Marquette and Crystal Falls regions: [specimens] 25166-[25197]. No. 145 1892-1893

Van Hise, Charles Richard, 1857-1918
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U. S. GEOLOGICAL SURVEY

FIELD SECTION BOOK

Marquette and
Crystal Falls
Regions

CR Van Hise

25166

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.

6—747

#145

C. R. Van Hise

Ishpeming Michigan,
Tuesday, July 19, 1892.

In company with Dr. Wadsworth and Mr Seaman I visited again the localities in Sec 34, T. 48 N., R. 27 W., east and west of the bend in the Carp Dead Lake river road where it crosses the quartzite range.

A close examination of the relations of the rocks west of Carp river led to the conclusion that there is here only one series of quartzites. In following the quartzite downward from its regularly bedded form which occurs at the quarry, it is found to be somewhat plicated, then more plicated, and finally closely plicated into a series of axes plunging steeply to the south. This plication is so sharp near the contact with the greenstone schist series that Reibungs breccias have formed at several places. One of these was regarded by Dr. Wadsworth as a conglomerate, but seemed to me to grade into an ordinary bed of the quartzite. Against its being a true conglomerate is the fact that no pebbles are contained other than those which are identical with the rock in which the supposed conglomerate is contained; second, the gradation from the brecciated phase into the non brecciated phase along the strike. One place was shown us by Mr Seaman where the quartzite faces the green schist on the south as a mere skim, and here the same unconformable relations are seen which occur east of the road.

25166
25167 represent the quartzite at the contact
25167 shows fragments of chert and green schist.

25168 is the green siliceous schist at the point of contact, showing the characteristic way in which it is cut by several cleavages and having a small thin facing of the detrital material

25169 is the typical green schist here.

Several other localities were found where the intensely plicated quartzite faces the green schist series on the south, and always where an opportunity could be found to get at the contact this was perfectly sharp between the two rocks. In only one case was the plicated quartzite found in any other position than on the south slopes of the schist. Here it wraps around the east end of a small knob of schist and is found on the north side in its typical form. This occurrence is explained as being caused by a headland projecting off somewhat diagonally from the old shoreline and therefore giving a bay in which the detrital material could be deposited upon the schistose rock.

The gray, acid, talcose or micaceous siliceous schist was examined again and is found unmistakably to grade down into the typical green schist of the region. In some places there are strong appearances of sedimentation, and one place in the green schist just on the east side of the road is a conglomeratic layer having numerous round fragments of green schist which seem clearly to be water-worn. I have but little doubt that a portion of the green schist series has been deposited in or arranged by water, and that the banding in some places is true sedimentation.

In the afternoon I drove with Thompson out to and somewhat beyond the Winthrop mine and followed the contact between the Upper and Lower Huronian from that place in to Ishpeming.

The pits in the NE 1/4 of Sec. 20, T. 47 N., R. 27 W. Mich., were found to be cherts containing bands and shots of ore; that is typical of the lower part of the Lower Huronian iron formation.

Passing on to the east, an examination of the pits along the north and south quarter line of Sec. 21 showed the following phenomena: A thin layer of material; On the south side of the pit is the original jasper; at the east and northeast end of the pit the original jasper occurs again striking, not east and west as is general for the region, but north and south, showing that it is at the extreme end of one of the fingers of the great westward plunging synclinal. The original jasper here dips to the west at an angle of 50° while the dip of the overlying Upper Huronian ore conglomerate is only 20°. Northeast of this place, and lower down on the hill, is another exposure of original jasper. The structure is here plainly a westward plunging closely compressed synclinal overturned to the north. The exposures in the NE1/4 of the NW1/4 Sec 21 were all found to be the fine grained iron conglomerate intermediate between the ore conglomerate and the quartzite. The strikes and dips were not here taken, but the dips are very flat, and the strikes impressed nce as being nearly north and south, but this ~~without~~ could not be determined without accurate instrumental measurement on account of the flatness of the dip.

The open pits near the extreme southwest part of the southeast corner of Sec. 16 were found to have a north and south strike instead of an east and west one as platted. In the case of the southernmost pit this strike is almost due north and south, while the northern one has begun to turn a little east of north. The eastern part of the pits is the original iron formation, while the western parts are the decomposed material. The dip of the original material is here about 20° to the west. These observations show that at this point is the end of the westward plunging synclinorium. Passing northward, the strike follows closely the outlines of the diorite bluffs and the topographic lines; the dips are however all very flat. That of the ledge at the point of the diorite bluff is

30° to the northwest, while all the other ledges northeast of here are not more than 15° to 20°!

The recomposed material mapped as occurring in the upper part of the great open pits of the Lake Angeline mines at their east end was searched for, but nothing was found but the brecciated chert and jasper of the Lower Huronian.

Ishpeming, Michigan.
Wednesday, July 20, 1892.

With Bayley we went to the contact between the green schist series and the quartzite in the south part of Sec. 33, T. 48 N., R 27 W., Mich. Here a great conglomerate bearing numerous pebbles and bowlders of quartzite, as well as many fragments of green schist, were found resting against the south face of a great bluff of schist. In certain places the conglomerate makes an important facing, but in other places is quite thick, while in one place the discordance between the foliation of the green schist and the sedimentation of the conglomerate is seen. The phenomena here were found to be identical with those already described near the ~~quarter~~ quarry in the south part of section, except that the sharp plication of the basal layers of the quartzite does not here occur.

In the afternoon we drove north from Negaunee on the road which strikes the contact between the green schists and the quartzite series somewhere near the lines between Secs. 31 & 32, T. 48 N., R. 26 W. Mich.

In passing in toward the quartzite ~~at~~ an exposure of shale or slate was seen alongside the road. We then next found exposures of graywack, and then appeared the bold range of quartzite. The quartzite is found to have a steep dip, 60° to 70° to the southward. Its lower horizon was seen to be conglomeratic, and in this basal conglomerate at one locality west of the road were discovered quite numerous pebbles of jasper, some of them an inch and a half in diameter. The contact between the quartzite and the schist is perfectly sharp, being generally at the base of the quartzite. At the westernmost place at which the contact contact was found, under the west side of a hill, the quartzite appears to cut in under the schist, but this relation is due to the steepness of the inclination of the quartzite. If it were turned back to a horizontal position the relations would be those of a sedimentary rock resting against a moderately sloping cliff. The localities here supplement those west of Teal Lake in that the conglomerate found directly in contact with the schist grades upward without any break whatever into the typical regularly bedded southward dipping quartzite of the region.

Cascade, Michigan,
Friday, July 22, 1892.

In company with Dr. Wadsworth and Mr. Seaman we visited the exposures southeast, south and southwest of Palmer. A short distance south of the Platte mine is an exposure of magnetitic jasper which varies down into a conglomerate. The conglomerate is schistose and contains many fragments of white quartz. A little to the south is an exposure of the green schistose rock supposed on the previous days work to belong to the Archean. The Platte mine soft ore rests on this schist.

We now went a little west of the Platte and then south. Here was found a great hill of jasper exposing a very considerable width. The upper and middle parts of this jasper are in every respect a typical rock of its kind, exactly like the Republic jasper. In going towards the lower horizons the jasper is interstratified with layers which have a distinctly fragmental appearance, which are in fact no more than a ferruginous quartzite alternations of jasper and the quartzitic layers were seen again and again, the quartzite grading into the jasper.

Passing now to the lowest horizon, there appears a great bowlder conglomerate which contains very numerous fragments of granite-schist, quartz and other rocks, that is the great mass of its material appears to be derived from the immediately subjacent complex to the south. At one or two places within it there appeared to be jasper fragments, and in a number of places there are certainly present pebbles which are now composed of iron ore, but these appeared to be the ferruginous replacement of an original schistose rock.

25170} Probably this conglomerate. May possibly
71} be conglomerate above (collected by Bayley)

In passing north over the jasper there suddenly appears an upper conglomerate which in all respects appeared to be like that below, except that it contained very numerous fragments of jasper. It was, however, not found in such relations to the underlying and overlying rocks as to wholly convince me that it belongs to an unconformable superior series. The appearance suggested by the remarkable likeness of the conglomerate of the two horizons is that it has been brought to the surface again by faulting along the strike. However, in passing to one of the open pits between the Platte and Volunteer, over the banded ore and jasper and cutting across its strike, is the typical overlying jasper conglomerate.

At the west end open pit of the Volunteer the irregular erosion of the underlying jasper before the deposition of the overlying quartzite is plainly seen, and at the south end of the pit the schistose conglomerate which frequently appears in the lower part of the jasper also was found. Here the two conglomerates are almost in juxtaposition, the erosion having cut out the whole or nearly the whole of the jasper formation.

In following the face of the granite nearly south of Palmer it at one place was found to be faced by a vitreous schistose quartzite containing much feldspar. This appears plainly to have been a much squeezed fragmental rock and not a sheared granite. It is believed to be the basement formation at this point. It differs from the upper quartzite in that it is so much modified and contains such an abundance of feldspar. This contact was not very clear and could not be certain from this locality that the granite had not intruded the quartzite rather than lying unconformably below it. A little way to the southeast from this contact appears the green schist which is cut through and through by veins and dikes of granite, just as in the exposures southeast of Bengley's camp to be described below. Taking all that was seen together it seemed to me quite clear that there are in this vicinity the pre-Keweenawan series, the Archean, the Lower Huronian, and the Upper Huronian. The Archean is represented by the green crystalline schists cut through and through by granite; the Lower

Huronian is represented by the great jasper formation interlaminated in its lower part with quartz-schists and schist-conglomerates; while the Upper Huronian is represented by the little altered quartzite unconformably overlying the jasper. Specimen represents the typical-jasper of the Cascade range.

About half a mile east of Bayley's camp, that is about a mile east of the Wheat mine, a section was made from north to south. Here the jasper bearing particles of quartz was found dipping to the north. Crossing a narrow ravine there appears a great cliff of green schist. This green schist is cut by joints in various directions so that under the hammer it falls into polygonal blocks. It is much sheared and on its northern face becomes a fissile slate having an almost graywacke-like appearance, which is however believed to be illusory.

Passing south farther into this schist it becomes more massive and it is then found to be cut across by granite veins. Also these veins follow along the planes of schistosity.

In passing still farther south the granite veins parallel to the lamination become more and more abundant until the rock consists of sharply alternating
25172 layers of green schist and bright red granite, giving the whole a strongly banded appearance. At the same time the green schist has become more coarsely crystalline and has apparently passed over by insensible gradations into a hornblende-gneiss. This increased coarseness of crystallization is believed to be due to the contact action of the intrusive granite. On the south side of the exposure the granite is predominant. In following a spur southwest a great dike of granite is carried over to the next hill which is solid granite. These exposures seem to represent in typical development the granite-gneiss-schist complex described as Archean. At one place it seems probable that a close study would give the relations of these schists to the jasper but time did not permit this point to be determined.

Dam above Mansfield mine, Michigan
Wednesday, August 10 and Thursday Aug 11, 1892.

With Merriam I examined the ledges above the dam and along the Mansfield trough south to the mine.

At the Mansfield mine the dump, obtained by sinking the shaft in the material overhanging the ore, shows large masses of conglomerate bearing numerous fragments of ore, chert, etc. from the iron formation. These fragments are well rounded and there seems to be little doubt that the rock containing them is a true conglomerate. Above the ore formation at several places along the west side of the river was seen the conglomerate which overlies the ore and the fragments of which are mainly derived from the green schists and amygdaloids adjacent. This is also true of the conglomerates bearing the ore fragments.

According to the captain, the downward succession in the mine is (1) greenstone, or diorite as he called it; (2) the conglomerate bearing ore; (3) "paint rock" which is apparently a green schist carrying much iron and in places 30 feet thick; (4) ore formation; and (5) black slate. Below the black slate, as shown by other test pits, is a green banded pyritiferous and argillaceous slate. In the many pits about the mine the same materials are found and from their relations this was judged to be the true succession before talking with the captain, with the exception that the paint rock was not found. However, in a number of pits, as shown by the material coming out, the rock immediately above the ore formation is an amygdaloid which in a few cases is very well defined.

In a small exposure of conglomerate just west of the river at the Mansfield bridge the alternation of coarse and fine sediments is seen and the strike is here nearly north and south while the dip is at a high angle, about 80° to the west. In this conglomerate was seen a large fragment of the green banded slate or shale constituting the lowest horizon of the sedimentary series. Above the conglomerate, not more than 15 or 20 feet distant, is found the massive greenstone.

Merriam's study at the dam and vicinity has shown that the rocks consist of numerous alternations of green schist, greenstone, greenstone breccia, amygdaloid of ~~evenly~~ finely laminated layers, and of conglomerate; the two last being almost certainly of sedimentary origin, while the former are surface volcanics. The schistose structure and the bedding are almost at right angles. The true bedding takes a turn to the west near the dam. In the sedimentary ~~series~~ layers, inter-laminated with the volcanics, are found fragments of black slate which to all appearances is exactly like that exposed in the river below the dam near the southeast corner of Sec. 7. Also in these same conglomerates are fragments of slates which appear to be like the finely laminated phase of sedimentary rocks above mentioned, and which occur among other places near the river at the falls where it bears small layers of chert. These fragments may however, be derived from the green argillaceous slate at the bottom of the ore series. Merriam also found at some distance west of the dam in an amygdaloid rather numerous fragments of jasper.

The certain interpretation of the above facts is exceedingly difficult. The presence in the ore-bearing conglomerate above the ore formation of numerous fragments from the green schist series shows that at the time of the formation of this conglomerate not only was the ore series present but that rocks of the green schist series existed. The only hypothesis which occurs to me which appears to fit all the facts is that after the ore series was deposited an erosion interval occurred. The first episode of the new period was a volcanic outbreak. When the overlying conglomerate formed it derived the most of its fragments from the lavas, although a portion was obtained from the inferior sedimentary series. This supposition would explain the presence of the paint rock between the conglomerate and the ores at the mine. Also it would explain the fact that amygdaloids in some places are immediately above the ore formation. The fragments of chert found by Merriam in the amygdaloids may have been caught in in the volcanic eruption. We would then have in the Mansfield district an older sedimentary series containing the ore formation, and unconformably above this a great series of interstratified amygdaloids, massive greenstones and detrital beds, the debris of which is mainly derived from the contemporaneous volcanics, but which also bears fragments derived from the more ancient unconformable series.

The amygdaloids of the upper series

Merriam finds to be very persistent. Most of them are more or less magnetic and when the exposures are not continuous the flows may still be traced by their magnetic property. The amygdaloid magnetic line adjacent to the Hemlock mine at Amasa has been traced by Merriam nearly all the way to the Hollister mine, and the latter will probably be found to have the same relative composition to this amygdaloid as has the Hemlock.

Lavas of the newer series show beautifully in places a spheroidal weathering. At times the great blocks are separated by mere films. In this case the corners between the spheroidal blocks are often quartz filled as though by rupture cracks had been formed. At other places the spheroidal blocks are separated by wider zones of soft material, and in two places the west sides of the blocks are much more markedly amygdaloidal than the remainders. In still other cases the spheroidal weathering amygdaloids pass into an undoubted breccia, perhaps formed at the time of the cooling of the lava by its onward movement.

The explanation which suggests itself for the above facts is that the lava flows toward their ends, as a result of an onward push while in a viscous condition, were broken into blocks which are similar to those made by cooling in the cases of the simple spheroidal weathering. The onward movement has stopped and the joints which have been formed in the viscous lava have allowed the outer parts of the blocks to harden. The interior parts have then slowly crystallized and the gases in attempting to escape have risen to the upper sides of the blocks and has thus made these sides amygdaloidal. This would explain the extremely fine crystallization which these blocks show, since each one would in this case be like a separate independent mass to cool by itself, except that the surrounding hot blocks would prevent radiation from going on rapidly. As to the correctness of this explanation for the amygdaloidal blocks, it may be said that all gradations are found between these phases and the true lava-breccias. Moreover, that the amygdaloidal portions of the blocks are towards the tops of the flow is shown by their occupying a position parallel to the strike of the rocks, and on the sides of the blocks, which would be their upper portions if the series were turned back to a horizontal position.

25173 } From bed of Michigamma river
25174 } several miles below dam above Mansfield near Glidden prospect. Show strong lamination, uncertain whether sedimentry or ash.

Specimens collectected on trip in central Missouri in company with Arthur Winslow, Prof Potter, F. Nason and Erasmus Howarth

25175 Perlite - from north side or slope of Pilot Knob. Other exposure shows same 1½" to 2" in diamater.
25176 Conglomerate from small exposure in stream at bridge just south of Ironton. This passes into coarse conglomerate with pebbles 1" in diameter.
25177 Conglomerate or breccia from near crest of Cedar Hill

25178 Felsite from near crest of Cedar Hill, but short distance from conglomerate.
25179 Conglomerate or breccia from near crest of Cedar Hill at north end. Layer of same prospected. Overlain by

typical felsite with horizon-
tal, or nearly so, flowage.
25180 Specimen of ore in breccia
or conglomerate from Cedar
Hill. Same is interesting
as showing formation of
undoubted secondary red
jasper.
25181 Porphyry from flow asso-
ciated with porphyry tuff
-Several miles East of
~~I~~ronton.
25182 Fragment from porphyry tuff
showing parts of two large
fragments an intervening
layer of matrix

Oct 17-1892 (date of letter.)

Cores from diamond drill hole made by the United Mining Co. on Sec. 13-47-46. Collected by R. H. Channing Jr. as showing the southern limits of the iron bearing member at that point.

Collar of this hole ~~430 feet north of ¼ Cor~~ was at about 430 feet north of E.&W. quarter line and 100 feet west of the range line; the dip 64° to the south and total depth of the hole 540'.

25183 After passing thro 73 feet of Surface material 25183 was encountered 73' to 92'

25184 92-99-

25185 99-144

25186 144-152

25187 152-160

25188 160-484

25189 484-500

25190 500-540

(Letter date)

Dec. 31.92. Quartzite met with at a depth of 567' with no ore upon it.

11-6E

Devil's Lake, May 12, 1893.

An examination of the cliffs along the railroad track showed that shearing had occurred between the beds, so that the quartzite, in approaching the bedding plane, is fractured. These fractures gradually turn toward the bedding, and this produces a schistose rock, the schistosity of which is parallel to the bedding.

Even the most massive beds show to some extent shearing effects. In these the coarser grains of blue quartz loose their lustrous fracture and blue color on the outer parts, apparently becoming granulated at the same time, and having a white color. Cutting across the beds at one point is a vertical shear zone. The massive beds of quartzite are generally 2 to 4 feet in thickness. The shear zone is made up of trapezoidal blocks which may be picked out with the point of a hammer. This zone varies in width from 2 to 4 feet. On one side of the zone is true friction clay. Higher up on the slope the shear zone has weathered much faster, and is marked by a depression covered by vegetation between the protruding cliffs. The amount of throw of the fault could not certainly be determined, but a close examination makes it probable that it is not great. The beds are red at the left above, and the lower layers are more massive and white. On the right the layers are red to the bottom. If the red layers are taken to correspond, the amount of throw would be from 20 to 30 feet.

Photo 1158. Fault zone looking east from distance of 25 feet.

Photo 1159 View of same from distance of 10 feet, and showing gniss on left hand side.

Sp. 25191 Quartzite taken from the middle of the massive layer, as showing least amount of shearing. The greater width of the specimen is across the bedding.

In the rear of the Cliff House there is seen another shear zone between 2 beds. The amount of slipping has not been sufficient to produce the double curve seen on the track with the middle zone of shist, but merely to make across a more argillaceous bed a cleavage at an angle of approximately 45.° Laminae may be seen cutting across the cleavage parallel to the heavy beds.

Sp. 25192 Specimen of this schistose quartzite parallel to the cleavage.

Photo 1160 Shows the bed above described cut by cleavage between 2 more massive beds.

12 54

Ablemans, Wis., May 13, 1893.

Revisited the Gorge of the Baraboo at the Upper Narrows. The cliff at the south side of the Narrows is fractured for many feet by dynamic action, so that the massive beds of quartzite are broken into lozenge shaped blocks, the longer direction of which is parallel to the bedding, or in other words parallel to the movement. In places these brecciated masses have not been recemented, and this is taken advantage of for the purposes of quarrying.

In other places there has been an earlier and more irregular fracturing of the rock, the whole being recemented by white quartz, this constituting a series of reticulating veins. There are 2 wide zones of this recemented quartz along the railroad track, 100 to 200 feet across. At one place in one of these zones, the movement in a vertical direction has been so great as to cause the rock for a distance of 10 feet to pass into a true Reibung's breccia, which might readily be mistaken for a true conglomerate. All the zones of fracture are vertical, or nearly so, and parallel and not crossing the bedding, showing that the movement is in the same direction.

Photo 1161 shows this belt of Reibung's breccia.

Conglomerate near Michigamme Dam.

Photo 1162 ~~Nearer view of same~~.

" 1163 From a block of same (1161) detached from the main ledge.

Sp. 25-193 A specimen of the massive vitreous quartzite from a zone of veining. After the rock has been first broken, and then cemented by vein quartz, there has been a later movement, which doubtless corresponds in direction to the first, because the veins are fractured in the same way, but not to the same degree as the the quartzite. Hence there have been here 2 dynamic movements separated by a considerable interval of time.

In places toward the north end of the gorge the shearing has produced a cross cleavage, which effects only the more contiguous beds, but leaves little changed adjacent more massive beds. In the least altered beds, the cracks are rather fractures than cleavage, which cut across the beds nearly at right angles. As the action becomes more acute the angle of fracture becomes more nearly parallel to the bedding, and in the most intense phase there are well developed shear zones of micaceous quartz schist, the schistosity of which is parallel to the bedding. As a result of these shear zones, there is a tendency for the rock to pass into a crystalline schist, the foliation of which is parallel to the original bedding.

These shear zones affect most the finely laminated layers, which are leaner in quartz, while the relief in the more massive layers has been reached by fracturing the quartzite into lozenge shaped masses cemented by secondary veins of quartz as explained above.

Photo 1164 Massive nearly vertical beds of quartzite, between which is a bed much sheared. Distance 30 feet. Looking west.

Photo 1165 Nearer view of the shear zone, showing details of structure, and on the left part of the broken massive layer.

Sp. 25194 Quartzite from last massive layer representia in Photo 1164

Sp 25195 Specimen from schistose bed represented in Photo 1165.

Cutting across the bedding in the main eastern ledge are heavy joints inclined to the north at an angle of 20° to 30°. If faulting has occurred parallel to this in one direction, this might greatly reduce the thickness of the beds as estimated by Irving. However the shear zones described above weather out on the face of the cliff more readily than the more massive ones. If slipping had occurred these ought not to match unless the joints and slipping occurred before the shearing which is not probable. However these shear zones match perfectly above and below the joints. Hence no evidence of faulting was discovered.

Photos 1166 }
1167 } Nearly vertical beds of quartzite on west side
1168 } of gorge.

Photo 1168a View of broken quartzite at quarry on west side of gorge. On the left is a ravine which separates the quartz from the Cambrian.

Photo 1169 Another view of the same, showing broken quartzite on right, and horizontal Cambrian on left. On left between the 2 is a ravine in which alluvium covers the rocks, and trees have grown.

Sp. 25196. Red quartzite from trail at south end of East Bluff at Devils Lake, about half way down the cliff.

Sp. 25197 Quartzite impregnated with hematite from Gorge of Baraboo River near Ablemans. Location from Weidmann, who presented specimen.