Georgia and Alabama, Spring of 1894 ; Southern Appalachians, Spring of 1895 ; N. Y. with Merrill, 1895: specimens 25560-25649. No. 183 1894[-1895]

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

FIELD SECTION BOOK

Georgia and Alabama
Spring of 1894

Southern Appalachians
Spring of 1895

N. Y. with Merrill, 1895.

C. R. Van Hise.

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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Demorest, Ga., March, 1894

Find all the rocks in this vicinity to be foliated mica-gneiss - deeply disintegrated. Wells 50 ft deep do not reach the bottom of the rotten rock. On the steeper slopes of hills the more resistant phases stand out as occasional ledges. At these places and especially along cutting streams the rock takes on a more massive aspect and becomes a foliated gneissoid granite. The major part of the rock seems very homogeneous, as though it were a single great mass. The variations from this, so far as observed, are due to quartz veins and other secondary water action, and injections of igneous material.

Everywhere the foliation of the rock strikes NE - SW and the dip is to the SE at an average angle of about 30° - estimated.

Went on the train to Tulula Falls, and all the way in the Ry cuts, as I could observe on the slow train, have a similar character and a like strike and dip. None of the cuts penetrate to the solid rock, but they well show the red soil which results from the decay of the rocks, the color being due to the peroxidation of the iron. Even in the rock which is so decayed as to be shovelled out without blasting the foliation still shows plainly. Indeed so rotten are the rocks that even in a deep well it is usual to use only picks and shovels.

At Tulula Falls the gorge is 500 ft or more ~~th~~ deep. Here one may see all steps of the disintegration process. The top is the same as about Demorest, the iron being completely peroxidized. It gradually changes in going downward to a condition in which it holds together; then into reasonably solid rock, but still showing a very marked foliation; from this the rock becomes more and more solid until at the bottom of the canyon it becomes very massive and would be called a massive gneissoid granite. Upon the sides and bottom of the gorge the rocks show a regular arrangement in layers parallel to the foliation. These layers differ in thickness from a fraction of a foot to several feet, and simulate in a remarkable degree the regular bedding of sandstone, which the rock might be called if it were looked at only on a large scale and the foliated crystalline character were not noted.

It is perfectly apparent that the extremely laminated arrangement of the upper part of the country rock is due wholly to weathering; this being really developed, however in the laminated arrangement of the mineral particles, even in the solid and apparently massive ledge at the base of the gorge, i.e., the schistosity is brought out by weathering. This corresponds with what has been repeatedly noted elsewhere, but I know of no other case so marked as this.

The road to Tolula goes NNE., and therefore somewhat across the strike of the rock; just how far in the 20 miles it is difficult to say. At these Falls the dips upon the whole seemed flatter, especially at the highest point. Up the gorge it was perhaps 20° or less. This suggests that in passing toward the Blue Ridge we are nearing the crest of an anticlinal fold in the foliation which dips away from the mountains. That the foliation or even the arrangement in layers noted at the falls can be bedding is hardly possible.

In nearly every respect the appearance of the rocks about the district appear to be the same as near Baltimore; only about

Dempest, etc. no intrusives were noted.
The remarkable similarity of bedding here, at Baltimore, and along the French near Marshall, N.C. is very hard to explain. The most plausible suggestion is that the enormous stress to which this Piedmont belt has been subjected, produced a parallel foliation and parting along the foliation, later simulating bedding. This might occur in a homogeneous layer of sandstone or one approaching uniformity, or in a great mass of granitic rock.

(Look up notes in N.C. section and see whether the unmistakable sedimentaries of the Blue Ridge grade off in each direction, i.e., on the Piedmont Plateau and in the valley to the west into the crystallines. If so, could this be explained by regarding the anticlinal (?) axis of the Blue Ridge as an area of relief?)

March, 17, 1894 Demorest.

Made a cross section in a wagon from Demorest in a N.W. direction through the first outer range of the Blue Ridge to a valley separating these mountains from the main range, and a section on foot for about ½ mile in the outlying hills of the main range. The dips are steadily to the S.E. away from the mountains for the six or eight miles in a right line N.W. of Demorest and also in the outline range. This continues as far as Mt. Lynch upon the S.E. side of the Soquee Valley. This mountain has a comparatively gentle S.E. slope agreeing with the dip approximately and an abrupt N.W. cliff is caused by the rocks breaking down along a joint.

In the Nacoochie Valley there are exposures where the crown of the anticline is seen. Here several complete secondary anticlinal rolls may be seen, and also places where tertiary crumpling comes in, showing a series of minor folds; such as is very characteristic of the crown of an anticline.

Passing to the N.W. side of the

Soquee Valley which as a side stream continues the Nacoochee Valley, the dips are now decidedly to the NW, but with a moderate dip 15° or 20° degrees. Continuing to the NW the dip is found to be in this direction, the angle of dip increasing until dips as high as 45° or higher are found within a mile. Went about ½ mile farther and the dips continue in this direction at about the same degree.

It is evident that in this vicinity the crystalline schists are folded in a great anticline, one side of which is the foothills to the SE, and the Piedmont Plateau to the other side of which is the Blue Ridge proper. How far it is to the other side of the anticline in the Blue Ridge and what other folds appear before the later rocks appear, and how the crystallines pass into the less crystalline rocks were undetermined.

Upon returning to Demorest close observations were made upon the occasional outcrop which occur along the road. It was found that the crystallines are of a much more complex character than was first supposed. There are numerous places at which black hornblende-biotite gneiss occur. Also coarse mica gneiss is abundant and cutting through this is white gneissoid granite. More often than not the intrusive is roughly parallel to the foliation of the closely laminated gneiss, and has a foliation in the same direction although stringers cut across the lamination of the gneiss in a most intricate fashion. This white gneissoid granite is more resistant than the ordinary gneiss, and hence makes numerous outcrops.

25560A 5(?) ~~[illegible]~~ Specimen of the black gneiss cut by granite half way between the Nacoochee valley and Porters Mills.

25560B 6 ~~[illegible]~~ Gneissoid granite forming the falls at Porters Mills. At the lower Mills the main fall slides along a bed of the gneiss and gives the pitch of the shoot about 45°. Besides the foliation here there is a rough parting parallel or nearly so to the foliation which gives the rock strongly the appearance of bedding. As at Tulula Falls, if the rock were not closely examined it might be mistaken for a sandstone.

Cutting through the series are also black gneissoid rocks, now foliated and altered, but taken to be much altered basic.

eruptives.

Upon the whole the crystallines appear strongly to me to have the characters of the Basement Complex or true Archean.

Whether the foliation of the series was produced prior to the folding which produced the anticline, or was one of the results of the folding, it is difficult to say. Perhaps the latter is the most probable. However, on the other side it may be possible that the old gneiss is a rock produced from a sediment with schistosity parallel to bedding, and the whole folded, as at the Fort Section, N. C.

Talking with Keith as to the general relations of the above crystallines, their broader folding, and their relations to the Ocoee group, he gave me the following information:

Their anticline in the crystallines when going to the NW passes into a syncline, and in this syncline the Ocoee group appears. However, in the S.W. the Ocoee have become crystalline schists in part, although even in the extreme SW end of the belt unmistakable sheared conglomerates are found, and the finer grained phases give mica-slates, phyllites, sericite schist, etc., staurolite-schist, etc., as indicated by Keith's specimens, which do not at all resemble the granites, gneisses, and schists of the Basement Complex. However, at the contact between the Ocoee and the Basement Complex there is conformity of foliation, and Keith says conformity of bedding of Ocoee and foliation of Basement.

In going to the N.E. before the Asheville district is reached the Ocoee becomes less crystalline and here at various places the unconformable contacts with basement conglomerates are found.

The Ocoee is correlated with the two semi-fragmental belts to the E. upon lithological character and order of beds. The three belts occupy three synclines, while the Archean occupies the anticlines. The anticline N.W. of Demorest is between the western and central belt, although Keith does not know whether the central belt extends as far S.W. as S.E. of Demorest, but knows it does extend into Georgia.

The section made by Willis, Pumpelly and I across the Piedmont Plateau to

Asheville and W up the French Broad
is as follows according to Keith. The
rocks of the Piedmont Plateau are Archean.
The apparent transition at Old Fort is
only apparent, and to the NE. conglomerates
are found at the bottom of the belt. The
sedimentaries making up the Blue Ridge
are the central belt of Ocoee. In passing
toward Asheville we again pass by grada-
tion into the Basement Complex, and this
continues all the way along the French
Broad until seven miles from Hot Springs
where a tongue of Ocoee comes in. Here at
the first visit we supposed there was a
gradation between the French Broad gneisses
and the Ocoee but the second year, as I
remember it, the change seemed somewhat
abrupt. Some miles before Hot Springs are
reached we pass from the belt of fragmental
Ocoee down to the Basement Complex. The
first year this seemed to us gradation, but
after closer examination of the second year
convinced us of an unconformity, a break
occurring in the exposures and the lowest beds
of sedimentaries being a distinct conglomerate,
although fine grained and bearing fragments
of feldspar, quartz, etc

From Hot Springs the Ocoee extends to the N.E, comprising the Big Butt. On the S side of Big Butt Keith says that the relations between sedimentaries and Basement may be seen. To the SW the Ocoee comprises the main mass of the Great Smoke Mts.

On the Nolychicky River the Paleozoics and the Ocoee are both found.

Keith in his mapping divides the western belt of Ocoee into six distinct formations, comprising conglomerates, quartzites, limestones, slates, etc. These are said to be very persistent.

Demorest, Ga. Mar. 9-16, 1895.

At various places about Demorest the rocks were examined. They consist mainly of black & white gneiss, the former appearing to be hornblendic. This gneiss has a regular strike and a somewhat ~~ir~~regular dip. The former is NE-SW, the latter to the SE. At one place on Cascade Creek where there was an exceptionally good opportunity for obtaining strike and dip, the first was found to be N 35 E magnetic and the second 40° to the SE. This dip is about the average of several observations taken at various places.

The gneiss is cut by many veins of coarse pegmatitic granite. These are of all sizes, from mere strings to great veins several feet in diameter. These veins have a tendency to an arrangement parallel to the schistosity, but they break across the schistosity in a minor way at many places. The harder ridges consist of a coarse gneiss or gneissoid granite. The relations of this to the ordinary gneiss could not be well observed. They may be bosses or sills. Their schistosity corresponds with that of the ordinary gneiss.

V5560 Black gneiss cut by pegmatite veins.

V5561 White gneiss quarried as building stone from Cascade Creek.

V5562 White gneissoid granite making rapids and falls at Hazel creek. From the Lower Falls below Demorest.

V5563 Black gneiss from the same place.

The exposures along Hazel Creek are nowhere extensive, and the fact that the above make falls and cascades renders it probable that these rocks are harder than the average along the creek.

In the vicinity of Demorest the rocks at the surface are everywhere disintegrated. However, if one can judge from this, the country appears to be composed of an intricate complex of finely laminated gneiss, black and white, with gneissoid granites of various kinds, all with parallel lamination, but with intricate structural relationships.

Mr. Bean reports as occurring a few

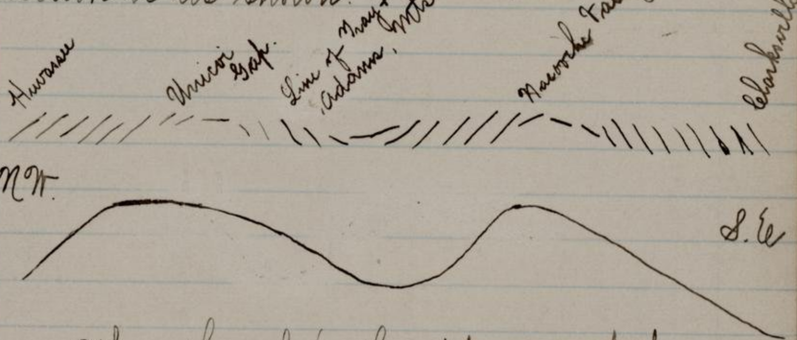
miles E. of Clarksburg, a persistent belt of limestone, in places 150 ft. wide, from which lime is made. He thinks the belt runs N into N. Carolina. At Greenville and on the Ry. between Greenville S.C., and Demorest, the phenomena are essentially the same as at Demorest. On the way saw many beautiful boulders of disintegration on the surface. These were scattered about in an irregular manner, and have an appearance both in shape and distribution very similar to the irregularly distributed glacial boulders to the N.

March 18.

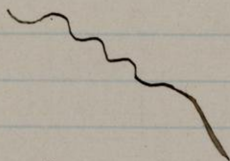
Hames, Keith and I road from Demorest to Hiwassee. As far as Nacoochie we followed the same road as I followed last year. The observations then made were confirmed that the village and the creek which extends to the NE + SW from this village are on the crest of an anticline. The dips from Demorest to near this village are high to the SE, averaging about the same as at Demorest. The strike varies from N 35° to 45° E. Before

Nacoochee is reached the dips rapidly flatten. Through the village they are sometimes to the NW and sometimes to the SE, and beyond the village they become predominantly to the NW. Numerous minor rolls were observed for a distance of 3 miles. On the NW side of the Nacoochee anticline the dips are steep, running as high as vertical. The dips continue to the NW until within about 2½ miles of Unicoy Gap, when they are again observed to be to the SE, showing that a synclinal has been passed. This syncline is about on the line of Tray and Adams Mts, thus making it probable that the culminating points in this vicinity are synclines.

At Nacoochee pass and for some distance to the S. and N there are numerous minor rolls, just as at Nacoochee. After making the pass the exposures were not good for some distance, but the first good exposures, found about 2 miles N of the pass, were rather flat, being 20° to 30° to the NW. Continuing onward the dips rapidly increase, running up to 45° to 70° or even higher, and the higher dips continue all the way to Hiwassee. It thus appears clear that the Blue Ridge is a great anticlinorium which has a central syncline which in its dip corresponds to the higher peaks. The first subordinate anticline corresponds with a valley and the second with the knob. The scheme of dips on section is as shown.



Upon the whole the dips seem to be somewhat steeper on the Hiwassee side of the ridge than on the SE side. Thus both major and minor folds have axial planes inclined to the SE but the folds are not overturned. Upon the secondary folds, and especially at the crowns of the anticlines, there are folds of the 3rd order and these those of the 4th order, + so on. The legs of the folds are with steep dips, and in places of maximum shearing show a little secondary rolling. The minor folds are beautifully shown in the Chattahoochee river after passing the Nacoochee anticline. Here pegmatite veins parallel to the schistosity have been sheared until they are broken into lenticular pebble-like areas. While in general the pegmatite follows the steep NW dips, they show minor rolls. Also the schistosity did the same - thus.



Here the pitching of the minor folds to the SW could also be well seen.

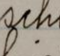
25564 is gneiss from this point

The general characters of the rocks are the same as those seen at Demorest and vicinity mica-gneisses, hornblende-gneisses, pegmatites, etc.

The so-called folds above described are of course schistosity. Apparently schistosity developed before the folding. The question arises whether such major folding has caused sufficient accomodation between layers as to develop schistosity parallel to the folding at the same time the minor and major rolls now seen were produced.

Mar. 19, 1895.

We rode from Hiwassee to Murphy. Continuing from Hiwassee Ga to Hayesville N.C. the same gneiss continued for some distance. These gneisses with vertical dips were seen on both sides of the Hiwassee river after leaving Hayesville about a half mile from that place. Shortly after the river is crossed
25565 a mica-schist is found which Keith says is the beginning of the Ocoee. So far as we could see, the strike and dip of the two series, or at least their schistosity, correspond. The schists where first found have a secondary schistosity cutting across the bedding at a high angle or nearly parallel to it. The beds are in a series of very closely compressed folds and this gives an appearance at first glance of correspondence between bedding and schistosity. However, when the rock is closely examined, the crowns of the minor anticlines and the troughs of the minor synclines are seen thus:-

 The dips being therefore isoclinal.

The continued readjustment and flowage.

have brought the two structures for much of the rock into close proximity. The mica-slate continues for a distance of 2 or 3 miles when

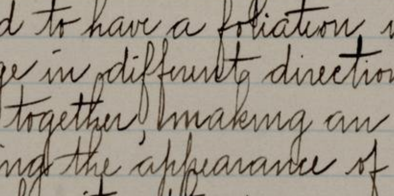
25566 Quartzite beds are found in it.

Passing along there are found fine inter-
25567 bedded slates and graywackes, which Keith said is particularly characteristic of the lower formation of the Ocoee, the Wilhite slate. This peculiar slate has a cleavage cutting the bedding. In some places the cleavage is nearly flat.

25668 Mica schist somewhat farther on, showing cleavage cutting the bedding diagonally.

25569 Garnetiferous mica-schist in which the discrepancy between the cleavage and bedding is very apparent, and is about 45°.

At this locality the mica-schist was found to have a foliation in a part of the ledge in different directions, the two coming together, making an angle of 35° and having the appearance of a certain sort of unconformity, thus:-



As seen on top.

However, while the lower beds are truncated by the higher, the latter contain no pebbles of the former. The two are equally crystalline and of the same character. It was therefore thought that this was a case of false bedding in which the integrity of the beds was maintained, although the rocks have become entirely crystalline.

All of the above specimens were taken on the first half of the distance between Hayesville and Murphy.

In the afternoon similar schists were seen and especially along the Hiwassee in the last three or four miles before reaching Murphy. Here were seen great beds of slate which were cut with a slaty cleavage, and are apparently less metamorphosed than those which were specimened. As it was raining specimens were not taken from this area.

Two miles S of Peach Tree creek Keith says a bed of limestone follows the valley to Peach Tree.

Mar. 20, Murphy to Thompson

We followed the Marietta & North Georgia Ry to Ranger, and thence to Thompson. Along the Ry to Ranger slate was seen. Upon leaving the Ry & going NW, according to Keith we crossed a syncline consisting of limestone and quartzite, separated by calcareous slate. The limestone was not seen but the
r5570 quartzite, which is very crystalline, was seen in the Nottley River.

Beyond the limestone is said to be a gneiss and this Keith regards as Archean upon its lithological character, although it is not cut by hornblende gneiss nor by granite.

Passing onward, the Pigeon slate was seen,
r5571 and in this are coarse graywacke layers the cleavage cutting across the bedding. The specimen is from Persimmons Creek

In the afternoon it rained hard, and the slates and graywackes which were seen at numerous points on the way to Thompson were not closely studied.

Mar. 21.

Walked along the R.R. from Thompson to Livingston.

The following is the list of specimens collected.

25572 Micaceous graywacke, shortly after river was first reached. (Thunderhead conglomerate!)

25573. Fine grained micaceous graywacke. farther on. The layer shows bedding, and suggests that the graywackee is calcareous. (Thunderhead conglomerate).

25574 Slate somewhat farther on. (Hazel slate)

25575 Slate somewhat farther on, showing intersecting cleavage and bedding. (Hazel slate)

25576 Carbonaceous black slate somewhat farther on. (Hazel slate)

25577-8 Specimens of slate showing effects of movements. - Hazel slate.

All of the above Hazel slates about 1 mile N. of Hiwassee

25579 First conglomerate showing blue quartz after passing Hazel slate. According to Keith, typical specimen of Thunderhead conglomerate.

25580 Calcareous fine grained graywacke, showing weathering on surface and along quartz vein. Thunderhead conglomerate.

25581 Conglomerate carrying slate and blue quartz pebbles.

25582-3 Conglomerate containing fragments of limestone, blue quartz, gneiss, granite, and slate. Some of the larger of the limestone fragments are a foot across. Not all of the varieties of pebble are shown in the specimens. According to Keith, from bottom of Thunderhead conglomerate.

25584 Slate showing movement of material, and beginning of formation of dynamic pebbles in harder layers. NW of MacFarland. (Pigeon slate.)

25585 Folded novaculite layer.. Half way between MacFarland and Livingstone.. Pigeon slate formation, upper part.

25586-7. Folded veins of same kind in slate. 3 miles from Livingston. Pigeon slate.

25588 Folded quartz vein. 3 miles from Livingston. Pigeon slate.

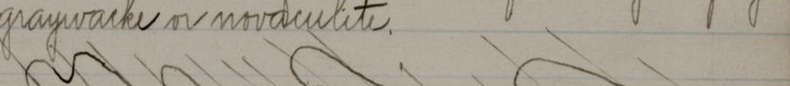
25589 Schistose graywacke 2½ miles from Livingston. Sitico conglomerate.

25590 Conglomerate containing blue quartz and slate pebbles. 1 mile from Livingston. Typical Sitico conglomerate.

The exposures along the Ry are magnificent. They consist of slate, graywacke and graywacke conglomerates. The rocks are in a series of folds of complex character, small folds on large ones etc. to microscopic plications. For the first part of the distance the folds have axial planes inclined to the S.E., but the folds are not overturned. For the last part of the distance the folds are overturned, giving on both sides S.E. dips.

The change from the first area to the second is gradual. The secondary structures frequently cut across the bedding on both legs as well as on the anticlines. However there is a tendency for the secondary structures to more nearly follow the longer gently inclined limbs and to cut sharply across the steeper shorter ones. In many places this correspondence on the longer side is complete. In the parts of the area where the folds are only inclined they are also more open. In the parts where overturned they are very close. In the first part the heavier beds are in gentle curves. In the latter part they are turned back on themselves, oftentimes within their own radius. (25585)

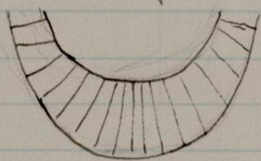
At any given place the thinner the beds the more frequent and close are the plications. In a given bed the plications are much more numerous along a trough or crest than along the limbs of the folds. Where the plications are followed to the best advantage there are thin interlaminations of slate and fine light gray graywacke or novaculite.



The plications in beds of slaty phases are so minute that they cannot be followed. 25778-9 25784). It is doubtful if this could be done with a microscope.

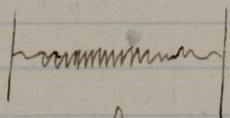
In the openly folded part of the area the accomodations take place mainly along weaker beds, producing a schistosity parallel to them. In the stronger beds a diagonal cleavage is formed which curves in nearing the softer beds and joins the parallel schistosity in them exactly as at Devil's Lake. This shows in each case the relative direction of movement, and that the upper portion has slid relatively up over the lower. The cleavage is to the SE.

The diagonal cleavage is believed to be due to differential movements on the two sides. In the softer layers no large cracks have formed, the beds apparently not having sufficient strength to allow such cracks, while the stronger beds are still in the zone of fracture, and thus considerable cracks form. This is exactly the same principle as the crevasses in glaciers. Along the crevices many small and large quartz veins have formed, the former being by far more numerous than the latter, but the rock being healed. These quartz veins heal the rock. These quartz veins are often very abundant on the crests of anticlines and the troughs of synclines, especially in the closely folded area, and in some places they have a regular arrangement.



In various places of the first openly folded area, there are all combinations of the diagonal structures, fracturing, and fissility parallel to the bedding. When the beds are ~~of~~ alternately of different character and are thin, fissility parallel to bedding predominates. Where the slaty beds are thin and the massive graywacke beds plentiful, the diagonal fractures predominate. In passing toward the closely folded area quartz veins are often found which are closely plicated, while others are seen which are not plicated. It looks as though there had been a dynamic movement which produced the first set of cracks, after which one set of quartz veins had formed by infiltration, and that later, in the area toward the western end of the section, there had been another movement of a somewhat intense character, which closely folded the quartz veins.

In proportion as the folds become close, the cleavage becomes predominant, and the less discordance ~~there is on the average~~ between the bedding and the secondary structures on the average. In the arches and troughs the cleavage is usually approximately axial and the folds approach the isoclinals. There is no great discrepancy between the bedding and cleavage on the limbs of the folds at any one place. However, it would apparently be hopeless to estimate the thickness of the beds. When the folding is close the troughs and crests are greatly thickened relative to the limbs. It seems to be the principle that where flowage applies it results in the thickening of the layers, and where accomodation applies it results in the thinning of the layers. The former principle is beautifully illustrated in a massive layer of graywacke, which had been fractured across, and quartz veins formed. When mashed the material flowed, so that the quartz veins which ~~had once~~ at the end on ~~the~~ side of the layer is merely gently waved, in the center is plicated into a seriated mass several times as thick as the original vein.



This shows the amount which the layer must have thinned in this case to be so great that it is probably not more than 1/3 or 1/4 its original thickness

The first facies of the formation of pseudo conglomerates was beautifully shown at many places. As a result of the strong thrust, the brittle layers are first distorted, then severed

and finally rotated into cleavage planes. In the process the separated pieces are rounded, and thus a pseudo-conglomeratic appearance is presented.

Very often the stronger beds control the direction of major accomodations, and the softer slaty layers are greatly enlarged here and greatly thinned there as demanded by the stronger layers.

In many places, and especially as we neared Livingston, the slates showed true cleavage, while the accomodations along the beds near Thompson appeared to be fissility. However, this appearance may have been due to weathering. Certain it is that the belts as a whole are in the zone of combined fracture and flowage. It must be very often the case that the beds obey the law of flowage in folding, which are yet strong enough so that in them small cracks and crevices may form.

Mar. 22.

In the afternoon we road on lever car from Johnson City to Cranberry. Upon reaching the gorge of Doe River we find the Cranberry quartzite. This quartzite has in general a N.W. dip, but there are many minor rolls, and in places the rock is locally overturned to the S.E. at steep angles. Consequent upon the minor folds the dips vary from these to those not more than 45° N.W.

Many of the minor rolls are very sharp. In such places of close folding the accomodations of the beds over one another have smoothed and slickensided them on both sides. Where the rocks have parted along these polished surfaces the minor waves of the layers are beautifully shown. The quartzite is cut by cross fractures, which with great uniformity dip to the N.W. Keith says there are in this vicinity numerous overthrust faults which repeat the beds from the Knox to the Archean.

In passing through the Archean on the way to Cranberry, the schistosity of the gneissoid granites and gneisses was seen to dip to the S.E. + N.W., and at other places was flat. The strike of the schistosity varies from parallel to the range to nearly E. + W. Keith says the schistosity of the granite gneisses dips on all sides under the hornblende gneiss of Roan Mt., thus forming a synclinal canoe.

However this may be, it is clear that the schistosity of the Archean does not all dip to the SE as usually reported, but is in open or gentle folds. The character of the folds is the same as that of the Blue Ridge N.W. of Clarksville. As compared with the folding of the beds of the Ocoee series, as seen in the Murphy-Livingston section, the schistosity of the Archean is much less closely plicated. If the schistosity of the Archean was present before the folding of the Ocoee series, this may imply that the former as a whole is more rigid, for if the schistosity existed before the folding of the Ocoee the granite-gneisses have certainly not been closely folded since.

Mar. 22 - Afternoon.

On horseback from Cranberry to Linnville.

Our course was first E. about 2 miles, then S. 7 miles then E about 4 miles. A short distance E. of Cranberry, about
25591 2/3 mile, we pass from granite (25591) to gray-
25592 wacke (25592)

In places this graywacke is conglomeratic, containing pebbles ½ in. or more in diameter. The graywacke is somewhat metamorphosed, but not nearly so much so as the closely folded Ocoee of the Hiwassee river. In passing farther E. we go on to the Archean. This we follow through our southern course.

In passing E we crossed a sharp ridge which lies N. of the road S. This is again composed of graywacke.

We then pass around a sharp ridge of material which Keith says is sheared
V5593 diabase.

From this we again pass to graywacke, and then on to a broad belt of diabase, and for the last mile on to Linnville on to graywacke.

Keith regards the diabase schist as older than the graywacke, and a part of the basement upon which the latter was deposited. The different belts of graywacke Keith explains by overthrust faults, the hades of which dip to the N.W. The second and third belts, according to

Keith, are somewhat folded.

Sunday, Mar. 24

From Linnville to Banner's Elk by way of McCandles Gap, thence to Fall Creek, and thence to Blowing rock via Schulk Mill.

After leaving Linnville we followed the valley of Linnville river, and here was seen a greenstone-schist, which Keith says constitutes this valley. At McCandles'
25594 Gap, the greenstone is rather massive and shows clearly its igneous character.
25595 About ½ mile beyond the Gap the quartzite outcrops on the side of the road. At some distance farther on about 1¼ mi.,
25596 the quartzite shows ~~bt~~ beautifully the bedding and schistosity

The road from McCandles Gap to Banners Elk winds several times from the schist to the quartzite. Keith says the quartzite dips to the ~~SE~~ NE away from the schist, ~~the~~ the strike being parallel to ~~the~~ the road

At the bridge crossing the creek at Banner's Elk is a beautiful sheared con-
25597-8 glomerate, containing many kinds of pebbles, among which are white quartz felsite and schist. The latter may have been derived from a fragmental rock or from the greenstone schist. The rock is so much sheared that the most resistant pebbles are much elongated. The less resistant ones are pressed into ribbon-like bands, and the matrix appears to be completely crystalline. In going from Banner's Elk up to the gap and down Crab Orchard ~~gap~~ creek, the granite is at the ~~bed~~ left, and the gray-wacke quartzite and conglomerate on the right. In places the quartzite is so much sheared as to approach granite in appearance. In places, also, the granite is sheared into a fissile schist.

Keith places a great overthrust fault along this line with westward dipping hade, in the same direction as the schistosity.

About 2 miles SW of Cal Cruces in a straight line on a new road near head
25599 of a large creek, is found a schistose gray
25600 rock, which Keith takes to be a part of the

gneiss, but which appears to me to be a much sheared graywacke.

In passing on toward Tal Cruces a similar schistose rock is seen at many places, certain phases of which appear to be fully crystalline finely schistose gneisses, and others of which appear to be fragmental. The transitions are very uncertain, but a short distance to one side Keith says it is clear that the granite is found, and a short distance ~~to the~~ other side the altered graywacke. Keith regards the junction of the two as a thrust fault, the granite being thrust over the fragmental rocks. There would be explained the extremely crystalline character of the clastics and the finely laminated character of the gneiss, the 2 rocks of nearly the same composition being brought to a nearly like condition, one from a sediment and the other from a granite, by the powerful dynamic movement. Keith says the above thrust fault runs in approximately an E & W direction, and cuts off a part of the graywacke and conglomerate belts which run in a nearly transverse direction. The graywackes and conglomerates are seen as a number of sharp N + S. ridges, while the granite is a great E + W. mountain.

The conglomerate at various places is in a number of parallel ridges, and each of them has about the same eastern dip. Keith explains the phenomena by a series of overthrust faults.

After we reach the Watauga river,
25601 beautiful epidotic amygdaloid was seen making a considerable point. This continues for some distance

In continuing the journey to Blowing Rock we passed various belts of greenstone-schist and graywacke which were not closely studied as it was growing late.

As we reach the highest base level at the gap 2½ miles N W of Blowing
25602-3-4 Rock a beautiful volcanic rock is found, which shows beautiful plications of the bandings, these passing into overfolds and these into parallel minute overthrust faults. This carried to an extreme gives fault-slip cleavage. Along the cleavage cracks mica has developed.

It seems highly probable that the

same dynamic forces may have produced major faults such as described by Keith. Keith says the minor overthrusts dip to the SE, just as do the major thrust faults

Monday, Mar. 25.

Road from Blowing Rock to Lenoir.
The rocks found upon leaving Blowing Rock and for some distance is a coarse porphyritic granite containing large crystals of feldspar and showing all phases of shearing. In some places the granite approaches a massive character but more generally it has been sheared to such a degree as to have a distinctly gneissic structure, and to have rotated or fractured the feldspar crystals so that their longer directions are in a common direction. In the most extreme phase of alteration the rock approaches ~~a~~ the augen gneiss of the French Broad River.

25605 Fine grained variety of augen gneiss.
25606 Little altered feldspar crystals from gneiss.

25607 Cracked feldspar crystals, the cracks being parallel to the cleavage.

75608 Broken feldspar crystal, in which parallel cracks are healed by secondary quartz.

75609-10 Gneiss showing fracturing in rotation of feldspar crystals. Exposures show that the amount of elongation in the major direction is much greater than in the minor.

75611 Specimen of schist in dike-like form (10 ft wide) in the porphyritic gneiss.

In passing to the SE down the steep mountain slope from Blowing Rock the porphyritic gneiss becomes strongly sheared, and it or some other gneiss becomes a finely fissile schist with leaves as thin as paper. In many places this schist shows minute plications, and in some places cross-fractures and minute overfolds passing into faults. This finely fissile gneiss continues for several miles along the ridge road. The dip of the schistosity, both of the porphyritic gneiss and the fissile schist, is at a high angle to the SE, 45° or more.

In the latter part of the journey the gneiss is more variable in character, containing bands.

of black hornblende gneiss and of pegmatite. In short the rocks become a complex precisely similar to that occupying the Piedmont Plateau and the lower part of the Blue Ridge NW of Clarksville, Ga. In places the gneisses is closely plicated.

April 1 1895.

Holmes and I took a train from Washington to Gaithesburg. The rocks at the latter point are in Williams phyllite series.

We followed the Ry track for a short distance to the SE, where we found pegmatized fine
25612 grained schist or gneiss; the foliation of which shows beautifully plications and overfolds.

~~25614~~

Following the wagon road to the SW where the road ~~crosses~~, the phyllite or mica-
25613 schist is exposed. It is here much pegmatized many of the veins being coarse. The intense shearing has deformed pegmatite masses in places into oval areas, and where the compression has gone far enough the rock has a decided conglomeratic appearance.

r5614 An interbedded area of peridotite, mapped by Prindle, was found, and its alterations into steatite or crysotile were noted. The foliation of the schist or gneiss is to the E at a high angle, 60°-70°.

We now returned by rail to Rockville.
r5615 At this place is coarse gneissoid granite

Drove nearly S on road. At about 4 miles was found coarse hornblendic
r5616-7 gneiss, which is extremely foliated.
The pegmatite veins and basic segregations have been sheared and broken so as to suggest that the dissevered fragments are waterworn.

Going a little farther to a cross in the roads about 5 miles from Rockville is a
r5618-21 peculiar gneissoid rock containing round areas of feldspar, of quartz, and of black material. These have to a remarkable degree the appearance of waterworn pebbles, but the matrix is a completely crystalline gneiss.
Taken in connection with the previous exposures, it appears most probable that the rock is a much sheared porphyritic granite in which the basic segregations and formation

of quartz and pegmatite veins had occurred before the shearing.

Turning W on the road toward Bells
25622 Mills, the same peculiar hornblendic rock was found, which occurs at the 4 mile place.

At Bell Mills we turn NW toward Rockville. For nearly the whole length of
25623 this road there is a peculiar epidotic green schist, interleaved with quartz layers. This perhaps the quartz-schist of Prindle.

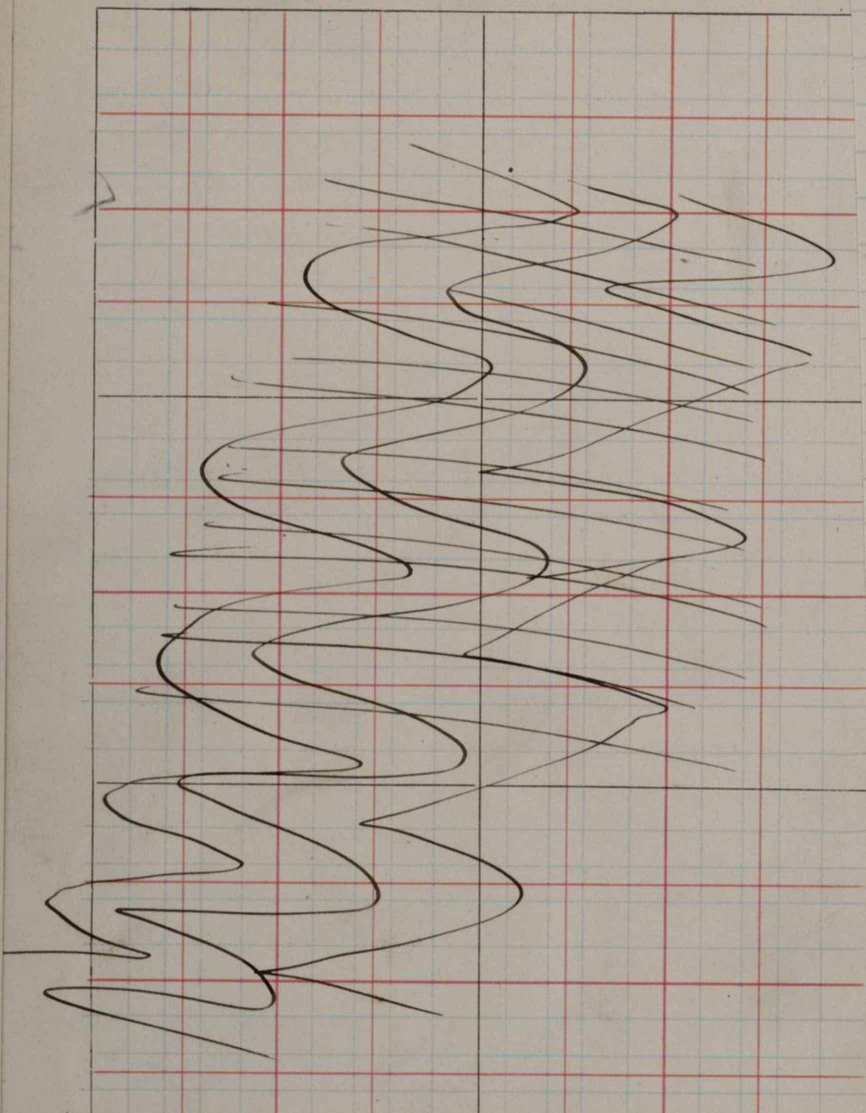
25624 Graywacke slate from Dickson.

25625 Quartz schist from same place.

April 2, 1895.

From Point of Rocks to Harpers Ferry. The section along the RR between these two points was examined. At Point of Rocks the dip of the schistosity of the Catoctin is 28° S of E. The average dip of the bedding of the lava or what appears to be bedding, is 70°. A series of quartz lenses follow the schis-

S. T. R.



6—747

tosity, the laminae of which have probably been separated by movements. This occurrence is interesting as being the locality in which the schistosity has a lower dip than the bedding of the lava. In places the beds are plicated and dip at a high angle to the N., the schistosity still dipping to the E.

The following specimens were collected along the section. (This set missing.)

25626 - 25637 inclusive.

S. T. R.

6—747

Friday, April 5, 1895

New York and vicinity with Merrill.

Took 6th Ave car N to terminus. At this place E of the station is an exposure of gneiss and granite which is much pegmatized, and different parts of which have ~~their~~ very intricate structural relations. The alternation of different constituents gives it a banded appearance, which Merrill regards as bedding, but which is very like the bands of very ancient gneisses, and may be due to other causes than sedimentation. This banding has been most intricately folded, the folds being isoclinal and the dip to the E at a high angle. The anticlines, and one particularly, show beautifully plication on the crest. In lithological character the whole has the complexity which I have been disposed to regard as evidence of great, if not of Archean age. This exposure Merrill regards as Fordham gneiss, the oldest rock of the district.

Passing W across a narrow valley in which Merrill says there is limestone, we find the Manhattan schist. This is plicated in the same fashion, but has a homogeneity in its schistose laminae which strongly contrasts with the heterogeneous coarse and fine banded and pegmatized Fordham gneiss.

We now went N by rail to Mosholu. We followed the RR for nearly a mile to the N over Fordham gneiss to near Lowerre. Here is the northern part of the gneiss. The Fordham here has plications, the axes of which plunge steeply to the N under a valley said to be limestone. The average strike across the minor folds is here E + W instead of N-S. Under the Ry trestle just N of the station and at the S side of the cross valley we
25638-9 find on top of the gneiss - mica-schist.
25640 And on top of this micaceous quartz-schist. These beds may represent metamorphosed basal fragmental material deposited below the limestone.

We now went N across the limestone valley along the Ry to the point where the Manhattan schist appears, and found it to have numerous plications, the axes of the minor folds plunging to the northward. This locality appears to give the clearest kind of evidence that in passing from the gneiss to the schist we have an upward succession.

Continued walk to Yonkers. Driving from Yonkers, at the eastern turn of the limestone we found the schist to have plications with southward plunging axes.

Driving N along limestone valley, went by Nepperhan to S end of next limestone. Here at the end of Bryn Mawr we found the gneiss as expected with northward plunging axes of the minor folds. Dip of axes about 20°. Corresponding to this is a wide belt of limestone.

We now drove to quarries in Yonkers gneiss, where granite is taken out. This rock is strongly foliated and has evidently taken part in the general folding of the district,
25641 as shown by 25641, plicated gneissoid granite. In the places not at the axes of the
25642 folds the gneiss is finely laminated. Along the movement planes abundant mica developed.

We now drove to Bronxville, and found the southern end of the Fordham gneiss, having minor plications with southward dipping axes at flat angles of 15°-20°.

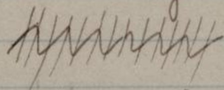
At marble quarry on E side of anticline at Tuckahoe, found limestone about 150 ft. wide, bounded on the E + W. by gneiss. The rock to the W. Merrill regards as Fordham, and to the E. as Manhattan. I could see no difference, and thought narrow belt of limestone to be a syncline. Bearing in this direction we found plications of gneiss and banding of limestone with high dips to the W. This is the first western dip seen, except at the crowns of the folds.

All rocks E. of this belt to Long Island Sound have heretofore been regarded by Merrill as Manhattan. Found places where the rock seemed to have the characters of the Fordham, being heterogeneous, containing acid granite bands and hornblende gneiss bands. Bosses of granite with intrusive relations alternate with the schists. If no Fordham is here the Manhattan schist in places cannot be separated by its lithological characters from the Fordham. This complex lithological character continues to Long Island Sound at New

Rochelle, where beautiful exposures are seen at the water's edge. The same rocks were also again seen in fine exposures along the RR track between New Rochelle and Mt. Vernon.

From the above it appears that the Fordham gneiss, the limestone and the Manhattan schist are in folds which run E. of N. The folds are closely compressed, mostly isoclinal anticlinoria and synclinoria of an exceedingly complex character. The folds run from those of the first order to minute plications. The folds are also cross folded, as shown by the dips of the minor plications at points where limestone belts run E + W. These cross folds have dips as high as 60° to 80°, but in other places are only 18°-20°. This cross folding is, however of less importance than longitudinal folding, because the latter controls the distribution of the beds in large measure.

I have nowhere seen better illustrations of the principals that there are few minor plications along limbs of folds and many and conspicuous ones at the crests and troughs. Along the limb there is apparent conformity of bedding and schistosity, but plainly this is the place of most severe shearing. At crests and troughs and particularly where plunging under the limestone valley, Peach's paradox of the relations of bedding and schistosity are beautifully illustrated. The schistosity planes cross the schistosity thus



The overturned folds have eastward dipping axial planes. The limestones are usually in synclines. When overlaid by Manhattan schist the W limit of the syncline of limestone is relatively broad to the E, and much narrower at place where major shearing took place, and this is believed to be explained by the character of the folding. If the force is supposed to come from the E, the shearing is much more intense along the E. limit than along the W limit.

28643 Hornblende gneiss in Manhattan schist from upper part of Central Park.

28644-5 Manhattan gneiss from large western area across limestone belt west of the upper part of Central Park.

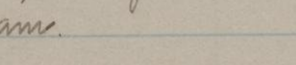
r3646 Biotite-gneiss near terminal of elevated, supposed to be Fordham, the locality first visited yesterday. Specimen selected as nearest like Manhattan obtainable. Not typical of ledges.

r5647 Garnetiferous biotite gneiss from Fordham. Typical area, but not average specimen. Selected as being most like Manhattan.

r5648 Massive phase of Manhattan gneiss near Bronxville. Not typical of the Manhattan, but specimen selected as most like Fordham.

r5649 Typical Manhattan schist from near Bronxville.

On the N side of Manhattan Island on 110th St. the schist has heavy beds of different character which are folded into a recumbent position as per figure



The pegmatite veins follow along and between the layers. The heavy beds are composed of layers of slightly different character, and there are ~~f~~ minutely crinkled with folds of the same type as those of the beds as a whole. These layers are doubtless secondary to those of a still higher order. The fresh rock is strongly feldspathic, and technically is undoubtedly a gneiss, although placed in the formation here considered as Manhattan schist.