ *six* or some bands varying from 4 to 6 inches wide which were recognized as gabbro, 29462. That is, they have gabbro textures, are composed of gabbro minerals, including abundant feldspars, and were seen to contain the peculiar large crystals which Grant says are hypersthene and are so common in the Animikie rocks. Unfortunately fresh specimens could not be collected so that this could not be determined. Other black bands were seen of ~~similar~~ *smaller* size down to those a fraction of an inch across, which also were believed to be gabbro but the likeness in color with the iron bearing formation prevents any such close discrimination in this case as is possible when a rock of one color intrudes a rock of another color. This exposure appeared clearly to me to be a case of parallel injection of gabbro in the Animikie. How far the process

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has continued downward into the Animikie it is of course impossible to say. For when the bands of gabbro become more remote from the main mass one would expect them to undergo important changes in texture and in composition, precisely as do narrow granite injections in rocks of a different character. It is, however, supposed that many of the black bands contain gabbro material ~~and~~, including coarse hypersthene, and are more largely gabbro than Animikie, although it is not doubted that similar minerals develop in the Animikie bands. Indeed this is precisely what we have in the case of injection at many localities. The gabbro-like bands bearing hypersthene, though so abundant at this point, ~~was~~ not found, at least to anything like this extent, in the clear cut Animikie at the next point to the S. W.

Unfortunately no repeated examinations such as should have been made are recorded of the Animikie formation between Gunflint lake and Fay lake. That is, no observations have been made as to what changes take place in the iron bearing formation in passing from lower to higher horizons, although the metamorphism by the gabbro as a

whole has been recognized.

We next went to the western point already mentioned. Here on the shore is a narrow band of typical Animikie iron bearing formation. (For specs. see Clements' and Leith's notes.) This occupies but a few feet on the ~~N.~~ shore, to the point, then appears a coarse band of rock which seems to be typical gabbro. Just before the S. shore of the point is reached another narrow band of Animikie appears, and S. of this the gabbro, making the water line. Clements says that in the bay to the W. the rock is all gabbro.

In the bay, between the two points, the metamorphosed conglomerate, Winchell's muscavado, was found. The rock is coarsely conglomeratic and has sheeting but no banding which could be recognized for strike and dip. The Animikie bands on the point to the S. W. dip steep to the S. The Animikie bands on the point to the N. E. dip flat to the S. These facts of varying steepness of dip, combined with the appearance of the conglomerate between the two, indicate some sharp foldings unless the dips of the Animikie be explained by intrusions of the gabbro. For exact determinations of strike and dip see Clements' and Leith's maps.

At all of the localities examined along the contact the gabbro is found to become very distinctly heavy and ferruginous.

In places it becomes so nearly like the black coarsely crystalline ore of the true Animikie that it is difficult to recognize the difference, in the hand specimens, at least. These iron bands seem somewhat irregularly distributed. To what extent the large content of iron is due to this part being a basal portion of the gabbro and what part due to the presence of the Animikie, one can only conjecture; but I suppose that the heavy iron content is largely explained by fractional crystallization and gravity rather than derivation from the Animikie. That is, to the heavily ferruginous parts of the basal portion of the gabbro the same explanation will largely apply as applies to the heavily magnetic gabbros at Mayhew and Iron lakes. This fact of the heavily ferruginous character of the gabbro in this basal portion is another point which explains why Chauvenet did not discriminate between the gabbro and the bedded Animikie.

September 11th &12th

Lake Ogishke Muncie with Clements. Clements and I examined the border of the mass of greenstone about a mile S.W. for about a half a mile. At several places contacts were found between the greenstone and the Agamok slates. The contacts first found were somewhat obscure because of the mashing along the border of the two formations. However, there seemed here to be a more graywacke-like character to the slates near the greenstone than farther from it. The contacts found more to the E., where the slates swing around into an embayment in the greenstone, were perfectly clear. At two places here a conglomerate was found bearing numerous pebbles of the greenstone immediately below. This conglomerate was at a maximum where examined 9 feet in thickness and graded rapidly up into graywacke and this into banded slate typical of the Agamok formation; the entire transition taking place in a distance of 30 feet or thereabouts. In short we find the descriptions given by Winchell of the contact of the slates and greenstone to be essentially correct. Although he did not state this it is certain that there is an unconformity between the two and that the greenstone is older, perhaps much older, than the

Agamok slates.

On the S. border of Ogishke Muncie we found a belt of amygdaloid running from the mouth of Ogishke Muncie creek W. half a mile or more. Also another belt of entirely similar rock was found along the border of the lake ~~and~~ the islands and in the country to the W., S. of the S. W. part of the lake. Here again contacts were found between the greenstone conglomerate and the porphyritic amygdaloid, one clear contact being found for each belt on the main land. Here, as in the case of the great greenstone mass to the S., the amygdaloid is the older rock and yields abundant fragments to the overlying formation of the greenstone conglomerates. At one place on an island the porphyrite makes the core of the island and is flanked by greenstone conglomerates both on the N. and S. and furthermore has a little embayment of greenstone conglomerate on its E. side. In all of these conglomerates abundant fragments of the underlying amygdaloidal porphyrite were found, showing that the conditions of the conglomerate are due to folding and not to interbedded flows of the conglomerate and porphyrite. The same thing is indicated by the embayment of conglomerate. To the S. W.

of this locality we found the typical greenstone conglomerate carrying ~~the~~ jasper fragments. ~~bes~~. On several of the islands between the typical Ogishke conglomerate making the N. part of the main arm of the lake and the islands, and the greenstone conglomerates making the S. part of the main arm of the lake and the adjacent islands, there is a belt of slate as indicated by at least 4 islands between and by the belt of slate at the W. end of the lake. ~~between the typical Ogishke conglomerate and the greenstone conglomerate.~~

The work of the two days led to the conclusion that the small mass of greenstone on the N. side of the lake marked a subordinate anticline; that the great mass of greenstone farther S. marks a larger anticline; that the typical Ogishke conglomerate to the N. is along another anticline, the core of which has not been discovered at Ogishke lake, although it appears to the N. E. The slate belt in this syncline is marked on the maps as being cut out about three quarters of a mile W. of the Ogishke and the two conglomerates coming together. If the observations are correct and no slate gets through, this doubtless means that the subordinate syncline dies out

and we have a broad belt of conglomerate at the W. end of the fold marking the Ogishke conglomerate proper and the greenstone conglomerate. On the S.? side of the mass of greenstone near Ogishke Muncie creek, the contact was again found and here is a narrow belt of conglomerate which, however, passes quickly up into the slate exactly as does the conglomerate on the diorite to the S. There is no such thickness of the conglomerate S. of Ogishke Muncie creek as appears S. of this same subordinate anticline to the W. This doubtless means that for the western part of the greenstone there were no prominent cliffs.

Leith reports from his day's run that he found another belt of greenstone to the N. E. about half way between the two greenstone masses discovered by Clements and myself, and the greenstone mass to the N. E. This shows that this anticline continues for a number of miles. However the cross folds cause the belts of sedimentaries to overlap so that the greenstone below appears as detached masses. Still farther to the E. is another belt of greenstone which joins on to the main mass of the Saganaga-Sea Gull greenstone-granite area and

this protrudes to the E. and is undoubtedly a probable continuation of the same anticline, as the slates occur to the N. of it and between it and the main mass of greenstone of West Gull lake.

The narrow channel just N. E. of the mouth of Ogishke Muncie creek has upon one side of it the typical Agamok slates and on the other the greenstone conglomerates.

However, the slates strike parallel to the conglomerate and at the N. part of the bay is a little island which contains peculiar calcareous schists. These same schists were found between the amygdaloid and the Agamok slates inland a short distance. They may continue a little farther to the W., S. of these slates. The boundary between the slates and the greenstone conglomerate to the E. is marked by a topographical depression which continues for a long way. Along this topographic depression no search was made for these carbonate slates but, as the topographic depression has been followed by Leith for nearly a mile and in it he found no exposures, the carbonate slates may continue for that distance, and indeed it may continuously extend between the Animikie slates and the conglomerates to the

N. E. Leith reports the topographic depression to continue for 4 miles to the E. at all his cross sections. This belt may extend indefinitely to the N. E. but nothing is known as to whether this is the case or not.

September 13th.

Clements, Leith, and I followed along Ogishke Muncie lake from the camp on the island just N. of Ogishke Muncie creek to the N. E. corner of the lake.

Some of the Ogishke Muncie conglomerate islands were examined and we particularly studied the kinds of pebbles which make up the major part of the conglomerate. First in abundance were the porphyritic greenstones; also a great many massive non-porphyritic greenstones were found. Granite pebbles also were very numerous. Next perhaps in abundance would be black flints and cherts. Few jasper pebbles were seen. A great many indeterminate, fine grained, gray feldspar pebbles were noted. A few hornblende schist pebbles were seen.

The greenstone conglomerates were found at various points on the S. side of the lake, and the Ogishke Muncie conglomerate at various points on the N. side of the lake. The points which approach farther toward the center of the lake are, however, in each case composed of slate. Some of the islands in the center are composed of slate. The slate makes a considerable part of the points of the S. eastern boundary of the lake.

Between these slates and the greenstone conglomerate, wherever exposures were found, from the first place where the greenstone conglomerate appears at the narrows to the portage trail into Town Line lake, a belt of heavy carbonate slate containing a considerable amount of iron carbonate was found. This belt has at least a width of 75 paces. Where it does not appear, there is between the two formations a marked topographical depression. It therefore appears clear that there is a persistent horizon for at least this distance. Whether or not it extends between the slates and the greenstone conglomerate at the W. end of the lake is not known. At one point on the N. side of the lake where a point projects well into the lake, a similar calcareous rock was found, although it was here coarser, more gritty, and less distinctly a slate. Also it did not contain nearly pure limestone bands as did the slate to the S.

sl
29463 This is an average sample of the calcareous slate.

sl 29464 A sample of the pure carbonate bands. Both specimens are from the

S. side of the lake.

29465 The carbonated graywacke from the N. W. side of the lake.

From the work of the three days it is perfectly apparent that Ogishke Muncie lake is a slate synclinal, being carved out of this soft rock, the main body of water covering the slate formation as indicated by all the central islands and various points on the shores of the lake. Nowhere inside of this central slate belt have unmistakable conglomerates been found. On the N. W. side of the lake is the typical Ogishke conglomerate and on the S. E. side is the typical greenstone conglomerate. The difference in the character of these two conglomerates is fully explained by the fact that they are along separate anticlines, the southern one being composed wholly of greenstone and the northern anticline, where it appears to the N. E., being greenstone cut by granite. From the gabbro on the S. to the N. side of Ogishke Muncie lake, it appears that there are three distinct anticlines, between which are the sedimentaries. The thickness of the sediments, even if measured without reference to any

subordinate folds, from the greenstone to the center of the syncline, would in no case be very great. The greenstone N. of Kekequabic lake almost certainly marks another anticline and doubtless the greenstone along Knife lake marks another anticline. How many other anticlines in the broad area of Knife lake slates to the N. are wholly unknown can only be conjectured. Perhaps several exist, although erosian has not cut deep enough to develop the greenstone below.

In the typical greenstone conglomerate of Town Line lake numerous jasper pebbles were noted.

At West Gull lake Leith showed us a locality, where, on the W. side of the lake, the granite makes a point. This granite to the W. becomes schistose and then a schistose rock appears of uncertain character, and finally a schistose rock with unmistakable pebbles of jasper and other material. It is wholly impossible for one to designate the exact spot where the one ceases and the other begins. The schistosity is marked and vertical. It is, however, ~~un~~certain that there is here a great unconformity, as indicated by the granite and jasper pebbles in the overlying for-

mation. Yet this structural break is indicated by no more marked phenomena than was found between the greenstone ridges and the overlying slates S. of Ogishke Muncie.

September 14th.

With Clements and Leith make a reconnaissance of a part of the northern arm of Otter Track lake. The E. side of the arm was found to be entirely composed of slates except that the eastward projecting arm at the very N. end of the bay was not examined. At the point just E. of the portage into Jasper lake, within the slates, are narrow bands of heavy ferruginous material which contains a large amount of iron carbonate. These bands are for the most part from a few inches to 2 feet in thickness. The slates are well banded and at the time of examination were supposed to belong to the Knife lake slate formation.

sl (fl)

29466 A ferruginous slate from the heavily iron-bearing beds.

sl

29467 From the interstratified band of slate.

September 15th.

With Clements an examination was made of the W. side of the bay just mentioned. The spheroidal greenstones were found to occupy about the first mile or mile and a half of the distance with the exception of a few ~~under bases~~ hundred feet which were occupied by jasper. The spheroidal weathering greenstone seems to be perfectly typical of this formation. The jasper is largely of the brilliant red weathering variety although with it is a considerable amount of gray chert and jasper interstratified with the iron bands and having the character of ferruginous chert. The contact with the jasper was examined for a number of yards there being an actual contact. There seemed to be some movement between the greenstone and jasper and no evidence whatever was found of a fragmental sediment between the non-fragmental jasper and the greenstone, not even a band an inch in thickness. The jasper is very closely plicated, in this respect being similar to that of Jasper peak. Indeed the minor folds are perhaps closer. They plunge steeply to the N. At this pl
29468 place was taken spec. 29468 representing a close anticline of jasper and

showing the stretching of the jasper bands at the time of folding.

About half a mile N. of the jasper, which occupies the eastward projecting point, slates appear at the water's edge on a point and occupy the remainder of the W. side of the bay. It forms the portage between this bay and Jasper lake, also the S. W. part of the shore and a few of the S. W. islands of Jasper lake. The W. and N. W. shores of Jasper lake are again occupied for the most part with typical spheroidal weathering greenstones. However, at the little bay where the portage passes into the next lake into the N., jasper is found on both sides of the bay coming to the water's edge. That on the W. side of the bay was more closely studied. Here Clements found the jasper to be in a syncline, with a little central anticline, opening out to the N. This jasper is again in contact with the spheroidal greenstone for many yards. The contacts are in all respects similar to those in the bay of Otter Track lake. The jasper on the E. side of the bay extends inland to the portage trail between Jasper lake and the next lake to the N. This jasper is not so largely of the red variety. While some red jasper is present it is main-

ly the kind of jasper known as ferruginous chert and in it are many bands containing undoubtedly carbonate of iron, as shown by the peculiar red weathering and by the fact that these bands disolve out more readily than the chert bands, giving depressions. This variety was specimened by Clements.

Almost directly to the E. of this jasper with but a few paces of intervening greenstone, the Knife lake slates are found unconformably upon the greenstone. Details are given in Clements notes. While there was conformity of schistosity, there were thin conglomerates containing pebbles of greenstone and of jasper. On the portage trail this belt was about 15 steps wide. How wide at any other point was not determined. It is rather probable that the less altered character of this jasper as compared with the other jasper bands is due to the fact that this is so near to the overlying slates. The other jasper bands are at a greater distance from them. A similar relation is observed at Tower hill, only when the jasper is in the overlying slates and is more or less protected by them can the unaltered iron carbonate be found.

The very sharp contact between the

jasper and the underlying greenstone is in all respects similar to the contact of the Animikie jasper at Gunflint lake and from there to Paulson's mine, with the underlying greenstone. Only in the case of the jaspers of Otter Track lake and Jasper lake the contact is even more sharp, there not being a trace of clastic matrix, whereas in the Gunflint area a few inches or even a foot of conglomeratic material was found. It might be suggested that the jaspers of Otter Track and Jasper lakes are really Animikie jasper, being overlaid by the slate, the same as is the Animikie jasper, and resting unconformably upon the greenstone, as does the Animikie jasper. However, opposed to this view is the undoubted unconformity of the Knife lake slate on the jasper-greenstone series. And by no one has the Knife lake series been placed later than the Animikie, while by some it has been regarded as pre-Animikie. However, if the Knife lake slate be taken as the equivalent to the upper slates of the Animikie an argument could well be made for equivalence of age between the two iron formations; but opposed to this is the unconformity already mentioned between the Knife lake slates and the jasper. Furthermore, the jasper in its intricacy of folding and in its intimate association with the sphe-

roidal greenstone is parallel in every respect to the jasper of Ely and of Tower rather than to the Animikie iron formation. While the Animikie iron formations in the neighborhood of Paulson's mine, and especially to the W., is folded in large crenulations, even this folding does not approximate in intricacy of structure to the plicated jasper of the Jasper lake and Otter Track area. Indeed nowhere in the Lake Superior region is the upper Huronian jasper known to be plicated although at various places it is regularly folded. This implies the earlier age of the Jasper lake jasper, having undergone earlier and more severe orogenic movement than the Animikie formations. These ~~formations~~ do not apply to the small bands of jasper interstratified with the slates at the head of the N. bay of Otter Track.

Observations

September 17th.

With Clements made a round trip from camp on Otter Track through Cache bay and Jasper lake to ~~the~~ Otter Track lake again. At the point in Swamp lake where Smith marks the granite as appearing we found the rock to be a coarse recomposed rock containing numerous feldspar crystals and also very numerous large quartzes which seemed to be not water-rolled but practically identical in appearance with the quartzes in the original Saganaga granite. The result is to give a rock which in its external appearance resembles granite to a remarkable degree. However when broken and examined closely the quartzes are found to be in considerably greater abundance than in the granite and the feldspar, and especially the bisilicates are distinctly deficient. Furthermore the distinct granitic texture is not present. While on the belt of rocks I was in some cases doubtful as to wh whether the rock was recomposed or original, but after getting the granitic texture in mind there was no difficulty in discriminating between the two rocks. For the most part the schistose ~~facies~~ of the rock are recomposed although in places the Saganaga

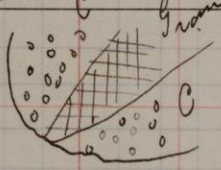
granite itself gets to be somewhat schistose and has distinct parting or sheeting planes. This belt affords one of the best examples we have seen of a rock which is made up of the constituent crystals and individuals of an original rock scarcely, if at all, water-rolled and comparatively little assorted, thus producing a rock which when recemented resembles granite. In cases where the two rocks have become schistose, it is practically impossible to tell where one ends and the other begins. This belt is about one half mile wide at ~~at~~ Swamp lake. The boundary between the granite and the slate series appears in the first bay of the next lake to the E.

At the narrows going out of this lake E. of Swamp lake into Saganaga lake we again found rock which had the appearance of being recomposed and in which I have found minute pebbles at one place, but this on account of the schistosity was not a certain determination, although it seemed reasonably clear that the rock was a recomposed one.

Passing now around the point in the Cache bay, Clements took the N. shore and I the S. shore of the bay. At the S. W. angle of the two bays a coarse

boulder conglomerate is found just W. of some islands which are made of typical Saganaga granite; also just S. of the same granite on the shore line. But the contact was not seen. The boulders are well rounded, varying in size from those less than an inch to those more than a foot in diameter and the matrix is entirely composed of granitic debris. In short it is precisely like the recomposed rock just mentioned except that it also contains numerous boulders of granite. The rock varies upward, that is, to the S. E., into well banded coarse recomposed rock without the granite pebbles. The strike here is N. 20 W. and the dip 80 W. At the northward projecting point in the S. bay the W. part of this point was again occupied by conglomerate. Here a little anticline of granite comes down from the N. and makes the shore for a space of 15 or 20 feet. On each side it is flanked by conglomerate. On one side there is a short break and on the other an actual contact, the worn face of the granite being directly against the great boulder conglomerate. Two or three feet of the rock at the actual contact seem finer grained and less bouldery than the coarser mate-

S. T. R.



Shows true position of shore. Opposite plat otherwise C. L.

rial immediately to the W. but this appearance may be due to movement at the contact plane. The appearance of the northward facing cliff here is roughly thus, looking at it as it appears looking S.

In the next little bay to the W. the great granite boulder conglomerate composes the large part of the shore but at the N. W. part granite appears and occupies all the narrow E. arm o between the two parts of Cache bay. Portaging over this arm, granite was found to the little bay about one-half mile S. of the river. Here, first, there appear patches of greenstone in the granite, then the greenstone becomes predominent but is cut by granite dikes. These continue also along the river or bay to the falls, the granite, however, appearing just ~~before~~ above the falls on the S.

side, but the green schist occupying the N. side.

At the falls on the N. side is the green schist in typical development. For an interval of 3 or 4 feet there appears to the W. a schistose conglomerate containing many granite pebbles up to those 6 or 8 inches in diameter. These are much flattened and the conglomerate evidently has been much more mashed than those heretofore described. This conglomerate differs from other conglomerates also in that the matrix is essentially a recomposed greenstone and the pebbles mostly granite. This is explained by the fact that the conglomerate is against the greenstone but was so near the granite headlands that abundant granite could be derived from that source.

Passing along the river below the falls, the slates and greenstone alternately appear on opposite sides showing numerous minor flutings of the formations, the green schist however being mainly to the S. and the other to the N.

When Saganagons lake is reached the slates are found to strike to the N., sometimes parts of the E. sides of the little bays being occupied by the greenstones and the W. sides by the slates. Here on the N. W. side of the first little point Clements found a coarse

boulder conglomerate and on the N. E. side of the second little point to the N. I found a great boulder conglomerate the matrix and boulders of which are composed of the green schist material there being comparatively little granitic ~~degree~~ débris although granite pebbles are present.

We thus have in the short run thus far 3 kinds of conglomerates differing radically from each other in & lithological character, one being granite, the other granite and greenstone, and the other green schist. Undoubtedly all belong to the same formation and their radically different character so far as constituent material is concerned is simply due to place of deposition, yet they are only, at an extreme, two miles apart.

The slate belt was found to constitute the shores of both sides of the E. arm of Saganagons lake, and where these unite with the E. arm to form the main lake. On account of time work did not go beyond the line of 48 15'.

Going S. on the W. arm, slate is again found to form both sides of the bay about one mile to the S. where green schist appears. Clements found the peninsula between the two bays to have an anticline of green schist

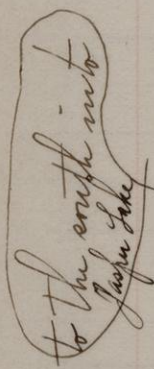
which on the W. side is flanked by jasper. And indeed the water cut in so that it is flanked by jasper on the E. side. I also found a belt of jasper on the W. side of this little arm next to the slate. All of these jaspers are alike in containing a large amount of iron carbonate, 29469, and also a considerable amount of slaty material. They hold comparatively little red jasper although the southernmost exposure at its upper part is of red jasper.

29469

29470 The green schist immediately below the jasper about 2 feet from the contact.

Just about E. of the easternmost jasper Clements found on the peninsula a slate conglomerate which, besides containing the usual materials of the slate conglomerates, contains more numerous fragments of black and gray chert similar to that in the jasper, and also red jasper. The jasper bands while spread in places are much crinkled in other places. If it were not for the fact of this conglomerate it might be considered doubtful whether or not they were basal parts of the slate series infolded with the greenstone. However, the presence of very

numerous jasper fragments immediately adjacent to one of the jasper masses is conclusive evidence that this is not the case and that the jasper is prior to the slates. The contact between the jaspers and the greenstones was found to be absolutely the same as in the work of Saturday. On these there was an absolutely sharp contact between the jasper and the greenstone. The greenstone in no case was found to be in tongues intruded in the jasper and was intricately infolded with it. The relations are those of two sedimentary formations sharply separated from each other in character of material but with no transition phases whatever.



The boundary of the greenstones and the iron formation was traced through the next little lake, connecting with the work of the previous day and here, as elsewhere, is seen to have a number of minor folds, so that the jasper passes ~~into~~ the slates on the anticlines and vice versa on the synclines. If the boundary could be traced in detail, it would be found that these boundaries are far more complex than discoverable in the hurried mapping.

The fact that the two synclines of slate unite to form a larger syncline of slate just at the line 48° 15' and

a continuation of that depression ~~as~~ is indicated by the lake in a line extending in a curve away N. E. from the Saganagons lake suggests that this lake is in a syncline largely composed of slates. Doubtless on the shores and perhaps on the islands would be found greenstone. Perhaps a large central island would be a subordinate anticline of greenstones. But I have little doubt that this is the fact as to the character of the rocks, since Smith designates these areas by the special letter E and also uses the same letter to designate the character of much of the rock which we have determined to consist of the slate series between Otter Track and Jasper lake and between Jasper lake and Saganagons. E. he calls dark green hornblende and chlorite schists, discriminating them from the greenstones and later traps which he called D. Also with E are G, soft fissile greenish gray schists, which almost certainly are the slate series, for the greenstones have not been found in this area to make any extensive areas of fissile schists, in which strikes and dips can be determined and Smith has numerous strikes and dips in this area. This seems

almost certain evidence of the sedimentary character of this lake. The strikes and dips continue directly to the granite to the N. It is thought probably that if time permitted numerous contacts would be found precisely as at Cache bay.

September 18th.

With Leith and Clements paddled from the E. end of Otter Track lake to the W. end of Emerald lake. We found the Knife lake slates to be on the S. side of Otter Track lake ~~and~~ for near the W. end of the lake, in fact to the last point; then the greenstones appear; they are found on the portage between Otter Track lake and Big Rock lake, on Big Rock lake throughout on both sides. On the portage between Big Rock lake and Emerald lake a ~~peculiar~~ big mass of jasper was seen, estimated to be 100 feet across N. and S., and its contact was found by Leith with the greenstone on the W. side of the jasper, S. of the trail. Here, the contact is knife-like in its sharpness, there being absolutely no mechanical material between the greenstone and the jasper. The jasper is much broken, has a very fine jointing, and is, in large part, of the brilliant red variety. Some of the jasper bands of the bright red variety are 6 inches across.

At Emerald lake Leith and I ran the N. side. Clements found jasper immediately on entering the lake on the S. side at the little point. We found jasper on the N. side behind the first little point, on the large is-

land W. of this point, and at two or three points on the N. shore. The relations were not studied closely on account of lack of time.

September 19th.

I again ~~re~~examined the N. shore of Emerald lake and the big island mentioned. On the N. side greenstone was found and on the first western bay. On the point on the E. side of this bay, however, jasper is found.

About a mile to the E. there is another bay setting back in which is jasper ~~found~~ on both sides of the bay. The contacts here are good and were somewhat closely studied. At the bottom the jasper is much broken and there is more or less evidence of movement between the jasper and the green schist. This may account for a band of conglomeratic looking material, 29471, which grades into a somewhat schistose looking material, 29472.

29471
29472

Below this is an indefinite graywacke-like specimen, 29473, which I suppose to be greenstone. Between this and the greenstone, however, no contact could be found. It seemed to grade into the spheroidal greenstone.

29473

The jasper at the westernmost of these two places is largely black and gray jasper with many ~~bands~~ specks of sideritic looking material. Here, there are taken near the supposed mechanical sediments, specimens of magnetitic chert, 29474, containing especially large granules of chert, which I think

29474

might possibly be fragmental.

In the ~~well~~ altered jasper is a band of 1 or 2 feet in width of sedi-
29475 mentary material, 29475, which is rich in iron carbonate.

On the other side of the point, just W. of the big island, jasper, mainly of the gray chert kind, that is, cherty jasper, is also found.

On the island both the red and gray jaspers appear in great force, occupying about the N. half of the island, the S. half being occupied by the spheroidal ~~and~~ greenstone. Here the relations between the greenstone and the jasper are substantially the same as at the other localities. That is,
29476 there is a zone 2 or 3 feet wide of material which looks conglomeratic, 29476, and this apparently passes, with no sharp contact, into the greenstone.

All the jaspers of this Emerald lake area are beautifully and curiously folded. These may be seen at almost any of the points but is best seen on the W. side of the large island mentioned. Here, as one rows along the shore, he sees most intricately folded jasper bands which closely resemble the jasper figured by H. V. Winchell in the reports for Otter Track lake. There are fan-shaped folds and curious interlockings which would be almost incredible if they were not seen. The

jasper, although so rigid, has evidently obeyed the law of flowage in filling up every chink and corner through the complex deformation. How far was this formation folded before being jasperized? At this ledge the broad jasper bands were seen to turn around and elbow with a radius of 2 to 4 inches giving a roundish surface like a set of pipes on top. Indeed, as I climbed up over them, they made me think of a series of closely laid iron pipes. These minor folds pitch to the W. at angles varying greatly, but ranging mostly between 30° and 50° to the W.

I now returned to the W. end of Emerald lake, portaged into the little lake to the N. where greenstone only was found. I portaged from this lake into That Man's lake; greenstone was found for the larger part of the portage, but just before the water was reached slate appeared. Going to the S. W. along this lake, jasper was seen at one place but there are no relations. It is supposed to be on the greenstone and below the slate. Slates occupy both sides of the lake to the W. end. On the N. side of the lake the slates have a somewhat exceptional character, in fact, when they were first struck I was not cer-

tain as to whether or not they were Knife lake.However, close examination showed the typical Knife lake slate ledges, and furthermore, showed in them what appeared to be jasper fragments, so that I could not doubt that they belonged to the Knife lake series. They contain graywacke bands, certain other bands almost quartzitic, and certain of the graywacke bands are schistose. Also,some of the bands are ferruginous. The rock is beautifully and regularly banded.

29477 This represents the schistose graywacke.

29478 Represents the dense graywacke variety.

29479 Specimen with ferruginous bands.

Portaged to the S. W. into the triangular lake. The Knife lake slates occupy the portage and the shores of the lake throughout, with the exception of the headland at the E. end of the lake, making the western projecting peninsula. Here, for the space perhaps of 200 steps, is greenstone. This is flanked both on the N. and the S. by slates. These slates continue

to the Carp lake portage. But passing into Carp lake, these greenstones are found almost immediately on the shore showing that the appearance of the slates S. of the greenstone is but due to a very subordinate syncline.

The Knife lake slates on the N. side of That Man's lake resemble very closely indeed, if they are not identical with, the Moose lake slates which I thought might possibly be lower Huronian. Like them also they contain some ferruginous bands, although not such distinct jasper bands as in the Moose lake slates. Furthermore, the slates on the N. shore of That Man's lake are schistose and ~~granulate~~ granulated, and they have suffered somewhat more than the average metamorphism. However, no reason was apparent for separating them from the Knife lake slate.

The slates at the portage into That Man's lake strike N. 65° E. and dip 65° to the S. At the W. end of the lake, they strike N. 50° E. and dip vertical.

September 20th.

The following notes refer to the main eastern portion of Carp lake. The portion W. of the narrows was not visited until the following day.

Made the circuit of the E. end of Carp lake following the shore to the left. In the little bay shortly after leaving camp I found slates. These slates were continuous along the shore of the lake to the extreme ~~western~~ eastern point ~~(western point of day's run)~~. At this place there is a little projecting arm in the bay and on this is a belt of jasper. This belt of jasper is flanked to the N. by coarse
29480 graywacke or quartzite, 29480. This jasper belt at the lake end is not more than 50 feet wide. It was followed inland for about three-quarters of a mile so that I looked down into the bay of Emerald lake. The ridge continued to rise for perhaps 150 steps, then it gently broke off at the center, leaving a depression to the N. E. along its general strike and having two arms, one swinging E., the other to the N. E. The N. arm was followed for perhaps a half a mile. Frequent traverses were made to quartzite and slate overlying structurally (underlying as to dip). Conglomerates at the

bottom of the slate were searched for definite but while certain knobby things were found, no ~~division of~~ conglomerate containing ore and jasper fragments could be found. When the depression made by the S. W. bay of Emerald lake was neared, I cross cut to the S. E., and here went down a steep hill of jasper. The jasper band is here wide, 150 to 200 feet at least, perhaps more. I cut across the steep valley and upon the slope to the S. E. found greenstone of the normal type. About 10 or 15 feet to the S. E. came upon a second belt of jasper. This jasper belt was again followed to the S. W., and there found to join on to the central jasper upon which I first started. Slates flanked it to the S. E., there, however, being an interval of 50 steps or more. At the point itself the jasper and slates are much crenulated and the pitch of the folds is to the S. W. rather ~~than~~ steep. These relations led me to infer, on the ground, that we have a southwestward plunging anticline, the greenstone being in the center and flanked by two belts of jasper, which join to the S. W. and make the point mentioned, and flanked on both sides by the slates. The jasper is much folded and crenulated and it is supposed to be the green-

stone jasper. However, it cannot be stated as an absolute certainty that it is the jasper belonging to the Animikie horizon. Opposed to this, ~~however,~~ is the absence of slates at its bottom, but the jaspers have a somewhat slaty appearance.

In the supposed anticline of greenstone and jasper, at the E. end of the lake, the dips throughout the series are to the S. This applies to the N. limb as well as to the S. limb. The dips of each vary from 60° to 80° to the S. It is, therefore, although a pitching fold, one which is overturned, the axis dipping to the S.

29481 Represents the jasper at the lake and shows the closeness of the crenulations and also one of the peculiar flinty forms which there occur.

The main part of the E. bay, speaking of the lake as composed of an eastern, central, and western bay, (this refers only to the part of the lake covered by this day's run), is of coarse graywacke and graywacke slate. In places this is schistose.

29482 Represents the schistose phase.

29483 At the big headland between the E. and central bays, the rock is very calcareous or dolomitic, 29483.

The graywacke at the narrows into the W. bay is very dense and peculiar,
Gw.?
29484 and contains large crystals of a green micaceous mineral.

The slates were found to compose the entire central bay with the exception of the N. shore, which is composed of the ordinary greenstone. The big island between the central and E. bays is largely composed of slates, but the S. W. part is composed of greenstone and jasper.

On a little projecting point on the N. side of the island is jasper. This jasper is on the greenstone, that is, greenstone is ~~above~~ both to the N. and S. of it, but between the normal greenstone and the jasper on the S. side is a belt of diabase. The ore is flanked to the N. by a peculiar schistose rock which, I thought, might be
Gw.?
29485 sedimentary, 29485.

29486 The jasper and chert is well developed, but in places it bears distinct bands of carbonate. To the S. of the ore belt are peculiar slates and jaspers which are different from anything that I have seen before in connection with the jasper. These lie, however, between the jasper and the diabase.

sl ?

29487 Represents the most flinty phase.

The remainder of the island, that is, the southern two-thirds or three-quarters of the island is to a large extent composed of schistose cal-
29488 careous graywacke, 29488. However, there are also normal slates upon this island.

Continuing now, all the islands in the middle and central bays, with the exception of one island just before reaching the narrows going to camp, are covered with slate(?). Here on the N. side of the channel is an island composed of peculiar porphyritic greenstone with big round feldspars.

The N. side of the narrows to the camp and about one-half of the W. shore of the little bay, in which the camp is situated, are composed of slates. However, just at the turn of the narrows into the bay there is an exposure of jasper of a peculiar kind, and just to the N. is a peculiar
29488 calcareous rock, 29488??

Just before reaching the camp on the W. shore, the normal greenstone appears, and at the camp itself a red, plicated jasper, which is associated with greenstone. Also the same jasper appears between the camp and Emerald lake. It seems that we have here the normal succession, which Clements

found in the Man lakes series, that is, greenstone associated with the normal plicated jasper; slates of moderate thickness; above these peculiar cherts and jaspers of the slate horizon; and then, to the S. of these, the great belt of Carp lake slates.

September 21st.

With Clements visited That Man's lake and No Man's lake. Here, at the bay of That Man's lake, is a series of jaspers 50 feet wide, below which are slates and above which are slates, the dips, however, being all to the S., although rather steeply so. No dips were taken which were less than 60 to the S., although at one place I thought they were rather less steep at the end, ~~fold~~ where Clements had a dip of 55°.

At the E. end of No Man's lake Clements showed me ~~the~~ a succession of slates and jaspers, which appeared clearly to be a synclinal. There are here two iron bearing bands, which consist of three jasper belts, the whole having a breadth of 50 feet. These again are separated by a belt 75 feet wide, 50 feet of which shows the slate in place. Below, ~~Above~~ both to the N. and S. of the two ore belts, are again slates, and N. and S. of these again are slates and graywackes. The greenstone which should appear to the N. and S. was not here cut. There seemed to be no reasonable doubt in the mind of either of us, that these jaspers are really interstratified with the slates, and that we have here a synclinal structure.

A traverse was made from about a mile E. of the portage, in a general course somewhat W. of N. Shortly after leaving the lake we found a great mass of conglomerate, which we called greenstone conglomerate, although it is somewhat different from that rock to the S. W. to which this name has been applied. It, however, contains numerous less recognized pebbles of chert, jasper, greenstone, and other varieties. Close search was not made for all kinds of pebbles on account of the time.

The course carried us over a high hill, probably 700 feet or more above the lake. On the S. E. slope of this hill are some peculiar banded rocks, which I thought were mashed igneous rocks of various kinds. Clements was less certain and thought they might be conglomerates. The core of the hill itself is undoubtedly composed of somewhat mashed greenstone. Continuing to the N. W. we have a belt of rocks which, to a remarkable degree, simulate sedimentary structure. There are bands which are finely fissile slates with beautiful cleavage but even these bands, when looked at closely, seem to have small porphyritic crystals. Other bands, which look like graywacke, turn out to be mashed porphyry. Other bands having minutely banded structures, it was at first thought must be slates,

but a close examination shows no clearly clastic texture and I concluded that they must be some kind of mashed igneous rock. There was in them undoubtedly a considerable amount of secondary impregnation and injection, although these grew before the mashing, so that the mashing gives a banded appearance. At one place, however, we found the explanation of the finely banded fissile rocks. The areas, which we thought to be pebbles, turned out to be either very much mashed spheroids in the greenstone, or else mashed fragments produced by shearing along diagonal planes. Unfortunately we did not bring with us one of the specimens which presented the most conglomeratic appearance. I have nowhere else seen a series of igneous rocks, which so closely simulates sedimentary structures. If one were guided only by the external appearance, he would call them banded sediments. They resemble the sediments associated with the ores at No Man's lake. However, when the two rocks are broken, the difference appears. Furthermore, the bands of the slates and graywackes are far more persistent than they are in the other bands. Pebbles of the conglomerate

are distinct and clear instead of merging into the matrix , the way they do in the schistose bands. Notwithstanding the difference I suspect any one not experienced in working with the metamorphic rocks would class the igneous series as sedimentary.

September 22nd.

With Leith worked from camp at Carp lake to Basswood lake, thence to Sucker ~~cor~~ and Newfound lakes.

Directly at the camp is the regularly banded, beautifully crenulated, jasper associated with the greenstone, that is, the greenstone is N. and S. of it, although, on account of the wooded character of the ground, no actual contacts were found. The slate appears in the first little bay S. of camp. At the turn into the channel running W. of S. is found a banded ore and jasper, which is similar to that found in the Man lake series. Just to the N. of it is a peculiar calcareous rock, specimened on the previous day. We evidently have here the full series in this vicinity. that is, we have a basal greenstone, upon this the jasper, unconformably upon this the slates carrying both the calcareous and true jaspery horizons, and above all, on Carp lake, a true belt of slates.

The central headland of Carp lake, as well as much of the western bay, and the headlands besides the narrows, are largely composed of a coarse graywacke, which is characteristic of the lower part of the slate formation.

These headlands are directly along the strike of the plunging anticline at the E. end of the lake. Corresponding to them is an eastward projecting headland in the W. bay of the lake, and this also is composed of the coarse graywacke. The southern part of the western bay is composed of the normal slates. Thus, while Carp lake is as a whole a part of a monocline dipping to the S., it very plainly has a subordinate anticline through the center, which makes the graywacke part of the same predominent

Birch lake was found to be surrounded by slates for about the first mile. Here at a little bay just before the long westward projecting point is reached, the greenstone touches the north shore for a short distance, but the slates make up the point to the S. W. The greenstone appears in the next bay to the N. and with a minor fold swings up into the extreme N. bay, and then swings inland, the shore being composed of slate in the narrow part of the lake next to the narrows, where greenstone again appears. The relations are such as to indicate a series of infolds, the slates occupying the depressions, and the green-

stones the headlands and high lands to the N.

In the narrows and across Prairie portage, greenstone only was found. In passing to the N. W. into Basswood lake along the S. shore, and before reaching Basswood lake, the greenstones become hornblende-schists, which become coarser and coarser and finally are cut by granite dikes. The granites appear predominently about one-half mile N. W. of the portage.

At various places, intersecting the contact at Birch lake between the greenstones and slates, the peculiar calcareous slates were found but no jasper. These calcareous slates were found to be an almost sure guide to the close proximity of the greenstones.

Running from Basswood lake to Sucker lake, the contact between the greenstones and the slates was found to cut the shore at 4 places. At each of these places, the calcareous horizon already mentioned appeared.

On Newfound lake the slate series only was found.

On the hill N. of the W. bay is a coarse rock of somewhat intermediate character cut by granite ~~facos~~ veins or dikes.

sl

29490 Calcareous ~~m~~praculite on Birch lake between the greenstones, where they first appear at the shore in ~~a~~ traveling from E. to W., and the normal slates. The calcareous slates are here much brecciated.