[Notes on the geology of the Boundary Waters region, Minnesota and Ontario]. No. 328 [1899?]

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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.

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Notebook No. 378

The next succeeding formation, that lying above the jasper, is a great fragmental formation. It consists of conglomerates, graywackes, and slates. There are in addition to the in places among these sediments iron ore deposits which owe their origin to the replacement of carbonateous beds which were probably chemical deposits.

This great sedimentary series is of somewhat different characters in different parts of the region and no absolute areal connection between the sediments occupying exactly the same relative position on the E. and W. sides of the district was obtained. It will therefore be necessary to describe briefly the W. and E. ends of the district separately.

The W. end of the Vermilion district from Tower within about 6 miles of Ely. In this part of the district the succession is slightly different from that at the E. side so that it is necessary to interpolate between the jasper and the sediments a formation different in character from that occurring elsewhere in the district. This formation is an eruptive one. It is best exposed on the islands and shores of the E. end of Vermilion lake. The eruptive rocks are of acid character and consist of several varieties of quartz-porphyry and microgranites. All of these have a very light color upon the weathered surface. These rocks are found to have cut through the greenstones and the jaspers and hence are younger than they and are in this scheme placed above them.

These porphyries occur in isolated dikes ~~contacts~~ throughout the western part of the district. They occur, however in very large quantity upon that portion of Vermilion lake above mentioned and it is here that they play an important role in the formation of the succeeding younger sediments. Their influence cannot be noticed in the case of the isolated dikes.

Immediately overlying this porphyry and overlying of course the greenstone and jaspers we find the sedimentary series of which mention has already been made. It consists of conglomerates, graywackes, and slates. ~~with their greatest development in the~~ order ~~weather given from the bottom up~~. The conglomerates are made up of pebbles of the underlying formations and lie upon these with unconformable relation The graywackes are somewhat finer grained fragmentals and occur interlaminated with the conglomerates and represent the gradation from these into the slates. Both of these coarse grained forms of the sediments are very light gray to white in color, the only dark fragments occurring in them being the jaspers and greenstones The slates are also relatively light colored in light gray to bluish gray and greenish tones.

It will probably be possible upon the map to separate this series into the graywackes and the conglomerates on the one hand and the slates on the other although it must be borne in mind that this division cannot be an absolutely sharp one.

It will be found that the distribution shown by these rocks will indicate in a way the structure of the area occupied by them. On the whole the conglomerates are found to occur on the tops and around the flanks of the anticlines and high up on the limbs of the synclines. The slates occupy the synclinal depressions and are low down on the flanks of the anticline.

As these sediments are followed to the S. around the great greenstone-jasper anticline they are found to become more and more metamorphosed. ~~as we go to the S.~~

At one place upon the railroad near

mile post 92, there was noted a conglomerate succeeded to the S. by sediments becoming finer and finer grained and with a N. dip. Is it possible to correlate this conglomerate here with the Stuntz conglomerate or is the lithological difference to be explained by the distance separating them? That is, in the Stuntz conglomerate porphyry pebbles are the essential constituents for the porphyry ~~are~~ is the predominent rock just where ~~they are~~ it is developed. In the conglomerate at mile post 92, the greenstone and granite pebbles are the predominent ones. The source of the granite pebbles can not be readily determined. The greenstones are derived from the greenstones lying below the sediments and occurring areally to the N. and N. E. of them.

Let us now return to the sediments in the eastern side of the district. In this part of the district the sediments lie immediately upon the jasper and conglomerate without the intermediate eruptive rocks which occur on Vermilion lake. At the bottom of this series of sediments we have an enormous thickness of conglomerates. These conglomerates vary lithologically according to their proximity to different kinds of rocks from which they were derived. Those S. of Moose lake where the sediments lie immediately upon great greenstone masses can almost be spoken of as greenstone conglomerates as the greenstone is the predominant pebble in the conglomerates This same statement is true for the conglomerate in the vicinity of the greenstones N. of Peter, Paul and Fay lakes and extending out W. along the S. side of Ogishke Muncie. As we go farther E. of Moose Lake the granite pebbles become more common; especially is this true in the vicinity of the Saganaga granite where the sediment is an arkose in many places and can with difficulty be separated from the true granite. In other places in this Saganaga granite area there is a good basal conglomerate consisting almost solely of enormous boulders of Saganaga granite lying immediately upon the Saganaga granite but even here, in one place on the W. side of Cache bay,a N. trending bay of Saganaga lake ~~over~~ in Canadian territory, where the greenstone occurs in close proximity to the granite, we find the greenstone pebbles mixed with the granite pebbles. Where the jasper lies upon this greenstone we ~~will~~ find great quantities of jasper associated with the greenstone pebbles. See W. end of Ogishke Muncie. Then again where the granite cuts through the greenston stone and jasper and where the conglomerate is near them we ~~would~~ get a conglomerate containing pebbles of all three of these rocks. Such conglomerates occur S. of the E. end of Moose lake and on Ogishke Muncie lake and in other places. The thickness of the conglomerate series cannot be estimated.

The graywackes which normally overlie the conglomerates cannot be given a separate color in mapping representing as they do the transition in the sediments from the conglomerates to the slates. The best that can be done is to separate the conglomerates from the slates. An attempt is made to carry out this separation, the coarse graywackes being put with the conglomerates.

The slates of these series are most typically developed upon Knife lake and in that vicinity; hence we have spoken of them usually as the Knife lake slates. These slates are usually dark in color, very hard, fine grained, and fissile. Associated with the rocks which are normal slates there are certain peculiar phases which are very characteristic. These are the exceedingly hard cherty slates which break with a sharp conchoidal fracture ~~strike~~ giving sharp edges and from which Knife lake received its name. These upon weathered surface are in many cases pure white, sometimes grayish. Upon fresh fracture they are black cherty rocks of exceedingly fine grain~~ed~~. They now stand practically upon edge. ~~Probably~~ They occur in a synclinal depression but have not been folded once alone. The beds have probably been duplicated a great number of times, thus it is impossible to estimate the thickness. At one place between Fox lake and the greenstones to the S. a syncline was found which seemed to give a single repetition of these slates and it is possible there to get a maximum thickness. The~~se~~ data for making the estimate can be obtained from the details in this season's note book.

In places near the bottom of the slates there has been found an iron formation. This is well developed in its typical position and unaltered character upon the N. E. trending string of lakes occurring N. of Knife lake within Canadian territory and known as That Man's, No Man's, This Man's and the Other Man's lakes. A somewhat similar though not nearly so well marked ferruginous horizon occupying essentially the same place in the geological column was noted upon Ogishke Muncie. Here the formation is thin and is represented by a ferruginous schistose carbonate horizon on the N. side of the anticline. Immediately on the opposite side of this anticline the corresponding carbonateous formation has not been traced. As we examine the rocks in the vicinity to the N. of Paulson's mine we find in places immediately overlying the green stone a deposit which is ferruginous and was almost unquestionably original carbonates which may correspond to these. These are known as the Animikie and owe their peculiar characteristics chiefly to their metamorphism by the great gabbro which lies S. of them. As the contact between the greenstone and this iron formation is followed W. we find a narrow tongue of greenstone conglomerate beginning, upon which this sediment rests. This greenstone conglomerate tongue widens as it is followed to the W., the iron formation in this way being separated from the greenstone by a greater and greater distance. This same iron formation occurs in poor exposures upon the S. side of Gobbemichigomok lake. On the N. side of the lake occur the sediments grading from fine grained Knife (Agamok) slates to the N. into the greenstone conglomerates which lie upon the S. side of a great anticline. It is perfectly possible that Gobbemichigomok lake lies in a syncline in these sediments and that the small exposure of Animikie on the S. side corresponds to a ferruginous carbonate horizon, which may exist on the N. side of the lake. It must be borne in mind, as already stated, that the Animikie, so-called, being in close proximity to and having been much metamorphosed by the gabbro would be lithologically totally different from the unmetamorphosed carbonate. This correlation is given tentatively for no carbonate horizon is at the present time known to exist on the S. slope of this anticline.

Thus far no attention has been paid to the eruptive rocks, with the exception of those forming the Stuntz conglomerate, which are known to be intrusive in these various sedimentary rocks. Of these intrusives there are a number of acid and basic forms. The acid rocks vary from the coarse grained granite to the fine grained felsitic rocks. In chemical composition we would probably find that while most of them are granites there are some which are dioritic in character.

The basic rocks are predominantly dolerites and basalts though a number of basic dikes have been found which microscopically were determined as being camptonites and minettes, and others again were not determinable. The oldest acid rocks are clearly those which demonstrably cut the greenstone alone, that is, are younger than these but older than the succeeding sediments. The granite north of Vermilion lake and extending up into Basswood lake is known to certainly cut the greenstones. Along the contact of these two rocks the greenstone has been changed into a mica-hornblende- schist, partly, I think, without question as the result of the metamorphism of the granite and partly also as the result of regional movements. The next younger acid rock is presumably the granite which is well exposed in the vicinity of White Iron lake, occurring also to the N.E. and S. W. of this point. This granite is known to cut the greenstone and likewise the jasper, metamorphosing the ellipsoidal greenstones into mica-and hornblende- schists in which the ellipsoidal structure and amygdaloidal structure can still be observed. Of essentially the same age as this granite are those porphyries occurring on Vermilion lake and to which reference has already been made. Very interesting is the fact that at the extreme E. end of the region, the great Saganaga granite was intruded at this same period. It is found cutting the greenstones. There has not been found to my knowledge a dike in the jasper. I am convinced, however, that this is due chiefly to the fact that the jasper and greenstones near where the Saganaga granite is developed has not been thoroughly explored. These rocks in this area are best developed in ~~granite~~ Canada and this is a task for the members of the Canadian Geological Survey. I wish at this point to call attention to a rather striking resemblance of the granite-porphyry with big quartz eyes which occur in abundance in the western part of the region to the rock of Saganaga lake. This is itself a granite-porphyry with great quartz eyes the essential difference macroscopically between this and the granite porphyry of Vermilion lake being in the size of the grain of the matrix. There are two further areas of acid rock which must be considered. These are the areas in the vicinity of Snowbank lake and Kakekabic. I shall consider first the Snowbank area. Here the granite has been found to cut through the sedimentaries of the upper Huronian series. In addition to the fact that dikes of the granite have been found in the sediments, the sediments are observed to have been metamorphosed in the vicinity of the granite, showing clearly its intrusive character. These sediments here have been altered into micaceous schists and gneisses.

The Kakekabic granite occurs in a small area and is found also to cut the sediments of the upper series. These are the only acid rocks known to cut through the upper sedimentary series. The rocks just enumerated represent all of the acid eruptives which occur to me at the moment as occurring in the region. The ages of the basic rocks cannot be outlined so readily. The basic rocks apparently represent the latest intrusive action of the region for they are found lying in and cutting through the very youngest of the rocks, the highest sediments + youngest igneous rocks.

If we include the great gabbro in this discussion then we must put its age as of course much younger than that of the rocks heretofore mentioned. This gabbro has had a very important metamorphosing influence upon the sediments with which it has been in contact, having produced micaceous schists in places and having caused the spotting of the rocks. In addition to the facts which have been observed macroscopically, microscopical examination, in a few instances by myself and in a number by Dr. Grant, show that it has produced changes of far reaching importance upon the chemical and mineralogical characters of the adjacent sediments. These will be studied and described when occasion offers. It is itself, however, cut by dikes of basalt which may correspond in their period of formation to those found in the rocks of the Vermilion district proper.

There must be a number of these basic dikes cutting through the ellipsoidal greenstone formation. Some of these were found. Many others were probably seen but their relations not being disclosed were considered a part of this formation.

Dr. Grant who has to some extent already studied these various basic eruptives macroscopically suggests the possibility of separating the young basic eruptives from the old ones by the presence of augite in the younger. He states that he has found this mineral in the younger rocks but never in the older greenstones.

Reviewing briefly the succession for the Vermilion district which has been given in the preceding pages we have at the bottom the ellipsoidal greenstone separated by an unconformability marked by thin beds of sediments from the jaspers above. This unconformability is presumed to correspond with that which has been found throughout the Lake Superior region to exist, and which has been used to separate the Arcean, here represented by the ellipsoidal greenstone complex, from the lower Huronian. In the Vermilion district this lower Huronian consists of the normal fragmentals with the great iron formation which is of such vast economical importance. In the presence of this great iron formation, the lower Huronian of this region corresponds in a striking manner to the lower Huronian of the Marquette, Crystal Falls, and

Menominee districts of Michigan. This iron formation is separated from the next higher formation by a great unconformity which corresponds ~~with~~ to that existing in the remainder of the Lake Superior region and which separates the lower Huronian from the upper Huronian series. The upper Huronian series consists of the fragmental deposits with an unimportant iron horizon and in its stratagraphical position as well as in the presence of the iron horizon corresponds with the upper horizon of the Penokee-Gogebic, Marquette, Crystal Falls, and Menominee districts of Wisconsin and Michigan.

In the correlation of these rocks perhaps one of the most striking features of the correlation will be the striking correspondence of the Ardean of the Vermilion district with the Ardean of the Marquette district and the correlation of the upper sedimentary series consisting chiefly of slates with an iron formation in it with the ~~upper~~ slate series of the Penokee, Marquette, Crystal Falls and Menominee regions, in all ~~both~~ of which there ~~is also~~ an iron formation. Considerable lithological differences exist between the lower Huronian of the Vermilion district and of the other districts, although in all of them the ore bearing rocks are the jaspers associated with ferruginous carbonates from which the ores were derived.

The various sedimentary rocks of the Vermilion district have associated with them and cutting through them eruptive rocks of both ~~an~~ acid and basic character and of various composition and various ages.

STRUCTURE

The structure of the Vermilion district is of a very complicated character. A complete description of it would carry us too far for the present notes. In a broad way this district is a great synclinorium trending to the N. 70° to 80° E. Within this main syncline there are to be found a number of minor synclines and anticlines, all having their axes striking in essential accord with the trend of the main synclinorium. Some of these anticlines are really the most prominent features of the district, for instance, the great anticlines of the Soudan, Tower and Lee hills, and the great nose of greenstone projecting W. from the extreme E. end of the district. In addition to this folding which has been produced by pressure coming from a direction approximately at right angles to the trend of the major syncline, folding has taken place at right angles to this, resulting in cross folds. This folding is of very much less importance than is the major folding produced by the N. and S. pressure. As a result its structural features are very much less prominent. It is due to this that the anticlines and synclines have their axes pitching at various angles. The extremely wide spread exposures of greenstone lying just W. of Ely are probably due to the fact that this represents the crest of one of the main anticlines produced by the E.W. folding. Certainly just E. of here in the Ely iron formation the pitch is very noticeably to the E. Other cross anticlines and synclines unquestionably occur to the E. but it is difficult to determine their existence in all cases. For a number of years the Vermilion district has been considered as that one of the Marquette districts in which the folding had reached its acme. ~~The study,~~ The unraveling of the structure shows us that in reality the folding here has not been so great as it has in some of the Michigan areas, notably the Menominee. In the Vermilion district one can trace the gently rounded ends of of the synclines and anticlines, whereas in the Menominee the folding has been so extreme that the synclines and anticlines run out practically to knife edges. Some of the sketches in this year's note books will show clearly the intricate character of the folding. This has in many cases resulted in producing exceedingly complex relations between the rocks ~~and~~ which have presented in numerous instances very perplexing problems.