Vermilion district, Minnesota, with Clements + Leith: [specimens] 29491-29499, 42001-42013. No. 321 Summer of 1899

Van Hise, Charles Richard, 1857-1918
[s.l.]: [s.n.], 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. 29491 - 29499
47001 - 47013

Summer of 1899.

Vermilion district, Minn.
with Clements + Leith.

Notebook 371

September 23d.

Moose Lake.

With Clements and Leith ~~began~~ again examining the exposures N. of Moose lake along the Wind lake portage. The only facts additional to those of ~~the~~ a previous day are, (1) that the second jasper band between the two conglomerate hills is about the same width as the jasper band in the first conglomerate hill. This suggests that the double appearance of this band is due to infolding. (2) The greenstone overlooking Wind lake was found to be a core, the sediments wrapping around it. The rock here called greenstone is a finely fissile rock, as noted before, and it might not be regarded by some as greenstone.

The shore E. of the headland S. of the portage at Moose lake was examined and found to be mashed greenstone, as was also half the little island to the E. This clearly makes an anticline plunging into Moose lake, and shows, in connection with the embayment of sediments N. of the portage, that the sediments and greenstones are folded in a series of embayments, and ~~that the~~ with this idea, ~~of~~ the topography of the lake corresponds.

Upon the little island in which the greenstone appears are the calcareous sediments and also upon the point of the main land to the S. W. These

calcareous sediments again appear on the S. side of the large island directly to the S. The little island, between the main land and the island having calcareous sediments to the S., is composed of the normal banded slates. The northern horizon is clearly close to the greenstone, as heretofore. The horizon along the islands is explained by its being brought up by the anticline of greenstone, which makes up the headland E. of the island and along the main shore. This area is spoken of as an anticline because of the contact which is believed to exist between the conglomerate and green schist along the shore. If this is true and the green schist is overlain by the sediments to the S. and N., it must be an anticline, and the calcareous schists are in exactly the correct position for the iron formation.

In the conglomerates overlying the schistose rock making the S. shore, which is believed to be a large mashed porphyry, pebbles were observed which closely resemble this, if not identical with it. In the belt of greenstone, about 500 paces in from the shore, the slate fragments were again looked at. On the part of all it was agreed that they were undoubted

slate fragments. One of them is a boulder about 8 inches in diameter, which consists of bands of slate and ferruginous chert.

On the portage trail, as noted the day before, is one boulder of conglomerate. The source of these slate pebbles in the conglomerate was discussed, and it was suggested by Clements that they were intraformational in character. Leith suggests that some of the slate is autoclastic. While some of them may be dynamic, at least the varieties which are different from the matrix of the conglomerate must be explained either as from a lower horizon of the formation or else from some series which antedated the conglomerate series.

The geology above Moose lake is very intricate, from several causes. In the first place, it is one of the most closely folded areas of the district. As the result of this, the mashing both of the conglomerates and of the original rocks has gone to an extreme. Close infolding combined with this in many cases make it difficult to determine whether a rock is infolded or whether it intrudes the rock with which it is associated. Also it is difficult to say certainly where

the greenstone schists begin and the slates end. This point is of so confusing a nature that it is highly probable that any geologist going into this lake,without a good idea of the geology of the region, would confuse the sedimentary slates and greenstone. Finally the rocks are cut by intrusions. Some of these are unmashed. Their pebbles are not found in the conglomerate and they are easy to discriminate. Others are more difficult to discriminate. Consequently it is the case that some rocks which seem to be intrusive in the schist, so far as their relations are concerned, resemble pebbles in the conglomerate. Also some of the pebbles and boulders in the conglomerates are amazingly like the graywacke bands in the sediments. Indeed the likeness is so remarkable that it would be difficult to discriminate the three rocks. No other area is known to me which better illustrates the absolute necessity of doing the geology in the field and having an idea of the structure. The geology made up of a study of specimens would lead to hopeless confusion. The jasper horizon at Moose lake is supposed to be a continuation of the iron formation of the Man lake series and the Carp lake series. The pres-

ence in Moose lake of the calcareous schists at various places on the lake, and the horizon at which the jasper occurs on the Wind lake portage, the presence of the calcareous rocks, and the close association and apparent gradation of the calcareous rocks to the iron formation at Carp lake, seem to me to very suggestive of the supposition given on the previous day, that the calcareous horizon between the conglomerates and the slates at Ogishke Muncie is representative of the same iron horizon. These things join together to confirm the general idea that this horizon is the equivalent to the Animikie iron horizon, and that the great Animikie set of slates is equivalent to the Knife lake slates, and that the conglomerates and associated slates below are, in a general way, equivalent, although here on account of the headlands and thinning and thickening the equivalence is only general. Between the mashed greenstone cores and the mashed recomposed rocks, especially when fine grained, there is more appearance of gradation than at any other place I visited in the district, but not more so than at various places in the Marquette district.

September 25th.

With Leith and Clements examined little Neck between two little lakes in Sec. 4. T. 63. R. 9. At the S. central end of the Neck are several bands of jasper associated with greenstones with very sharp contacts. No evidence of sediments between the jaspers and greenstones were found. One of the bands at the S. end of the Neck diverged and reunited in such a way as to indicate strong infolding with the jasper. See sketch by Leith. The greenstone appeared to be the lower rock although the dips are so steep that this cannot be ascertained. At places the greenstone on the Neck could be interpreted as intrusive in the jasper and having fragments of the jasper, although this interpretation would probably be somewhat forced.

At the N. side of the Neck is the typical spheroidal greenstone. Immediately S. of this is a belt of banded rock having all the appearance of a sedimentary slate and graywacke. Next to the greenstone is interbanded slate and jasper. The jasper bands are here very narrow and so poorly exposed that the relations could not be made out. Next above this interlaminated jasper and slate is 15 feet of

slate at its widest place, and immediately overlying this is a jasper 4 feet wide. This jasper is of the brilliant red, clean cut variety, almost entirely free from any slaty material, and a specimen of it could not be separated from the most typical jasper of the Ely and Tower areas. Also it seems certain that this jasper is substantially the same jasper as that in the remainder of the ~~N~~eck next to the greenstone. At least, any separation of the two would seem to be gratuitous.

The natural explanation of the phenamena here is that we have a set of mechanical sediments with some chemical sediments near~~er~~ the greenstone, then a belt of mechanical sediments, and over these the chemical sediments of the jasper. That these belong to a lower series rather than to the series to which the Man's lake jasper belongs, seems to be strongly indicated by the fact that the overlying conglomerate of the series immediately to the N. contains numerous fragments of chert, jasper, and slate rocks identical with those here found. The fragments in the conglomerate were examined yesterday with special reference to their being greenstone and it was agr~~ee~~d that they were true fragmentary rocks.

It was also agreed to-day that the fragments were identical with these slate rocks associated with the jasper whatever the origin of the slates. The question was raised as to whether the slates are really mashed phases of the greenstone. On this point the following statements seem to favor the sedimentary character. The bands are not discontinuous and broken as in the case of schistose rocks made by flattening spheroids of greenstone; the bands are not regular alternations of coarse and fine layers of similar kinds as in the case of the spheroidal greenstone, the coarse layers being made by the cores and the finer layers by the periphery of the spheroids; but the bands are of varying width, some of the so-called graywacke bands being 2 feet in thickness, and these being overlain by other bands of varying width from those a fraction of an inch across to those several inches across. So far as the field appearance is concerned it has every aspect of a sedimentary rock rather than of an eruptive. Little eyes of what are supposed to be quartz are seen in some of the coarser varieties. I have little doubt that we have here one place where mechanical sediments were

deposited under the jasper horizon so intimately associated with the greenstone.

Leith has full sketch of field relations.

A short distance to the N., about one-half mile, Clements showed us a place where the green schist contains narrow bands of jasper, and also has upon its upper surface a narrow band of brilliant red jasper, probably not more than a foot or two in thickness. This green schist and jasper is overlain to the N. by a conglomerate. In direct contact with both, for the jasper is not continuous and sometimes the conglomerate is against the jasper, in other places against the green schist, the conglomerate contains numerous fragments both of the greenstone and of the jasper. The jasper is of the brilliant red variety usually associated with the greenstone. There can be no question that at this place the conglomerate is basal and rests upon the green schist and jasper as a basement.

Leith made a sketch of relations at one point where the conglomerate rests upon the jasper, the jasper being between the conglomerate and the greenstone at this particular place (see opposite page).

In the immediate vicinity Clements showed various places where the jasper is between the greenstone and the conglomerate; showed other places where the jasper is apparently in the greenstone, the conglomerate and the basement below it intricately infolded, and tongues run in and out in a most curious way. Nothing but a close examination would reveal the true relations for, if areal distribution alone was looked at, one would be as apt to find one rock as the other. Only the fact that the greenstone and jasper are contained as fragments in the conglomerate gives a true guide to the succession.

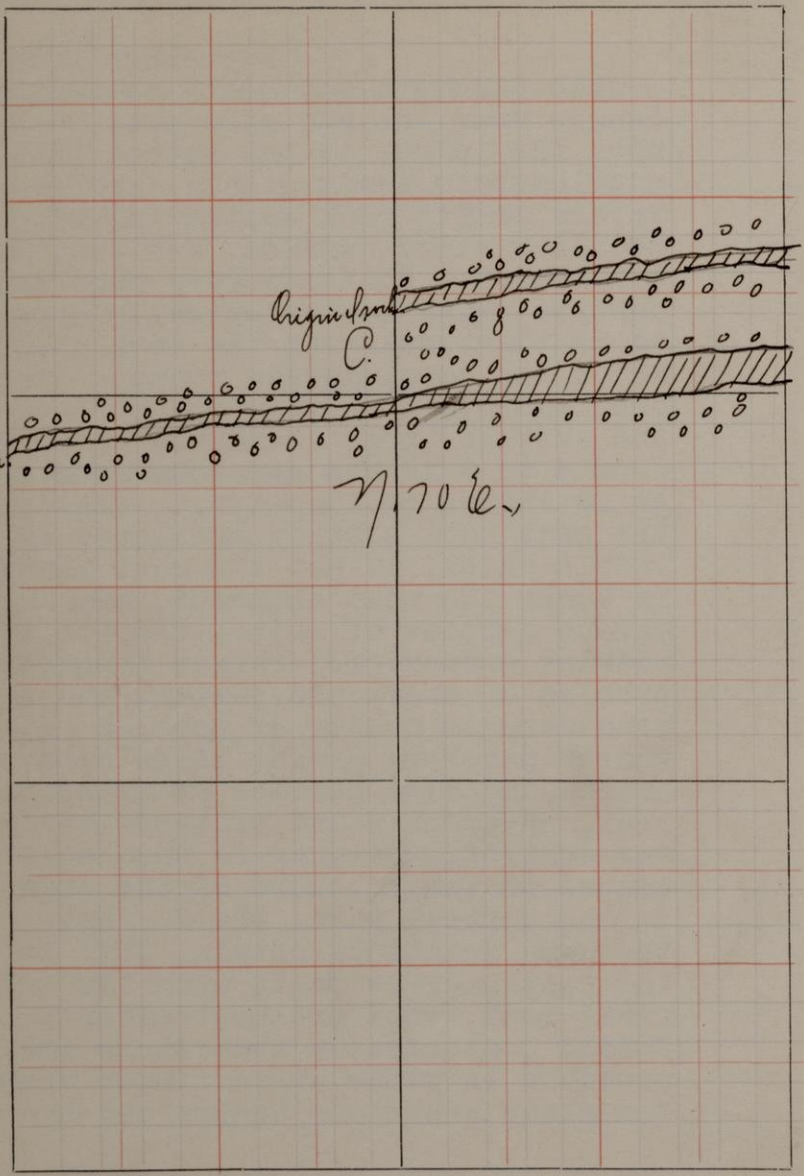
This occurrence taken in connection with the occurrence mapped by Leith between the two lakes, makes it highly probable that the jasper between the lakes belongs with the greenstones and not with the jaspers associated with the slates, such as occur at the Man's lake area, for the jasper both between the two lakes and at the place where this unconformable contact is found is of identical character and of comparable magnitude, and seemed in every way to be the same formation. The association of the sediments with the jasper between the two lakes, as above stated, seem to unite these two forma-

tions. If this conclusion is correct, we have here at least some mechanical sediments associated with the jasper and resting on top of the greenstone. The query which arises in this connection is, why similar sediments do not occur in the adjacent jaspers and furthermore there is the possibility although it was not considered probable, that the sediments intimately associated with the jasper represent the upper series to which the overlying conglomerates belong, closely infolded. However, in favor of this view there are certainly no discoverable facts, although it cannot be absolutely denied as a bare possibility.

September 26th.

With Clements and Leith reexamined ledges near the 92d mile post. Here upon the ledge, it was agreed that a conglomerate rests upon a dark gray rather acidic rock weathering with a peculiar ridgy surface, and that the conglomerate contains very numerous pebbles which macroscopically appear to be identical with the rock upon which the conglomerate rests. The conglomerate is a very coarse one, the average large fragments varying from 4 to 8 inches and some from 12 to 18 inches in diameter. Beside the gray rock already mentioned as the pebbles which, if not the most abundant is among the most abundant, are numerous pebbles of rather massive appearing greenstone; rather frequent pebbles of chert and jasper, and a considerable number of pebbles of quartz porphyry having large eyes of quartz, and also pebbles of granitic rock, apparently two or three kinds. The contact mentioned is seen at two places on the N. slope of the ledge, in the central part, and N. part. If the same relations obtain, that is, the conglomerate rests upon the original rock, they are most closely folded , so closely that it is impossible to place one's finger upon the place where one begins and the

S. T. R.



other ends, -- so closely infolded that a casual examination would almost certainly lead to the conclusion that the two were interbanded. However, it is Van Hise's belief that, in consideration of the facts of the derivation of the abundant fragments of the underlying rock, it is a series of close isoclinal infolding rather than of interbanding. The original rock, and apparently the sediments also, are cut through by greenstone dikes, and in places the banded rock has numerous little dike-like areas arranged in a parallel manner, which can be interpreted either as ~~parallel~~ metamorphism without mixture, or as injection, or as gradations between the two. For my own part I suspect that all phases, from the bands which are essentially sedimentary but have been somewhat influenced by the jasper intrusion to bands which are clearly parallel injections may be found.

The ridge of original rock, or what was taken to be this, is on the N. slope of the hill. It is well exposed at two places for the space of 20 to 30 feet. Between the two, if it does not altogether disappear by the overlapping of the conglomerate, there is an overlap of two feet.

Higher up the hill at the E. end is a ridge of the original rock near the crest. This is traced for a distance of 50 feet and is at its maximum 4 feet wide. It narrows down to not more than a foot or two wide and it looks as if it would join on to the western exposure. That is, the three exposures are in a triangle all being flanked by conglomerates on either side.

Next we examined a series of ledges to the S. which Merriam and I went over and which we thought to be sedimentary the first time, but which the second day judging from the small areas of the rock adjacent to the conglomerate, we supposed to be igneous. Our close reexamination convinced us to-day that this series is sedimentary. It consists of slates approaching mica-schists or micaceous graywacke, and of fine graywacke conglomerates, clearly interstratified, varying in coarseness, well and continuously banded, and, in short, having all the characteristic structures of sedimentary rocks. In it at one place is a ferruginous slate. this rock like the conglomerate was found to by cut by a large altered basic eruptive, which Clements specimened.

29491 Specimens representing varieties of
29492 graywackes.

29493 Represents the very fine grained conglomerate.
Clements has specimens of the slate.

29494 This is a specimen of the ferruginous slate which, when first looked at, resembles a jasper band, but which was found merely to be a ferruginous mica-schist.
Returning now to the conglomerate ledges, specimens were obtained from the pebbles which are believed to duplicate the graywacke and slate phase, or at least a part of them.

29495,
29496 These represent three of these
29497 varieties.

29498 Represents the coarse porphyry pebbles.

29499 Not collected, vacant number.

The section on the railway track was looked over again and it was very, very difficult indeed certainly to discriminate between what is taken as the core rock and what is taken as conglomerate. In short, we have the

same difficulty there as in previous days.

While the occurrences are somewhat obscure and very peculiar, the finding of pebbles apparently metamorphosed resting apparently on rock of like character, combined with the fact that pebbles are found which in every macroscopic way resemble the graywackes and slates to the S., led me still to hold that in the coarse conglomerate we have a newer series resting on an older series of sediments which were probably considerably metamorphosed before the upper series was laid down. We find basal conglomerates upon other classes of sediments and there is no reason why a basal conglomerate may not rest upon a conglomerate of a prior age, only such a series requires the utmost care in discrimination in order to be sure of conclusions.

Continuing N. on the railway track the next ridge found was about one-half or three-quarters of a mile N. of the conglomerate above described. This rock, while metamorphosed, still ~~suffered~~ distinctly shows its fragmental character containing readily recognizable blue eyes of quartz, specimened by Clements, 40008.

Continuing farther to the N. the slate and graywacke are at places interstratified. While as a whole very

much less metamorphosed than the supposed older series S. of the conglomerate, they are at places very close to mica schists and present a peculiar ridgy weathering, which is very similar to that of the sediments S. of the conglomerate.

A little farther on, the porphyry was again examined and compared with a pebble from the conglomerate and found to be different.

No new observations were made on the greenstones and greenstone schists except that it was recorded that a number of the ledges were distinctly schistose, more so than in general for the region, although not more so for the immediate area about Tower and Ely, perhaps.

September 27th.

With Clements and Leith examined the various points and islands on Vermilion lake. The first point visited was the N. hill of the Burnt Forties. Here Clements and Leith showed me a fine grained quartz porphyry which was cut by the porphyry which we have called the big-eyed porphyry. There seemed to be no doubt about the relations. They also called my attention to the peculiar character of the iron ore formation at that locality. The bands instead of being interlaminated with layers of pure chert are more generally interbanded with layers of slate having a slaty cleavage, ~~than any~~ which I had not before observed in the region. Clements collected a specimen which showed the slaty cleavage going directly across the bands of slate and stopping abruptly at the layers of iron ore, the latter being crenulated in such a way as to show the direction of pressure + shortening. I collected a large fold 42013 which showed the same ~~thing~~ thing 42013, the cleavage on the flanks of the fold in the slate not being parallel and showing the relations of folds to cleavage in slate beautifully. Leith collected two specimens of typical slate.

a thing which

Finally Clements called attention to a structure which he stated resembled cross bedding in bands almost gray-wacke-like between the iron bands. It seemed in this case to be perfectly clear that the iron formation is partly mechanical, much more clear than I have seen at any place in the district. Some of the slate bands appear to contain iron carbonate. Above specimens are in Leith's series of numbers.

We next went to the prominent point on the main land N. of the Burnt Forties. Here is a big eyed quartz porphyry flanked on either side by conglomerates but the conglomerates are not in contact with the porphyry. Pieces of the porphyry were taken to the conglomerate near the end of the point, and Clements and Leith decided that in the conglomerate they were able to find pebbles which so far as all macroscopical appearance was concerned are identical with the porphyry. This is the same conclusion which is contained in my notes of a previous day. We next went to the point S. of Mud Creek bay and spent some time in examining the different rocks there occurring. Without reference to order of examination the following facts were observed.

There is a greenstone making a part of the point and a large part of the country farther inland which seems to be clearly cut by the big eyed porphyry. It contains, or at least is very closely associated with another rock which I was inclined to think to be some kind of igneous rock allied to the porphyry but which has certain ferruginous and schistose phases that may be slates. Upon the point itself are several areas of porphyry. Some of these areas of porphyry cut diagonally across the topography at an acute angle. Others of them seem to be in rounded or irregular patches, although I did not follow them out so as to be sure of this.

Intimately associated with the porphyry and either cut by it or conformably overlapping it is a rock which Clements and Leith held to be a conglomerate. I was at first doubtful as to whether it was a conglomerate or not but afterwards had no doubt on the subject because of the fact that it contains pebbles of different kinds of slates with very numerous chert and jasper fragments.

The point is occupied by undoubted slates. These slates at places, as pointed out by Clements, appear to

grade into the conglomerate through peculiar banded rocks, the coarser layers of which are novaculitic looking. The only element about which there was any doubt was as to certain graywacke-like phases which Clements and Leith thought to be an integral part of the conglomerate slate series but which I thought might be mashed porphyry. ¶ It seemed to me highly probable from the relations at this point combined with the observations at the previous point, that the conglomerate is subsequent to the greenstone and to the big eyed porphyry which intrudes it. Whether it is subsequent to and unconformably upon the apparent porphyry which occurs at various places along the point, could not be conclusively determined at that place, as two persons with equally fair mind might hold the relations to be explained by intrusion and by infolding and overlapping. Probably that can best be decided by ascertaining whether porphyries like the porphyry of the point are elsewhere intrusive or unconformably under the conglomerate.

A large scale detailed plat of this point was made by Clements and Leith a few days later.

We now went to Ely island where Clements and Leith showed me a very much crenulated contact of porphyry and conglomerate the general strike of which was across the schistosity of the conglomerate and the general strike of the region. The contact was not well exposed in the dimension but seemed to show in the case of the longest and best exposed contact ~~with~~ that the porphyry undercuts the conglomerate at a gentle angle. In two other places the reverse was true at a steep angle, although this seemed to be exceptional. Finally the porphyry contained a little of the conglomerate about a foot or two from the main mass of the conglomerate along the contact in which the porphyry undercuts the conglomerate. The question there again was raised as to whether this meant intrusion of the sediments by the porphyry or whether the conglomerate is intimately infolded with it. Upon this point it seemed to me that no decisive evidence was available, although I personally, guided by the facts previously observed in the district, was inclined to believe it infolding rather than intrusion.

We next visited some of the small islands S. of Ely island in reference

to Smyth's theory of the brecciation origin of certain of the conglomeratic appearing rocks. It was decided in the case of a number of islands that the rocks are largely, if not wholly, conglomerate. The bases for this conclusion are:

1. That various porphyry fragments are contained in a single exposure rather than a single kind of porphyry.
2. That these porphyry pebbles are in a well defined matrix different from them.
3. That in various places the rocks exhibited a distinct banding similar to the slates and conglomerates elsewhere.
4. In the conglomerate are numerous chert and jasper fragments.

However, one small island was examined just S. of the W. end of the larger of the islands S. of Ely island, where a different state of affairs exists. Here again the rock is broken up into pebble-like areas somewhat although rather rounded and at least very old. Weathering progresses more rapidly between these areas and thus the rounded areas portrude as seen along the shore. When the island was first seen, we all three supposed that we had a conglomerate such as that contained in the islands

just described. However, going on shore we found that all the lines of evidence upon which we relied to prove the conglomeratic character of the other islands here failed. Between the roundish areas there is no matrix but merely a skin of material. These roundish areas fit one another somewhat closely and between them are various triangular or curious irregularities which fill~~ed~~ out the space. Many of them can be seen to have roughly quadrangular forms which Smyth describes. They are all of one kind instead of various kinds of porphyry. In the part of this island in which this rock occurs no fragments of chert or jasper are discovered. It was therefore concluded that Smyth's explanation of this rock as an autoclastic rock is correct. A person reaching this conclusion in reference to the rock of one of these islands might very readily extend the conclusion to other islands truly conglomeratic, overlooking the facts already mentioned as being in favor of the conglomeratic origin.

Finally, as it occurred to both Clements and myself independently, this peculiar brecciated porphyry is the one which is very abundant in the

conglomerates, as pointed out by Leith and Clements in various places.

Upon the S. side of this little island Clements found an interbanded slate and iron formation very similar to that seen in the Burnt Forties.in the morning, closely folded and in places brecciated. This furnishes a source near by for the jasper pebbles in the conglomerate.

We next went to Stuntz island making a section from N. to S. Here is a rock which Clements had been disposed to think was graywacke, and which I, on a previous visit, had been inclined to think was porphyry. The porphyry, as pointed out by Clements, is different from the ordinary quartz porphyry of the region and from the big eyed porphyry. It is cut as described by Clements by the ordinary quartz porphyry, or at least so the relations looked to me from the hasty examination. Fragments of this porphyry were taken to the conglomerate and pebbles sought but they were not satisfactorily matched, although the conglomerate contains many of the ordinary quartz porphyry which is cutting this rock.

It was late in the afternoon and, so far as I am personally concerned, I did not sufficiently examine Stuntz island to be sure of the above, al-

though they seemed to be satisfactory.

As a result of the day's work combined with the previous work upon the region, I am inclined to believe that the greater portion of the porphyry of the district antedates the Stuntz conglomerate, for the following reasons:

1. Some of the porphyry can be absolutely matched in the pebbles of the conglomerate. This statement applies, I think, to the big eyed porphyry, to the so-called ordinary porphyry, and to the dense peculiar porphyry with feldsitic matrix which composes the autoclastic rock above referred to.

2. The porphyry and Stuntz conglomerate are most intimately associated. The porphyry or porphyries are found on Stuntz island on the two points already described in the day's notes on Ely island and on the islands to the S. In each of these groups also is the Stuntz conglomerate. Moreover the Stuntz conglomerate in its typical development is close to the porphyry, frequently, as indicated in the notes of the day, in direct contact with it.

3. In passing away from the porphyry at a number of places, the conglomerates disappear, being replaced

by graywacke or slates, more ordinarily by slates, although in the case of Canoe island Clements and Leith say the slates are in close association with the porphyry. Also at one place on the point S. of Mud Creek bay, the same relations obtain. The question which I would regard as open is not the priority of the Stuntz conglomerate to the main mass of the porphyry of Vermilion lake, but the question as to whether or not some of them cut the conglomerates and slates. Undoubtedly, the relations of the points S. of Mud Creek bay and on the E. end of Ely island, would ordinarily be explained as intrusion of the porphyry in the conglomerate although, influenced by the general relations and order of the district, I am myself personally inclined to the contrary view.

September 29th.

With Leith and Merriam visited Tommy Walsh's exposures of jasper in the N. half of section 3 immediately S. E. of Tower junction.

We there found, just S. of the low lying area which is supposed to be underlain by the upper slate, an extremely contorted belt of jasper underlain by amygduloids. The amygdaloid has the normal appearance of an altered amygdaloid a little away from the jasper. Near the jasper it is micaceous and if it were not for the amygdules one might suppose it to be a mica schist.

42001 Specimen of amygdaloidal schist.

At places this rock so closely resembled a sedimentary rock that it was supposed to be a mica schist, and indeed I was not certain that close to the jasper the material might be a mica schist recomposed from the amygdaloid. This, however, is doubtful.

42002 This represents the mica schist which is free from amygdules and looks very much like a sedimentary rock.

42003 At places the rock becomes banded and ferruginous, and still more closely resembles a sedimentary rock. How-

ever the banding seems to be due to movement planes. This rock taken by itself would unhesitatingly be called a ferruginous banded mica schist.

42004 At places very close to the jasper the rock is somewhat coarser and suggests a fine grained conglomerate.

42005 At other places the rock near the jasper contains small fragments or amygdules of jasper rather than of white quartz.

42006 At still other places the rock is dense green and schistose and has a fine even banding, which however is believed to be secondary.

If any of these rocks are really sedimentary they are probably 42003 and 42004. If there is really a recomposed band at the top of the amygdaloid, it is an exceedingly narrow one, not more than 2 or 3 feet in thickness. For below that the rock takes on an amygdaloidal character and appears to grade into a ordinary amygdaloidal green schist. The exceptional characters of 42001 and 42002 are apparently largely due to silification and other metamorphism. At places there is a porphyritic green schist closely associated with the

amygdaloid, but whether it cuts the amygdaloid or grades into it was not certainly determined.

The jasper itself is very closely folded so that it makes a series of plunging folds, with axes dipping steeply to the N. These wind in and out on the ridge so that if one did not keep track of them,he would not know whether he finds himself upon the jasper or upon the amygdaloid. One considerable fold spreads for quite a distance into the amygdaloidal area and is clearly a syncline which shoots off to the S. E. If one keeps track of the way the jasper runs, he has no difficulty in seeing that the amygdaloid is always at the bottom, and that the two rocks maintain the the same relations, although at one or two places the infolds are very close.

The jasper itself is exceedingly peculiar. In general it is of the kind which I have called black jasper but it has some exceptional characteristics. In places it shows a very fine banding, which makes it look almost like banded feldsite.

42007 At other places with this material it has narrow bands of material which Leith thought might be injected igneous rock.

42008 Apparently these very narrow bands of possibly igneous material grade into belts a foot or more in width, which have round and irregular areas partly filled, and which Leith thought are certainly amygdules. The bands having these areas vary from those of feather width to those 2 or more feet in width.

42009 This specimen is from a band about a foot in width. In places the igneous looking material appears clearly to cut across the jasper bands, and this favors the idea of intricate injection. If this has occurred, it has been an intricate parallel injection with some cutting across, and the injecting material has in some way become amygdaloidal. However, I myself am not completely satisfied as to the origin of the peculiar rock represented by 42009, and the varieties between it and the other narrow bands of igneous looking material in it. In places the feldsitic jaspery bands are brecciated, or, if not brecciated, are conglomeratic or pseudo- conglomeratic.

42010 These bands in many respects are similar to 42007 and 42008, only that they have very numerous roundish areas

The injecting and cutting material in the jasper is probably a different rock from the underlying amygdaloid. It has a different appearance and is not connected with it. As already stated, the amygdaloid seems to be the bottom rock upon which the jasper formation was deposited. Also all the igneous looking material in the jasper, that which bears areas which might be interpreted as amygdules has a different aspect from other bands which seem to be cutting.

Specimens of the normal red jasper and black jasper which occur there were not taken. The specimens are of the exceptional varieties of the rock rather than of the normal varieties, although a considerable quantity of exceptional material occurs near the contact with the underlying amygdaloid.

In the amygdaloid in places there are considerable quantities of jasper in roundish areas which simulate amygdules, but which may be due to brecciation. If one examined only this series of ledges and did not consider them in reference to other areas of the region, he might conclude that a considerable breadth of material at the bottom of the jasper formation was due to silicification of the amygduloid

Certainly it is the case that the amygdaloid has been silicified to a certain extent. This would be the natural consequence of the abundant material making a jasper formation just as the veining of jasper is a natural off shoot to a peculiar jasper formation. If the explanation is applicable it is applicable only to some of the exceptional varieties, nearer the bottom of the formation, at the particular place visited.

Afternoon of September 29th. With Merriam and Leith visited various places on Lee and Tower hills. We examined again, the intricate infolding of the green schist and jasper and were again impressed with the extraordinary complexity of this folding. Not only are the dips substantially vertical E. and W. but the pitches of the folds are vertical or nearly so. The result of this is that where the green schist and jasper come together, the contact is a most extraordinarily complex one. It runs in and out; in places the jasper might be supposed to be ~~from~~ the green schist, in other cases the reverse: in other cases one might be supposed to cut the other as an intrusive. In some places there is a brecciation along the contact of the two, so that in the green schist there are pseudo-conglomerates, and in the jasper pseudo-conglomerates. One of these conglomerates, which is believed to be of dynamic origin, has a green schist matrix in which are numerous fragments of banded jasper. Some are well banded, others subangular, others with curious points, and a considerable number in roughly rhomboidal form. It seemed probable to Leith and myself that this pseudo-conglomerate is really dynamic.

The schistosity follows roughly E. and W. It cuts the schist but usually stops abruptly at the jasper bands. This adds still another form to the complexity of the structure at the contacts. However much one were confused along the contact if he considered these things alone, if he looked out for the broad distribution he would find, as Merriam and Clements have found in their mapping, that the schist belts and jasper belts away from the line of contact are broad bands, which can be separated as such, the major folds being made out and the schist being along the jasper. While ~~the~~ curious brecciated and conglomeratic appearances were found at a number of places, no rock was found which I could be sure was a true conglomerate below the jasper.

In places the central parts of the green schist show spheroidal structure much flattened and schistose but apparently unmistakable.

At only one place was any satisfactory evidence found of a mechanical sediment below the jasper. This was at the ends of the plunging folds of jasper at the central cross anticline, mapped by Merriam, by means of which the green schist runs N. and S. paral-

lel to the plications of the jasper and above across the general strike of the hill. Here, as described in the notes of a previous day, are bands of schist and graywacke-like material which seem to be very strongly indicative of sedimentary origin. A rough sketch of one area is found in my notes. Merriam makes a sketch of a larger area, the part represented by myself being on a smaller scale.

Further examination in this locality showed that the bands of graywacke schist extend for some distance N. and S. along this cross-anticline, and moreover are found on both sides of the cross belt of jasper. It appears perfectly clear that these bands underlie the jasper. The bands varying from those but a fraction of an inch across to those a foot or two across go crinkling across the schistosity of the interlaminated schists and strongly suggest sedimentary structures. In this connection it should be remarked that this is the place on the hill where such structures are most likely to be retained. The bands of the sedimentary material can at most be but a few feet in thickness. Supposing the pitch to be vertical and no thickening

to occur by crenulation, the apparent thickness would not be more than 8 or 10 feet and the original thickness may not be more than a half to a third of this amount. The contact could be traced at the E. end of the sedimentary material with the schistose material which contains the big round areas characteristic of the spheroidal greenstone. This contact seemed to be fairly sharp for the few feet where the rock was exposed, so that it looked as if we had here both the bottom and the top of the mechanical sediments. A little to the E. of the bottom contact the apparent sedimentary rocks again appear but this could be explained by a subordinate fold bringing up this belt a third time, precisely as it is brought up twice by plunging under the jasper.

42011 The coarser material is represented by 42011.

42012 This represents the schistose material between the bands of graywacke.

While the occurrence of the banded slate and graywacke is not conclusive evidence of mechanical sediments below the jasper, this is the most satisfactory case of such material which I have

found in the district with the exception of the Robinson lake case. The difficulty of accepting material as mechanical sediments is that the bands found cannot be traced along the sides of the folds for any distance. In the bands there occur also, ~~match~~ magnetite ing has so changed the banding of the rocks that they cannot be certainly recognized as sedimentary structures. Often, indeed in general, next to the schistose long sides of the folds there is more or less of banding. In places this banding is rather continuous and suggests sedimentary structures. However taken by itself one can never be certain that they are not produced by the flattening of the spheroidal greenstones combined with cementation, but taken in connection with the apparently well banded graywacke schists cutting across the schistosity, it seems very probable that the gray schists along the sides of the folds close to the jasper are also sedimentary, at least in part.