[Lake Vermilion area, Minnesota]: [specimens] 40002-40028. No. 327 [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.

No 5

40007 – 40028

No. 327

In the greenstones conglomerates there were also found a number of slate pebbles and their source has not been very satisfactorily accounted for. If we accept the presence of the sediments, mentioned a few paragraphs above, ~~and~~ found lying in a position between the jasper and the greenstones as indicative of a fragmental sedimentary horizon underlying the jaspers, then these slates are accounted for as they occur in conglomerates younger than the jaspers and containing fragments of the jaspers. Such conglomerates would of course likewise contain some fragments of the sediments underlying the jaspers. Going N. across the ridges of greenstone we pass, in a number of places, very good exposures of breccia zones. Such zones in these greenstones and also the numerous sheared fractures which traverse the greenstones we think have been caused by its subjection to great stresses. These have not, however, been sufficient to produce a very noticeable schistosity in them, the greenstones on the whole being very massive. The movements in the rock have taken place for the most part by fracture. Shearing has occurred in places, especially in the ellipsoidal greenstones. Moreover some of these seem to have been more sheared than others. It is among

these ellipsoidal greenstones that we find numerous cases of good friction breccias.

40002 At one place upon the N. face of the high greenstone ridge, just before we reach the overlying greenstone conglomerates, I notice a number of depressions in this ridge; depressions which can be spoken of almost as troughs. At first I supposed that they were due to glacial action, representing troughs dug in the rocks. At one place, however, in following one of these troughs I noticed that there remained in it still some rock 40002 represented by spec. 40002. Further search showed a number of places upon this ridge where this rock occurs. Does this rock represent an igneous flow which having overflowed the ellipsoidal greenstone filled depressions in its surface or does it represent a crystal tuff which, being deposited upon an ellipsoidal greenstone flow, filled the depressions in its surface? Or is it possible that these are remnants of dikes which have followed along depressions in the greenstone? Crystal tuff, I use this term having reference to a tuff made up for the most part of crystals. Such a tuff is of frequent occurrence in the vicinity of Vesuvius and other modern volcanoes.

October 10, 1898.

Continuing N. over the greenstone I find a dike of very micaceous minette like rock cutting ~~them~~ it. A specimen was taken as nothing exactly similar to this had been previously noted. This specimen was given one of Leith's numbers.

Just S. of the portage from Moose lake into Wind lake and on the W shore of this bay there are a number of exposures of green schist which followed W. join on to a massive ellipsoidal greenstone which forms a high hill at this place. This hill, being surrounded by sediments to the N., S., and E. at least, should be put in as a greenstone anticline similar to those S. of the lake. Examine carefully the runs of previous years in order to see whether or not this is cut off to the W. by sediments or is connected with greenstone running into Pine lake area.

There should also be put on the map a greenstone anticline lying N. E. of the above mentioned portage including the amygdaloidal and massive greenstones which have sediments to the E., S., and N. of them.

From the camp on Moose lake we moved the entire outfit to Ely making the trip comfortably in one day. The following day discharged some of the men and with the remainder moved to Tower by train and established a camp on Stuntz island at the mouth of Stuntz bay in Vermilion lake. Professor Van Hise, Leith, and I went down the railroad to study the rocks in the vicinity of mile post 92, specs. 40003-7. These rocks have been studied upon a previous occasion early in the season and some specimens were then taken. We find here a clear case of interbedded sediments, graywackes, and slates, represented by specs. 40003, 40004 and 40005, and also specs taken by Professor Van Hise, to show some coarser phases. These rocks are cut by dikes, represented by specs. 40006 and 40007, which are ~~thus~~ extremely metamorphosed. There can be no question of the dike character of these rocks. Both of them appear to be basic in character. 40006 is an offshoot of a large E. and W. trending mass about 20 paces in width. A number of these off-shoots were noticed cutting across the sediments from N. to S. The dikes represented by spec. 40007 are for the most part narrow, rarely more than 3 feet in width and more commonly from 6 to 8 inches. These last mentioned dikes show a very

40003 -7

sw + sl

40003 -4-5

B.

40006 -7

met. b

Hb. + m.s.

marked zonal arrangement. The center is of a dark green and appears to consist chiefly of chlorite. On each side of this between the center and the sediments there is a zone of much lighter colored rock which is very much more feldspathic than is the center. Is this the result of differentiation in the dike, or endomorphic contact action in the dike? As these sediments are examined from the S. to the N. we find that they increase in coarseness to the N., coarse conglomerates occurring on the exposures at the N. end of and E. of the railroad cut. The dip of the beds is from 45° to 60° N. This conglomerate has already been described as consisting of pebbles of granite, greenstone, and jasper, with some sedimentary slate fragments. Spec. 40003 is a specimen of rock occurring with the sediments and which I am convinced is a graywacke but which Professor Van Hise believes occurs in pebbles in the conglomerate. He has a number of specimens which should show the identity or dissimilarity of these rocks. If this graywacke occurs in the conglomerate then the succession would be sediments to the S. dipping N. with an overlying conglomerate. I am not so confident that this relationship is the true one. To the N. of this exposure I have observed upon

hw
40003

previous occasions sediments which are practically identical with these and having a dip to the N. slightly steeper than these have. Moreover to the N. of this point occur the greenstones and other rocks which we find in pebbles in the conglomerate whereas they are not known to occur to the S. I am rather inclined to consider this conglomerate as a basal one, the sediments to the S. belonging above it and owing their present northern dip to an overturn. This is a question which it is impossible to determine with our present knowledge of the distribution of these rocks. It had best be left for the work of the following season which may disclose relations between them and other rocks somewhere E. of here between the railroad and Birch lake.

Near the county road which runs S.E. only a short distance E. of the exposures near the railroad there is a good outcrop, and just S. E. from this there is a good exposure of a rock which looks like a greenstone tuff or a conglomerate. It appears to me to be identical with that exposed almost due W. in an outcrop on the railroad right of way and which is there interbedded with the normal sediments. The outcrop here is separated from the

other sediments although they occur in exposures around it. Good exposures showing the characters of these rocks occur on the hills E. of the county road and separated by a narrow swamp from it. Upon the exposures on the railroad the sedimentary characters are unmistakable. Upon some of the exposed surfaces of the graywackes one can see as beautiful cases of cross bedding as can be seen in the Recent or Tertiary sediments. It is to be noted, however, that in these cases, although macroscopically the sedimentary structures, such as bedding, are clearly preserved, the rocks themselves have been extremely metamorphosed. For instance, the false bedding lines are marked by the accumulations of certain minerals and upon ~~weathering~~ they stand out from the rest of the surface. In many cases the rocks appear macroscopically to be mica-schists. The origin of such schists it would be impossible to determine in the field if they occurred in small exposures. However, here their original characters are unmistakably shown.

The country to the S. E. of these large exposures just mentioned is covered with the drift of a great moraine. Exposures are therefore wanting over the greater part of this area.

Jw
40008
Hb.S.

Continuing N. along the railroad an exposure is reached in the first cut N. of mile post 92. This is the nearest exposure to the sediments described above and shows the character of the rocks lying to the N. This seems to me to be practically identical with the graywackes in the railroad cut to the S. of us and of which a specimen was taken upon my previous visit here. In this spec., 40008, as in the one taken before, bluish grains of quartz can be readily recognized as forming an important part of the rock.

On the whole I am inclined to believe that these sediments, a number of exposures of which we can see as we go N. along the railroad, have suffered a less and less intense metamorphism, the farther N. they lie. This is probably due to the fact that the distance increases from the red granite to the S. whose intrusion may be the partial if not the complete cause of their metamorphism. Regional metamorphism has of course affected them as it has all the rocks of this region. There is one thing to be noted, and that is if the red granite to the S. or the gray granite there is the cause of the metamorphism of these sediments, it has not produced the staurolitic

rocks and others containing metamorphic minerals which are so common in the contact zones of granite. At least none of these minerals have been recognized macroscopically as being present.

September 27.

Professor Van Hise, Leith, and I visited various points on Vermilion lake in order to check up certain relationships which had been determined in the earlier part of the season. We visited the Burnt Forties and noted there the fine grained quartz porphyry which we agreed was cut by the big eyed quartz porphyry. Upon this same hill included in the porphyry there is an exposure of jasper very much plicated, which has interbanded with it material of a greenish color and slaty character, which may possibly be fragmental in nature. The minute folds here show beautiful ~~fractures~~ structures. Specimens were taken illustrating the material and showing some of these ~~fractures~~ structures. See Professor Van Hise's books for supplementary notes. Upon the point N. of the Burnt Forties which was next visited the big eyed quartz porphyry is exposed and not very far from it there are outcrops of the normal Stuntz conglomerate. Close examination convinced me that this quartz porphyry is contained in fragments in the conglomerate as is also the fine grained quartz porphyry. Hence the conclusion that they must be older than the conglomerate.

Qp.

40009

In the Stuntz conglomerate wherever seen upon Vermilion lake there is a rock which occurs with pebbles in it forming perhaps the most striking constituent among the eruptive fragments. This has very large quartz phenocrysts lying in a dense matrix. This dense matrix weathers to a white or cream color, although upon fresh fracture it is finely granular or aphanitic, or of a greenish gray tint. Thus far no such rock has been found *in situ* in the region.

Visited now the point S. of Mud Creek bay. Professor Van Hise was convinced that the mapping was in error here and that there are no sedimentary rocks upon this point. Convinced him, however, of the sedimentary characters of a number of areas of the rock exposed here. Doubt remains as to certain of the rocks which may be porphyries or graywackes. This area will be remapped in detail and doubtful rocks specimened.

Visited also the E. end of Ely island and here was able to discriminate easily between the eruptive rocks and the associated sedimentaries. These relations are very intricate due to infolding of the porphyry in the later sediments derived from it. Visited next the small islands between Ely and

Stuntz island. The most of these are made up of the sediments. However, on one small island there was found the porphyry from which the pebbles like 40009 were derived. The exposure here shows the phenomena described by Smythe in his paper for the American Institute of Mining Engineers in which he attributed the conglomeratic characters of all of the rocks on Stuntz lake to shearing. This is true for this particular instance and to a less degree in the case of some of the other porphyries on the lake. He made, however, the mistake of generalizing too much and applied ~~essentially~~ his explanation to rocks which are unquestionably true conglomerates and not sheared porphyry.

QP. 40009

On the S. side of this island I found a hitherto overlooked small area of extremely plicated jasper and slate exactly like that observed this morning on the Burnt Forties and there thoroughly examined. See specs. in Leith's series and Professor Van Hise's notes. This is here the top of a small anticline of the iron formation coming up through the sediments and porphyry. Porphyry lies to the N.; sediments to the S. Possibly it may be included in the porphyry. Still

its structure is anticlinal.

F.P.
40010
micrgr.

On the way in to camp got out on N. side of Stuntz island and there took another specimen of the rock formerly taken to be a graywacke but which I am inclined to consider as a micro-granite. Going S. over this we come to the small eyed quartz porphyry succeeded to the S. by the same rock like 40010 again which is succeeded by a topographical depression on the S. side of which lies the Stuntz conglomerate, containing fragments derived from these various porphyries.

As the result of to-day's work I get the following chain of evidence of the relations of the various porphyries which I am now convinced form the basement from which the Stuntz conglomerate was derived and on which it rests. First the big eyed quartz porphyry is observed cutting the small eyed quartz porphyry in the Burnt Forties. Then this small eyed quartz porphyry cuts the microgranite or feldspar porphyry, as we have called it in the field, on the point S. of Mud Creek bay on the island E. of Stuntz island and N. of Jasper point. The relations of the felsitic porphyry to these others is

not known. This seems to be a pretty clear case of the porphyry underlying the Stuntz conglomerate. The relations on Ely island on the point S. of Mud Creek bay cannot therefore be explained as due to intrusion but must be due to complicated infolding.

40011 While upon Otter Track lake I noted on the Canadian shore occurrences of a dense greenstone containing large porphyritic individuals of feldspar. In one place these feldspars show a peculiar alteration. The ~~porphyry~~ seems to have been altered into a basic chloritic mineral. This greenstone containing this altered feldspar looks in places strikingly like a conglomerate, the feldspars representing pebbles of slate. Of course when broken their characters could be readily seen. The specimen taken and to which this number has been given represents the fresh forms of the feldspar and that with the zonal weathering.

September 28th.

Had made preparations to visit the jasper in the vicinity of Walsh's property near Tower. Upon getting out of the tents found 2 inches of snow on the ground, the first ~~real~~ word snow of the season. Crossed Stuntz bay in a howling gale. It was impossible to do the work which it was intended to do so remained to-day in the hotel. Continued to snow almost all day.

September 29th.

Was not well enough to accompany Professor Van Hise, Merriam and Leith to Walsh's property in the forenoon. ~~although~~ Tried to go on Tower hill with them in the afternoon but was forced to turn back.

September 30th.

Returned to camp this morning and with Leith began mapping in detail the E. end of Ely island. The map used was upon the scale of 16 inches to the mile, a scale which will enable us to put down very nearly the smallest exposures.

G.W.

40012 The N. E. point of the island is a most intricately folded complex of quartz-porphyry, conglomerate, and graywacke. The graywacke, spec. 40012, and quartz-porphyry when looked at casually resemble each other very strongly. Examined closely, however, one can readily distinguish them. The quartz-porphyry is the small eyed quartz-porphyry which weathers with a very rough surface. The graywacke has grains of quartz in it which in many cases are clearly the phenocrysts derived from the porphyry and are very slightly worn in some cases. However, the rock weathers with a smooth surface and this difference in the weathering will usually enable one to distinguish them. As a rule the quartzes in the quartz-porphyry are larger than are the quartzes in the graywacke, ~~although~~ also the phenocrysts stand out somewhat more prominently from the main

mass and are not so much rounded as in the case of those in the graywackes In general the grains in the graywackes are of a more uniform size.

40014 This is a specimen taken from one of the graywackes which in the field can be traced grading down into a conglomerate and up into a slate. There can be no question as to its sedimentary origin in the field. This is a specimen of the graywackes which by a casual observer might readily be mistaken for a sheared quartz-porphyry. Compare the sections of the quartz-porphyry and graywacke derived from them and reproduce some of them as illustrations upon one plate showing the resemblance of a sediment derived from the porphyry to the porphyry itself. Upon this N. E. point the infolding of the porphyry and of the sediments is very complex. Flutings are very common between them, the direction of this fluting running to the E. and W. The plane of contact between the porphyry and the sediments varies very much. In most cases the porphyry is below but in some cases the contact is overturned so that the conglomerate lies apparently under the porphyry. Between these any dip of this contact from very flat lying ones to those which are vertical can be

obtained. The schistosity continues through both the porphyry and the sediments cutting across these flutings. It agrees in a general way with the bedding of the sediments. This last varies from N. 80° E. to E. and W. The dip varies from 75° to the N. to vertical. Continuing S. across the E. end of the island I find that the southern point is made up chiefly of a dirty white to grayish weathering rock like 40013. This is very evenly grained and weathers with a smooth surface. Quartz phenocrysts are not seen in it. Occasionally a feldspar is large enough to stand out as a phenocryst but usually even these are absent. The rock appears to be very feldspathic and is probably a microgranite which becomes at times porphyritic, the feldspars being the phenocrysts. This rock contains scattered through it, though relatively scarce, small areas of yellowish green which evidently represent inclusions of some kind of rock. These yellowish green inclusions are usually about 3 inches in length by a half inch to an inch in breadth. They look like pieces of sericite schist, possibly presenting much altered fragments of slate.

F. P. 40013 Microgr. P.

This porphyry has been sheared along two planes at about 45° to each other

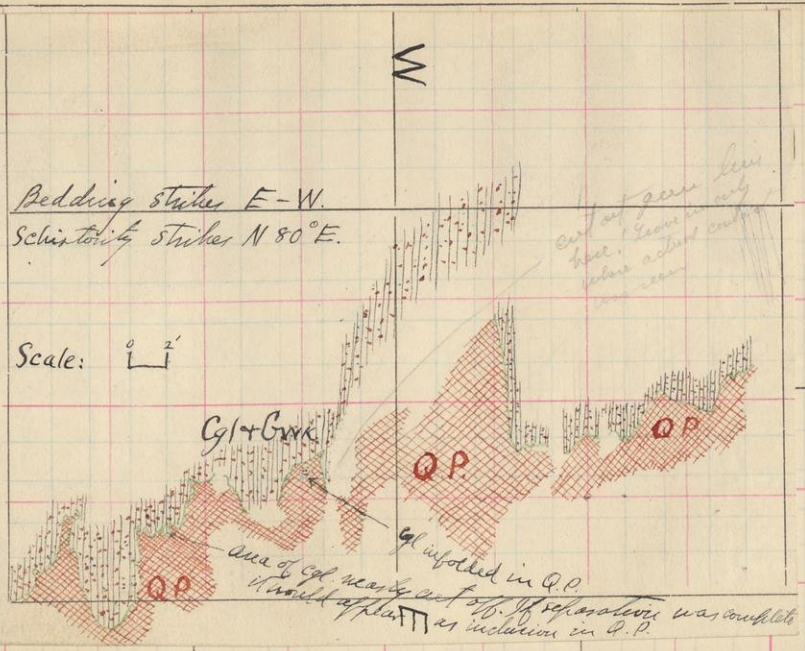
and the result has been the rounding of the areas between these planes. In continuation this weathering gives the rock at times a pseudo-conglomeratic character. All the pebbles are of exactly the same character, hence the rock can be readily distinguished from the normal conglomerate. To the S. and S. E. of this porphyry making up the main part of the S. point of the island there occur the sedimentary rocks. These sediments consist predominently of graywackes and slates with conglomerates in minor quantity. Moreover the slates lie along the shore. They occur apparently farthest from the porphyry which according to my idea of the structure lies near the crust of an anticline. The graywacke shows very commonly a peculiar ridgy weathering which in most cases enables us to readily separate it from the massive even grained eruptives. At times, where the graywacke is in very massive exposures and where it has been sheared as has the porphyry the fact that both of them have a somewhat ridgy weathering as the result of the shearing and subsequent weathering might cause them to be confused. In no case was this ridgy weathering so noticeable upon the porphyry as upon the graywackes.

The schistosity observed on these sediments had a strike of N. 70° E. The slates on the S. side of the point are greenish and grayish in color. The strike of the interbedded series is N. 70° E. with a dip of 75° to the N. All gradations from the conglomerate into the slate can be traced on these exposures. Here where these gradations can be traced one can see how strikingly the resemblance ~~to some~~ of these graywackes is to some of the porphyries. The discriminations at first are difficult but become easier after a while. Moreover I believe that the separation can be easier made and with greater certainty in the field than in the laboratory owing to gradations which can there be studied, which the sections cannot show. In 1897, on visiting this same point with Professor Van Hise and Bayley it was thought that the interbanding which I now recognize as that of graywackes and slates was due to parallell intrusion of porphyry along the parting planes of the slates. When the bands presumed to be porphyry were examined it was noticed that they grow finer and finer grained as the slates were approached. This was then taken for a saalband of the dikes. It is now clear that this is a pseudo-saalband representing merely the gradation

from the graywacke into the slate. We traversed this point a number of times at short distances apart and mapped as accurately as we could the various rocks here exposed. On the S. side of the island the quartz-porphyry is practically wanting, its place being taken by the feldspathic rock, 40013. This continues out to the W. along the crest of the hill. There is more of it exposed than there is of the quartz-porphyry. Its relations to the sediments were not seen in as many cases as were those between the quartz-porphyry and the sediments.

F.P.? 40013

The quartz-porphyry is found for the most part on the N. side of the island and the contact between it and the sediments was seen in a number of places. The field relationship between these two kinds of rocks is especially well shown ~~upon the point projecting N. into the lake~~ upon the first point W. of the extreme N. eastern part of Ely island. Here the relations exhibited in the accompanying sketch can be seen. This sketch represents as accurately as possible the relations of the rocks. The most minute ~~relations~~ relations it was necessary to combine and join. The ~~relation~~ relation which it was possible to reproduce upon the scale here used has been re-


W
Bedding strikes E-W.
Schistosity Strikes N 80° E.
Scale: 0 2'
Cgl+Gwk
Q.P.
Q.P.
Q.P.
Cgl infolded in Q.P.
Area of Cgl mapped out by U.S.G.S. reconnaissance was considered
it would appear as inclusion in Q.P.

produced. The solid line represents the actual contact which was observed. Where this line is wanting the actual contact has not been seen, exposed rocks being separated by the distances shown on the map. The strike of the bedding where observed on the sediments just W. of this contact line which is between the conglomerate and the porphyry is E. and W. The dip is vertical. The schistosity runs N. 80° E. It is present both in the sediments and in the porphyry and is continuous across the line of contact. Examining the contact between the rocks very closely it was noticed that occasionally a pebble from the conglomerate was present in the prophyry. This was never far from the contact. At one place, see map, an irregular area of the conglomerate was seen completely surrounded by the porphyry. The conglomeratic nature of this rock was not questioned as it contains in addition to the fragments of porphyry those of jasper and of veined quartz. The irregular contact and the presence of these pebbles in the porphyry would be sufficient in most cases to ~~describe~~ cause determined this contact as an eruptive one and the porphyry would hence be adjudged as younger than the sediments. A clue to the occurrence of

this fragment in the porphyry was found ~~evidently~~ not very far from it at the place on the sketch located by the arrow. At this place we have a small area of the conglomerate projecting into the area occupied by the porphyry and connected with the conglomerate only by a narrow neck. Let this neck be severed and we have a pebble of conglomerate in the porphyry. In the case of the pebble like area it was observed further that the plane of contact between the conglomerate and the porphyry is very flat. Clearly the conglomerate covered up this porphyry and has been gradually eroded away from it, leaving in one place a small mass still upon the eruptive. A cross fold might, in this particular case or in a similar case, by folding the conglomerate in the porphyry, preserve such an area and make it look much like an inclusion.

October 2nd.

Rested yesterday as that was the first day for a good while that we have not been on the move. To-day we went to the point S. of Mud Creek bay and began detailed mapping there. Used a scale of 40 inches to the mile. The map contains the results of the work, the following notes having reference only to special things. The infolding of the sediments and the porphyry is clearly shown in a number of cases. In one instance, for example on the S. slope of the hill I find a long E. W. face of the porphyry with conglomerate on the E. and W. ends. At both of these places fingers of the conglomerate and porphyry are interlaced. Clearly but for erosion the conglomerate would have been continuous over this porphyry. Erosion now has removed some of the conglomerate leaving at each end the small areas of conglomerate infolded in the porphyry.

40015 Near the S. crest of this ridge running through the middle of the point there is a dense rock which does not show very distinct sedimentary characters. I believe that it is a sediment from its association

S. T. R.

F.P.
40017 Spec. of dense, white weathering rock which may be sediment.

with other sediments here but the section in this case will have to afford the final proof.

A.P.

40016 Here again on the top of the hill there is a mass of white weathering dense massive rock which I believe to be a sediment but of which I am not sure.

F.P.

40017 *F. opposite page!*

40018 A.P. Upon the top of the ridge there occurs in a number of exposures a uniformly coarse grained rock which seems to consist for the most part of feldspars. This rock we have called in the field a feldspar-porphyry, although strictly speaking it is not a porphyry. It seems to me that it differs chiefly in coarseness from ~~40015~~ the microgranite, spec. 40013 on Ely ~~40010~~ island and spec. 40010 from Stuntz island. This feldspathic rock is found in a number of places on the hill and in a few places itself in direct contact with the sediments. Here infolding of the sediments and of this rock was seen with no gradation between them hence my belief that it is an eruptive rock belonging with the complex below the sediments.

As will be seen from the map the greenstone is the rock which occurs in the most numerous exposures on the hill. This greenstone varies from fine to coarse in grain. It is predominently massive but in a few places shows a schistose character. It also shows in places traces of ellipsoidal parting. One curious feature of this greenstone is that it contains a great number of round areas which look strikingly like pebbles or fragments. I find among these areas a great variety of greenstones chiefly those of coarse grain. There are some of the areas which look like granite pebbles and there are others which are unquestionably jasper fragments. Where this greenstone ~~jasper~~ is found in association with the sediments and porphyries thus far described it seems to be infolded with them. Whether or not it is the basement upon which the sediments rest could not be determined for in no case was the greenstone found in pebbles in the sediments. These sediments being made up almost entirely of porphyry fragments with some jaspers and quartz fragments, consequently ~~they~~ have a very white weathering surface. The greenstone must certainly be younger than the jasper since it includes pebbles of it. It is possible to in-

terpret this greenstone as an intrusive, the fragments of jasper having been obtained from the spherulitic greenstone, as thus cut through them. This rock is itself in places spherulitic and resembles very strikingly the predominant greenstones in this region The fragments other than the jasper might have been obtained from the greenstones of which it practically forms a part and through which it was intruded. This may be in other words a dike possessing in places the character of an eruptive breccia, due to the inclusion of such a large number of fragments adjacent from the rocks through which it was forced. Possibly some of this mass of greenstone was a flow of essentially the same age as the jasper and ellipsoidal greenstones. As it was poured forth it incorporated within itself fragments of the jasper and also fragments of its own cooling surface and from the adjacent lavas thus being a flow breccia. I could not reach a definite conclusion concerning this greenstone.

On the top and extending some distance down the N. flank of the hill I find a big eyed quartz porphyry trending a little to the S. of E. and N. of W. This porphyry undoubtedly cuts

this greenstone. The contacts between them are sharp ~~but irregular with dense~~ but with irregular areas of the one projecting into the other. Near the E. end this interlocking of these two rocks is shown on a large scale. This is clearly due to the infolding of the two rocks and is in all respects similar to the infolding of the sediments and the porphyry ~~under~~ on the W. end of this ridge. The true relations of these two rocks are shown by the presence in the porphyry near the contact of more or less rounded greenstone fragments which have clearly been derived from the adjacent greenstone, although intrusive in the greenstone the porphyry does not show a distinct selvage. This dike was traced by a practically solid outcrop for a considerable distance E. and W. as shown on the map. A deep valley has been cut into the N. side of this hill and at this point there are no exposures of porphyry. W. of here in line with the western continuation of the dike a number of E. W. exposures of a similar porphyry were found. These in some cases are in the midst of an area occupied by the fragmentals. The relations of a porphyry similar to this to the sediments similar to this on this point

N. of the Bunker 40-Tie

have been already determined ~~at other places~~ and it was there found that the sediments were unconformably upon the porphyry. Hence these exposures are not interpreted to mean that this porphyry is intrusive in the sediments as well as the greenstone but that it was here overlaid by the sediments and that erosion having cut through them in places has exposed the porphyry. From the relationship of the sediments to the porphyry we are now able to determine approximately the age of the greenstone, for since the porphyry is older than the sediments and cuts the greenstone the greenstone must of necessity also be older than the sediments. This is conclusive although no pebbles of the greenstone have been found in the sediments on this hill.

Lying to the N. of this greenstone and porphyry there is found a rock which is very rotten and very much broken up. It is practically impossible to get a good hand specimen from it. The fragments break into irregular rhombs. The rock is fine grained and on fresh fracture one sees scattered through it a great number of areas ~~in places~~ more or less quadratic in shape, which are occupied by limonite. This seems to indicate that

the rock must have ~~been~~ contained originally either ~~of~~ siderite or ~~of~~ pyrite, probably the former. This rock extends over a very large area N. and S. and also E. and W. On the W. the exposure gradually narrows down and runs out to a narrow edge against the greenstone where erosion has cut through the rocks. This rock, recognizable as such at least, was not found W. of this depression. Spec. 40019 is as fresh a piece of this rock as I could get. Another spec. was taken from near this place in 1897. This same rock is exposed over a considerable area E. of here along the top of the hill forming with the greenstone the major part of the hill. East of here this rock, like the greenstone, is either cut through by the big eyed quartz porphyry or else this, if a sediment, overlies the porphyry. The areal distribution is quartz porphyry with this rock around it and one could not determine the relative ages.

Sr. 40019

In the course of our study of this hill I have attempted to get a number of strikes on the sediments but with very poor success. In most cases the sediments exposed are conglomerates or graywackes in which good strikes were not obtainable. Where the slates were exposed the beds were so crumpled that good strikes could not be obtained on them. The strikes and dips

which were observed are inserted on the plat. In a general way the strike of the sediments may be said to be ~~about~~ a little to the S. of E.

The strikes of schistosity upon the porphyry, the massive sediments, and also upon the greenstone, were taken and were uniformly N. 80° E.

Looking now at this point broadly I interpret the structure as follows. In the main the hill is an anticline with the sediments lying upon the flanks of the hill and along the shores of the point, the coarser sediments rising higher on the flanks and being on the E. end of the ridge, the finer sediments lying farther away near the shores. There is a small syncline superimposed upon this anticline. The center of this syncline is occupied by the large masses of sediments which occupy the central part of the top of the hill. The sides of this syncline are represented by the greenstone and porphyry which looked at broadly surround these sediments. In detail of course it will be seen that small knobs of the greenstone as well as of the porphyry occur outside, that is, away from these so-called limbs of the syncline. The core of this anticlinal hill, that is the basement upon which the sediments rest, is made up of greenstone predominantly

which is cut by the big eyed quartz porphyry and then the small eyed quartz porphyry and the feldspathic porphyry
40018 or granite represented by 40018. The relations of these two porphyries to the greenstone are not known. In one place upon the hill this small eyed quartz porphyry occurs in such a position as to appear as a dike cutting across the greenstone. This relationship, however, is not certain.

In the early part of the summer Leith was instructed to study the islands in the lake while I was engaged in studying other areas. The rest of our time on the lake we will spend in revisiting these islands and checking earlier determinations. Notes on them and maps of the islands can be found in Leith's note books.

40020 This is a specimen of microgranite or so-called feldspar porphyry from island No. 19 of Leith's notes.

40021 This is a specimen taken from that island between Ely and Stuntz islands where the porphyry has been so sheared as to look conglomeratic. At this place the porphyry is broken into rhombs by two sets of parting planes.

The strike of these can be found in Leith's notes which also see for notes taken while upon the exposure. These parting planes are nearly two feet apart breaking the rock into large blocks. Parallel with these fractures which are relatively large there are numbers of small fractures which break the rock into correspondingly small rhombs. The trend~~ing~~ of these small parting planes agrees with the trend of the larger parting planes. The shearing of these small rhombs has rounded the corners producing a rock which upon its weathered surface simulates very strikingly a conglomerate. The fresh surfaces, however, show these parting planes and the conglomeratic structure is then not so noticeable. An important fact to be observed in connection with the exposure is the fact that no matter how conglomeratic it may look a close study of the rock shows that all of the pebbles are alike and of essentially the same size over the entire area of the exposure, something which it would be very difficult to explain in a normal conglomerate.

In examining the conglomerates on these islands especial attention was paid to the character of the pebbles and the conglomeratic characters could in all cases be readily recognized by

the variety of pebbles. In some cases where the pebbles are all of these quartz porphyries, the jaspers being absent and ~~from~~ where these ~~the~~ conglomerates have been very much sheared it is difficult to be absolutely sure as to the character of the rock without close study, which has been made in each instance.

Thus, while the correctness of Smyth's observations as to the formation of a pseudo-conglomerate from this porphyry by shearing is substantiated, it may be readily seen how gross was the error made in carrying his generalization so far as to include under this method of formation the vast quantity of true sedimentary deposits of conglomerate occurring around Stuntz bay and upon the shores elsewhere and upon the islands in ~~the~~ Vermilion lake. On the way to camp revisited the island between the E. end of Stuntz island and the jasper anticline on the main land. Was able to trace the quartz porphyry all the way across this island from shore to shore. It trends as shown on Leith's map to the N. W., S. E. This porphyry cuts through the rock of which specimens have been taken, which is the microgranite or feldspar porphyry similar to 40010.

F.P
40010
microgr.

and other specimens. This micro-granite shows variations in grain from the medium grained porphyry like 40010 up to that very nearly like spec. 40018. Cutting across this porphyry though not found cutting the quartz-porphyry there was noticed a dike of green basic rock about 6 to 8 inches wide running approximately E. and W.

Q.P.
40022
& 3 F.P

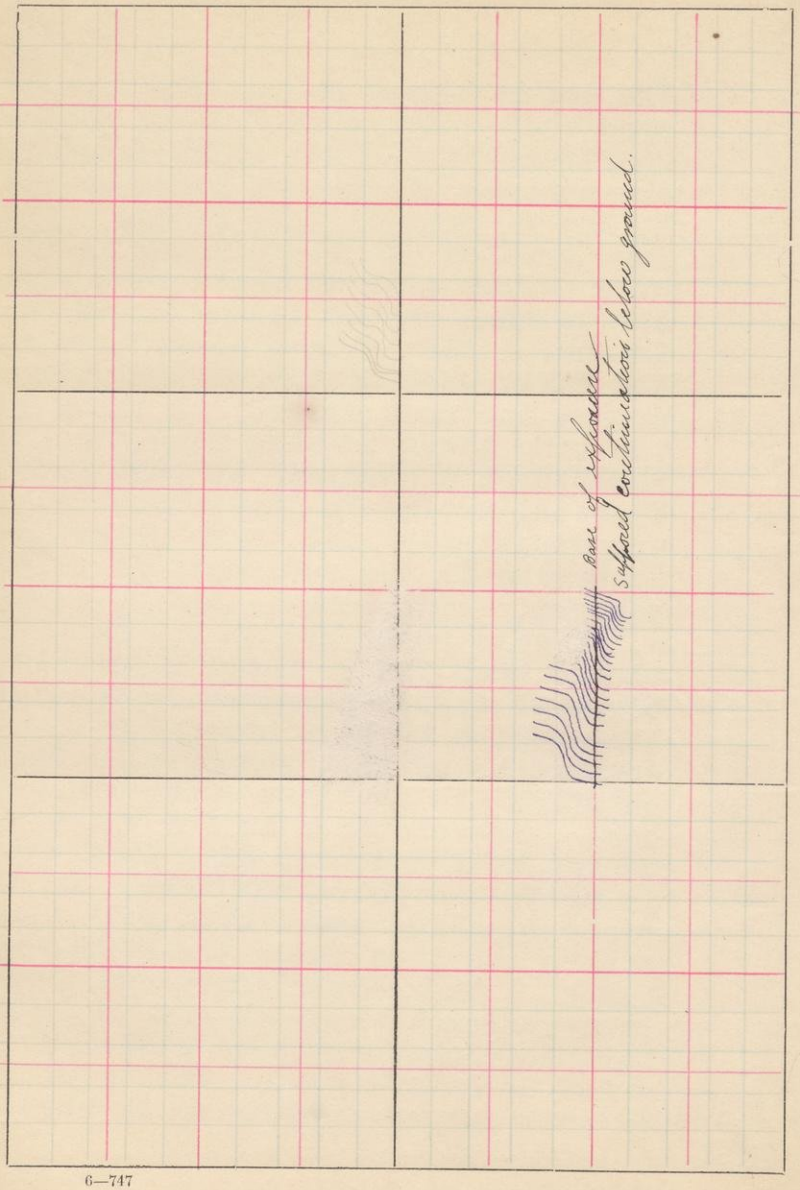
October 4th.

Visited this morning island No. 7. See Leith's note book for notes on and plat of this island. These two porphyries represent a porphyry with visible quartzes in it and a micro-granitic rock. These two seem to be infolded and it is not possible to say which cuts the other.

We find ipon the island E. of No. 7 this porphyry again with jasper in a small exposure on the S. E. shore. Go E. to the main land and traverse this high ridge again. See Leith's notes for plat of exposures. At the W. end of the ridge there is an area of jasper which to me has an anti-clinal structure plunging E. From this anticline a narrow band, part of the N. limb perhaps, continues to the E; the exposure of jasper widens out to the W. along the shore. N. of this jasper occurs a big eyed quartz por-phyry. On the S. side at the W. end the quartz porphyry also lies next to the jasper and in one place a small V of jasper with the opening of the V lying to the W. is distinctly infolded in the porphyry which is schistose along its contact with the jasper. The entire ridge consists chiefly of the big eyed quartz porphyry occurring upon the N. and S. sides of the top,

The lower slopes of the hill are covered with drift, with a finer grained quartz-porphyry like 40022 occupying the centers of the two knobs at the E. and W. ends of this ridge. This fine grained quartz-porphyry is cut by a narrow dike of basic rock similar to that on the island E. of Stuntz island. See Leith's notes made in the early part of the season with reference to these dikes. I think when visiting these islands with him I must have taken a specimen at that time. My recollection is that these dikes are strikingly like those noted as occurring in the sediments at mile post 92. The long E. and W. island N. of this point has in a number of places upon the S. shore exposures of big eyed quartz-porphyry. Throughout this region we have noted the common occurrence of this porphyry. The quartzes are at times clear and vitreous. Associated with the vitreous quartz we frequently find that which is white and porcelain like. In this place I notice associated with these others quartzes which are ~~decidedly~~ black. They occur scattered irregularly through the rock and no reason for their occurrence or distribution could be determined. The major part of this island is made up of the sedi-

S. T. R.



ments as shown on the plat.

Revisited the Burnt Forties to examine the jasper with especial reference to the presence of a sediment below it, between it and the greenstone. Near the lake shore the large jasper exposure shows in cross section from N. to S. the structure shown on the accompanying diagram. To the N. of it lies the rock which in the early part of the season I was inclined to consider as a graywacke though owing to some doubt took a specimen for determination of the character. Leith showed me the jasper exposures in the Burnt Forties and we examined it closely for sediments. No sediments were found nor did these jaspers, for the most part the black jasper, have the slaty material in them which was observed a few days ago on the jasper N-E. of here by Professor Van Hise, Leith and I, and of which specimens were taken. A number of specimens showing characters of the jasper and associated cherts were taken from the Burnt Forties exposure. See Leith's notes for specimen numbers. Returned to camp for lunch and then moved across the lake with the remainder of the camp outfit.

Ascending the hill from the compres-

sor I noticed in the gravel pit on the S. side of the road just beyond the first turn an exposure of rock which seemed to me unquestionably the same as the big eyed quartz porphyry with the dense felsitic matrix represented by spec. 40021. Its exact relations here to the jaspers and associated rocks could not be seen but its presence on this hill clearly indicates that it is intrusive in the jaspers.

Q.P. 40021

I have heretofore held the opinion very strongly that many of the sericitic schists with oval to round quartz areas in them which are found apparently interlaminated with the porphyry and green schists were originally quartz-porphyry. According to my idea they have become sericite schists as the result of the extreme mashing and shearing to which they have been subjected. Along this N. slope of Soudan hill within a short distance of the exposures of this big eyed quartz-porphyry (which are found in a gravel pit opened since I studied this side of the hill in 1897) there are a number of exposures of rocks yellowish to green in color and with small vitreous quartz areas scattered through them and associated with the jaspers and which may have very readily been derived from acid porphyry by shearing.

The occurrence of green schists with quartz eyes upon Soudan and Tower hills, associated with the jaspers has been mentioned. In some cases I have been confident that these represented extremely metamorphosed amygdaloidal greenstones. Is it not possible or in fact highly probable that many of these green schists with quartz-eyes are really sheared acid intrusives? The green color their only essential difference from the yellow sericitic schists being due to the infiltration of iron and the production of ferruginous green silicates, chlorite, which gives them their color.

40024 Just to the E. of the top of the inclined railway on the N. side of Soudan hill there is an exposure which shows very well the infolding of the jasper and green schist. A photograph was taken which shows a westward opening U of jasper and ore surrounded by the green schist. This green schist has scattered through it in many places the eyes of quartz already spoken of. These eyes, by the way, are not of a single quartz but consist of a number of grains and have the appearance spoken of as saccharoi-

dal. Moreover these quartz eyes are not scattered uniformly throughout the rock but are bunched and are in irregular areas of varying size, resembling to my mind more closely the appearance of the amygdules in an eruptive than grains of quartz in a sedimentary. Just a short distance away from this jasper-green schist exposure, and in fact connected with the green schist with saccharoidal quartz eyes, there is an area exposed which does have a conglomeratic appearance. Here there are oval to rounded areas of light greenish to white color, in many of which saccharoidal eyes of quartz can be seen, lying in a green schist matrix in which quartz eyes occur, and which in all respects is like that described above. These oval to round areas do not appear to me after close study of them like pebbles in a conglomerate. I noticed that instead of having a smooth rounded or oval shape some of them swelled and narrowed several times thus having somewhat the appearance of concretions or of areas produced by shearing than they did of normal water worn pebbles.

G.A.?

40025 I went around the sides of the large open pit lying about SE. of here, seeking for the continuation of this rock and endeavoring to find its relations to the jasper, and trying to get a sedimentary basement below the jasper and ore on the N. at the top of this hill. Immediately next to the jasper and on the N. side of the large open pit, I find a green schist represented by spec. 40025. This looks to me like a sheared amygdaloidal greenstone. In one place to the N. and some distance away from the W. end of this pit and separated from it by the schistose amygdaloidal greenstone, I notice another small area of rock similar to that described under ~~40024~~ spec. no. 40024. Went all around this pit and found nothing on the sides but the greenstone in some places with the quartz eyes in it of which mention has already been made.

40026 &7 Now started around the N. side of the Montana open pit. Upon the dump made up of rock coming from this pit and from the greenstone lying to the N. of the jasper I find a very good specimen of the green schist with the quartz eyes. This I am quite sure

was specimened in 1897 and probably has already been sectioned. This is in all respects similar to that schist which forms a matrix of the pseudo-conglomerate E. of here near the inclined railway. In addition to the above specimen I took another from the same dump, spec. 40027, which shows in it a pebble like area of cherty or felsitic rock. This does not look to me like a conglomerate but I am unable to explain its origin.

a.p. 40027

Went on around the open pits on the top of the hill and in no place found indications of any conglomerate. The green schists lie to the N. and on the S. sides of the open pits there are the yellow to green and red schists which seem to be more sericitic and may possibly in some cases be derived from the acid eruptives.

c. 1. 40028

I remembered having obtained in 1897 from the dump of the mine at the end of the spur running N. W. from the Company's office a rock which at the time impressed me as a conglomerate. I visited this dump again and took a specimen, 40028, which shows unmistakably its conglomeratic nature. Moreover I think now that I can recognize this conglomerate as belonging

with the Stuntz. It resembles very strikingly some of the fine grained conglomerates which I have seen upon the islands in the lake. It is essentially a recomposed quartz-porphyry. Now associated with this rock upon the dump there is a great quantity of a light yellow and green fine grained rock with a soapy feeling which appears now to be essentially a sericite-schist. Of this rock a specimen was taken in 1897. This rock is, I believe, but an extremely sheared phase of the fine grained sediments, a phase which has been so much metamorphosed that it is now a sericite schist. In fact, wherever found, the blocks of this rock on the dump show slickensided faces. This rock in its general appearance, but for the absence of the quartz eyes, resembles very much many of the sericitic schists associated with the jaspers and greenstones. Since this as I believe has been formed by shearing from a sediment derived from the porphyry, there can be no reason for discrediting the formation of the sericite schists with quartz eyes essentially similar to the above schist, and which is associated with the greenstones and jaspers, from porphyry dikes

This closes the work for the field season of 1899.

General Conclusions.

As a result of this season's work the following general conclusions have been reached. In the Vermilion district there is from the bottom up the following succession of rocks. At the bottom and as the basement upon which rests all sedimentary deposits of later age and through which have been intruded all younger eruptive rocks there is a mass of greenstone. This may be found from Tower as far E. as the vicinity of Gunflint lake. Throughout this area of about 70 miles in length, this rock possesses one very common feature. I refer to the ellipsoidal parting which will be described in detail when occasion offers. The greenstone varies from that which is very fine grained to that which is very coarse grained. Moreover it is in places porphyritic, amygdaloidal and spherulitic. These various structures and textures occur in the most irregular way. On the whole a massive structure may be said to predominate in these rocks. A schistose structure is in some places very well developed. It is almost always of purely local occurrence, however, and it would be misleading to speak of this formation as consisting of green

schists. It does not consist predominently of greenstone. ~~they~~ that In many cases have been found grading over into each other so that we can consider these rocks as belonging to the same eruptive mass, although it is perfectly possible that certain of these forms have been erupted somewhat later than others, as is always the case wherever there is any ~~great~~ long continued eruptive activity. Since this ellipsoidal parting is so ~~good~~ common in these rocks and since so far as known it is totally absent in the younger rocks of this area ~~with~~ having essentially the same chemical composition, ~~as~~ these ~~we have~~ will been spoaken of as the ellipsoidal greenstone. This will avoid circumlocution and enable the reader to discriminate between rocks of dissimilar age. It is impossible to make any absolutely unqualified statement as to the mode of origin of these rocks other than to say that ~~we note that~~ they are of igneous origin. However it is of great interest to know ~~that~~ whether thay are the result of volcanic activity or possibly represent a great batholite. To my mind there is sufficient evidence to show that these rocks are volcanic in nature but ~~and while~~ using this term I must qualify it by stating that by this I do not

old eruptives / rocks forming the various features and structures mentioned

mean that the rocks ~~should~~ necessarily all have been erupted upon land. It is to be distinctly understood that ~~they~~ some or all of these may have ~~all~~ been formed under submarine conditions. I am strongly inclined to think that this is true for the greater part if not the whole of these rocks. The evidence which I have for the volcanic character of these rocks may briefly be stated to be as follows: in the first place an amygdaloidal structure is of very frequent occurrence in them and has been frequently noted by ~~the~~ various observers. In addition to this there is to be noted the ellipsoidal structure which in my opinion, as expressed in Monograph 36, is indicative to a certain extent at least of the result of flowage of a viscous lava. There is one further structure in these rocks to which I have thus far not called attention. Many of the ellipsoidal greenstones are made up almost completely of spherulites. These spherulites have been found to have a definite arrangement. The small spherulites occur upon the periphery of the ellipsoids and those of increasingly large size are found farther away from the periphery. This occurrence points to the fact that these ellipsoids have in cases

where this arrangement is noticeable acted as units, and is further evidence in support of my published explanation of the surface mode of origin of these ellipsoidal greenstones. The spherulitic texture is itself one which has been observed so far as I am aware only upon volcanic rocks, and this fact is further support of the contention that these greenstones are of volcanic origin.

Next above these greenstones occurs the Tower and Soudan iron formation. This iron formation is the one which has given to this district its enormous economic importance. It is from this that such great quantities of the iron ore of the Lake Superior region is obtained and it is one of the most important of the factors in the economic life of the United States. This iron formation is made up of two complexes each of which is composed of a number of units. These two complexes given in their succession from below up are first a thin series of normal fragmental deposits; second the iron formation proper consisting now of interbanded black, gray, and white cherts, or as they are sometimes

called jaspers, red jasper, bands of magnetite and of hematite. Associated with these are certain carbonateous bands presumably representing remnants of the original rocks from which the ores ~~porphyries~~ and jaspers have been derived. Associated in very small quantity with these rocks just mentioned, which are to some extent at least of chemical origin and may possibly ~~are~~ be justified in attributing this mode of origin to all of them, there is found some bands of greenish slaty rocks which appear to ~~be~~ normal fragmental sediments. Where we find these slates associated with the jaspers we may have beds representing the transition from the fragmental deposition of the series below the jaspers into the chemical deposits represented by the jaspers and ores. It would be out of place to describe here in detail the ores and associated rocks, ~~in this place~~. Of very great interest is the relationship which these rocks bear to the greenstones. It has been already stated that the greenstones are the base upon which these rest. In a few cases, to be described in detail in the notes and in the proper place in the final report, some fragmental sedimentary deposits were noted. These fragmental deposits lying upon

the greenstone gave good evidence of their derivation from the greenstones. Such evidence consisted in the presence of a basal conglomerate consisting essentially of greenstone which graded upwards, away from the greenstone, into finer grained sediments and were finally overlaid by the chemical deposits of jaspers and associated rocks. This is the basis for the placing of a fragmental series between the greenstones and the jaspers. In by far the great majority of cases in which contacts between the jaspers and greenstones have been found, and these cases can be numbered by scores, the contacts were absolutely sharp no gradation whatever being found from the greenstone into the jasper. The nearest indication of any such ~~greenstone~~ gradation existed in the greenstone becoming somewhat more schistose and perhaps containing some infiltrated iron immediately below the jasper and along the contact with it. This schistosity, however, can be very readily explained by the fact that in the case of shearing this movement would take place along the plane of contact between these two dissimilar rocks.

In previous field seasons a number of cases were observed of jasper, in small areas, lying in the midst of massive coarse grained greenstone. The

contacts between these two rocks are sharp. Such occurrences were in many cases considered as indicative of eruptive contacts, that is, the jasper was believed to be included by the greenstone. It must be admitted that in some cases this relation probably does exist. How long a time elapsed after the cessation of the violent volcanic activity which produced the ellipsoidal greenstones and the time when the chemical sediments were deposited whom ~~before~~ them cannot be measured. We have no criteria whatever in this region for even estimating approximately this time. It is not unreasonable to suppose that some flows or intrusions may have been produced which include some of this jasper. This fact would by no means detract from the general accuracy of the statement that this ellipsoidal greenstone formation was older than the jaspers.

At other places in this district certain jasper areas were observed occurring in the greenstones in such a way as to indicate that they are the result of secondary infiltration. These areas are of irregular shape and size. They are found to possess on the whole a concentric structure with the bands in the jaspers running parallel with the contact of the greenstone.

~~and being on the whole concentric~~.

It is impossible to make any definite statement concerning the thickness of this jasper formation. It is in all cases extremely plicated and the folding has been so intense ~~as to~~ have caused the rocks to be ~~ruptured~~ *wrinkled* many times across the area. Moreover the formation is essentially alike throughout there being no clearly marked horizon within it which could serve as key-rocks, hence it has been found impossible to trace with certainty the bands across the area, and hence also impossible to determine the thickness. This must, however, be very considerable for in some places we find continuous exposures of the interlaminated jaspers exposed over an area of ..... feet N. and S. How many more feet should be added to this it is impossible to say. From a maximum this formation dwindles down until it disappears, in some cases the next higher horizon lying immediately upon the greenstone basement.

Associated with this ~~higher~~ *iron* formation occurs all of the ore bodies which have thus far been exploited on the Vermilion range. The most important of these are the ones at Soudan and those at Ely. At Soudan the ore bodies worked by the Minnesota Iron Co. have a synclinal form and plunge to the W. having greenstone both

below and above them. This syncline is apparently a subordinate, ~~a~~ syncline within a large anticline, the main structure of Soudan hill being anticlinal with this minor syncline near the center.

The ore bodies, or more properly speaking perhaps, the ore body at Ely lies in a syncline trending E. and W. and lying immediately upon the greenstone. This syncline plunges to the E. and narrows down also in this direction. At the W. end it is a distinct syncline with the sides dipping in opposite directions. As we go to the E. this dip changes and instead of dipping on the S. side to the N., it is overturned and the dip is to the S. No other ore bodies of any extent have thus far been observed. Active exploration is now going on and if the places where the geological structure suggests the occurrence of ore are explored, it is probable that larger ore bodies will be found.