New England: [specimens 42215-42327]. No. 348 1901

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

FIELD SECTION BOOK

9-891

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

#348

C R Van Hise

New England

1907

July 4th, 1901.

Manchester Center, Vt.

With Dale and Wolff visited the contact of Vermont formation with granite on the west flank of the mountain southeast of Manchester Center. At the actual contact the granite seems to be pegmatized. The actual contact is visible. The Cambrian rock at the contact is a schist, which however is clearly of sedimentary origin. The foliation of the pre-Cambrian granite and that of the Cambrian schist at the contact are nearly at right angles to each other,- a rather unusual thin in Green Mt. structure. The Cambrian schists of the Vermont formation on the west slope of the mountain have many minor folds which pitch to the west, and thus show the general dip of the formation to be in that direction.

July 5, 1901.

With Wolff drove from North Adams, Mass., to Heartwellville, Vt.

We saw the large outcrop of limestone just north of North Adams. From this point no outcrop of limestone was seen; nor has any been found by Wolff. However, he maps the limestone as extending about 5 to 6 miles farther north upon the basis of the topography. The facts are that from North Adams all the way along the Hoosac river to Heartwellville there is a valley filled deeply w drift from 1/4 to 1/2 mile wide, which shows no exposure whatever. So far as I could see, the limestone or its equivalent might extend all the way to Heartwellville over the divide, and to the flat of the North Deerfield river upon which Heartwellville is located. Upon the other hand the limestone may not extend any considerable distance north of North Adams.

In the published Taconic quadrangle Wolff's interpretation of the disappearance of the limestone of the Hoosac river north of North Adams is th the horizon of this limestone is taken by the Hoosac schist. As evidence of this we saw a short distance north of the good limestone exposures certain exposures of calcareous schist or schistose limestone. The question arose in my mind however as to whether or not the Hoosac schist is not unconformably on the Stockbridge and Vermont formations at this locality, the limestone being cut out by differential erosion. This is a mere suggestion based upon the fact that Dale has found between the schists of the Equinox quadrangle an unconformity which he would not have detected except for fossil evidence. He finds in juxta-position a schist which is Cambrian, as shown by fossils, and on top of this a schist which is well up in the Silurian, the Stockbridge limestone being missing by unconformity. However this fact would not have been known had it not been for the discovery of fossils. This unconformity is however a long way from North Adams, and the same explanation may not apply.

It is apparent that there are great difficulties in explaining the relations of the Hoosac schist. For instance in passing from the core of Hoosac Mt. south of the tunnel west, we passed over the pre-Cambrian and the Vermont formation; then have a belt of Hoosac; then the Cambrian again; then the Stockbridge limestone; and finally the Berkshire schist. This makes a belt of the Hoosac below the Stockbridge. However in the succession east of Clarksburg Mt., as mapped by Wolff, the order is: pre-Cambrian gneiss, Vermont formation, Stockbridge limestone, and Hoosac schist. There seems here to be a discrepancy, which makes me wonder whether the Hoosac schist west of the core of Hoosac Mt. is not merely a schistose phase of the Vermont formation, and not the equiavelent of the main mass of the Hoosac schist. In short, the areal mapping looks to me as if the Hoosac schist were a lithological unit, and that the formation has been extended wherever the peculiar albite-schist of Hoosac Mt. has been found without reference to other structural relations.

At one place we made a section to the northwest to Clarksburg Mt. core. Here we found the Cambrian to be a schist, in some places approaching a quartzite; but nowhere did we see any clean-cut quartzite. However the formation is much more quartzite in its character than the Hoosac schist to the East We visited two small areas clastics 1/2 mile or more within the general area of pre-Cambrian core. One of these Wolff regarded as quartzite; the other is a graphitic gneiss which Wolff was inclined to believe belonged to the pre-Cambrian gneiss, but which so far as I could see might perfectly well be a part of the Vermont formation. Indeed, in its general structural appearance it seemed to me to be more nearly allied with the adjacent area of quartzite which Wolff regarded as Cambrian than the gneissoid granite of Clarksburg Mt. with which he associated it.

42215 42215 Pre-Cambrian Stamford granite, showing large microcline eyes. From bed of Roaring Brook, 1 mi. northwest of Stamford, Vt., where old road crosses creek.

42216 42216 Mica-schist, with quartz veins. From shearing plane in Stamford granite. 100 yds. down creek, same locality as above. Shearing plane vertical, about 4 ft. wide. Appears like basic dike in granite; but transition traced from granite to schist.

42217 Cambrian Hoosac schist, 5 mi. northeast of Stamford, Vt., on mountain west of Heartwellville road. The lower slope and crest of this mountain shows the pre-Cambrian Stamford gneissoid granite, the Cambrian schist being an inlier in the granite towards the crest of the mountain, apparently left by erosion.

42218 Graphitic schist (pre-Cambrian ? by Wolff), found in the pre-Cambrian Stamford granite near crest of mountain from which 42217 was taken. Exposure about 15 yds. long and 1-2 yds. wide. Rock weathers a reddish yellow, and considerably altered onthe surface.

With Wolff intended to make the section up the North Deerfield river to see the contact of the Hoosac schist and the Vermont formation; but rain prevented.

In the afternoon we drove from Heartwellville down the North Deerfield to Hoosac Tunnel. This entire distance, to about 1 1/2 mi. below the Monroe bridge, is through the Hoosac schist, which is finely exposed in the beautiful gorge.
This schist, as usual, shows abund-
42219 ant albite twins. (42219) The road then passes on to the Rowe schist; but for 2 or 3 miles no exposures are seen. When about 1 1/2 miles from Hoosac Tunnel exposures of Rowe schist are found; and here the rock appears to differ from the Hoosac schist mainly in that the albite feldspar crystals are absent. The rock contains much chlor-
42220
42221 ite and numerous garnets. (42220,42221)
In some places, as for instance at the mouth of Hoosac Tunnel, feldspar is
42222 found (42222). 42223 represents the
42223 Rowe schist free from garnets.

July 8, 1901.

Hoosac Tunnel, Mass.

With Wolff and Emerson examined the end of the belt of serpentine, talc, etc., on the north side of the Deerfield river about 1 mi. below Hoosac Tunnel. This belt, which is called the Chester amphibolite, is regarded as separating the Rowe schist and Savoy schist.

The rocks belonging to this belt, so far as we saw them, are quartzose
42226 serpentine (42226), dolomitic
42226a talc rock (42226a), chlorite-
42226b schist, etc. Emerson says the extension of this rock to the northeast passes into hornblende-schist, and of this I have no question.

The southern continuation of this belt Emerson regards as appearing on the south side of the river about 2/3 of a mile northwest, thus making a fault with a horizontal throw of about 3000 feet; and this takes no question of the vertical throw. The only evidence of this fault, so far as I could see, is the serpentine-talcose character of the Chester amphibolite. This evidence seems to me not to be adequate. Indeed, I am by no means certain that the serpentine-talc rock is not a much metamorphosed eruptive, as is the case in so many other areas. For instance, Miss Bascom refers all her serpentine-talc rocks to metamorphosed eruptives. This raises the question whether the entire Chester amphibolite is not an igneous rock. If so, it would not have a stratigraphic value unless it were a metamorphosed lava belonging to the time in which various rocks of the series were laid down.

At one place in the Rowe schist I found some pyrite and graphite, but these minerals are subordinate.

The distinction between the Rowe
42224 schist and the Savoy schist (42224-5)
42225 is a very slight one indeed. They both contain garnets; both are chloritic; both contain very numerous quartz veins; both are much crumpled. But possibly the Savoy schist is more crinkled than the Rowe schist; and possibly it may be somewhat more quartzose. However if it were not for the Chester amphibolite I suspect it would be practically impossible to map the two as separate formations.

In the afternoon we drove from Hoosac Tunnel to Charlemont, and from Charlemont to West Hawley mine, and returned to Charlemont.

All that has been before said concerning the Savoy schist was fully confirmed by the fuller section along the Deerfield. The Hawley schist seems to be different from the Savøy schist in containing more iron, which appears in

the biotite, in abundant hornblende,
in very abundant garnet, in pyrite, and
42227 in magnetite, and in carbonate (42227).

Emerson has mapped several belts of hornblende-schist, some of which he regards as continuing for long distances and as very distinctive things. Associated with these ferruginous phases of the schist is also a carbonate to which Emerson applies the terms dolomite and ankerite.

The so-called West Hawley mine is at the west border of the Hawley schist, at the contact, indeed, between this schist an the Savoy schist according to Emerson, who also believes that there is here a fault. At this locality for a short distance the schist for a thickness of 3 ft. or thereabouts, is so heavily impregnated
42229 by hematite (42229) as to be a hematitic schist, with beautiful sheeny micaceous hematite which resembles mica flakes, and which Emerson thought might be a replacement of mica.

The schist above the hematitic slate also contains a great deal of the hematite. Associated with this specular hematitic rock, or at least along the same horizon, is granular magnetite-gar-
42228 net rock (42228), a schist with great spangles of brilliant hornblende, a variety of rock containing much pyrite and magnetite; and frequently indeed in a single hand specimen showing several
42230 or all of these. (42230) It seems to me very probable indeed that Emerson is

correct in thinking that there is a fault at this horizon. However I shoul regard the specular hematite as having been formed before the last severe movement, and made into micaceous hematite at this time. The granular magnetite, pyrite, and very likely the coarse crystals of hornblende and garnet are probably a later formation deposited by water in t openings formed at the time of the movements preceding. In short, the phenomer of the belt seemed to me to combine dynamic phenomena upon minerals previousl ly existing with the ordinary vein phenomena by deposition by circulating waters after movement has ceased.

July 9, 1901.

Amherst, Mass.

With Emerson and Wolff by train from Charlemont, via Shelburne Falls, to Amherst, Mass.

On our way to Shelburne Falls we saw numerous railroad cuts which are in Emerson's Sc, Conway schist. The train went slow enough so that I could see various limestone beds. The same phenomena were seen beyond Shleburne Falls. Near Shleburne Falls we saw gneiss, mapped Becket by Emerson; but could obtain no idea as to whether it was probably igneous or not.

At Amherst we looked through many of the specimens of the various formations of the region. I examined a number of the slides of Emerson's hornblende-schist placed in his sedimentary series west of the Connecticut, and could see nothing in them that clearly indicated an igneous origin. Indeed, their structures were substantially the same as those of many metamorphosed sediments.

Also I examined slides of a number of hornblende-schist belts bordering the granite east of the Connecticut, and these seemed clearly to have igneous structures, thus confirming Emerson's conclusion that they are igneous rocks.

From Amherst we drove east into Pelham township. We here saw the Pelham gneiss mapped as Becket by Emerson; and also at one locality quartz-
42231 ite (42231) which hemaps as associated with this belt. The quartzite is a granular quartzite which does not show extreme metamorphism. That is to say, the original clastic granules appear to be present; but upon this point I would not be positive.

As to the Pelham gneiss, I could discover no structure whatever which led me think it to be a sediment. It is a fine grained, evenly granular, remarkably uniform textured and structured
42235 rock (42235). Indeed in this respect it is an ideal case of my criterion that when in doubt as to whether a rock is igneous or aqueous, if one lamina is just like the other lamina, it is probably igneous because sediments which are of a composition to change to a schist are never so remarkably uniform.

42232 Shows hornblende bands in the Pelham gneiss.

On the west side of the gneiss belt the foliation dips to the west. We did not get far enough east to see its dip at this place; but Emerson said it was to the East. At the Ward quarry near the center of the belt, the dip or foliation is almost absolutely horizontal. This foliation apparently has an anticlinal structure.

While the original gneiss is as above described, along the foliation planes there has been much pegma-titization and development of
42234 feldspar. (42234) Indeed, this is a very characteristic thing in reference to it, and is more often present than absent. Besides the fine feldspathic laminae shown by the hand specimen, there are associated with the gneiss coarse pegmatitic dikes which have their greater direction parallel to the foliation. Occasionally small pegmatite dikes are seen cutting across the foliation. Thi pegmatitization however may be much later, and have no bearing upon the origin of the rock.

As to the relation of the quartzite the gneiss, Emerson said that the two were interstratified; that is, he spoke of the gneiss as being both above and below the quartzite. However, upon thi point I myself saw no evidence, and can see no reason why, so far as its distribution is concerned, that the quartzite may not rest unconformably upon the gneiss. This hypothesis apparently had not occurred to Emerson who supposed that the gneiss must be eith the Becket, and sedimentary, or an intrusive granite. The other hypothesi is that the gneiss is a pre-Cambrian ig-neous rock, and that the sediments, including the quartzite, are laid down upon it.

Prof. Emerson apparently had not looked for contacts between the quartzite and gneiss, and could not tell what the relations are between the two. My own conjecture as to what is most probable, simply based upon the relations of the forms on the map and what I have seen and without any adequate evidence that this is so, is that the Pelham gneiss is a pre-Cambrian igneous rock, and that the sediments, including the quartzite a are unconformable upon top of it.

We also visited an old asbestus
mine where there is a basic igneous
42233 rock containing enstatite and olivine
which has extensively altered into
various other minerals, and especially
into serpentine, anthopyllite, etc.

Cutting across this rock are vein-like
masses of asbestus, Emerson says of the
anthopyllitic variety; and in some plac
this is very finely granular, almost
hornstone-like in the center and fib-
42233 rous along the borders. (42233a) Alon
a the contact of the igneous rock with
the Pelham gneiss is a set of bands of
contact minerals, including a broad
belt of biotite, another belt several
inches wide of tourmaline, and a third
belt of anorthite, in places 2 ft.
wide containing crystals of allanite.
Actinolite, corundum, and other min-
erals are plentiful.

July 10, 1901.

Ware, Mass.

With Emerson and Wolff went west from Ware.

We soon came to the east side of Emerson's first granite area west of this town. Bordering it is a belt
42236 of fibrolitic schist, bearing garnet and graphite (42236). Also along its border we found interlaminated with it black bands of amphibolite, making a
42237 banded gneiss and amphibolite. (42237) This rock strikes N. 25-30 E., and dips 40° W. The gneiss itself, when free from amphibolite is fine and dense, with
42238 regular lamination. (42238) Also within the area of the white gneiss there was
42239 one considerable area of amphibolite.

All of these rocks, instead of having axial planes in the usual direction, dip toward the west at angles of about 40°.

In the center of this mass of granite Emerson showed us another belt of fibrolitic schist with amphibolite. We continued west along and across the area to the west side of it. The granite belt which Emerson says is the continuation of the Monson granite, makes the valleys for the most part; althohgh Emerson pointed out several sharp bluffs within the valley itself.

On the west side of the valley the schists come in again. Here we found the rusty garnetiferous iron-bearing schist; associated with this the amphi-

bolite, and on the steep hill the granite
Looking at the relations of the
schist and amphibolite closely, we
came to the conclusion that the
42240 amphibolite (42240) is intrusive
42241 in the fibrolite schist (42241), since
stringers of it were found in the schist
some distance away from the main masses
and in a minute way cuts across the lami-
nation of the schist. The granite also
seems to have a somewhat similar rela-
tion; at least a large mass of it comes
in diagonally across the foliation of bot
the schist and the amphibolite;and very n
near to each other, only a few feet
away, the schist on either side contin-
uing its strike right into the granite.
Going farther north we found the
amphibolite and granite in such relations
to each other as to show that the granite
is intrusive in the amphibolite. Put-
ting these two relations together, it
seemed perfectly clear that the order of
these two rocks is: (1) schist, (2) am-
phibolite, and (3) granite. This is
the order which Emerson supposed to be
the correct one.
Returning now to the south of the
locality where we first saw the relations
of the schist and amphibolite and gra-
ite, we again went up the slope. Here
we found both the amphibolite and
schist. These continued up the slope
to near the crest. Here in a little
42242 valley is a rock which is different from
42244

the schist which we had before seen, and which Emerson places with a quartzite belt,and a little farther to the west, just across a little
42243 depression, is a mica-schist. (42243) At this particular locality the question arises as to whether the metamorphosed schist intruded by the granite and amphibolite may not be older than the mica-schist, the latter being unconformably upon the former. However, so far as we saw evidence, the explanation which most would make would be that the schist becomes progressively metamorphosed in approaching the amphibolite and granite, and that there is no unconformity. If there is here no break, it is certain that the schist both in its extremely metamorphosed and in its less metamorphosed variety, is the latest rock.

July 11, 1901.

Ware, Mass.

With Emerson and Wolff drove east from Ware, across the granite area, towards Coy's Hill. About 1 mi. from Ware we came upon a contact of the granite and schist. Normally the schist is a fibrolitic graphite-
42245 schist (42245,'46,'47). Immediately
42246 adjacent to the granite it is a very
42247 coarse fibrolitic and graphitic schist
42248 containing very numerous large garnets. The fibrolite wraps around the garnets. In the garnets are frequently crystals of graphite, biotite, and feldspar. It is difficult to give the exact contact between the granite and schists, so completely metamorphosed and granitized is the schist adjacent to the granite. None of us have any doubt that this granite, which normally is a somewhat mashed porphyritic granite, is intrusive in the schist.

We drove across the granite to near the top of Coy Hill; thence northeast; thence northwest to Gilbertville, crossing the schist and granite again.

So far as we saw the exposures of the schists southeast of the granite area they are the same as those to the northwest. Where the road is a half mile or more away from the granite area no exposures of the schist were seen; but Emerson said it keeps its coarse fibrolitic character. Upon the western side of the granite area the schist also dips flat to the northwest about 20°. On the southeast side of the granite the schist also dips to the southeast, the foliation thus corresponding with the border of the intrusive granite. This same thing was seen even with reference to smaller granite masses within the schist; for the granite is not a simple one, but has various stringers which pass off into the schist with inclusions of schist in main area.

At Gilbertville in the railroad cut
42249 we found a quartz-diorite or tonalite
and adjacent to this again fibrolitic ~~sc~~ schist.

Returing from Gilbertville to Ware, we followed the river, but the drift was so heavy that practically no exposures were seen except in the river just as we entered Ware, and here the rock appeared to be the same coarse rusty schists elsewhere observed, but it was not closely examined.

Emerson has always regarded the granite mass east of Gilbertville intrusive. He says it not only cuts across the fibrolitic schist; but also in its southwestern extension traverses the granite areas themselves.

In the afternoon we took the electric car to Palmer.

From Palmer we drove west a short distance, and, as pointed out by Emerson, we found a laminated mica-
42250 ceous quartz-schist (42250) which Emerson has regarded as Cambrian. This quartz-schist Emerson told me occupied a position between the mica-schist and the fibrolitic schist the same as at the locality where we observed it yesterday near Enfield. Indeed, he regards it as a continuation of the same stratigraphical horizon.

We next drove south from Palmer for about three miles, to the Monson granite quarries. Here a large area has been stripped, and shallow aurrying carried on over an extensive area. The foliation of the granite is nearly vertical. It apparently intricately intrudes and encloses large and small areas of amphibolite. Indeed in many cases so in tricate are the relations between the two that they seemed interbanded. The normal granite (42235) has a very well marked foliation. The folia, the amphibolite, and other various mixtures are cut by pegmatitic veins. Indeed, in some places one can make out two or three different steps in the intrusion; a granite dike of one kind being cut by pegmatite of another kind, and this by another of slightly different kind. However from all I saw I take these intersections to be all produced by the same great period of igneous activity and not independent intrusives. Certainly the relations of the amphibolite and schistose granite, the intricate intrusions and bandings, gave evidence of a very prolonged dynamic and metamorphic history. Indee in all of these respects the rock reminded one of pre-Cambrian rocks. The closest analogy of which I could think in the East would be the Storm King granite masses of the Highlands of New York.

The quarry is cut by one small trap dike about 15 inches across, having a cross columnar structure well developed.

The most remarkable thing about the quarry is the later dynamic phenomena. Notwithstanding the fact that the well developed foliation is vertical, the rock is clean cut into a series of almost horizontal slabs parallel to the surface by joint cracks. These are clean-cut and sharp, and extend for great distances so that the granite is easily taken out in blocks with parallel sides. These horizontal parting planes are nearer to gether at the surface, and become farther apart as depth in the quarry increases. While I have frequently seen parting parallel to the surface, I never have elsewhere seen such a clean-cut, regular, and extensive partings as those exposed in the Monson quarry when this structure cuts directly across the cleavage of the rock. The rock is now compressed, and by elastic expansion moves when it is parrtly released in the quarry. For instance, when a mass is drilled and wedged apart, the loosened part expands so that the opposite sides of the drill holes do not match. Also when the upper layers have been taken away in some cases a large bed has risen up and formed a low arch. The men report that this property of the granite is take advantage of, and is very helpful in the artificial opening. They say that many of the cracks form with sounds like pistol shots. A number of large cracks in a mass in which there is much hornblende, and therefore unfavorable for quarrying and hence left as a horse in the center of the quarry, contains numerous large and deep cracks, all of them formed, according to the workmen, as result of natural causes and not by the use of powder. All of these phenomena show that the rock is under great stress and that when partly released it will further release itself by elastic expansion. While I have heard of localities of this kind, this is the first one which I have personally seen.

July 12, 1901

Westfield, Mass.

With Wolff and Emerson, drove west from Westfield to the serpentine quarry along the border of the granite. Here in a rather small quarry, which is at present being developed, is found an enstatite rock which has extensively altered to serpentine; or, as it is
42251 locally called, bastite. (42251-2)
42252 Where this rock is most exposed to the
weather the serpentine has further gone
42254 over into talc (42254). All of these
rocks are more or less calciferous.

On the east side of the quarry is a layer of very calcareous and talcose
42253 material which Emerson spoke of as a
limestone bed. Immediately adjacent to this, and in contact with it, is a coarse pegmatite dike.

So far as one could judge from the quarry without tracing out relations, all of the phenomena looked like those which would result by the metamorphism of a very basic igneous rock which was intruded in the schist and had pegmatization along the contact of the two. Bearing in this direction was the fact that a little way from the quarry along the contact was found coarse layers of biotite and abundant garnet, etc., exactly similar to the material we found in Pelham township adjacent to an enstatite-serpentine rock which Emerson regarded as intrusive.

42256 Adjacent to the granite (42256),
which is just south of the quarry,
42255 was found a schist full of cyanite.
The relations of this schist were not
traced out.

In the afternoon took train for Chester, and from Chester walked up railroad track to the Becket quarry.

In the village of Chester is schist which has a sedimentary appearance, and is regarded by Emerson as Savoy.

Next to the west of this is a broad band of hornblendic and epidotic ~~which~~ rock, much of which is well foliated and more or less banded. It is this belt which at its eastern contact contains the emery mine. This hornblendic schist is serpentinized near the mine, and it is regarded by Emerson as the equivalent,- indeed, the southern continuation,- of the serpentine-schist seen at the mouth of Hoosac Tunnel.

However, how much of this hornblende
schist is igneous and how much is sed-
imentary, I have no idea; only it seem-
ed to me in our journey across it that
probably the adjacent schist had been
intruded by and modified by various
bands of hornblende-schist. West of
the hornblende-schist area is a belt
of schist which Emerson divides into
42257 two parts, Rowe schist (42257) and
42258 Hoosac schist.

The eastern part of the belt

which we saw is perhaps less feldspathic than the western part; but it would not have occurred to me from this section to divide the schist into two different formations.

As we went up the track, all at once we found within the schist coarse pegmatite veins. Going on a little farther we found another exposure in which the schist itself was very gneissic, containing many crystals of feldspar, but was plainly banded. It seemed to me that this schist had been granitized; that is, the granite had supplied material to it which had changed its composition. Also at this locality the schist is cut through by various dikes of granite and of pegmatite.

Continuing on, we came in the bed of the brook upon a white schistose granite which Emerson says was typical of th Becket gneiss. A little farther on we came again to granitized schist, cut intimately by dikes of granite and pegmatite, and still farther to the west we came upon a white schistose
42259 granite in which some quarrying had been done. This is near the switch-back.

Going on to the quarry we found
42261 the normal rock (42261) to be a some-
what even textured granite without
anything like so well defined a rift
as at the Monson quarry; although
it had a rift which assists greatly
in quarrying. It is however so mas-
sive that blasting is resorted to, and
in such cases the rock in some cases
breaks with a beautiful conchoidal
fracture. Within the ~~schist~~ quarry is a great
42260 irregular inclusion of banded gneiss,
which we regarded as having been deriv-
ed from the schist to the east but gran-
itized by the effect of the containing
granite.

Also in the quarry is a great area
of amphibolite; but this was in such a
position that we could not make out the
relations. At places where the am-
phibolite and granite are mixed up, it
resulted in appearances very similar
to those at the Monson quarry. Great
dikes of pegmatite were found in the
granite, and these were especially
prevalent at the contacts of the in-
cluded fragments and the granite. In-
deed, this pegmatite seemed almost to
surround the big mass of amphibolite, be-
sides cutting through it with numerous
small dikes. None of us had any ques-
tion that this granite mass, which is
Emerson's area of typical Becket
gneiss from Becket township, is intru-
sive in the schist which is supposed
to be the equivalent of the Hoosac
schist. This area is so near to Hoosac

Mt. that the question arises to what extent the white gneiss there found is intrusive in the sedimentary rocks, and is not their metamorphosed equivalents as has been supposed.

July 13, 1901.

Shelburne Falls, Mass.

With Emerson visited the rocks in the vicinity of Shelburne Falls.

We first examined the rock at the falls and at a quarry about a half mile west of the falls. At the falls the evidence seemed to me to be perfectly
42262 clear that the hornblende-schist (42262) or gneiss has been intruded in a most
42264 complex way by white granite (42264) Dikes of granite cut through the schist, parallel injection is very well shown; the whole is pegmatized. However since the injection it is perfectly clear that both the gneiss and schist have been folded together, giving a most remarkably complex crinkling and folding in places.

42263 Shows the granitized hornblende-schist intruded by the granite.

At the quarry along the railroad, about 3/4 mile west of the falls, the granite is seen in the base of the quarry; upon the wall is a great inclusion of folded schist; and above this granite is found again. Interbandings of granite and hornblende-schist are also found on the highway immediately to the east. One can very readily understand how it may be supposed that the granite is a sedimentary rock interbanded with the hornblende-schist. The schist is granitized by the intrusive; the granite adjacent to the schist has suffered an endomorphic effect; so that it seems somewhat more basic than the ~~xxxx~~ away from it; and the two are interbanded because of the parallel injection. Thus one who believed in the sedimentary theory of these rocks might readily believe that there is a gradation between the two, and that there are alternate beds of material which has crystallized into a white schistose granite and into a black hornblende-schist. However, I myself have not a particle of doubt of the intrusive relations of the schistose and folded gr granite,to the hornblende-schist; nor do I doubt that the hornblende-schist is of igneous origin; but the two have been subsequently folded so as to present a most extraordinary crinkled character.

These rocks have all the intricate relations which I have thought might be pre-Cabrian when found at other places.

After dinner we went down the river on the north bank; found there the hornblende-schist intruded by granite, a at the quarry for perhaps two miles. Then came at once upon a feldspathic mica-schist which has all the characters of a sedimentary rock. However the hornblende-schist and granite are separated from the mica-schist by a score or more of feet with no exposure; but there was no evidence of unusual alteration of the feldspathic mica-schist.

We next went back to Shelburne, and then down the river on the south side, where Prof. Emerson said he thought the two rocks were in contact. Here the contact was found between the
42265 hornblende-schist (42265) and the
42266 mica-schist (42266), which Emerson has called the Conway schist. The hornblende-schist on the highway is intricately intruded by granite. Going up the slope of an open field just after passing a wood, the feldspathic schist is found in direct contact with the banded hornblende-schist. The contact is minutely irregular, so that the mica-schist cuts diagonally across the bands of the hornblende-schist. The irregularities are such as to cut diagonally across bands aggregating 2 or 3 feet in thickness, and at various places from this amount to a few yards of the hornblende-schist; but certain it is that the bands of the hornblende-schist come directly to the contact and are diagonally truncated.

42267 Shows the mica-schist near the contact with hornblende-schist, with cleavage of mica across the rock cleavage.

Just above the banded hornblende-schist is the dense evenly laminated mica-schist. The contact is absolute in places; in other places there are a few inches of vein formation material. However the two rocks are absolutely distinct;and all of the appearance is that of unconformity between the mica-schist and hornblende-schist, although the contact could have been produced by faulting. Certain it is that the mica-schist here is nowhere intruded by granite dikes, which however cut intricately the hornblende-schist. In the second place the contact is absolutely sharp. In the third place the mica-schist adjacent to the contact is not more metamorphosed than away from it. All this bears strongly against the idea of faulting. For my own part I have comparatively little doubt that the hornblende-schist intruded by granite represents an older complex upon which the mica-schist was unconformably deposited. If the contact observed were a faulted one, it might explain the absence of granite in the mica-schist; but Emerson said, after having looked over his maps, that in all the localities which he visited in the entire vicinity nowhere had he found a granite dike in the feldspathic schist; and this seems to me to be almost conclusive as to the unconformity between the hornblende-schist-granite complex and the mica-schist.

We drove to the top of the hill beyond the hornblende-schist about a mile, and there found numerous bands of clastic material in the mica-schist (Conway schist). In places
42268 the limestone is gray (42268), and not so very impure, although it everywhere shows abundant mica. In other places it is very impure. It is evidently very ferruginous, as shown by the brown weathering crust. At the contacts of the bands of the limestone beds with the more purely micaceous beds are bands in w which the metamorphism has developed a little garnet and hornblende, making a fine grained garnetiferous horn-
42269 blende-schist, which however is wholly different in its appearance from the hornblende-schist or gneiss of Shelburne Falls, the latter having, as already explained, igneous textures and structures; whereas the other is just such a rock as one would expect to develope from an impure limestone by the deep-seated metamorphism through solution.

Certain areas of the Conway mica-schist bear numerous bands of the clasticmaterial; other bands are somewhat barren in them. It seems to me not at all improbable that the long bands of hornblende-schist which Emerson has mapped as being in the Conway schist may be metamorphosed calciferous bands of the Conway schist; but these rocks are fundamentally different in character from the hornblende-schists whih have been noted throughout the week associated with the granite masses. Indeed, Emerson showed me a number of slides of the two classes of rock when I was at Amherst, and I had no difficulty whatever in discriminating between the hornblende-schist or gneisses associated with the granite, which I told him had the textures and structures of igneous rocks, and the fine grained hornblendeic schists associated with the calciferous mica-schist.

July 15, 1901.

Worcester, Mass.

With Emerson and Perry visited various localities about Worcester.

First going northeast of west, east
of granite mass northeast of the
town, we found the formation which
Emerson and Hobbs have mapped as
42270 quartzite (42270); but which I should
42271 have called a micaceous quartz-schist
42272 or simply a mica-schist. (42270,1,2).
While this rock is much metamorphosed it
is plainly sedimentary, as shown by its
banding and other characteristics. At
one locality east of the granite mass
mentioned the corrugations of the more
quartzose bands are very intricate;
indeed, the general direction of the
corrugation cutting directly across the
foliation which is vertical and par-
42273 allel to the granite (42273)

We next went to the so-called old
coal mine north of the granite. Here
we found the formation which Emerson and
Perry have called the argyllite. It
has many varieties, consisting of car-
42274 bonaceous slate (42274), graphitic
42275 sâate (42275), and various other var-
42276 ities (42276,77). That it is a meta-
42277 morphosed carbonaceous shale cannot be
doubted.

42279 We now went to a quarry in granite
42280 at the top of the hill near the State

Lunatic Asylum. Here the mass of gran-
ite contains unquestionable fragments
42278 of the argyllite (42278). Also the
coarse granite is cut through by fine
grained granite, which Emerson and Perr
call aplite.

We returned now to Worcester, and
went west across the argyllite for-
mation, and went in a general course
west through the formation which
Emerson and Perry called argyllite, but
which is mica-schist. This formation
was specimened consecutively toward the
42281 west, in which direction the meta-
42282 morphism increases. The extremes of th
42283 the specimens will probably be a dis-
42284 tance of about two miles across the
42285 strike. (42281,2,3,4,5). At the
second locality (42282) granite dikes
were found in the mica-schist; and in
the last locality the mica-schist is cu
cut by the granite in an intricate
manner, and the rock is the most metamo
phosed of anywhere noted for the
formation. Emerson says this rep-
42285a resents the extreme of metamorphism.
42285b and that we might have continued 10
42285c miles to the west through the same
formation having practically the same
character and metamorphism.

We next went to South Worcester, an
thence southward to find the argyllite
in the more metamorphosed form. This
was seen at various localities. At
the southernmost point visited a
specimen was collected in which the
42286 rock is garnetiferous and staurolitic.

However, it is rusty, contains pyrite, is graphitic, has the same essential structures and textures as the argyllite elsewhere, and I have no doubt of the correctness of Emerson's and Perry's determination of this rock as the continuation of the Worcester coal mine argyllite.

We now went east of Worcester to Bullard's quarry. Here the rock quarried is mainly granite, being a part of a small granite mass mapped by Emerson as east of Worcester. The oldest granite is a white pegmatitic-looking rock, similar to that found intrusive in the mica-schist west of Worcester. There is also present a later fine-
42289 grained granite, aplite (42289). However the remarkable thing at this quarry is the parallel banding of the granite, and especially the white pegmatitic granite, with mica-schist. Of
42288 the very complex parallel injection there can be no mistake. The specimen too feebly represents the intricacy of the injection phenomena. The bands of granite vary from those of filmament-like thickness to great masses of pure granite, 8 or 10 or 12 feet across. Precisely the same statements may be made of the schist. The specimen represents a variety in which the schist and granite are finely interlaminated. After the complex injection of the schist, the fine grained granite was intruded, as shown by the fact that it cuts both the pegmatitic

granite and includes fragments of the schist. Where the schist is in fine laminae in the granite it is impossible to recognize this original character; but at one or two places where
42287 there are belts of schist (42287) of some thickness, a dozen or more feet, it resembles so closely the mica-schist (Emerson's quartzite formation of Worcester) that I cannot doubt it is the same formation.

This being the case, we have here a most remarkable instance of parallel injection of a sedimentary schistose rock by granite, in which there are all mixtures of metamorphic igneous and metamorphic aqueous rocks. In a singl hand specimen the major or minor part may be granite or may be sediment. Of course there are both exomorphic and endomorphic effects. The intruded schist is modified throughout to the very ultimate minute particles by the granite; the granite is modified by absorption of the schist. I know of no other case in this country which for perfection of parallel injection ph nomena is equal to that in this quarry with the sole exception of the Manhattan schist in the neighborhood of New Rochelle.

Going west from the granite quarry we found a mass of basic intrusive igneous rock, and then the mica-schist of Worcester in its normal corrugated and plicated form, exactly like that seen in the same belt to the northward

in the morning, except that the mica-
42290 schist (42290) near the quarry contains small bands of granitic material, and is cut diagonally by beau-
42291 tiful pegmatitic dikes (42291) similar to those of the granite in the quarry, thus completely confirming the conclusion as to the meaning of the phenomena observed in the quarry.

Perry has found in the so-called coal mine of Worcester fossils which have been determined as Carboniferous. It therefore appears that in the neighborhood of Worcester there are mica-schists and argyllites metamorphosed completely to crystalline-schists and that these rocks are cut in a most complex fashion by at least two granites, which therefore are Carboniferous or post-Cabroniferous. This represents the latest age in which I have myself personally seen profound and deep-seated metamorphism of sedimentary rocks and intricate intrusion of granites, making up a complex mixture not greatly different from the Basement Complex of the Lake Superior region.

It is but just to say that Perry and Emerson have correctly interpreted all of the above relation, and showed th points during the day to me with great clearness.

July 16, 1901.

Westboro, Mass.

With Emerson and Perry went to Westboro.

We there saw in the railroad cut
42292a schistose granite (42292a, b) contain-
42292b ing interlaminated belt of black schistose rock which were supposed to be much modified basic dikes. The schistose granite is very regularly laminated, and shows evidence of profound mashing. At one end of the cut is a
42293 small mass of quartzite (42293) on one side, but is not shown upon the other. This was regarded by Emerson and Perry as faulted in. However the mass is no larger than the included masses of mica-schist and argyllite in the neighbo hood of Worcester, and I can see no rea- sone whatever why it may not be an inclu ed mass of quartzite in the granite.

We next went some distance northeast of Westboro, and there saw considerable belts of white schistose
42294 quartzite in close proximity to the schistose granite, similar to that at the railroad cut. At one place the strike of the foliation of the quartzite and that of the schist run directly into each other, and this relatio Emerson and Perry explain by a cross ~~fold~~. fault.

We went next northwest toward Worcester. We saw phases of micaceous
42295 quartz-schist (42295) with associated areas of hornblendic schist and intrusive basic rock approaching diorite. These formations occupy a
42296 wide belt. (42296) Outcrop along Northboro road, 2 1/2 mi. N. W. of Westboro. Excluding the hornblendic varieties they seem to me to be in no respect different from the micaceous quartzite, called Carboniferous, in the neighborhood of Worcester. At various places, as at the church in Northboro, the micaceous quartz-schist is ver
42299 fibrolitic. (42299, 42300) (42301 rusty
42300 schist at church.)
42301 Continuing northwest we found belts of rusty weathering, Carboniferous,
42302 schist (42302) which Emerson regarded as an infolded mass of the Worcester argyllite on top of the mica-schist which Emerson supposed to be Cambrian; but why this mica-schist should be Cambrian at this place, and Carboniferous at Worcester is difficult to understand. If one is Cambrian and the other Carboniferous, there ought to be an unconformity between the two, as the entire Silurian and Devonian would be absent. Emerson, using the hornblendic rock as a guide, figures out a diagonal cutting of the upper part of the micaceous quartz-schist from the lower part; but to me the boundary seems to be purely hypothetical; and I can see no reason whatever for regarding any of the

area of rocks from Westboro to Worcest
er as other than Carboniferous.

42303 andalusite phase of argyllite, same locality as 42302

42304 normal phase of argyllite, same locality.

July 17, 1901.

Danbury, Conn.

With Hobbs and Gregory visited various points about Danbury.

First we visited a quarry where a schist is injected by granite in the same complex way that the Carboniferous mica-schist is injected by granite at Worcester. The black, schistose base is subordinate, and the injection phase dominant. The main injection material is a white pegmatitic
42305 granite (42305), similar also to that seen at Worcester; and from one great pegmatite dike various stringers running off in the schist insuch a way as to show beyond doubt complicated parallel injection.

Immediately adjacent we found large ledges of gneissoid granite, both pegmatitc and fine grained.

In the afternoon we went toward Bethel, and there found the black micaceous schist parallel injected by granite of two different varieties, the granite being in thin laminae and in various small oval areas. Adjacent to this locality, across a little valley, perhaps 100 paces distant, are large masses of limestone exposed at a quarry. This limestone is coarsely crystalline, full of chondrodite, and contains bands of granite injected parallel to the bedding. It contains large oval inclusions of granite about which the bands of limestone bend in a beautiful manner. Certainly the limestone is here pretty thoroughly permeated with granitic material as there are a number of parallel injection bands besides irregular masses.

Near this locality we saw a coarse basic, dioritic schist, which contains large oval feldspars mostly simply twinned and showing very good orientation. Some of the feldspars are granulated on the border and have tails; but the majority are not so much mashed. The rock has a well developed foliation. Both the large and the small feldspar crystals seem to have a marked tendency for orientation. This rock Hobbs regards as one of the later intrusives with the exception of the pegmatites. However, it is cut by granite, and it seems to me to have suffered very considerable dynamic action.

The mica-schists of Danbury injected by granite are not so markedly different from those at Worcester injected by granite that the two could be said on any lithological basis to have different ages. However we do not find any place at Danbury where the mica-schist is as little metamorphosed as it is adjacent to Worcester, and the similarity of their charatter and injection of course is no proof of equivalence of age.

July 18, 1901.

Litchfield, Conn.

With Hobbs and Gregory drove north from Litchfield to see areas of Warren
42306 schist and their intrusive relations to the granite.

While all the area was mapped as Warren schist, much of it, according to both Hobbs and Gregory, had Becket phases. Indeed, they both seemed to think that a number of individual areas would be mapped as Becket rather than as Warren. In places the rock is a coarse micaceous and feldspathic schist; but for the most part it is a banded gneissoid rock, often finely grained and having a distinctly granitic aspect. Indeed, it seemed to me that much of the rock was schistose granite. Other areas of it appear to be a more ancient schist injected in a most complex manner by granite. Great g granite dikes and pegmatite veins cut across the schist and run parallel with it. As to the origin of the ancient incjected schist itself, no evidence was obtained. It seemed to be a fine grained mica-feldspar schist, which might perfectly well be produced, so far as one could tell, from from a sediment by metamorphism and granitization.

In the afternoon saw a complex of basic rocks south of Litchfield. Here the rock in greatest force is an olivine gabbro. This is cut by dikes of various ages and kinds, including fine grained diabase, porphyritic feldspar rock, etc. This complex of basic igneous rocks Hoobs says extends for some distance, and that it is rather exceptional for the region.

July 19, 1901.

Canaan, Conn.

The morning was occupied in going from Litchfield to Canaan.

In the afternoon with Hobbs and Gregory drove from Canaan north, for the most part following the Stockbridge lime stone valley. On our way the road took us by an island, which is of
42307 mica-feldspar schist (42307) which Hobbs has mapped as Becket.

Continuing on our way we visited a marble quarry in the valley, where solid, uniformly grained marble is exposed.

We next went on the road north-east from Ashley Falls over the spur of Cambrian extending south from Warner Mt. Here we first found heavy masses of quartzite which extended well up on the hill.

After passing the quartzite we came to an area of gneiss mapped as Becket gneiss. We then went to the place where the little limestone tongue projects from the valley of the Kankapot into the Becket gneiss. Here we found below the limestone, and but a very short distance from it, a well defined bed of quartzose schist (42310) which is unquestionably sedimentary. Almost immediately to the north of the same, not separated by a distance of more than 20 paces across the strike, are exposures of Becket gneiss which at once struck me as having the characters of a mashed and injected granite. Asking the question as to evidence of transition between the quartzite and the Becket gneiss in the area of the Housatonic sheet, I found that Hobbs knew of none. It at once occurred to me that the great variability of the quartzite formation of this quadrangle might be explained by supposing the Becket gneiss to be pre-Cambrian and the quartzite the bottom of the Balezoic series. This would explain not only the variability in the thickness of the quartzite formation, but the great break in the character of the material between the two sets of rocks; and indeed would explain the absence of the quartzite at many localities; because if a pre-Cambrian shore is to the east, the limestone by overlapping the quartzite could be in contact with the pre-Cambrian gneiss.

After this idea was suggested we worked on this theory for the remainder of the day and the following days.

We next went near Mill River, where we found a cross road going up on the top of the oval shaped mountain to the west. Here reaching the top of the mountain we found gneissoid granite injected by granite; going down the slope toward Mill river we found many varieties of gneissoid granite and various forms of injection. In short, exactly the complex set of gneisses and granites which I have been accustomed to associate with the pre-Cambrian complex. This continued all the way down to Mill River, where in the valley of the Kankapot, the limestone is exposed. Here the gneiss goes directly to the west bank of the river, and the limestone is found on the east side. At this point Smith found immediately below the limestone in
42311 contact with it the Becket gneiss (42311
42312 42312), and he states that the change from the limestone to the gneiss is abrupt; that the limestone immediately above the contact seems to be the same as for some distance above; that between the two the limestone is weathered out so as to project backward from the schist. No evidence was found by him of mechanical sediments at the base of the limestone. Whether the contact is a normal sedimentary one or the limestone is thrust over the Becket gneiss by fault was not determined.

We next followed the road around to the New Marlboro area, mapped Wh (Washington gneiss) by Emerson. Between the Washington gneiss and the Becket gneiss Hobbs reports that he had found a conglomerate. However, upon revisiting the locality, while a rock was found in which in an even fine grained mica-feldspar schist matrix are numerous large rounded areas of feldspar, I regarded these as secondar porphyritic developments rather than as pebbles. Indeed, it seemed to me to be extremely unlikely that had these feldspars been in their present position when the schist was metamorphosed from a sediment that they could have withstood granulation. Indeed, I saw nothing whatever to indicate that either the Washington gneiss or the Becket gneis in this locality is sedimentary.

July 20, 1901.

Canaan to Meriden, Conn.

With Gregory and Hobbs.

We stopped first at West Norfolk; went about a mile west through a cut mapped as Becket gneiss and Warren schist by Emerson. What we found was an ancient mica-feldspar schist cut through in a most intricate way by granite, the latter being in great dikes and in small masses, both being cut by later pegmatitic veins, and the pgematite veins at least cutting the amphibolite which is present in considerable force. The amphibolite itself seemed to have the form of a great dike which cut through the schist; but its relations to the schis were not worked out in detail to ascertain which of the two rocks is the older. However I have nowhere seen a more perfect case of a cut where the complex has all the characters that I have called those of the Basement Complex than here. The ancient schist is permeated with granite; the amphibolite is cut with granite; we have both acid and basic rocks, and the acid rocks certainly of various ages,- all in an ancient banded gneiss which seemed to me to be probably a metamorphosed igneous rock rather than a sedimentary one. At any rate no evidence indicating sedimentary origin for any of the rocks was found. This cut convinced me that the hypothesis of the previous day is correct; for if the limestone adjacent to West Norfolk had been laid down at the time the gneiss and schist were intruded in such a complex fashion by the granites of various ages, it would be incredible that the limestone was not also cut; and if the limestone were in any way intricately intruded, unquestionably dikes of granite would have been found in the limestone. No such dikes had been found from the south end of the Housatonic quadrangle to its northern part; nor have such intrusive masses been found in the Taconic quadrangle to the north of the Housatonic.

We went by train from West Norfolk to New Hartford. Here again we saw in the cut just to the northwest of the N. Y., N. H. & H. Ry. station another cut not so extensive as that near West Norfolk, but showing substantially the same classes of phenomena. The schist or gneiss, whichever one chooses to call it, was in places more evenly laminated, more uniformly fine grained, but very feldspathic, and having precisely the characters which I would expect a fine grained normal granite to have as a result of mashing and recrystallization without pegmatization. However, this variety of the gneiss is only local; for the rock is cut through by great amphibolite dikes, and also is intruded and pegmatized by granite. All the elements are the same precisely, therefore, as at West Norfolk, with the difference that certain areas of the ancient gneiss or schist have been metamorphosed without so great an influence by injection, and therefore give a better idea of the character of the original rock.

We now went down the railroad about 3 mi. from New Hartford to where the Central New England RR. crosses the river. Here both upon the Central New England RR. and the Hartford RR. are great cuts in what Gregory has mapped as Hartland schist. The cut was only examined upon the Hart~~land~~ford Ry. Here the phenomena of injection are substantially the same as at New Hartford and West Norfolk; at least so far as granite is concerned. There are large areas of intrusive granite;there is later pegmatization affecting both. Amphibolite masses also appear. However the injected base is dominant in quantity, and is more nearly what would be called a schist. Indeed the mica, and especially the muscovite, is very abundant; so abundant that one thinks of the rock as mainly a mica-quartz rock, or typical mica-schist. It is only when one gets the rock at places where recrystallization has not gone far, and breaks a specimen across it that he still sees the very abundant feldspar. This variety of rock is unquestionably similar to the gneiss of the West Norfolk and New Hartford localities; but this grades off into a mica-schist in which one sees the felddpar with difficulty; indeed, one in which I believe that the feldspar is far less abundant. The question arises whether this is a different rock or is the same gneiss mashed and metamorphosed further. I believe the latter is the more probable explanation. It is well known that orthoclase has precisely the composition to change to muscovite and quartz. Moreover, it is known that this change takes place in connection with dynamic metamorphism and recrystallization; and it seems to me that the development of the muscovite and quartz from the orthoclase thus transforming the rock from what the Germans would denominate a gneiss to a rock which is a schist is right in line with the well known law of the metamorphism of the feldspars. Just as orthoclase alters to muscovite and quartz, so the more basic triclinic feldspars alter to muscovite, other micas, and quartz, with residual feldspa This locality seems to me therefore to differ from the West Norfolk and New Hartford localities only in that the meta morphism is of a somewhat different character. The injectionof granite has played a less important part, and the mashing, and consequent recrystallization and rearrangement of the minerals has played a very important part.

42313 The following specimens were collect-
42314 ed from this cut (known as Satan's
42315 Kingdom cut): 42313,14,15,16, 17.
42316
42317 We now took the railroad again
to Plainville, riding through cutsof the Hartland schist in many places, to Collinsville. So far as one could see from the rear platform of the cars, the rocks were substantially the same. Certainly there is the same complex of schist and granite and dark colored rock which I supposed to be amphibolite, as there was heretofore.

We next went to Bristol by trolley.
42318 At Bristol saw a granite (42318) which
has one remarkable peculiarity. The ordinary rock is a biotitic granite. However, it is blotched by great white spots in the cores of which are large crystals of garnet. It appears to me that the explanation of this is that during the metamorphism the development of the garnet demanded the constituents of the biotite; and thus surrounding the garnet, the absorption of the iron-bearing constituent leaves only quartz and feldspar, and therefore gives the rock a white appearance. I have long known that garnet would absorb the biotite with which it came in contact; but this is the first cases of which I have seen evidence that it abstracted the material from the biotite for some distance from the developing garnet. If this is a cor-

rect explanation , it gives a beautiful illustration of the principles of the development of larger and heavier crystals by the solution and redeposition of the smaller and lighter individuals which are in the neighborhood. This action at a distance cannot be done by the direct contact of the minerals, but must be done through the medium of the solutions; and therefore this peculiar metamorphism is very interesting in connection with my theory of plastic flow through solution and redeposition.

We next went by trolley to Lake Compounce which is just on the east border of the Hartland schist, immediately to the east being the great broad area of the Triassic. Here the rock is one which a person who believes that foliation is evidence of sedimentation would find most difficult to believe to have been derived from an igneous rock by metamorphism. The main mass of the rock here is
42319 an evenly laminated schist, one folium
42320 being like another (42320), the whole making up great cliffs. Moreover, this schist is crinkly in the most remarkable fashion. The main constituents of the rock appear to be mica and quartz, the mica including both muscovite and biotite; but I suspect a thin section will show more feldspar than has been believed. The rock is very garnetiferous and in places is said to be staurolitic although we did not see this phase. The uniformity of the rock, its homogeneous

character, makes me believe that the probable explanation is precisely the same as that applied to the cut east of New Hartford; that is, the dynamic movement along the border of the axis, and here we know the movement will be most extreme, has transformed the feldspar of the original granite to mica and quartz, and thus reduced very greatly the quantity of the feldspar. No large masses of granite are here intrusive; but pegmatization has extensively occurred. One big mass of pegmatite, 10 or 12 feet across, was seen at Lookout pond, and numerous other smaller masses. Associated with thispegmatite was much quartz, and as we passed over from the main masses of pegmatite, we found quartz veins without feldspar.

Therefore we have here an illustration of the gradation from pegmatite to quartz veins, so frequently observed in the Appalachian region. It seems to me that the absence of great masses of granite, and therefore injection, and the fact that this locality is along the eastern border of the great crystalline complex, is an entirely satisfactory explanation of the peculiar character of the schist. I therefore think it highly probable that the Hartland schist, which on the east borders the more massive complex exemplified by West Norfolk and New Hartford, is explained by the greater recrystallization of this rock, by more metamorphism under dynamic conditions, and the less importance of granitic intrusions.

General: The argument for the pre-Cambrian age of the entire complex of rocks from the West Norfolk cut to Bristol and Lake Compounce rests on the following general considerations:

(1) The only rocks which can be recognized as sedimentary are those of the Housatonic Valley; viz., the quartzite, the Stockbridge limestone, and the Berkshire schist.

(2) The quartzite is of very variable thickness, and indeed may be absent altogether. Moreover, it is the kind of a formation which ordinaril occurs basal to a sedimentary series. These facts are both fully explained by regarding this rock as the basis of the sedimentary series.

(3) The intricate intrusions of granitic and other igneous material into the ancient schists of the crystalline complex to the east of the determinable sediments could not possibly have taken place without intruding the sediments above mentioned provided they were present at the time the igneous intrusions occurred. This is the strongest of the arguments.

(4) While in the Hartland schists there are abundant garnets, and in places staurolite, there is not present anywhere in it any great quantity of graphite; nor does it have the peculiar rusty characters nor the coars stringers which are characteristic of the Berkshire schist. It has a single

evenly laminated strauucture, just such as is produced from a metamorphic igneous rock. Therefore on the basis of its structure and lithology, it seems to me proably not to be a metamorphosed sediment but a metamorphosed igneous rock For my part I am absolutely convinced that the great mass of this large area of crystalline complex is pre-Cambrian, although in thus positively stating this conclusion I would not for a moment hold that there may not be at various places within it small infolded patches of limestoneor schist or other rock of sedimentary origin. Indeed we know that the limestone at various places occurs in valleys far up in it; that the sedimentary formations have been removed from over considerable areas; and therefore it would not be at all surprising to find patches of sediments within it even considerable distances from the main area of sediments.

July 21, 1901.

New Haven, Conn.

With Gregory and Pirrson visited the Torrent schist formation adjacent to New Haven at a number of localities. The formation as a whole is generally schistose, but has the evenness of lamination which I have always associated with igneous rocks, except for quartz veins and other lenses which seem to be secondary. At one cut the view that this rock is igneous seemed to be fully confirmed by the structure itself Here associated with the chlorite-schist are oval areas and bands of considerable width of relatively unmashed material, which shows the structure of an igneous rock, and looks somewhat like a diabase. At the sound itself the foliation, after having been formed, is very much contorted, and between the contortions many quartz veins have formed. This phase of the rock looks more like sediments than any other; but still there was no clear evidence of sedimentation.

At one locality visited a diorite porphyrite was found; immediately adjacent to this a serpentine was seen in considerable force; and along one side of the serpentine belt is a small mass of ophi-calcite; that is, serpentine and calcite veined with calcite. However I little doubt that this calcite, or limestone as it is called, has been produced by the ordinary metamorphic and weatheringprocesses of the basic igneous rock. As evidence of this is the intimateassociation of the calcite and serpentine; and also the fact noted by Gregory that there are not present with the limestone the deep-seated metamorphic minerals produced by a sedimentary formation limestone formation, such as the pyroxenes and amphiboles. The case seemed to me to be strikingly analogous to that at Chester, Mass.

While we did not visit the locality, at one place this limestone used to be burned for lime; but it gave so poor a product that this use has ceased. The limestone is known only here and there in little bunches along the serpentine belt which is said to be traced for two or three miles. It seems to me the facts bear for a metamorphic weathering processes of the calcite, the source being an igneous rock rather than a sedimentary limestone formation.

July 22, 1901.

Cobalt and East Hampton, Conn.

With gregory, Rice, and Hobbs, we made a cross section of the crystalline rocks east of the Connecticut river on the Middletown sheet.

Starting in at Portland we found areas of red sandstone and conglomerate of the Triassic. These dip to the east at angles of 10 or 15° up to 30° or more, and are amazingly like the red sandstones and conglomerates of the Lake Superior region. Indeed, the outcrops of conglomerate and sandstone along the sides of the road could not be discriminated from the rock which occurs in the outer conglomerate of Eagle Harbor or Copper Harbor.

Passing from the Triassic, at a little rise we immediately come upon some chloritic and micaceous schistose
42321 rocks (42321), which a brief examination shows to be undoubted sediments. As evidence of this are bands of nearly
42322 pure quartzite (42322); of mica-schists of the ordinary form which are produced by sediments; and various gradations between these and the generally bedded,
42323 heterogeneous character (42323) so distinctive of sedimentary rocks.

42324 Limestone in above rocks.

Continuing to the eastward, we

found large cuts of material of this kind in which the sedimentary character is perfectly clear. Continuing east, within a short distance we came

upon a band of hornblende-schist, or more properly amphibolite, injected by granite in a very complex fashion, and also cut by pegmatite;- in fact, showing all the characters of the rocks which I have called the Basement Complex on the west side of the river. I have little doubt that this series antedates the sediments.

Continuing to the southeast, we came upon a belt of coarse schistose granite, which both Gregory and Rice supposed to be intrusive in both the sediments and the amphibolite series. However, the locality to which they took me to show this did not seem to be conclusive. At the locality where the sediments were seen, the cutting rock is pegmatite, and not this granite in its typical form. At the locality where the granite is in its typical form there is a large mass of included material; but this is amphibolite and not the sediments.

From what I saw I should be inclined to associate the granite with the amphibolite-granite complex, rather than regard it as a later intrusive.

East of the amphibolite-granite complex is a broad belt of sediments again. On a high hill, called Great Hill or Cobalt Mt., is a mass of quartzite making the crest of the ridge for a half mile or more, and has been traced by Gregory for several miles. The relations of this quartzite to the associated slaty sediments were not seen.

In a huge cut in the railroad to the east is exposed a great set of sedimentary rocks having slaty phases, graywacke phases, and quartzitic varieties. These are for the most part perfectly clearly sedimentary, showing the heterogeneity and all the characters of semi-metamorphosed sediments. The rocks are cut by a great pegmatite dike, and adjacent to this pegmatite they are
42326 more feldspathic, and the facies nearest
42327 to the pegmatite dike resemble gneisses of the Becket series; and by this might be regarded as igneous. However, it is perfectly clear that this is but a facies of the sedimentary rocks. One quartzitic variety of the rock is very
42325 rich in garnets (42325), approaching to an eclogite.

Continuing to the eastward, we came to the belt of rocks which Gregory says is the continuation of the Monson gneiss of Emerson, and it undoubtedly has the same lithological character. That is, it consists of a complex of schistose granites, amphibolites, and injected amphibolites, steeply inclined, precisely as at the Monson quarries.

On the east end of the railroad cut, where this rock was seen, associated with the Monson varieties is an injected rock having ferruginous stains, and perhaps sedimentary; but this could not be determined.

Continuing eastward there comes in at the east side of the sheet a broad belt of schists. Here the rock is a gneiss of the variety which has been called Becket west of the river; is injected and pegmatized by granite in the most complex fashion; but is dominantly a schistose rock, heavily ferruginous, and containing fibrolite. In short, it is the kind of rock which has been unhesitatingly called a sediment by Emerson; although neither here nor there are there clear evidences of its sedimentary character. For my part, I should be inclined to regard this complex as having the same relation to the Monson gneiss that the Hartland schists west of the river have to the old Becket gneiss complex. That is, it is simply a more mashed and metamorphosed variety of the Monson gneiss. However, it is entirely possible that there are included within it areas of sediments, or that it has a sedimentary background which has been injected by granite. In either case I should regard it as probably being related and associated with the Monson complex, antedating the sediments, rather than a part of the quartzite-graywacke-slate sedimentary series east of the river.

The age of this complex east of the river is of course not determined. Probably the sediments will connect with the Carboniferous sediments of Worcester. If this is the case, probably the basal complex will turn out t be pre-Carboniferous, and may of cours be vastly older; that is, pre-Cambrian and equivalent to similar rocks west o the river.