Menominee region ; Keweenaw Point ; Massachusetts with Dr. Hobbs ; New York with Merrill ; Southern Appalachians: [specimens] 25813-25832. No. 190 1896

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

FIELD SECTION BOOK

9-891

25813-25832.

Notebook 190

C. R. Van Hise - 1896.

Menominee region

Keweenaw Point

Massachusetts with Dr. Hobbs.

New York with Merrill

Southern Appalachians.

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

#190

Iron, Mt., July 7, 1896.

Visited the exposures south of Lake Hanbury. They consist of slate, but contain interstratified thin layers of quartzite. On the north side of the ridge the slaty cleavage and the bedding appear to correspond. At least only a single structure is observable. On the crest of the ridge, on the east end, the two structures may be seen intersecting and the bedding shows that the folding is of the most complex character. The cross folds, that is those running north and south, have dips of 80° and even as high as 90° The pitch of these minor folds is sometimes to the E and sometimes to the W, so that it was not determined whether the ridge as a whole was an anticlinorium or a synclinorium. Neither was the character of the longitudinal folding determined, except that it is very composite. Notwithstanding the complex folding and the corrugations, the cleavage runs nearly E & W with great regularity, being parallel with the beds when the bedding is in a favorable position and cutting the bed at various angles from acute to right angles at many places

Beside slaty cleavage is shown a fault slipping, which ordinarily follows the general direction of the cleavage, although oftentimes cutting across it. Below the thin outer layer of weathering the rock is dense and compact, and has a capacity to part. This is a cleavage rather than a fissility. On the weathered surface a fissility has developed parallel to cleavage. The cracks made by the fault slipping have been all healed by cementation. These fault slips are in the nature of thrusts, and were produced by the E-W. forces which caused the cross-folding, while the dominant cleavage was produced by the N-S thrusts which caused the dominant folds of the region.

July 9.

11 Visited the first & second falls of the Pine river. The first exposure found on the N side of the river about 1/4 mile
25813 below the first fall, is a chloritic slate or schist, having a distinct banding and cleavage parallel to the banding and a fissility cutting it in a diagonal direction.

After an interval of no exposure the banded actinolite-magnetite-schist of the first falls is found. This in general is very finely banded, but has
25814 certain layers of coarser material which has a fragmental aspect.

Going up the river the banding becomes somewhat less regular, a peculiar pitted weathering appears, and the rock has somewhat the aspect of a volcanic. After an interval of no exposure there appears again a green schistose rock, being in many respects similar to that of the first falls, but having a less regular banding and a much more ridgy and pitted weathering, an appearance which is so often characteristic of tuffs. This is the rock of the second falls. Interleaved with it are narrow bands of dense dark rock, containing coarse amphibole needles (actinolite). While the exposures are not continuous the appearance is very strongly that of a gradation between the rocks of the first and second falls, and those of the second falls have strongly the aspect of the tuffs which have ordinarily been placed in the Archean in this area.

Returning to the first fall, and going down the south bank of the river, the regularly banded actinolite slate
75815 varies into a banded slate having a very marked fragmental character, although it evidently contains a good deal of actinolite. There can be no question that the actinolite rock of the first fall grades into this.

Continuing down the river, this rock grades into a black slate, which

has the aspect of an ordinary indu-
25816 rated shale. That there is a gradation
between this slate or shale and the
actinolitic rock of the first fall there
can be no question because the exposures
are continuous. However there may
be a break between the rocks of the first
and second falls although I do not
think this is probable.

Numerous great bowlders of
the quartz and ore conglomerate des-
cribed by Brooks were seen, and his
description is accurate in every parti-
cular. In it he notes the corresponding
between the flattened pebbles and the
planes of schistosity. There was also
seen one great bowlder of conglomerate
or agglomerate, containing numerous
roundish pebbles of fine grained green-
stone. The rock from which this conglo-
merate came was not seen in place
although it must be near at hand.

It is possible that the entire
slate and schist series of the First
and Second Falls is Archean. In

order to determine whether any of the slates are fragmental, sections are necessary. If all of these rocks prove to be Archean, it is probable that the quartz and ore conglomerate is at or near the base of the Upper Huronian.

11

July 10

At Rockland and N. of Rockland examined the rocks of the main trap range. Found the traps where we could see them on end to be bedded and dipping to the N, as described by Irving.

V5817 The porphyry described by Irving was found on the range N of the village but beyond this at the foot of the hill was found an amygdaloid supposed to be Irving's outer trap, which here contains, among others,

V5818- beautiful agate ~~crystals~~ amygdules.

V5819

From one of the highest points above Rockland I was struck by the great equality in the highest points of the range. Looking over to the NE toward Houghton, so that the different peaks were brought together, an almost horizontal line was seen, very strongly suggesting that this trap range is a dissected plain of denudation. Occupying the lower ground to the S was seen the great area of Eastern Sandstone, and beyond it the south trap range could be seen.

July 11, 1896.

Drove from Rockland to Ontonagon and from Ontonagon to Greenland. After leaving the outer trap saw no exposures all the way to Ontonagon, and none from Ontonagon until within 7 miles of Greenland. The country is low-lying and nearly level, except where dissected by the streams, and where dissected appears to be alluvium.

At the point described by Irving on the small creek about 2 miles ~~below~~ before reaching Greenland, found at the base of the section there exposed a conglomerate (outer conglomerate of Irving). This conglomerate, as usual with the Keweenawan conglomerates, contains almost every variety of the acid and intermediate pebbles including augite-syenite, or granitell. Interstratified with the conglomerate are

25820 layers of coarse gray sandstone.

Passing upward the layers of conglomerate become narrower, and those of sandstone wider, until the rock is

25821 mainly coarse sandstone.

After a short distance this becomes finer grained, and passes by inter-

25822-3 stratification into a shale. (the None-

-4-5 such).

Continuing upward in the section that is, down stream, the rock becomes coarser and is regarded as the

25826 gray sandstone of Irving.

Visited the old mines about a mile south of Greenland. The mineral-bearing part is exposed near the mouth of the shaft, and shows very nicely its character. As described by Irving it is merely a place of shattered and mineralized amygdules at the top of the flow. The dense base of the overlying flow is irregular in form, its irregularities doubtless being due to the uneven surface of the amygdaloid. The shattering of the amygdaloid is probably in large part caused by the necessary movements of readjustment

75826A
75826B
Quartzites showing enlargements of quartz grains, from east of Chapin Mine, Iron Mt.

Massachusetts with Dr. Hobbs
1896

General notes on Cornwall sheets as result of observations made from July 23-30. C.

Observations were made on various schist areas ~~to~~ as to the relations of cleavage on opposite sides of synclines. The folds of the Berkshire schist in the great valley are somewhat fan-shaped synclines with axial planes dipping flat to the SE. In some cases the folds are almost recumbent.

An examination was made between the schist ridges in order to find the type of folding in the anticlines of limestone. It was found in general that the dip of the limestone on the E. front of the anticline is flat, and therefore the limestone spreads over a considerable area. As the schist ridge on the W. is neared the limestone turns over suddenly and gives steep dips to the SE, and therefore this limb of the fold occupies a comparatively narrow area. If one does not make very close observation, the sudden turning over of the limestone may be easily overlooked, and the dip be thought to be monoclinal. There is some variation in the inclination of the dip and the rapidity of the overturn, the extreme variations being perhaps as far removed as figures 4 and 6, and 5 may perhaps be taken as an average.

Figs 1, 2, and 3, represent the types of folding.

As a result of the folding there are steep slopes on the W side of the schist ridges, and more gradual slopes on the E side of the ridges. Also there are rapid variations in the dip on the W. side of the ridge, the exposures being frequently at the place where the material rolls over so that at the base of the ridge southeasterly dips are found, a little higher up vertical dips occur and then higher up, northwesterly dips.

On the E side of the ridge the dips are uniformly to the E. but in making a horizontal cross-section of a ridge from W. to E in the schist, the dips are apt to be steeper to the W. on the W. side of the ridge then vertical, and then steep to the E, becoming flatter, until near the center of the ridge they are rather flat - then in passing toward the E side they become somewhat steeper. The limestone on the E. side conforms in its dip to that of the schist, and on the W. side there is apt to be an interval without exposure, so that the limestone is found with a flat dip to the E, apparently passing under the schist as it apparently passes over the schist on the E. side. Because of the cross folding in the district nearly all of the mountains have a pitch to the N. or S., and the steep end of the mountain is evidence of a pitch in the reverse direction. For instance, on Turnip Top (?) the dip is to the S. and the pitch is

to the N. On Mt. Barack-
matack the pitch is to the S. and
the steep end of the mountain is
N. In one fortunate case, Turnip
Top the limestone on the steep
end of the mountain may be traced
under the schist in almost contin-
uous exposure, and until it turns
W. around the point of the recum-
bent syncline on the E. side, comes
up, and apparently overlies the slate.
An almost similar cross-section in
a mountain such as Tom Ball,
where the true relations cannot be
ascertained at the ends of the
folds would lead to the conclu-
sion that the mountain is an
anticline rather than a syncline,
since the bedding on opposite sides
of the mountain diverges upward.
However it is perfectly clear that
the schist ridges are slightly fan-
shaped, nearly recumbent synclines.

An examination of the relations
of bedding and cleavage in the Berk-
shire schist fully confirmed the law

that the cleavage on opposite sides of synclines converges downward. This is beautifully illustrated on Mt. Baraicknatack and upon the main mass of Mt. Washington. Near the base of Mt. Washington the cleavage is rather flat, about — In passing up the slope it becomes steeper and steeper until at Bear Mt. it averages about vertical. On the west side in passing up toward Mt. Thorpe, the reverse is true, the cleavage at the base being somewhat steeper to the E about 60°. As the top is neared the cleavage is steeper and steeper, and on the top of Mt. Thorpe is about vertical. The somewhat flat area to the E. of Mt. Thorpe was traversed for perhaps a mile, and the cleavage upon an average is vertical. In this central area both adjacent to Mt. Thorpe and Bear Mt., nearly pure mashing is illustrated, there being nearly pure horizontal shortening. As the rock is minutely heterogeneous, this of course produces innumerable sharp minor plications in the bedding the angles of which are cut by the vertical cleavage.

In both Mt. Barackmatack and Mt. Washington, the cleavage on the E. side of the mountains is steep to the W, and on the W. side of the Mts. is less steep to the E. The principle of the relations of cleavage to bedding is therefore applicable, whether the folds are symmetrical or unsymmetrical. In cases where the bedding is difficult to certainly determine, the type of the folding in an area may be indicated by the attitude of the cleavage. If upon opposite sides of a mountain of schist which is surrounded by some other formation, as limestone or quartzite, the cleavage converges downward the structure is probably synclinal. If it diverges downward, the structure is probably anticlinal.

The district beautifully illustrates the relations between topography and geology. These relations may be beautifully observed from the top of

Bear Mt. To the E. are seen the highlands composed of the hard resistant rocks of the pre-Cambrian, flanked on the western side by the resistant Cambrian schists and quartzites. Between these eastern Mts. and the Mt. Washington mass, is the great valley which is bottomed by limestone. However, this valley is furrowed by numerous hills and even Mts. of considerable magnitude. Each of its hills and mountains is a syncline of Berkshire schist. The Mt. Washington mass itself has steep walls on either side, composed of Berkshire schist, and it is bordered by a succession of peaks which have been given distinctive names. At the N. end of the Mt. is a great basin-shaped depression, which is underlain by the Bellowspipe limestone. This basin extends to the S. end of the Mt. but becomes more broken, there projecting above the basin various mountains of considerable size. In this part of the area the Bellowspipe limestone has been wholly removed, and the Berkshire schist below has emerged.

The general dynamics of the district were considered. The best ideas upon this point were obtained from the top of Mt. Prospect, from which one looks down upon the great valley of the schist ridge to the N., sees the Cambrian and pre-Cambrian rocks to the E. and the Mt. Washington mass to the W., and to the S. sees the cross ridges of schist which separate Mt. Prospect from the area of pre-Cambrian, which cuts across the valley, narrowing it very greatly, making it take a southwesterly course. It has been seen that the valley schist synclines are nearly recumbent. The axes of the folds are very strongly to the SE, and the cleavage is generally to the SE. The Mt. Washington mass is a nearly symmetrical syncline ~~who~~ with cleavage, as has been said, both E. + W. In the granitoid pre-Cambrian areas of the E. there are also areas in which the cleavage is to the W., the tendency for easterly cleavage being present but not dominant. In trying to reconstruct the mass movements which produced the present forms of folds, it appears to me that the upper part of the rocks must have moved bodily from the E. toward the W. This movement was largely concentrated at and near the contact of the schist and limestone. Hence here the two are infolded with monoclinal folds with southeasterly dipping axes. This condition of affairs between the limestone and the schist is discovered in the great valley where erosion has reached this plane. When denudation has removed the major portion of the Berkshire schist on Mt. Washington it is probable that the valley limestone and the schist adjacent to it would be found to be overfolded after the same fashion as the valley limestone. The amount of shortening of the earth's crust in the somewhat open fold of Mt. Washington is not very great. At first sight it might appear that the amount of shortening in the monoclinal folded area of the valley is much greater than this, but if the foregoing suggestion is true this cannot be the case. Upon this point a full discussion will be given later. If there be monoclinal folding under Mt. Washington, this district would illustrate the rapid dying out of folds above as well as below, for the folds of schistosity are open in the pre-Cambrian areas.

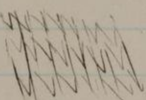
22.

New York City, Sat. Aug 1 1896

Made sections across the northern part of Central Park, across Manhattan Island in Harlem and above Manhattan Island adjacent to the Harlem river, and from High bridge to the Hudson.

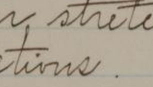
On the E. side of the N. part of Central Park the schistosity is commonly to the N., having many minor plications, thus:

A



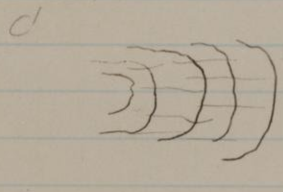
On the E side of the Park the dips are as clearly to the N., with longer stretches between the minor plications.

B



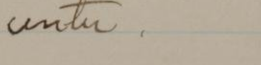
In the center of the Park the plications are across the schistosity, which in some places is to the E. and in others to the W. This section therefore illustrates the law that in synclinoria the schistosity on opposite sides of the synclinorium converge downward.

The continuous section N. of Central Park on 110th St. just south of St. Lukes Hospital, was closely examined. Here are seen recumbent folds with ~~purely~~ poorly developed schistosity. These minor folds are like those on the steep sides of the exposures in the Berkshire country.



In this vicinity that is near the Hospital, near the new Columbia College site and Grant Monument the prevalent schistosity is at a high angle to the E, but in this is a local belt with western schistosity. This and the plication of the bedding indicate a subordinate anticline in the schist.

In the park at Harlem, north from Central Park along the strike the schistosity on the E is clearly to the W and rather flat, while that on the W. is as clearly to the E. In the center there is again a deviation from the W. to the E. The whole is regarded as a synclinorium, with a secondary anticline and tertiary plications in the center.



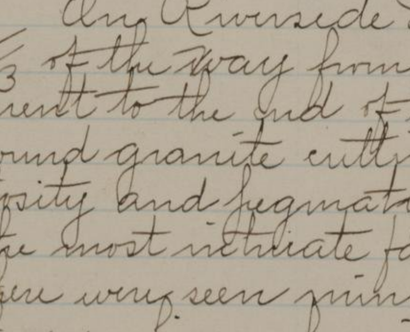
All of the above sections are in the Manhattan gneiss. At Harlem are 2 sections nearest the Harlem bridge that appear clearly to be anticlines. These are in the Fordham gneiss. The bedding and schistosity closely correspond. The dip is throughout to the E., but is steeper on the E. side than on the W. side, and therefore it diverges downward, and thus illustrates the law of schistosity in anticlines.

F'

By figure the minor foliations are poorly represented.

In the afternoon found the following facts between the Harlem bridge and High bridge. A section from E. to W. in passing from the Harlem river shows cleavage near the river to the W. This quickly turns to the E., and after a time is for a short distance W., before again becoming E. The latter continues to the Hudson river. Thus the relations of the cleavage indicate a major syncline with a secondary anticline between the Hudson and the Harlem. The relations of the schistosity to bedding between the two branches of the Harlem again correspond to the general principles. On the E. side of the tongue of schist the schistosity is to the W., and on the W. side is to the E.

On Riverside Drive about 2/3 of the way from Grant Monument to the end of the drive, we found granite cutting the schistosity and pegmatizing it in the most intricate fashion. Also there were seen minor plications of the syncline, showing them to be overfolds rather than underfolds, thus:–

W


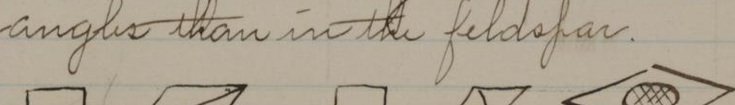
Aug. 7-14. In company with Keith, Holmes, and Stose.

General points illustrated by the Cranberry area, seen on trip.

In this district were observed magnificent illustrations of deformation by mashing and shearing, producing schistosity, the deformation being equivalent on a large scale to that of thrust-faulting. The deformation in the southern part of the sheet is without faulting. In the N.W. part of the sheet in the Cambrian and Silurian, where the load was less, are clean-cut faults, according to Keith.

In the southern part of the area the folds of the sedimentary and volcanic rocks are so close, that as a result of the cross-folding the formations come to a points, where they die out. This led Keith to believe that there are faults at many places at the contacts of the formations. I could not see that the evidence for faulting at the places regarded as faulted by Keith is greater than at the contact of other formations, where faults are not introduced by him. However, the evidence of the 2 great E-W. thrusts mapped by him, and especially the N one, is clear, although even in these places the faulting is distributive, or ie that of shearing resulting in schistosity, and differs in no essential respect from the shearing and accomodation along the N-S. folds. However, the result of the motion is to bring the granite in such a position as to cut off the sedimentary and volcanic rocks along the strike, and can therefore scarcely be called anything else but faulting. For such deformation the term distributive faulting would seem to be a good one.

For the N. distributive fault the movement seemed to be southward, upward and eastward. As evidence of this are sharp turns of the Linnville formation to the E., a small area just E. of Cranberry and at other places. This turn makes the schistosity where the quartzite first appears parallel with that of the granite. In some places the N-S. pressure was so great as to result in crinkling the Linnville formation for some little distance from the granite. The above movement is also shown by the direction of the scratchings and often grooves in the slickensided surfaces. The deformation of the porphyritic granite N of Blowing Rock on the Boone road is somewhat different from that to the ~~E.~~ S. of Blowing Rock, as shown by notes of previous year. On the road referred to the mashing has been more nearly in the zone of combined fracture and flowage, instead of in the zone of flowage, so that the diagonal fractures not only affect the feldspars but occur in the matrix. In the latter the fracturing is at more acute angles than in the feldspar.

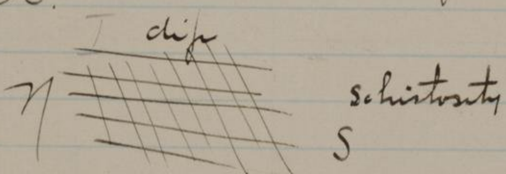


N

This is regarded as evidence that deformation first occurred in the zone of flowage, resulting in producing true cleavage in the matrix, and afterwards further deformation in the zone of fracture produced the phenomena mentioned.

I was greatly impressed in the Cranberry district by the immense deformation accomplished by an almost infinitesimal slipping between an almost infinite number of laminae.

The schistosity at the S end of Grandfather Mt. is very flat to the S, while the dip is steep to the S.



Vertical section

The dip of the schistosity of the Linnville formation and that of the granite correspond. By the distributed, indefinitely numerous minute slips the Granite country has started on a journey to the N. and thus overridden the sedimentary rocks.

At the center of the top of Grandfather Mt., the forces from the N. and S. producing the thrusting must have met, so that the deformation here did not produce such extensive interior movements. As a consequence the pebbles are much less mashed than on the S side of the Mt., the forces being equally balanced and not necessarily less intense. This lesser deformation may also be partly explained by the fact that the conglomerate at the crest is near the crown of a N-S. anticline, and therefore has been subjected to less shearing motion.

At many places on Grandfather Mt. and at Banner's Elk the longer axes of the pebbles correspond with the schistosity. This correspondence must have been observed in at least a score of places.

As nearly as could be made

out from what I saw, it seemed to me that the type of folding and the structure in this region is essentially the same as in the Berkshire district. Only the cross-folding is possibly more intense. Southeasterly dipping axial planes are the rule, although folds are by no means isoclinal. Judging by the conglomerate belts of Grandfather Mt. the axial planes are rather flat and the folds appear to be fanning.

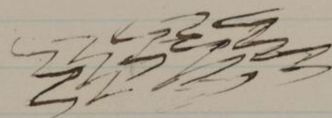
On the SW. part of the Cranberry sheet and on the SE. part of the Roan Mt. sheet there is exhibited a fine example of parallel injection and subsequent mashing.

The hornblende-gneiss areas of Keith are found to contain numerous belts of mica-gneiss or schistose granite. Also the belt of mica-gneiss running up Cane Creek to Cane Mt. contains much interlaminated hornblende-gneiss.

If I were mapping in the district I should work on the theory that the hornblende gneiss had been injected by a single granite, large masses of which constitute both the lower granite and the upper mashed granite or mica-gneiss; that these were deformed together at the time the Linville series was deformed; and that subsequently pegmatites were induced which pervade the region and as a result of which it is a mica mining area. It is certain that there has not been extensive regional deformation since this last injection, for the pegmatitic material follows the schistosity in and out sometimes, sometimes is directly across the schistosity, is most prevalent where previous folding was close and often ~~interlocc~~ continues directly to the walls of the hornblende gneiss without a sign of dynamic action.

The relations of the hornblende gneiss to the first granite injection are best exhibited on Cache Creek Mt. The history here is as follows:

The hornblende gneiss is the earliest rock (perhaps it was a gabbro or diabase originally) It underwent a period of mashing resulting in schistosity. After this fissility may have developed. Whether this occurred or not the granite injections followed the planes of cleavage or fissility producing as typical a banded gneiss as I have ever seen, exactly similar to the banded gneiss of Minnesota collected by Merriam. The bands of granite vary from a fraction of an inch to several feet, but bands from 1/4 to 3 or 4 inches are the prevalent ones. After the granitic injection there was another period of deformation the movements being mainly in the same direction as before, but partly differential between the layers, thus producing schistosity in the granite parallel to the hornblende gneiss. The movement seems to have been to some extent at right angles to the schistosity of the hornblende gneiss in one plane, but inclined in another plane, although the main differential movement was probably parallel to the schistosity of the hornblende-gneiss. That mashing was very important in the interbanded material is shown by the sharp minute plication, thus:-



Notwithstanding the closeness of the folds there is not the slightest sign of fracture. The deformation was wholly in the zone of flowage. As evidence of the later age of the granite is the more strongly developed schistosity in the hornblende-gneiss. Also in the bands of the schistose granite are inclusions of the hornblende-gneiss. The larger areas of mica-gneiss of Keith are in some places only a slightly schistose granite. As has already been said the final important event was the pegmatization of the district. Associated with this was much quartz-veining. The quartz veins of the Linnville series may be a correlative of this pegmatization, in which case we would have exhibited the various stages from cementation to injection. But this last is merely a conjecture.

25827 Quartz-schist from Linnville formation, Cranberry sheet, showing fracturing in shearing planes. From small creek off main road on first belt of Linnville formation just E. of Cranberry Inn.

Near Johnson City Tenn., Aug. 15 and 16. In company with Holmes and Stose.

Again studied the N.E. end of Cherokee and Buffalo Mts. The road going into the cove from the N.W. side about 2 miles W. of the Mt was again traversed. The limestone and slate belonging with the same and quartzite of Cherokee Mt, are perfectly conformable. The quartzite continues for some considerable distance, and then by gradation is replaced by graywacke. The dips of the formation average rather steep, so that there must be a considerable thickness of the quartzite and graywacke at this place, - certainly hundreds and perhaps thousands of feet.

The brook at the N.E. end of the Mt, passing near the contact of the limestone and quartzite, was followed, and again the 2 rocks appear to be in perfect conformity. At this place there are numerous minor waves in the limestone. This illustrates the principle that folding in two dimensions demands minor crenulations, just as when a globe is fitted with a plain piece of leather there are crenulations upon it.

The Mt. was ascended N. of ~~Oklahoma~~ Okalona, and again the Knox and quartzite are perfectly conformable, the 2 being found practically in contact, there being an interval of only a few feet between them. There was here no sign of any basal conglomerate or of faulting or other unusual phenomena. The entire appearance was that of 2 conformable, folded formations.

General Memoranda of work done on Mount Guyot sheet

(1) Small area of Citico 2 miles south of indistinguishable on lithological grounds from areas mapped as Chilhowie and Clinch.

(2) Pigeon River gorge, followed between Stone Mountain and Denny Mt. Entering from the N, for $\frac{2}{3}$ or $\frac{3}{4}$ of the way the quartzite has flat dips to the N, and for the remainder of the distance steeper dips to the S. Parts of the rock on the S side are coarse, and resemble in many respects areas which in other places are mapped as Citico. This major anticline well illustrates how large folds are composed of minor folds. Also the change from the Northern to southern dips are very sudden. The forms of the folds are here contrary to the usual ~~order~~ rule for the Appalachians, that is, the axial plane inclines to the ~~SE~~ NW instead of to

the SE, thus

On the N side of the quartzite the dolomite is impure and contains beds of quartzite, some of which are of considerable thickness, but having for the most part a calcareous aspect. On the S side of the quartzite are slates containing large beds of limestone, very similar in lithological character to the Knox at the N.

(3) An examination was made of the W. end of Denny Mt. Here the siliceous limestone wraps around the quartzite, and is more shaly on the W and S sides than on the north side. There is apparently here a case of lateral transition into less calcareous sediments in passing from the N around the end of the anticline. The limestone mapped by Keith as Knox is siliceous and contains beds of shales. The

formation here mapped by him as Wilhite contains beds of limestone, both above the Knox and S. of the area of Knox. Whether the entire encircling belt adjacent to the quartzite at the N. end of Denny Mt were calcareous shale or shaly limestone would depend on the general character of the formation with which this material occurs. It might be equally well considered as a part of the limestone or slate formation. Many lenses of limestone are scattered through the Wilhite formation for this area. Furthermore the slaty phases themselves are calcareous throughout. At the N. end of Denny Mt there seemed to be gradations both upward and laterally into less calcareous material. The minor folds of shale and limestone about the end of the anticline beautifully illustrate the laws of cross-folding. The position of the pitching axes of the cross folds give the direction of strike and dip of the major folding.

Also there is beautifully illustrated the principle of using minor folding to determine whether structure is anticlinal or synclynal. The axial lines of the secondary folds dip at the SW end of the mountain to the SW., and at the N.W. end of the Mt. to the N.W., showing beyond all question that we have here an anticlinal.

(4) In the area between Denny Mt. and the S.E. end of English Mt., the Wilhite contains every-where much uniformly distributed $CaCO_3$, that is, the slate is generally calcareous. Also it contains small beds of limestone indistinguishable from the Knox, also much conglomerate. One big exposure is close to the end of Denny Mt and close to the end of Keith's Knox. The Citico as mapped is certainly interlaminated with the Wilhite. Whether each area mapped by Keith is a lentile, or a syncline as regarded by him, was not determined, but I had the feeling

that many of them at least are small lenticular areas independent of one another, and not necessarily marking a single horizon. The structure is everywhere monoclinal, and thus the solution of the above problem can only be determined by closely studying the ends of the areas mapped as Athens. In this area are many beautiful large outcrops of limestone and conglomerate - the intraformational conglomerates of Walcott. This, indeed, was one of the type areas upon which he based the name.

(5) Instead of an overlap at the S.W. end of English Mt., as mapped by Keith, it is my conviction that the Athens, Tellico, and Wilhite are all the same formation. By me they are certainly physically indistinguishable. Moreover in a small stream a short distance E. of the area mapped by Keith as Clinch, ~~the axes of the~~ minor folds

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of the Athens Slate using his mapping ~~agree with the axes~~ occur, the axes of which pitch to the N., and indicate that this eastern arm of English Mt. is a syncline.

(6) The broad area of rock mapped as Cheshire S.W. of the main mass of English Mt underlies in absolute continuity the quartzite of English Mt. The ledges were traced, with no break whatever from the coarse conglomeratic rock called the Cheshire step by step upward into the pure quartzite of the Church with a transition between. It is true that the dip of the Cheshire is low to the S.W. on the little creek between the areas marked Cheshire and English Mt. but the almost vertical cliffs to the N more than overmatch this, and while the dip is to the S.W., the higher formations are to the N. Higher up on the Creek the Cheshire dips to the N.E. This creek is, then, probably on the crown of a subordinate cross anticline.

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1

Newport, Tenn., Sept. 1 1896.

Prof. C. R. Van Hise,
Demorest Ga.

Dear Sir:—

I returned from a four days trip to the west end of English Mt. last evening and have arrived at certain results which I will explain rather fully.

In coming south from Fair Garden I took the road near the point of the Sc area. The Tellico was a brown sandy shale with occasional harder beds. As I passed onto the Wilhite area position on Top. Map I noticed hardly any change. The shale became rusty & argillaceous with some conglomerate beds, & the uniform SE dip prevailed. I also found rusty sandstone (sample X (25898)) which might well be Tellico, & I see no reason why it should not be continued around the end, at least along the western side. The tongue of Wilhite from the south is probably an anticline of Athens, & the portion nearest the mt. is Tellico.

From the Citico area just S.W. of position 1 I traced two beds of ~~7~~ conglomerate into the Wilhite area & across the road. It seems that this conglomerate is not everywhere differentiated by Keith, as I will explain later by other areas, and Mr. Hayes view that it is local & changeable character of the Wilhite seems very true.

I studied the end of the Clinch area for structure, but found little as it is so massive. I found dips along the western margin to the SE. & at the bend in the road (#2 25879) there was a sharp syncline, probably local. On the SE side (#3 25830) there is some

46.

more of the brown shale & rusty sandstone (sample ~~1~~ 25829) and conglomerate, which I should consider Pellico.

In searching for structure in the shales about the point, I found no exposures nearer than the bluff south of the river. Here I found a surprise. Although I found shale with coarse sandstone – typical Wilhite & Citico, along the base of the cliff I found ~~at~~ the top of the hill capped by a massive quartzite (samples ~~2~~ 25830). This has a cliff facing the river & its western limit is another cliff striking S 20° W. It is evidently a continuation of the English Mt. quartzite, being right along the strike of it. It is cut into extensively by narrow gorges not shown on the map, & is well exposed there. One would not observe it, however, except by going up these gorges, & Keith probably never saw it, being satisfied with the outcrop at the base.

I ran a traverse all around the area & found the Wilhite shale & conglomerate on all sides with the characteristic N.E. strike in general, varied a little by numerous close folds poorly exposed. On the west side (# ~~X~~ 7-5831) the shale interbedded with sandstone showed folds pitching eastward, but I got little satisfaction in that way.

The structure seems to be a closed syncline with axis dipping to SE. It cannot be an anticline for the cliff at the river is exceedingly steep, & right below the cliff of quartzite is a crop of the shale & conglomerate (sample 4) 7-5831. It

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seems evident that the Wilhite is here the Athens and Sellico, same as at the south ~~of the~~ end of English Mt. I found also the rusty bed of sandstone like samples 5898.29 ~~X X Z~~ below the quartzite.

Now regarding the Wilhite as mapped. Along the road south of East Forks (No. 5887 ~~X~~) there are frequent beds of conglomerate from 1 to 15 ft. thick & yet it is all Wilhite. One ledge is larger & more massive than the areas mapped as Citico. I am afraid they are so variable that if mapped they would spoil the structure.

On the road down the river west of East Fork there is a small tongue of limestone jutting up a small creek

S. T. R.

6-747

as shown by Keith. It has a rusty shale on the west side, & a black slate on the east, both the shales & limestone being much folded so that the structure is hidden. It appears to be nothing more than the Knox uncovered by the stream erosion, with Athens on both sides. The same Knox extends across the valley, & shows on the south side of the river at #5 in a north facing cliff, with rusty shales above it. It would be very convenient to call these shales Athens & not Wilhite.

The small area at #6 is limestone & has shale ~~and~~ with sandstone beds on top. The copy of Keith's map must be incorrect here, for the Tellico is shown upon the Knox without any Athens between nor any fault.

Farther west at #7 the Knox dips beautifully towards the hill of Citico & Wilhite and appears to be a syncline with Athens on top.

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Now one more observation. On my return to town I crossed through the gap in English Mt. I passed over gray shales & conglomerate beds as shown in the valley to the south, but exposures were poor & decomposed. Instead of going through the lower gap to the west, as Keith evidently did, I took the eastern gap & very fortunately too. It is not shown as a gap on the map, but there is a deep depression at #8 over which the trail leads. As I said it was very fortunate, for that was the crest of the cross anti-cline. The south side of the slope is shale clear to the very crest, & just over the top facing north lies the Knox dolomite, away up on the slope. On the east side of the gap it dips S 20°E into the mt. and on the west it dips S 30°W, so it is evidently the crest of the anticline. As I said the Athens shale lies on top, then a brown sandstone, & the quartzite capping all.

Although I am not fully satisfied with the results I have obtained I am sure they are of some value, & possibly enough so to satisfy you regarding the problem in question. I was much disappointed not to discover some definite structure in the shales, especially <u>at the end</u>, but when I found the quartzite over in the Ocowee area I concluded that <u>the end</u> was farther south somewhere & hidden in the low hills. In fact the syncline dips out gradually, the last crop of the quartzite towards the south being large boulders on top

5.

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of the ridge.

I believe the Clinch area in the Wilhite and the Knox in the gap are two decisive points, & with the other observations I have noted I am entirely won over to your explanation of the problem, for this area at least, for it makes everything so plain.

I suppose Keith will be willing to accept my observations as to new areas, as he will undoubtedly admit that he has not been there, but he will have to go back to clear up his structure in the Wilhite, if he sticks to that subdivision.

I hope my explanation has been clear, and that my results are

Last page of letter unavailable.

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No rock which could possibly be called Wilhite is between the Citico and the Church. Keith says that this large area of Citico is certainly a synclinal! This agrees with the determination of the E. end of English Mt. as a syncline, and the area of Citico is believed to be an downward extension of the English Mountain syncline.
See report on W. end of Mt. by Stose. Opp. page

25828
25829
25830
25831
From W. end of English Mt. See letter on opposite page.

25832 Knox dolomite collected by Stose showing the siliceous character of this formation in places.

As a result of work on the Mt. Guyot sheet, I reached the provisional conclusion that a part of the Knox dolomite of this area is the equivalent of a part of the Wilhite and Tellico of the area as mapped by Keith. The facts obtained upon the opposite sides of Stone Mt., as shown by Pigeon River gorge; the lateral and vertical thrusts with no sign of unconformity or overlap at the N. end of Dunn Mt.; the absolute likeness of the Athens, Tellico, and Wilhite SE. of English Mt.; and the fact that the pitches correspond to a synclinal structure; the fact that the Tellico SE of the mountain grades up into English Mt; the facts given by Stose concerning the N. end of the Mt. and the general calcareous character of the Wilhite in this district — all correspond with this idea, while no fact was discovered which in any way has a contrary bearing.

Going over the area represented

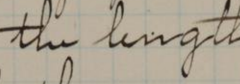
by the map I had the feeling that the various formations were mapped upon a lithological rather than on a structural basis. In places the Athio occupies great areas and becomes an important mountain-making formation, as SE of Stone Mt. In other places the formation is reduced almost to a filiament as for instance at the north of the little quartzite spur at the N. end of Denny Mt. The only important fact against this theory is the absence of discovered fossil remains in the bowlders of limestone in the very numerous outcrops of ~~limestone and~~ limestone-conglomerate mapped with the Athite. It is however, believed that the explanation of the phenomena about English Mt and Denny Mt. lies in the variability of sediments in nearing the shore line, that is the pure Knox of the northern part of the sheet varies gradually into a formation which is less and less calcareous, and more and more argillaceous in nearing the shore line - which must have been in the mountains to the south. Thus the Knox and associated Athens and Sevier or parts of them, are believed to be the equivalent of the formations mapped upon the Guyot sheet as Citico and Wilhite.

In company with Hayes and Stose, I made a transverse section from Wetmore to Macfarland, and from this section made a several days excursion on horseback through the area of Springtown, Rural Valley, White Cliff Springs, etc. In this section found the formations to correspond closely to the descriptions of them given by Hayes in the Cleveland folio, No. 20. However, was only able to discriminate between the Paleozoic slates bearing belts of limestone and limestone-conglomerate,- Sandschuck shale and Athens shale, - and the Wilhite slate bearing similar belts of limestone and conglomerate. The only difference between the two was that one of the conglomerates north of Starr's Mt, mapped as Athens, bears fossil remains in the lime-stone bowlders showing the lime-stone fragments to have been derived from the Knox. However, this limestone appeared to be in every respect lithologically similar to the limestone bowlders of the Wilhite - only in the latter fossils have not been found. One is inclined to suggest that wherever fossils are found the exposure is legislated into the Athens, and where fossils are not found the con-glomerate is legislated into the Ocoee. If this method is followed, it is of course impossible to prove that there are fossils in the Ocoee. In this connection it may be remark-ed that Bean's Mt and its nor-then extension was originally mapped as Ocoee, but that when fossils were found in Chilhowee Mt. the Bean-Starr Mt. series, being lithologically similar, was changed from the Ocoee to the Cambrian.

Of the fault on the published Cleveland sheet between the Wilhite and the Cambrian, not one scrap of evidence was found. In fact there seemed to be absolute gradation from the Cambrian up into the area marked Ocoee. The same is true of a portion of the area to the N.E., although the evidence of faulting at the northern end of Starr's Mt. as pointed out by Hayes, seemed to be conclusive.

The Tellico formation instead of being very uniform, as stated to be true of it by Keith in the Guyot area is reported by Hayes in the Cleveland-Murphy area to be exceedingly variable, different lithological members in sections 2 miles a fact not being easily correlated

In the section of the Ceru to Macfarland a number of interesting dynamic phenomena were observed. For 8 miles below Macfarland the bedding was very flat, and the cleavage was with great uniformity to the SE at an angle of about 30°. Also from less certain observation from the railroad train, from about 1 mile E of Macfarland to 3 miles E, the ~~parting~~ bedding of the slate is almost horizontal, with ~~minor~~ slight rolls and cleavage at about 30° SE. In this case it appears that monoclinal cleavage is produced by simple shearing, combined with uniform shortening one set of shearing planes being circum ~~tangential~~ ~~tangential~~ and the other radial. This deformation will neither lengthen or shorten the radius of the earth, and as a result of it the cleavage might be at any angle from steep to flat, depending upon the amount of shearing. This suggests that the SE cleavage of the extensive area of the Blue Ridge and Piedmont crystalline belt may not involve anything like the circumferential shortening which has generally been assumed. Also this may be true of other areas having monoclinal cleavage. Still further, in case along cleavage and shearing planes material is introduced by cementation or injection, there might be an absolute extension of the crust of the earth instead of shortening. For extensive areas the amount of injecting or cementing material is a large fraction of the entire mass of the rock - in some places more than ½ of the whole material. (Piedmont Plateau, Manhattan gneiss) This material must come from somewhere else. This involves sinking and consequent folding. This folding would be regarded as evidence of radial shortening, when nothing of the kind necessarily occurs, the elongation and shortening balancing and therefore involving in all readjustment of the outer crust. The same principle applies to gravity and thrust faults, either of a major kind or of minor slips along planes of fissility. In this connection, normal faults have been observed along such planes in the Blowing Rock area - see polished specimen. If shearing motion does not produce cleavage, but produces ~~[illegible]~~ fissility in 2 directions, the same principle applies upon the average as to cleavage. The total of the deformation on the average is the same. The two sets of minor diagonal slips may result in giving the same radial & circumferential thickness. It is also at once evident that jointing in shearing planes may also produce the same deformation. Further, irregular fracturing along shearing planes may accomplish the same kind of mass deformation. Also the question arises whether thrust-faults with flat hades, if accompanied by minor shearing along other sets of planes may not occur without producing circumferential shortening. Finally, in the production of cleavage there may be accompanying monoclinal folding, such as occurs in the Appalachians, and this possibly involve shortening. To accomplish this, it is necessary that the limbs of folds be much thinned and the length of layers increased. That this occurs is certain. If the crowns and troughs be taken as original thickness, the limbs of the folds are often greatly thinned, and therefore lengthened, thus:-



Overlooking these facts has led without question to great overestimates of the amount of shortening in the Appalachians, for this is a region of monoclinal cleavage and monoclinal folding. May this process affect a region and die out circumferentially without involving shortening of the crust? If this question can be answered affirmatively, the cleavage and monoclinal folding may not be in the same direction, and yet the crust may not be shortened. However, if the cleavage in different regions is in the same direction, the above conclusions as to overestimates of shortening would still follow. So far as pure shortening occurs in symmetrical folding or so far as pure shortening causes cleavage, - ~~and~~ this is certainly an important element in both thrust and circumferential contraction, but the shortening may be greatly overestimated if the overlapping layers or limbs be assumed to be of full original thickness. They may have been mashed, and also even stretched, to compensate in part for overlapping.

(Continued in Notebook -191)