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RIB MOUNTAIN QUARTZITE and T.28N., R.7E. SURFACE FEATURES

by

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This investigation was made May 14, 1933 at the request of Mr. L. A. Hatch of the Minnesota Mining and Manufacturing Company, St. Paul. The company is primarily interested in the homogeneity of that portion of the hill west of the park boundary and east of the west line of section 8, T.28, R.7E. Since the structure of the quartzite is discussed in the accompanying copy of the field report, and the petrographical character is described in Bulletin 16, I shall confine my discussion to answering six questions. My conclusions are based on the available data, and should be considered tentative.

1. What changes in character may be expected in a section across the beds?
2. What changes in character of the quartzite may be expected along the strike?
3. What changes in character of rock may be expected at depth?
4. Where should the plant be located?
5. What exploration should be conducted to determine the answers to the above questions?
6. Should the quarry face be parallel to or at right angles to the strike?

VARIATION IN CHARACTER FROM NORTH TO SOUTH

While there is some variation in character of quartzite exposed in the quarries, experience has shown that from the practical standpoint there is but little difference. The beds are practically vertical with the bottom to the north. We can only speculate as to the character of the basal beds. These may be conglomerate. The contact with the intrusive may be marked by a zone of quartzite fragments in a syenite matrix. The lowest beds(stratigraphically)exposed are in the "gold" mine tunnel. Here the quartzite is quite similar to beds farther south. Some beds are red, but others white. The magnetic line along the south side suggests that the upper beds (stratigraphically) should be avoided.

VARIATION IN CHARACTER ALONG STRIKE

Within the area under consideration there appears to be but little variation in character of the quartzite along the strike. The principal question is in regard to the significance of the saddles. The saddles may be due to joint or shear planes along which weathering has proceeded more rapidly. They may be due to an intrusive dike. The field notes report two small bowlders of syenite in the saddle near the N-S quarter line of section 8. I am inclined to believe that these bowlders may have been brought in as road surfacing material. An angle hole across such a saddle would dispel doubts. My opinion is that some of these saddles, at least, are due to joint or shear planes. These may prove objectionable as the freer passage of water may have resulted in increased iron stain. In the area under consideration I saw no evidence either in outcrop or talus to indicate that zones of heavily iron stained material are present. The quarry east of the NW corner of section 15 has a vertical zone of stained rock which cuts across the bedding. I saw nothing similar to this in the area west of the park.

CHANGE IN CHARACTER AT DEPTH

At the surface the quartzite is well jointed. It is to be expected that at a depth of 200 feet the joints will be somewhat less numerous. At the surface in a few places the quartzite is weathered to a friable rock resembling sandstone. The process has been quite similar to the weathering of granite. This weathering even in the earlier stages favors the entrance of water and may result in the deposition of an iron film. I believe that at depth the weathering effect will be less and the rock should be less stained with iron. The physical character of the quartzite at depth should be determined by tests of material secured in exploration.

LOCATION OF PLANT

There are certain physical factors that determine where the plant should be located. It appears that topography and economic considerations eliminate a site on the south side. The elevation of the plant on the north side is an engineering problem. It will be at the maximum elevation consistent with train operation on the railroad spur. The quarry floor should be at a height which will permit the delivery of stone to the plant at the lowest possible cost. I suppose, therefore, that the quarry floor will be slightly above the top of the receiving hopper. The plant should be so located along the strike that the cost of haul per ton during the life of the plant shall be as low as possible. In my opinion the plant should not be located near the west property line, but should be far enough east to make available short haul material for the life of the plant.

EXPLORATION

Assuming that the elevation of the quarry floor and the location of the plant have been determined, exploration should be conducted to secure a section across the beds and to determine the cause of the saddles. The section may be secured by diamond drill or by tunnel. The tunnel has some advantages over a diamond drill hole, since a larger sample can be obtained, and the rock can be examined in place. The exploration should give the maximum information at the lowest cost. This, in my opinion, calls for a horizontal hole at right angles to the strike. (If a tunnel is employed it would probably be designed to drain north.) I should recommend that the hole be started at a point south of the proposed plant site, at the elevation of the proposed quarry floor. This exploration will determine character of quartzite at depth and variation in beds across the formation.

The cause of saddles should be determined. As suggested above, this might be accomplished by an angle hole parallel to the strike so as to cross section the saddle at depth. Trenching across the crest of the saddle parallel to the strike would probably furnish the answer.

QUARRYING PROCEDURE

One method of attack is to develop an east-west quarry face. This has the disadvantage of requiring removal of a large yardage of talus before quarrying in ledge can be started. Another disadvantage is that quarrying at any stage will be confined to rock from about the same stratigraphic horizon. Considerable quarrying must be done before the maximum height of quarry face is developed. This method has the advantage of a long quarry face.

A second method is to cut a north-south trench into the hill, with its bottom at the level of the proposed quarry floor. The width of cut at the north end would be just sufficient to furnish an efficient haulage way out of the quarry. It would extend as far south as justified by the quality and height of ledge. Once the channel is completed, the quarry face can be advanced both to the east and west. This method has the following advantages.

1. A relatively small amount of talus would be handled. In my opinion this method will cut the cost of quarrying and at the same time do but little injury to the scenic appearance of the hill. The scar on the north face will be relatively narrow.

2. By working both east and west a long face will be available when large tonnages are required. Drilling can proceed at one face while broken material can be removed and the floor cleaned at the other.

3. It will be possible to work the maximum height of face from the beginning.

4. In case an objectionable bed is encountered this can be left in place.

5. A more uniform grade of material is available.

6. The haul to the plant will be shortest at the beginning of operation, when other costs are usually higher. I see no disadvantage in working the edge of beds, since jointing is well developed.

SUMMARY

1. The exposures indicate an ample stratigraphic thickness of good material to justify a large quarry. Exploration may show that a greater thickness of good material is available.

2. The principal change along the strike will probably be at the saddles. There are but two large ones. Exploration will determine the thickness and character of the material causing the saddles.

3. I see no reason why the physical quality of the rock should not improve with depth. Quarrying should not be more difficult.

4. The plant should be located on the north side far enough east of the west property line to make short haul material available for the life of the plant. The quarry floor should be slightly above the level of the top of the receiving hopper.

5. Exploration should be conducted by horizontal diamond drill or tunnel to determine the character of material available at depth. The nature of the material in the saddles should be determined by diamond drill or trenching.

6. The quarry should be worked at right angles to the strike.

T.28N., R.7E.

SURFACE FEATURES

The most prominent features in this town are the two hills, Rib Hill and Mosinee. Rib Hill, the largest of the two, lies in an east-west direction through sections 7, 8, 9, and 15. Its highest point has an elevation of 1925 by the W.G.S. elevations and one of 1940 by the U.S.G.S. The level of the plain surrounding this hill is about 1200 feet, making a relief of about 725 feet. Mosinee Hill, divided into two hills, the parts of which are called Upper and Lower Mosinee, lies in a general north and south direction in sections 22, 27, and 34. The elevation of Upper Mosinee is 1610 feet and Lower Mosinee 1500. These two hills are very pronounced, as before stated. The slopes above the 1400 foot contour are generally steep and climbing is rather difficult. On these steep slopes the quartzite generally forms talus slides and the blocks of rock are all sizes up to 10 feet in diameter. These hills are characteristically covered with brush and small trees so that from a distance the surface appears to be rather smooth, but on close inspection it is found that the top especially is beset with crags and pronounced hollows. The north, northeast, and east part of the town is as pronouncedly flat as Rib Hill is high. The Wisconsin flows through a flat, terraced in places back from the river, but generally having a bank of about 20 feet at the edge of the river. The hill at Rothschild rises about 80 feet above this plain. Undoubtedly this flat is of glacial origin, for it is composed of bedded gravel, sand, and clay.

A dam has been put in at Rothschild so that north of here the level of the water in the Wisconsin River has been raised about 25 feet with the result that considerable land has been flooded.

The southwest part of the town is rather flat and low, somewhat similar to the glacial outwash along the river, except that no gravel is found here to speak of, although in places the soil is quite sandy.

It appears that during the glacial period when these gravels and sands were deposited Rib Hill, Mosinee Hill, and Hardwood Hill existed as islands and that most of the rest of the land was flooded. Weidman says that he found no erratics above the 1400 foot contour. It is possible that the water never reached a higher level than this.

DESCRIPTIVE GEOLOGY

Rib Hill Quartzite. The Rib Hill quartzite is found in three places in the township. It forms the main bulk of Rib Hill itself, which extends from the quarter line of section fifteen west and northwest, as indicated on the contour map, through sections nine, sixteen, seventeen, eighteen, and eight, and seven. The same type of quartzite is found at the crest of Upper and Lower Mosinee hills in sections 22 and 27.

Descriptive. There are several distinctive types of rock, all quartzites, which are found on Rib Hill and the adjoining Upper and Lower Mosinee hills. The type found in greatest abundance is a white to grayish completely recrystallized, coarsely granular rock which resembles granular rock salt. It usually has parallel color bands extending through it of pink or gray tints. This type often has a pink tint all through. It is due in some cases to impregnations from the igneous rocks near contacts and in other places due to iron coloration. Specimen 1127 (36610) shows a dark brown granular quartzite in which case the iron stain is present in great abundance. The limonite is secondary after recrystallization because it fills in the interstices between the recrystallized grains. Also, if it had undergone the metamorphism suffered by the quartzite, it would likely be changed to magnetite (1127 (36610) for Rib Hill only).

Another type of quartzite found on all the hills is very fine grained with somewhat of a sugary texture. This type of quartzite is often pink.

Beds of chert ½" to 6" across and parallel with the main bedding planes can be found. They are undoubtedly primary chert beds. Occasionally a vein 1"-2" across of pure vein quartz is found cutting across the bedding of the quartzite. Since dikes of igneous rock are found on the hills, the presence of vein quartz is not surprising.

Another type of rock which may be quartzite is found on Rib Hill. This rock is reddish and frequently looks sheared. It is found near igneous dikes and represents either a highly impregnated quartzite or a very acid igneous fine grained rock. Another phenomenon of the contact zone portion of Rib Hill is the leopard spot rock, a contact rock, no doubt.

Stratigraphy. That the Rib Hill quartzite occurring at Rib Hill and Upper and Lower Mosinee hills is of sedimentary origin and of clastic sand materials is readily proved because of frequent findings of well preserved cross bedding, normal bedding planes, and occasional ripple marks. The ripple marks are of both symmetrical and assymmetrical types and are about 2½" from crest to crest and ½" high. Specimen 914 (36597). The cross bedding found was marine — littoral or neritic type and not river nor wind deposit type, i.e. the top and bottom set beds were parallel to the main normal bedding planes, the foreset beds were inclined 20-30° from the beds above. The foreset beds were nicely beveled off ending abruptly against the plane of the normal bedding on the top side. If the quartzite of Rib Hill was rendered flat lying once more, the cross bedding in most instances as found would be inclined toward the N and NE. One case of westward dipping cross bedding was found.

Near the center of the hill and extending in general E-W from there the quartzite is very well bedded. A splendid example of thin almost laminated bedding can be seen at about 5 T E and 2-3 T S of NE 16. At this same outcrop ripple marks and cross bedding can be found. The plane of the ripple marks and the top and bottom set beds of the cross bedding, and the coloration bands marking the bedding planes are present, and can be relied upon to give accurately the structure of the quartzite. From this and abundant other similar outcrops there can be no doubt as to the reality of the bedding planes and their authenticity and reliability to portray structure.

From numerous examples of cross bedding, all confirmatory, the north side of the hill contains the lower beds and the south side the upper beds.

An alidade and plane table were used to make a topographic map of Rib Hill and all outcrops and points of interest geologically were tied in to location and elevation points on the 20' topography map. Since the bedding is nearly vertical in the widest part of the hill, and all dipping parallel and in the same direction, a measurement across horizontally will give a fairly accurate measure of the thickness of the quartzite, at least for as much as has been preserved from erosion and the effects of the intrusions. It is found that the quartzite was at least 2600 feet thick originally.

To find that thick a formation of pure quartz sand points toward marine deposition, since in marine deposition a high degree of sorting is attainable. Further substantiating evidence of the marine origin of this sediment can be found in the perfect parallel bedding planes, type of cross bedding, and also the presence of cherty bands.

It is possible, as the dip of the cross beds suggests that deeper water lay to the N and NE and shallower or land area to the S and SW at the time these sediments were deposited. This is just a hazard, however, since ocean currents could cause the cross beds to be deposited at many angles not parallel to a shore line. Irregular indentations could have the same effect.

A generalized stratigraphic section across Rib Hill would show at the base on the north side a white to pinkish coarsely recrystallized quartzite in which bedding planes and cross bedding are not usually well defined. Toward the south the bedding planes become much more distinct and cross bedding and ripple marks and chert bands are found. This situation obtains with some exceptions until the south side of the hill is reached when again the quartzite is more massive, coarsely granular, recrystallized, and bedding planes are indistinct. The above distinction is not too diagrammatic since coloration or bedding planes and occasional cross beds can be found in most of the rock, however coarsely recrystallized it may have been, and further, much of the distinctly bedded rock is also highly recrystallized.

It is highly possible and even very probable that the attempt at stratigraphy in the above paragraph may be as well explained as being due to the more intense action of the intrusive magma along or close to the contact margins of the quartzite.

Upper and Lower Mosinee hills have a much smaller area of quartzite in place than Rib Hill. One observation of strike and dip was made on Upper Mosinee Hill and two on Lower Mosinee Hill. The rock is very similar to the Rib Hill quartzite as regards recrystallization, color banding, and occasional cherty and fine grained bands or beds.

In conclusion we wish to stoutly reiterate the assertion that bedding planes are present in this quartzite over extensive areas of outcroppings and that ripple marks, cross beds with top set, foreset, and bottom set beds, cherty beds, and the so-called discoloration bands were all found time and again, collectively and individually, and when found together the plane of one coincided with the plane of all the rest. Anyone wishing to check the above statements will find ample proof of them at the following locations.

Structure. For records of dip and strike observations of individual outcrops, see alidade-plane table map or original field notebooks.

The general structure of Rib Hill is that of a gently flexed syncline pitching steeply south slightly overturned 5-6° near center of syncline, but normal pitch for most of it. The trend of the ridge or hill is in general parallel to the structure of the hill. The syncline is in its normal position with the top beds toward the south, the bottom beds dipping underneath on the north side.

The relation of the structure of Upper and Lower Mosinee hills to Rib Hill cannot be as definitely given. One observation on Upper Mosinee showed a nearly N-S strike and an eastward dip. On Lower Mosinee Hill the quartzite strikes N.38 E and dips 65° SE. If these hills represent an interrupted continuation of the Rib Hill quartzite, and this seems the most probable, the quartzite of Mosinee Hills is likely to be overturned in position because of the eastward dips. It also seems probable that the intrusive quartz syenite or granite magma caused or helped to cause the folding and that Lower and Upper Mosinee hills were either torn off and sagged away from the Rib Hill mass and rotated by the syenite magma intrusive, or were engulfed and rotated in situ.

Quartz syenite (or granite) occupies the depressional spaces represented by the lowest saddle in Rib Hill and it also occupies the area between Rib Hill and Upper and Lower Mosinee hills. The same process of the magma coming up along a fracture or joint plane and forcing huge fragments of the quartzite apart or assimilating part of the quartzite may account for the three separate hills. Hardwood Hill to the west may tie into the other end of Rib Hill. Dr. Weidman, in Bulletin 16, also suggests the possibility of a crescent/shaped fold uniting the structure of the four hills.

The quartzite of Rib and Mosinee hills area has been folded in the zone of fracture. The movement has taken place largely by offsets and movements along fractures. The folding is by no means complex as suggested in Bulletin 16. Two examples of drag folds were seen and these were found on fragments not in place. The folds were so gentle as to hardly be properly called drag folds and the movement was chiefly through offsets along minute fractures. The folding is of the parallel type with no deformation nor distortion of the bedding planes. Two intersecting sets of fractures are noticeable near the central portion of the syncline. They tend toward a 45° slant across the bedding similar to this diagram; and are thought to represent a set of compressional joints.

<u>Contact Relationship.</u> From Bulletin 16 we know that the quartzite has an imbricate texture and becomes so coarsely recrystallized as to resemble vein quartz. However, certain zones are not as thoroughly recrystallized as others, as shown by the presence of chert bands and bands of very fine grain quartzite. It would be an interesting thesis to take specimens of the quartzite all the way across the hill and examine them microscopically for data on cementation, recrystallization, etc. It is entirely possible to do this also. Specimen
Test pit SW SE 9
1127 (#36610) has the characteristic of a secondary growth of crystal quartzite rather than a recrystallized one.

The relationship of the quartzite to the igneous rocks in contact is a special problem and any suggestions here offered on the basis of field relationships and examination should be followed up by microscopic examinations and chemical analyses in order to prove or disprove them.

Two types of contact phenomena are worthy of mention. The first consists of a mixture of quartzite and biotite schist inclusions in a granite or quartz syenite rock, and the second, quartz impregnation due to the influence of the intrusive rock. The two are related because both may be present at the same location and take place simultaneously. Around the slopes of Upper Mosinee Hill and parts of Rib Hill the quartz syenite or granite contains numerous inclusions of reddish to white, often impregnated, rounded fragments and large blocks of quartzite and also biotite schist resembling conglomerate. Sometimes the zone of mixed rock is one-half mile wide. The inclusions are usually nicely rounded or eaten into and honeycombed by the solution effects of the intrusive magma. The quartzite fragments are also frequently impregnated with orthoclase feldspar. Specimen 61 (36096). Specimens 297 (36333), 298 (36334), and 80 (36115) show contacts of quartz syenite and biotite schist. The widespread occurrence of this type of contact gives evidence of assimilation on a much greater scale than one ordinarily sees along contacts. The presence of the biotite fragments is difficult to explain. They are coextensive with the quartzite-syenite contact and may represent an older schistose rock near the base or top of the quartzite.

The other form of metamorphism is shown by a reddish, fine grained, sometimes schistose rock, highly quartzose which might be one of two things. This rock might represent a thoroughly impregnated quartz containing much material of igneous nature or it might represent an igneous rock highly quartzose because of absorption of the quartz from the quartzite along the contact. Slides of specimens 289 (36325), 288 (36324), and 61 (36096) would help to determine the exact nature of this alteration.

Contact. As stated before, the syenite has peculiar developments in the vicinity of Rib and Mosinee hills. Near the center of section 10 there is a quarry for road material where there is exposed a coarsely crystalline phase of the granite—syenite. This rock is peculiar in its close resemblance to the syenite found in the vicinity plus large globs of quartz. Specimen 56 (36091) shows this. When first encountered, it was thought suggestive of assimilation of the Rib Hill quartzite which lies just to the north. This, however, cannot be proven and seems somewhat doubtful, as a similar development was found quite removed from the quartzite.

On the north side of Rib Hill in section 9 (see stadia notes 107 E.C.E.

Book, p. 67) there is a dike of the syenite magma which cuts through the quartzite cutting the bedding planes and truncating the structure of the quartzite. This dike material is very quartzose and in places could not be told from the quartzite except by the coloration. In other places there is a distinct line of contact and the dike material is much more feldspathic. It seems that there has been two processes operating here. One is that of direct intrusion with actual displacement of the quartzite; the other is that of impregnation where it is improbable that the quartzite has been displaced. It is impossible, however, to tell which quartz is of magmatic origin and which is clastic.

Specimens 295 (36331) and 294 (36330) show contact, and specimen 1128 (36611) shows the dike material.

It is clearly seen that the joint systems of the quartzite do not extend across the dike. It is evident, however, that at least part of the joints developed prior to the intrusion because the latter follows some of the former. The rounded quartzite spots (seen on specimens dissolved brecciated quartzite or the whole rock may be impregnated with certain portions resistant to impregnation.

Magnetic Rock. Occurring just south of Rib Hill and bounded on the north by the steep rise to the crest is a peculiar formation which may be a sediment or an igneous rock. If it is igneous, it probably falls in with the syenite-granite magma, but if it proves to be sedimentary, then it appears to overlie the quartzite. This formation was mapped chiefly on the strength of bowlders and magnetic traverse. The north side of the formation seems to be more definite than the south side. It is very striking how the contact appears to follow the contours of Rib Hill. The formation extends in an east-west direction from the east line of section 17 to at least as far west as the west range line. The south boundary seems to be indistinct and can only be approximately located with the dip needle.

The formation is a fine grained pink rock with a somewhat arkosic texture. It is too fine grained for determination. It contains masses and drawn-out lenses of a dark colored material which is practically all magnetite. Large pieces of the dark material will adhere to a magnetic knife blade. Specimens 78 (36113) and 79 (36114) show the two phases of the rock. 78 (36113) shows the magnetite masses drawn out into lenses and 79 (36114) shows them more as rounded masses. Near 5 T N of S½-T was also found a conglomerate looking rock which might represent a rock between the quartzite and the magnetite rock. It is mainly a pink sheared rock containing pebbles and fragments of quartzite and black schist. In case these are sediments, this rock would be called a conglomerate. If there were erosion after the sandstone (quartzite) was laid down, a later formation deposited on this surface would contain pebbles of the quartzite. Now let this be sheared and metamorphosed as the quartzite shows the region to have been, then such a rock as this contact schist or gneiss would be formed.

We, however, feel that the magnetite rock is of igneous origin and that some ferrous formation was intruded by the magma and fragments drawn out by primary flow and partially dissolved remain now as the black magnetite lenses, or that there has been a very peculiar differentiation of the magma at the contact causing the magnetite of the formation to be formed in these lenses. The presence of relatively quite a few fragments of iron formation in the vicinity which cannot be accounted for by transportation aid in the theory that a formation here similar to an iron formation may have been intruded and torn apart by the igneous rock. The fact that the southern boundary of this formation is indistinct may be as well explained by one theory as the other. If a sediment, it is probably dipping down under the igneous rocks to the south and therefore magnetics would show a gradual lessening of intensity. If igneous, however, and the phenomenon is merely that of contact, then one would expect a gradation outward.

Another thing that favors the igneous origin of this rock is the relation to Rib Hill. Although lying in general parallel to the trend of the hill, it does not follow the bedding, but seems to follow the contours as a sediment would not. The possibility of any iron formation being present here is very small, although the possibility cannot be eliminated.