

THE CUYUNA IRON RANGE.

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The Cuyuna Iron Range lies in Aitkin and Crow Wing counties, Minnesota, running S. W. and N. E. Owing to the rarity of rock outcrops and its isolation from the other well-known iron ranges, its geological structure and relations have been difficult to make out. The writer recently visited the eastern portion of the range, and, under the guidance of Mr. H. B. Ayers,

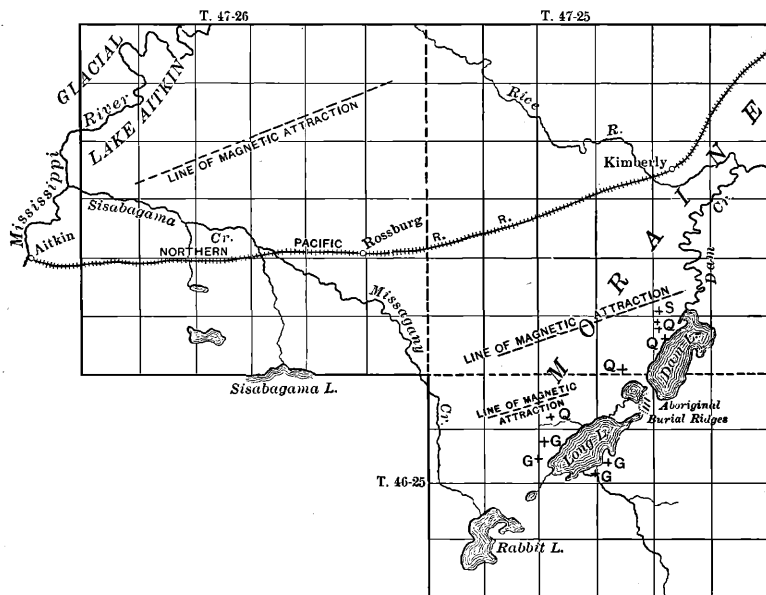


FIG. 64. Sketch map of the east end of the Cuyuna iron range. Scale approximately $3\frac{1}{8}$ miles to the inch. Crosses indicate outcrops: Q, quartzite. G, greenstone. S, schist.

saw several exposures of rock of which no mention has been made heretofore, and examined some rock drillings. Mr. Ayers also furnished part of the data for the accompanying sketch-map, Fig. 64.

About fifteen years ago Mr. Ayers brought to the writer samples of quartzite from the north shore of Dam Lake, which were recognized as belonging to the basal quartzite of the Animikie, which lies below the iron ore of the Mesabi range. At a later date this quartzite was visited and examined by Mr. Warren Upham when he made the survey of Aitkin County for the state geological survey. Its location is shown on the map¹ prepared by him and accompanying his final report on that county. In the same report² the greenstone outcrops in the vicinity of Dam and Long lakes are described. They are considered to be parts of a great diabase dike of date later than the Animikie and probably cutting the quartzite of the region.

The Quartzite at Dam Lake.—There is no unequivocal evidence as to the direction of dip at this place. The outcrop which appears on sec. 35, T. 47-25, extends along the shore about 250 feet, but is so much broken or so massive that no bedding planes can be observed, although two small areas are certainly in place. By the occurrence of other outcrops and by the topography the dip is judged to be southeast, a supposition which would cause the supposed Animikie ore to lie under the waters of several small lakes that stretch along a N. E. and S. W. belt to the south.

At a point about a mile toward the southwest from this outcrop is another exposure of the same quartzite. This is on the S. W. $\frac{1}{4}$, S. E. $\frac{1}{4}$, sec. 34, T. 47-25. It is in the form of two smooth glaciated domes, about 25 feet in length and 15 feet in width. While the rock here has the same massive aspect there was found, fortunately, a separation plane marking the sedimentary structure with unmistakable clearness. This also conforms with the general known direction of glacial striæ with which the surface is covered, with the stoss side of broken knobs, and with the slope of the main surface, and shows a dip of about 25° , S. 30° E. Hence from Dam Lake to this place it is safe to conclude that the quartzite continues with about that dip and strike. About a mile and a half still farther the southwest, *i. e.*, in the

¹ Minn. Geol. Survey Atlas, plate lvii.

² Vol. IV., p. 36.

S. W. $\frac{1}{4}$ of sec. 4, T. 46-25, the same rock was struck in sinking a shaft, thus proving an extension along the strike of two and a half miles for this rock.

Back from the shore of Dam Lake, in the S. W. $\frac{1}{4}$, N. W. $\frac{1}{4}$, sec. 35, T. 47-25, a drill hole also reached this quartzite at such a distance from the lake as to show, in connection with the dip there, that the quartzite must have a considerable thickness, say 150 or 200 feet.

The place of this rock in the geological series cannot be mistaken. It has the grain, the color and the thickness of the basal quartzite of the Animikie. It contains frequent lavender or amethystine grains of quartz which are referable to the granite on which the Animikie lies. They have been derived from that rock by disintegration and sedimentary deposition, and the quartzite is consequently younger than the granite. The dip toward southeast, however, is contrary to what has been supposed, for the quartzite has been thought to be in the southern limb of a syncline in the Animikie, the western end of the Mesabi range being the northern arm, and the bottom of the syncline somewhere under the intervening country. This quartzite, on the northern limb of this supposed syncline, can be traced to the north end of Pokegama Lake, and if reports of land surveyors can be accepted it extends to the Little Boy River in Cass County; but of this western extension we have no details.¹ Why this quartzite appears in two parallel belts, both dipping to the southeast, cannot at present be explained. There are, however, several hypotheses that may be suggested.

1. It may be a westward continuation of that structure of the Animikie which is seen much farther northeast, *i. e.*, a succession of parallel faults running N. E., on the south side of which the rocks are raised much above those on the north side. The same structure is apparently repeated at the falls and dalles of the St. Louis River in Carleton County.

2. This area of the basal quartzite of the Animikie may be entirely isolated from the main body of the Animikie, and while dipping southeast at the points observed, it may rise along the

¹ See 18th Rep. Minn. Survey, pp. 14-16.

southern side of Dam and Long lakes, and, if it could be seen, it would there show a northwest dip. As greenstone of the Archean is known to occur on the southeasterly side of Long Lake, it would necessarily be a small and shallow synclinal basin, the southern arm of the basin being near the lake shore, or perhaps entirely under the water. If iron ore exists in this syncline it would be under the waters of Dam and Long lakes.

3. The line of strike of the quartzite from the Mesabi range may take a zigzag course in passing toward the southeast, and the dip may vary in consequence of the Archean topography upon which the sand was deposited.

In the absence of sufficient data, the manner of connection of this quartzite area with the quartzite at the base of the Mesabi iron-bearing rocks must be regarded as an unsettled problem.

The Greenstone of the Region.—At several places northwest of Dam and Long lakes, and at two points on the south side of Long Lake (S. W. $\frac{1}{4}$, sec. 10, and S. E. $\frac{1}{4}$, sec. 9, 46–25) are outcrops of greenstone plainly belonging to the Keewatin of the Archean. These outcrops are so near the quartzite outcrops that it is apparent that the greenstone passes non-conformably below the latter and hence that a great chronological break exists between the two formations, analogous to that between the rocks of the Mesabi range and the Archean. One of these outcrops, that in N. W. $\frac{1}{4}$, sec. 9, T. 46–25, was visited and drillings were examined from some test-holes that have reached the greenstone north of the quartzite. Although it has been called, at different places, “gray schist,” “diorite” and “diabase,” it is everywhere the rock which constitutes the main part of the Lower Keewatin. It is the great Kawishiwin greenstone, and it indicates that toward the north and west, under the drift, is spread a wide expanse of the Archean.

The Iron Ores of the Cuyuna Range.—The ores of the range were not personally studied. According to Mr. Ayers they are magnetic, and are distributed in N. E.–S. W. lines across the country northwest of Dam and Long lakes. See Fig. 64. These belts of attraction are separated by belts of non-magnetic country rock. They can be traced, with some interruptions, as

far west as Aitkin and Deerwood and even to the vicinity of Brainerd. At several places exploring operations have been started and many drill-holes have been sunk. In some cases a lean magnetic ore, associated with some hematite, has been found. The structure of the rock, with which the ore is parallel, is nearly vertical. It is probable that this structure is a combination of schistosity, due to pressure, and bedding planes, as is universally the case in the Archean rocks of northern Minnesota. The beds have been closely folded and compressed and the repetition of the magnetic belts in this region is likely to be due to repetition of the same bed, the crests of the anticlines having been truncated. On the other hand magnetic iron ore is known to run in narrow belts in the Keewatin, where it cannot be affirmed that the containing rock is clastic. In other words, there are, in the great greenstone formation of the Lower Keewatin, narrow magnetic belts, rather capriciously distributed, which run parallel with the general structure. These may be original in the igneous part of the Keewatin and may have acquired their position and present structure through other than sedimentary processes. When a great basic mass has suffered the vicissitudes through which the Archean greenstones have passed it may have acquired structures resembling bedding, and been so altered as to segregate the iron in belts which, when coincident with schistosity, would simulate an original fragmental banding. What portion of the iron ore in the magnetic belts of the Cuyuna range is due to fragmental accumulation and what portion, if any, to secondary processes, acting upon a basic igneous rock during a dynamic metamorphism, appears to be entirely unknown.

It is premature to attempt to give any stratigraphic succession. That all the ore as yet discovered, and all that is likely to be found, in the region of these magnetic belts, from the Mississippi eastward to Kimberly, belongs in the Archean, and hence is analogous to that of the Vermilion range, seems to the writer to be beyond question. This ore, therefore, so far as it has been discovered, lies structurally below the quartzite of Dam Lake,

and cannot be correlated genetically or chronologically with any ore overlying that quartzite.

Volcanic Tuff.—Those who are familiar with the reports of the Minnesota Survey will remember that the ore of the Mesabi range was stated to have been derived from the alteration of basic volcanic rocks. Such rocks were found to have been altered on an extensive scale, but still show traces of their original nature. In almost every place where, at that time, mining had been sufficient to expose the strata, remnants of the volcanic rock could be identified. The chief of these remnants was stated to be the granular soft hematite of the range, which was considered essentially an altered obsidian sand accumulated along a sea beach in the near vicinity of the volcanic vents whence it came. The greensand, which has been called *glauconite* and *greenalite*, into which the ore grades, was explained as an altered form of this volcanic sand, and it was shown that this fine sand grades into coarse masses and blocks, and that these blocks and masses, which are often found in the midst of the granular ore, are identical in material with much of the country rock that contains the ore.

It is not intended here to review the evidence for this hypothesis, as the full discussion is published in the Minnesota reports (Vol. V.). It has remained to the present to discover remnants of the unaltered volcanic rock to which reference was there made. The writer has not visited the Mesabi range since the field-work of the state survey was concluded, and has had no opportunity to reexamine the field in the light of later developments, but has hoped some day to review this question.

Unexpectedly, however, some light has been thrown upon this matter by the discovery of a coarse volcanic tuff or breccia at the bottom of a shaft sunk by Pickands, Mather and Company, on sec. 8, T. 45-27, about eight miles east and three miles north from Brainerd. According to Mr. Jarchow, as stated to Mr. H. B. Ayers, of Kimberly, this tuff was about five feet thick and was called "conglomerate" by the workmen. It lies non-conformably on the vertical slates and ore of the Cuyuna range, and these are associated with more or less rock which Mr. Jarchow

called "greenstone." From the description, this rock seems to be a part of the volcanic tuff of the bottom of the Mesabi range. It is worthy of more full description. Specimens obtained through Mr. Ayers are unlike any rock hitherto found in Minnesota. While it appears like a conglomerate and contains numerous pebbles, up to half an inch in diameter, which seem to have been rounded by friction, it is composed wholly of volcanic material and its alteration products. It has a general hematitic red color. The matrix is fine-grained and in some places appears like brown quartz-porphyry or obsidian. This matrix is apparently composed of fine grains of the same kind as the pebbles. In some places are patches of hematite ore which appears to have been derived by segregation from the surrounding rock, but in most cases such hematitic rock has the shape of distinct grains or pebbles. Other pebbles are altered concentrically, having a center of some highly ferruginous mineral, or group of minerals, surrounded by rings of different composition but heavy with iron ore, the outermost coating being loose and limonitic. Some pebbles are altered uniformly from circumference to center. These were undoubtedly originally glassy. Some few are amygdaloidal. The most common and striking feature of the pebbles is their concentric alteration and the tendency of the iron to gather at one side or in the center.

Whether this rock belongs to the basal portions of the Mesabi range or to some part of the Keweenawan is problematic. It is far beyond any known extension of the Keweenawan, but it is in the area where the Mesabi is supposed to be present. No such rock has been discovered within the Keweenawan, though it is allied to the fine conglomerates of the Manitou part of the Keweenawan. On the other hand, it seems to accord with the hypothesis advanced to explain the origin of the Mesabi ores and its mode of alteration is identical with that of the pebbles and small grains that have been altered to form the Mesabi iron ore. If it has, as reported, a thickness of five feet and lies non-conformably on the ores and slates of the Cuyuna range, it cannot be considered a drift boulder, but must be some part of the unaltered basal strata of the Mesabi range.