ART. XLIII.—*On Taconic Rocks and Stratigraphy, with a Geological Map of the Taconic region* (Plate XI); by JAMES D. DANA.

Part II. The Middle and Northern Part.

(Continued from p. 276 of this volume.)

THE map of Middle and Northern Berkshire mentioned in the preceding part of this paper (p. 270 of this volume), is herewith published. For detailed explanations of the symbols and letters used on the map, the reader is referred to p. 206 of volume xxix (March, 1885) of this Journal.* The map illustrates fully the points presented on pages 271–276: (1) the eastern limestone with its intercalated and often isolated ridges of schist; (2) the passage of the eastern limestone belts into the western—as that of the Vermont through North Bennington, into the Hoosac and Petersburg area, that of the Vermont, through Williamstown and Hancock, into the Lebanon and Canaan area, and the near approach of the latter at Canaan to junction with the Stockbridge limestone in West Stockbridge; (3) the variations from normal directions and continuity in the belts, apparently due, for the most part at least, to earlier topographical conditions—exemplified (1) in the Williamstown and Clarksburg region; (2) in the town of Bennington; (3) in the

* For the convenience of the reader, the following explanations of the lettering on the map and the symbols in the figures beyond, are here repeated in brief. Q, quartzite; M, mica schist; M, (not used before) hydromica schist; Gn, gneiss; A, Archæan. In the figures, a dot stands for *quartz*, a hyphen for *mica*, and a cross (+) for *feldspar*, a *long hyphen* — for hydrous mica; dots for quartzite; alternating dots and hyphens . . . for mica schist; alternating dots and long hyphens . — . — for hydromica schists; and alternating dots, hyphens and crosses (· - +) for gneiss; alternation of four dots with a hyphen (· · · · ·) for micaceous quartzite; alternations of two or three dots with a hyphen (·) for quartzitic mica schist; the lines alternate with a rule, for a bedded or schistose rock as mica schist, hydromica schist and bedded quartzite; and groups of 3 or 4 lines with rule between, for gneiss or slightly bedded quartzite. In the section the dip of the lines is the true dip; an unfilled space in the inner part of a figure of a section signifies that the dip was obtained from exposures over the surface, and not from an actual transverse section; while an unfilled interval between the lines indicates a concealment by soil, and the figures added, the width of the covered surface; the end of a figure to the right is always the eastern or northern end; a circle with a letter inside means a quarry or ore-bed, and the letter indicates the material afforded: Fe, the iron-ore, limonite; Q, quartzite as hearthstone or sand. The map was plotted on the maps of Beers's Atlases, which, while of great value for the purpose, have not the accuracy of a thorough survey of the region; and hence some unavoidable errors are introduced which I could easily make right on a new map of equal size (mostly two inches to the mile), and having all of its details, including the positions and names of owners of all houses which aid in marking localities or as a base for measurements. Some of the areas, as the narrow one of schist in New Alford, might take a more probable form on such a map since the roads have been the chief means of fixing the courses of the outlines. As in the map of Southern Berkshire, it was not possible to adjust to the Massachusetts map the lines on the portion of Connecticut added to it, so it is as regards the addition of Vermont. Scale $\frac{1}{4}$ inch = 1 mile.

eastward extension of the Pittsfield limestone and the quartzyte south of it, and (4) in the Bear Mountain region with Monument Mountain west of it; the localities of Archæan being recognized by the presence of hornblendic rocks, sometimes zircon-bearing and chondroitic limestone, from eastern Tyringham northward and marked on the map by the letter A. The colored portion of the map is that covered by the limestone.

The next subject is:

2. *The Limestone and the conformably overlying strata.*

1. *Kinds of rocks and their distribution.*—The *kinds of rocks* observed in central and northern Berkshire, with the adjoining border of New York, are the same as in the southern portion, already considered, except that the mica schists north of the town of Sheffield have not yet been found to be staurolitic.

The limestone is mostly dolomitic, except to some extent (as made known by analyses in the Geological Report of Professor E. Hitchcock (1841, p. 80), in the more western towns of Berkshire. The same analyses show that the beds are rarely true dolomite, but partly calcite, by having a deficiency of magnesia, and that consecutive beds vary much in constitution. The subject needs investigation.

The rock varies in grade of crystallization, being coarsest (*a*) to the southward, and also (*b*) to the eastward. It varies in color, being usually white to the eastward, often gray in the more western belts of Berkshire, and generally gray west of Berkshire. It varies in impurity, being often very micaceous in the vicinity of the schist ridges, so as sometimes to be deceptive, and very quartzose near the quartzite. Tremolite and white pyroxene, abundant minerals in the Sheffield limestone and its continuation southward, (to New York Island, if all is the same limestone, as is probable,) occur also in belts of Monterey, eastern Great Barrington, Tyringham and Lee; and minute tourmalines are occasionally present.

The schists are hydromica schists to the westward and mica schists to the eastward, along with indefinite intershadowings through chloritic hydromica schists. Hydromica and chlorite are hydrous species, so that the difference in the metamorphic schists mentioned is largely a difference as to the presence of water; a hydromica containing 4 or 5 per cent (but like mica in other constituents), and chlorite containing 12 to 14 per cent. In the Greylock range the chloritic hydromica schist passes locally into a hydromica gneiss, which I designated in 1877 a protogine variety of gneiss.*

The more western schists west of Canaan, N. Y., are much like a glossy roofing slate, showing in the color no evidence of the presence of chlorite, though it may contain much of it.

* This Journal, II, xiv, 258, 260.

In the main Taconic range, along the Massachusetts boundary, the schists are chloritic hydromica schists, and on the eastern sides often garnetiferous, especially to the southward. In an east and west line through South Williamstown and Greylock they continue to be chloritic hydromica schists from the New York boundary to the eastern slope of Greylock, or seven miles, where are some portions that might be designated true mica schist; a mile and a half east of Greylock summit, near the east foot of the Greylock mass, the rock would be ordinarily called mica schist; and this is true, also, farther north, abreast (west) of the village of North Adams, as seen at the little railroad tunnel, although the mica is slightly greasy to the touch.

The mica schist is sometimes muscovite schist, often biotite schist, but generally both micas are present.

Looking at Berkshire as a whole, in the part of it *east* of a straight line drawn through the county, southward, from Greylock to the northeastern corner of Mt. Washington in South Egremont, about S. 15° W. in course, the schists are nearly all mica schist, while to the *west* of the same line, they are nearly all chloritic hydromica schist. A ridge in Lanesboro (which is nearly on this line), has the schist intermediate between hydromica and mica schist, inclining most to the latter. This line throws to the *west* the high ridges, Tom Ball and Maple Hill, of West Stockbridge, which are of chloritic hydromica schist, and to the east, ridges near by on the east of these. But to one going over the region the transition would be found to be a very gradual shading from one to the other, some portions at the northeastern foot of Tom Ball almost meriting a place with the mica schist.

Fifteen miles south, in Canaan, N. Y. (nearly west of Pittsfield), the schist *west* of the limestone is a very thin, slaty, glossy roofing slate; that of the ridge east of it, north of Queechy Lake, a coarse chloritic hydromica schist, except near the boundary of Lebanon (at B, on the map, a high point called Douglass Knob) where it becomes quartzose, a very hard chloritic quartz rock, not schistose; the high knob is the source of the famous boulder trains that cross Richmond into Lenox, first studied out by Dr. Stephen Reid, of Pittsfield.

East of the N. by E. and S. by W. line drawn from Greylock to the northeast base of Mt. Washington, the larger part of the mica schist is extremely arenaceous; and it often graduates imperceptibly into a bedded quartzite, or alternates with strata of quartzite, both that of the thin-bedded kind, and of the hard and massive, precisely as described in Part I of this paper for Southern Berkshire and the adjoining part of Connecticut; and, as there, the rock usually contains minute tourmalines. The narrow ridge entering the town of Great Barrington from Sheffield west of the railroad, consists of bedded quartzite

slightly micaceous. The ridge just north of this, situated to the west of the village of Great Barrington, consists partly of mica schists, of nearly normal type, though over-arenaceous, and largely of micaceous bedded quartzite, with also much hard quartzite especially to the north; and just northwest, a low quartzite area extends to the base of Tom Ball; while northeast are others of quartzite. North of Housatonic village quartzite beds alternate with true mica schists. Monument Mountain has two strata of hard quartzite with quartzitic mica schist between them; but the latter passes into a massive fine-grained micaceous rock, gneiss-like in aspect, which is calcareous (effervescing with acid). East of Great Barrington, a very similar gneissoid rock, somewhat calcareous, is the chief material of the lower part of a high ridge, and shows out gneiss-like in the great tumbled masses at the base of the bluff at the north end and where quarried; at the summit, the ridge is bedded micaceous quartzite, passing into micaceous or quartzitic mica schist.

The quartzitic mica schists and micaceous quartzite constitutes also Rattlesnake Mountain in Stockbridge and other ridges farther north to Adams. But for details I refer to the map.

A microscopic examination of thin slices of the gneissoid rock of the ridges east of Great Barrington, and of that in Monument Mountain, shows that, besides much quartz, considerable mica and a little calcite, it contains also considerable orthoclase, and merits the name of a quartzitic gneiss or a gneissic quartzite.

In Tyringham there is a well characterized gneiss overlying the limestone.

The destructibility of the bedded quartzite and the quartzitic mica schists is generally a marked peculiarity. It is very common to find decay extending down one or two hundred feet, concealing deeply the *solid* rock. The decay sometimes leaves a hillside covered with loose blocks of hard quartzite, derived from harder layers, or isolated harder portions, in the strata. The porosity of the rock renders it permeable by waters to great depth; and then the presence of a little removable calcite or orthoclase makes destruction easy.

2. *Limits between the limestone and other areas.*—The approximate limits of the limestone areas are in general easily obtainable, as outcrops are numerous. But there are many regions where, owing to the covering of drift and the extensive decomposition of the rocks (the arenaceous schists and the bedded quartzites), the uncertainties are great.

The first of these sources of doubt, as I have already said, affects widely the west sides of hills and mountains, the side that faced obliquely the moving glacier. The other may occur any where. Rattlesnake Mountain, in Stockbridge, is an ex-

ample of an obscuring of the north, west and south sides by both causes. Maple Hill, in West Stockbridge, has much of its west and north sides under deep drift—250 feet at an ore-bed on its northwest slope. These are examples. Long experience in the region helps one to probable conclusions in many such cases, but in others, doubts will remain. In Adams the limit at the west foot of the Hoosac Range is one of the worst cases—a region of half a mile or more intervening without outcrops; and between the central quartzite belt of the town and the range, it is still a question with me whether the quartzite formation with its arenaceous mica schist may not extend for a considerable distance quite to the base of the mountain. The first rock encountered on the ascent of that part of the mountain is a light colored very arenaceous mica schist, like beds in the quartzite area, and also like much of Hoosac Mountain elsewhere. The Clarksburgh region is one of much doubt on account of the few outcrops.

The quartzite boulders over a region are an assistance toward a knowledge of what is below, since they are often not drift boulders, but, as explained above, masses left where they now are by decomposition. But again they are very deceptive evidence; for the region just mentioned, east and southeast of Adams, has striking examples of an abundance of quartzite boulders over the surface where the rock below is limestone.

3. *Stratigraphic relations.*

Limestone, hydromica schist, mica schist and quartzite, and intermediate gradations between these, being the rocks within the limestone limits, the question is now as to their stratigraphical relations.

1. *No general overthrust faulting.*—The facts with respect to the relative positions of the rocks here set forth require no allowance for possible overturns except such as affect single or a few associated folds. That there has been no great overturn affecting the region as a whole, or over a large part, is proved by the following characteristics of the region and its rocks.

The gradual transition in *kinds* of rocks and in *grade of metamorphism* from east to west over the Taconic region; the like grade in the metamorphism of the limestone and the schist adjoining it, through all parts of the region; the absence of eastern rocks from the western part, and of western from the eastern; the gradual transitions in many cases from limestone to schist through impure micaceous and sandy limestones; these are all indubitable evidences on this point.

Not only are the transitions from limestone to schists marked by micaceous, arenaceous, and other similar impurities, but also in many places by feriferous conditions in both the schist

and limestone, and preëminently in the limestone which occurs adjoining the schist at intervals for long distances in western Berkshire (in Lanesborough, Richmond, and West Stockbridge and less abundantly in other towns), as well as in Vermont to the north and Connecticut and New York to the south—the limonite beds attesting to it. This is good evidence that the beds are natural in sequence; that there has been no great lateral move by a thrust-fault over the region of Berkshire and eastern New York, disturbing the order of stratification.

2. *The true stratification is not disguised by foliation, or slaty cleavage, or other effects of pressure.*—Questions, as to slaty cleavage, foliation, schistosity, are not a source of serious difficulty in the Taconic region. If the rocks were all slates, all mica schist, all hornblende schist, or all limestone, that is, were wholly of one kind, the uncertainties as to bedding or not might be well-nigh insurmountable. But where the three kinds are together in alternating layers or strata, the doubts disappear, for there is then distinct stratification between layers or strata of different kinds in constitution, and the study of it is like the study of stratified rocks in non-metamorphic regions. If in such cases the schistosity of a schist is parallel to the planes of junction between the layers or strata of the different kinds, its planes are essentially those of bedding whatever their origin; and this is eminently manifest in Berkshire where one of the rocks is limestone. Alternation in strata or layers of different kinds of rocks cannot be a result of pressure. The principle presented is as true for Archæan rocks as for any others and affords a criterion which is of great value in their investigation.

For the reasons stated, the Taconic region is as much a region of stratified rocks as that of western New York. It has its *strata* of limestones, sandstone (quartzite) and schist, the study of whose positions is stratigraphical study, far outside of microscopic investigation, though deriving great aid from such investigation as regards the constitution of the beds, metamorphic changes, and other points. The planes of junction between the strata are open to observation. And it is wonderful how very generally the planes of lamination in the schist correspond in position with these planes of junction. It is so general that the geologist of the region comes naturally to the opinion that it is exceptional for foliation to be any other than lamination conformable to the bedding. Stratification in the region stands out with the distinctness that characterizes ordinary regions of stratified rocks, and the anxious and sceptical petrographer has no occasion for his doubts, or for his expectation of settling all such cases with the microscope.

In many places, moreover, the strata are piled to mountain height while still nearly horizontal in the position of the beds. Such nearly horizontal lamination is not due to pressure attend-

ing uplift—the source of foliation or slaty cleavage; if to any pressure, it is to vertical, like that of the gravitating mass, or that pressure to which a shaly structure is attributed.

3. *Stratigraphy of the region.*—The question in this region of upturned, flexed and crystalline rocks, is, as in Part I—

Which is normally the upper stratum, the limestone, or the schist? Are the schist ridges usually synclinals or anticlinals? The fact that in the southern part of the Appalachians—the Alleghany Mountains—the *ridges* are usually synclinals shows that the view as to their being synclinals in the Taconic region, if it be sustained, is not exceptional.

a. *Characters of the flexures.*—The flexures over the area have usually the north-by-east direction or strike characterizing the main Taconic range. They generally, and probably always, have the axis inclined instead of horizontal—sometimes to the northward and as often to the southward, the two kinds being necessarily accompaniments in a complex system of warping (as not badly illustrated in the sleeve of a coat at the elbow-bend inside). The inclination is sometimes indicated by the form of the ground-plan of the schist ridges—that is by its widening from one end to the other. An example is seen on the map, west of the village of Great Barrington; the area narrows southward; and it necessarily follows that the axis of the flexure inclines to the southward if it is an anticlinal and to the northward, if a synclinal. Two similar areas occur in the town of West Stockbridge, those of Maple Hill and Tom Ball (the latter extending into the town of Great Barrington); others in Lee and Pittsfield.

The dips, moreover, often indicate the precise kind of flexure. At the narrow end, they are usually eastward on both the east and west sides, as in a careened trough, as in the annexed (fig. 4); but at the other, while eastward on the west side, they are often *westward on the east side*, indicating a *tray-like synclinal* (fig. 1)—the whole fold being, therefore, an inclined tray-like synclinal with the narrower end of the synclinal, or that where the effects of pressure were greatest, careened or overthrust. The succession of figures 1, 2, 3, 4, represent sections of a mountain ridge having a broad tray-like synclinal structure (1) at one end and a careened synclinal (4) at the other, with two of the intermediate conditions in 2 and 3; and if the series of figures is viewed upside down, they then serve to illustrate the corre-

sponding variations in an anticlinal flexure. (These figures are repeated on the map and numbered 52).

b. Descriptions of Sections.—The figures on the accompanying map of Berkshire and in the text beyond represent some of the many sections observed in the region: and, as already explained, they indicate also the kinds of rocks. The descriptions of the sections, as well as the numbering, here commences at the south. Numbers 1 to 21 are those already published in Part I. Of the 30 in this Part, figures 22 to 30 have appeared in my earlier papers on Berkshire, and are presented at this time only on the map; and I would refer to those papers for details with regard to the stratification.*

Section 22 (map). In the Konkapt Valley, on its northeast side, at the southwestern base of the high land from which Bear Mountain rises; part of the section is south of the road, and the rest north of it; the latter part terminates in "Devany's hearthstone quarry" (not now worked) which is situated a little to the eastward of the line. The several alternations of quartzite and mica schist with limestone, the micaceous character of much of the quartzite, and the small dip northeastward are the interesting points.

Sections 23, 24 (map). On the southwest side of the same Konkapt Valley opposite the locality of the preceding section, at the base of the high ridge. In section 23, the limestone does not appear at bottom, the soil covering it; but farther south, along the base of the same ridge, sections occur like 24, showing the true relations of the limestone to the quartzite and the overlying mica schist; the rocks are like those of section 22, but the dip is reversed as if opposite parts of an anticlinal. The localities are in the southeastern part of the town of Great Barrington.

Section 25 (map). Just *east* of the Housatonic River at the village of Great Barrington, extending eastward from the limestone in the valley at the base of the high ridge (with a fault separating it from the rest), to the top; a gneiss-like rock below, a micaceous quartzite at top.

Section 26 (map). *West* of the village of Great Barrington—a ridge consisting of arenaceous mica schist, micaceous quartzite and bedded and non-bedded quartzite. Limestone makes the western high part of the ridge opposite the village. Unfortunately, no section of the north end of the ridge is open to view.

Section 27 (map). Section 27 crosses a low N.-S. ridge just northwest of Vandeusenville (three miles north of Great Bar-

* This Journal, vols. v and vi, 1873, and xiii and xiv, 1877. The locality of each section is marked on the map by large numerals corresponding with the numbering of the figures here used.

ington, and east of Long Lake Valley), which consists mostly of quartzyte, but has quartzitic limestone within it, and limestone on the west side and arenaceous mica schist near the east base in Williams River Valley. At the outcrop the limestone portion of the quartzyte, as developed by erosion, shows that the dip of the quartzyte is beyond question conformable to that of the limestone.

Sections 29, 30 (map). Section 29 crosses the northern part of the schist ridge Tom Ball, where it is a tray-like synclinal, and 30 the middle portion where, as farther south, it is a careened synclinal. The number 29 on the map (back of a house near the bridge over the river) shows where the westward dip of the limestone underneath the schist may be observed. At this place, on the *east* side of the river and railroad, the limestone dips eastward, indicating an anticlinal in it crossing the valley. The high ridge of West Stockbridge called Maple Hill commences with a high eastward dip just north of where Tom Ball ends, and widens northward.

Section 31. On the north side of an east-and-west road a mile north of Housatonic Village (a road leaving the Housatonic Valley nearly opposite the "Old Furnace." It shows a low limestone anticlinal with mica schist covering either side. A short distance to the northward of the locality, the middle and eastern sides are cut away by denudation; the western continues northward as a ridge having a top of schist and a high base of limestone, both dipping westward as in the section. Southward the limestone disappears *beneath* the schist, the eastern part of which dips eastward toward Monument Mountain (only a mile distant on the east of the Housatonic) and becomes apparently the lower schist of the west end of the mountain with limestone beneath it.

To the southwestward of the above (see map) occurs a low narrow ridge which consists of quartzyte, and corresponds apparently to the overlying quartzyte of the same (west) part of Monument Mountain; and on its west side it is mica schist, answering to the schist of the mountain overlying the same quartzyte. The same rocks outcrop farther south through, and by the west side of Housatonic Village.

Sections 32, 33. On the road between Glendale and the Williams River Valley in North Stockbridge, and north side of road, at the south end of a spur of Lenox Mountain. Section 32 shows the very nearly horizontal position of the schist (a hydromica schist that approaches closely mica schist) and underlying limestone. Nearly the same dip may be seen farther west where the road descends into Williams River Valley. The limestone extends up 200 feet above the valley on the steep side of the mountain, and a railroad runs near the junc-

tion; and near the Fuarey quarry, section 33 was taken, showing the dip of the limestone under the schist. The synclinal character of Lenox Mountain, and the tray-like character at the

31. 1 m. N. of Housatonic Village, W. of "Old Furnace"

33. W. of Glendale.

33. W. Stockbridge, Fuarey's Q.

south, is sustained by the sections; and this indicates that the limestone of West Stockbridge and Stockbridge are the same continuous stratum; a fact further apparent from their actual continuity to the northward in the town of Pittsfield.

Section 34. Through Monument Mountain from the east side of the Housatonic River, at Housatonic village, in a southwest direction, nearly to the road from Great Barrington to Stockbridge. It gives the true dip at the east and west extremities of the section, and the mean dip of the intermediate portion; also the dip of the limestone at a quarry to the east of the eastern foot, near the Stockbridge road. It has two masses or strata of quartzite with arenaceous or quartzitic

34. Across Monument Mtn., Southeastward from Housatonic Village to Stockbridge road.

mica schist between, and a thin bed of the same schist underneath the western quartzite. No exposed section shows the rock underlying the western lower schist; but the dips of the schist to the westward of the river, with the underlying limestone, as explained above (p. 401), leave little doubt that the limestone passes beneath the mountain. The upper and lower quartzite may be the same stratum in an overthrust fold as represented in the following figure. In that case, the limestone off the east end of the mountain is a part of the underlying limestone at the upward bend. The position of the quartzite and mica schist strata west of the mountain and of the Housatonic River harmonizes with this view, as shown in the explanations already given (p. 401). A line drawn from the elevation

east of Great Barrington southeastward to the locality in the Konkaput valley affording section 23, is parallel to the Monument Mtn. section, and about three miles distant; it is similar in rocks and small dip, but reversed in dip, and in having the limestone at the *west* end nearly vertical in bedding. They seem to be counterparts, in the system of flexures of the same rock strata.

Monument Mtn. Ideal Section.

While the above view of the flexures affords a sufficient explanation of the stratification, it may not be the right one. There may be actually two distinct beds of quartzite, as the figure represents; or possibly, the beds may be faulted at the middle of the section, and a displacement sufficient to make *apparently* two beds of quartzite out of one; and this last view has in its favor the fact of much irregularity of dip on the line near the top. Again, there may be a reversal of the fold, making the quartzite underlying quartzite or Cambrian, and the schist of the mountain an *inferior stratum of the same formation*, with the limestone above the quartzite and also an overlying stratum of schist.

Sections 35, 36. From the village of Lee. Section 35 runs eastward through the western and larger of two nearly parallel areas starting from a point near the M. E. church in the village. Hard quartzite is overlaid by arenaceous or very quartzitic mica schist, and this again by quartzite. Section 36 is from

the western side of a more eastern ridge, just east of the village; it is remarkable for the absence of quartzite, and the normal character of the mica schist, notwithstanding the nearness and close relations of the two areas. At the top of this ridge the schist bends over rather abruptly and becomes nearly vertical. It may be faulted.

Sections 37–39 in Tyringham. Section 37 is on a line extending nearly westward from Tyringham village to the summit of “Cobble Hill” which stands in the valley near the village. Fig. 39 is a view up the valley, looking southward, showing the hill (at *c*) in the valley. The limestone dips beneath mica schist and gneiss, and the latter is the predominant rock.

37. Cobble Hill, Tyringham.

38. W. of Cobble Hill, Tyringham.

The limestone and schist of Cobble Hill extend westward, and are the rocks at a high level (300 feet or so) on the west side of the valley just south of an old Shaker establishment; and they extend from that place northward at about the same level all the way to South Lee, keeping nearly the same high level. At a point a few rods south of the Shaker establishment (now a summer boarding house) the limestone and schist outcrop on the road side, as in section 38, the former disappearing *underneath* the latter; but whether *normally* underlying or not is an undecided question.

39 Tyringham

40. Southern part of Lee.

On the *east* side of the Tyringham valley the limestone *overlies* quartzite or gneiss, and is not found anywhere much above the level of the valley plain.

Section 40. At the foot of the east slope of Tyringham valley, in South Lee, where bedded quartzite dips westward at a small angle, crossing the road; but at one place, just south of this crossing, in the field, the limestone is seen overlying the quartzite with similar westward dip and nearly the same angle.

41. E. pt of Wash., E. of Dewey's

43. S. Mountain, Pittsfield.

Section 41. On the western border of the town of Washington, west of the Hearthstone quarry, and south of the road from Dewey's Station.* A large outcrop of arenaceous mica schist

* On the map, fig. 41, the location of the section is wrongly stated to be *west* of Dewey's Station, instead of east.

with quartzite, the rock of the region, above. Only a few feet without rock intervenes between the schist and quartzite.

Section 42. In Washington, near Ashley Lake, quartzite and mica schist in contact, with like dip.

42. Ashley Lake, Washington.

Section 43. At the north foot of South Mountain, south of Pittsfield, near the road, where there has been quarrying. The westward dip indicates the synclinal structure of the mountain.

Section 32 (page 402) represents well also a section at the southwest base of Sugar Loaf Mountain in New Ashford.

Sections 44-48. These sections in Adams, North Adams and Williamstown bear on the question as to the synclinal structure of Greylock. Section 44 represents the limestone

45. W. side of Greylock, at the Hopper, Williamstown.

44. E. side of Greylock Section, W. of Adams.

46. Same as 45, but S. of Entrance.

47. West of N. Adams.

and schist at the *east* base of Greylock, in Adams, showing the westward direction of dip and its small angle, sustaining the observations of Prof. Emmons and Prof. E. Hitchcock.

Sections 45, 46 are from the western base of the Greylock Mountains, in Williamstown, at the entrance to the Hopper,

48. Saddle Mountain Section, Emmons.

48A Greylock Section after Hitchcock.

and also agree with Emmons. From these and other observations, Emmons's section, copied in section 48, was made. Farther west, in the southern part of Williamstown, the strike becomes

nearly east-and-west, and the dip southward; but this is true also of the schist, so that the conformability continues. This is true also to the north, as the T-shaped symbols on the map point out.

Abreast of North Adams, the dip of the limestone and schist is as given in section 48, the dip being eastward; and between this point and the locality of section 44, the dip varies to vertical and thence to westward as in that section. The facts make Greylock a broad tray-like synclinal at the south.

The synclinal character of the Greylock mass is manifest also from its high limestone basement which it has on both sides (except for half a mile, in the line of the range, between N. Adams and Williamstown), that is all the way from south of the Hopper, northward to within a short distance of the Notch road, nearly south of Braytonville; and then abreast of Adams for about three miles, the limestone has this great height above the valley, like a high substructure of 400 to 500 feet; southeast of Blackinton, by aneroid nearly 500 feet. The lower 400 to 500 feet of the Hoosac valley consequently were cut down through limestone. The upper limit of the limestone is, consequently, about 1150 feet above the sea-level; and this is nearly one-third of the whole altitude of Greylock—3,505 feet. The high limestone basement of Greylock in N. W. Massachusetts has its counterpart in the similar high basement of Mt. Washington in S. W. Massachusetts, and that of Mt. Anthony in Bennington, Vt.

Section 49 crosses the road on Stone Hill, Williamstown, where the limestone and quartzite outcrop together. The limestone, quartzite (the chief rock of the hill) and the black siliceous slate conform in angle of dip along the surface with only short intervals between the outcrops. Whether there is a fault or not between the limestone and quartzite I found no

section for determining. Deer Hill, south of Stone Hill, consists of arenaceous or quartzitic mica schist. Bald Mountain, between Williamstown and Clarkesburgh, is of quartzite with some schist, as described by Emmons; and a prolongation of it appears to extend south of Braytonville into the north end of the Greylock mass, along the ascending road (but chiefly on its eastern side) for a mile.*

Section 50. At the northwest base of Mt. Anthony, in Bennington, Vermont. At the eastern base I found the limestone and schist to dip westward corresponding in position

* The letter Q, which should be here on the map, is by oversight omitted.

very nearly with that of section 44 (Eastern Greylock). The synclinal character of the mountain, which is here sustained by my observations, was determined by the Vermont Geological Survey, one of whose sections passes through the mountain. An unpublished section by Prof. James Hall, made "about 1845," first described in 1854 (in this Journal, an engraved plate containing this among its sections having been sent by Mr. Hall to the writer) shows similar dips on the two sides. Mt. Anthony is, like Greylock and Mt. Washington, one of the more elevated summits of the Taconic range, the height being 2,606 feet. Mr. Hall's plate of sections also includes one of Mt. Washington, and sustains the synclinal character of this mountain. It is a further interesting fact that Mt. Anthony has on its north and east sides a similar high limestone basement; its height is about 400 feet by estimate above the valley at its east base.

51. Berlin, N. Y., East of river.

50. N.W. ft of Mt. Anthony, Bennington.

Section 51. The locality of this section is in Berlin at the west side of the Taconic range; it shows the slate and limestone in alternations at their junction, with the bedding somewhat contorted. The section conforms to all sections on the west side of the Taconic range in its eastward dip, and may be taken, with that at the western base of Mt. Washington, as a representative section. Other sections might be added from my note book from all parts of Berkshire; but the T-shaped symbols over the map make further additions unnecessary.

4. *Stratigraphic Conclusions.*

1. *Taconic schists and the limestone in the western half of the limestone region.*—From the sections through the higher points of the Taconic Mountains, Mt. Anthony, Greylock and Mt. Washington, the following conclusions are deduced.

(1.) The flexures in these three parts of the Taconic range are synclinal.

(2.) The limestone is the underlying rock.

(3.) The limestone lying along the eastern and the western sides of the range are continuous underneath the mountains and therefore one in mass,—a fact already proved for the western limestones and the eastern, by their continuity of mass at the surface. It follows, consequently, that—

(4.) The limestone must be the underlying rock in general, for the lower and narrower portions of the Taconic range—the schists of which are the same in kind and essentially continuous.

(5.) The above conclusions are, for like reasons, true for Tom Ball, Lenox Mountain, South Mountain and other minor ridges east of the main Taconic range in the western half of the Housatonic Valley, but not certainly of all. The hydro-mica schists and mica schists of these mountains are hence, for the most part, younger than the limestones.

2. *The quartzyte, quartzitic mica schists and limestones of the eastern half of the limestone region.*—In the eastern half of the Housatonic Valley, besides true or normal mica schist, there are, in alternating strata, as has been shown, arenaceous (quartzitic) mica schists, massive and bedded quartzytes, thinly bedded micaceous quartzites, quartzitic gneiss or gneissic quartzite. In the various sections that have been described, these rocks are shown to be conformable with one another and with the limestone; and this is the universal fact. Faults may occur besides those noted, and many of them not now exposed to view; but the conformability is a fact whatever their number.

With reference to these rocks, the question as to which is normally the underlying formation, the limestone or the schists with the associated quartzite, is a different one from that above answered, and one not admitting in all cases of so positive an answer.

Some have an opinion ready in advance of investigation, knowing that typical Potsdam is sandstone or quartzite, and assuming that the reverse is true,—that quartzite is Potsdam positively. But such assumptions leave the question still for investigation since sand beds belong to all ages and times; and, further, with special pertinence here, they occur as an important part of the Hudson River formation in eastern New York at Chatham (Columbia County) and in other regions. The quartzites graduate into mica schists; and so the sandstones of the Hudson River formation graduate into shales. Besides, the schists of the Taconic hills pass by gentle gradations eastward into the arenaceous mica schist and quartzite, as explained for southern Berkshire and the adjoining towns of Connecticut, on page 437 of vol. xxix, 1885.

Many of the sections seem to leave little room for questioning the overlying position and Hudson River age of the quartzite. In former papers,* I have presented, as evidence on this point, facts like those of sections 22 and 23, from opposite sides of the Konkaput Valley (see map); the rocks being there alike in kind, in stratigraphical relations, in small dip, but opposite in

* This Journal, III, v, 33, 1873, and xiii, 45, 1877.

direction of dip, and all in harmony with the idea of an anticlinal (northward in dip of axis) spanning the valley, with limestone as the inferior rock. Farther north a section crossing the same valley continued across Monument Mountain (p. 402) presents a closely parallel case, leading to the same view of the stratigraphic relations. The quartzite of the east end of the anticlinal over the valley covers the western flank of Bear Mountain from Devany's quarry nearly to Stockbridge.

Studying the facts connected with some of the other quartzitic ridges *within the limestone area* with an equal readiness for either conclusion under consideration, it is difficult to avoid the conclusion that the limestone is the older formation.

But doubts are introduced—not by the idea that Potsdam is sandstone or quartzite and sandstone or quartzite is Potsdam, but by the Berkshire fact that *some* of the quartzite is unquestionably Potsdam or Cambrian. This appears to be true of the quartzite of Bald Mountain between northern Williamstown and Clarksburg, as inferred from its position with reference to the Archæan mountain just eastward, and its connection with the great eastern range of quartzite in Vermont. It is true of that of southeastern Pittsfield, eastern Lenox, eastern Lee, eastern Tyringham, in which cases Archæan rocks are near by, a little to the eastward, and the quartzite usually dips westward toward the limestone as if passing underneath it, and at one locality has been observed to pass beneath it.

In the case of the quartzite over the west slope and base of Bear Mountain, referred to above, the fact that Archæan probably makes the higher part of this mountain* is good reason for reconsidering the conclusion which has been drawn, and ques-

tioning whether the fold in Monument Mountain is not the reverse of that on page 403, as here figured. The question has

* In my paper of 1873, in vol. v of this Journal, p. 367, and vi. p. 263, I describe a garnet rock consisting of garnet, quartz and some hornblende, as occurring near the summit of Bear Mountain; and as I have not found any similar rock elsewhere in the limestone series, and its aspect is Archæan. I have now little doubt of its Archæan relations. The loose mass of chondroitic limestone found on the south margin of the high region, as reported in the same paper, I believe to be further evidence for the same conclusion.

its two (or more) sides, and can be settled in this and other cases, only after a careful consideration of all the stratigraphic facts.

The quartzyte of Stone Hill and the quartzitic mica schist of Deer Hill, in Williamstown, may be either of the upper or lower quartzite formation, if judged only by the facts the hill presents. But the position of these areas, in the Williamstown valley, between high ridges of hydromica schist suggest rather that it is the underlying Cambrian; and this is to be inferred also from the quartzite spur of the Bennington range reaching toward it from the borders of Pownal.

The northern end of the Greylock range has an area of quartzite as a continuation of that of Bald Mountain, as stated on page 406; and the mica schist near this quartzite north and east of it may be Cambrian, as well as the quartzite. The mica schist has much resemblance to that of the western part of Hoosac Mountain; and whatever the fact about the former, there is some reason for making Hoosac Mountain Cambrian. In its western part the mica schist is highly arenaceous, like much of the mica schist of the Quartzite formation, and it is scarcely less destructible. I know of no evidence from my own observations, or from published accounts, that proves it to be Archæan. Prof. E. Hitchcock long since supposed a fault to separate it from the limestone formation of Adams; but the fault has not been proved to exist, and, if existing, it is no necessary evidence of true unconformability. Farther south, between the quartzite of Cheshire and central Savoy (see map), the mica schist is probably, like the quartzite, Cambrian.

This subject will be considered again in a following part of this memoir treating of the Lower Quartzite formation.

5. Conclusion as to the age of the Taconic Rocks.

When the paper on southern Berkshire was published two years since, the evidence as to the age of the Taconic limestone and schists consisted in the occurrence of fossils in the eastern belt of limestone in Vermont, near Rutland and farther north, and in the western limestone and schists of Dutchess County, N. Y., near Poughkeepsie and elsewhere. Since then, as already reported in this Journal,* the discovery of Lower Silurian fossils in Canaan, N. York, has given additional proof from the limestone at the western base of the main Taconic Range—the localities found occurring within one to two miles of the schists of the range, and but ten miles west of Pittsfield, Mass. Professor W. B. Dwight joined me in the search there for fossils, but did all the finding. The first account of them, by

* Vol. xxxi, 241, 248, 1886.

Mr. S. W. Ford and himself appeared in this Journal for April, 1886,* and announced the existence of crinoidal joints, and probably a species of *Cleiocrinus*, of *Pleurotomaria*, and *Murchisonia*; and made the age to be probably, or perhaps, Trenton. The localities then known are the two more southern of the four marked by *o* in a circle on the map, the northern of these two being that at the railroad tunnel where the most of the specimens were obtained. At the meeting of the American Association in last August, Professor Dwight made known other fossils from a locality two miles north of the tunnel, at Mr. Hemmingway's, including species near *Ophileta*, one to nearly two inches in diameter, others related to *Holopea*, and numerous small crinoidal disks. Since then he has discovered, in the limestone 500 yards farther north (on the property of Prof. Drown) still other kinds, including a *brachiopod*, a *Litutes*, or related form, an inch and a quarter across, and *Orthocera* nearly a foot long and two inches in diameter, remarkable for the closeness of their septa, with also Trilobites resembling the *Bathyuri*, and other kinds not yet determined. He has the fossils under investigation and will report on them before long. The age of the fossils at the last mentioned locality, he regards as either Calciferous or Chazy.

Whatever doubt may exist as to the particular periods to which the species collected should be referred, it is beyond doubt that all are Lower Silurian in age. Other fossils which are decisively Trenton in age, I have reported as occurring in loose masses of limestone in Canaan on the farm of Mr. E. S. Hall, not a mile from the schist of the Taconic range.† The masses consist largely of the minutely columnar coral, *Solenopora*, which occurs in small nodule-like forms and makes a limestone that looks like a limestone conglomerate. Along with this coral, occur crinoidal stems and other small fossils. The rock is nearly identical in species, and in aspect, with the *Solenopora* limestone found far to the southwest at Pleasant Valley, within eight miles of Poughkeepsie, and described by Professor Dwight. The loose masses are not worn, and this favors the view that they are from some underground ledge to the northward or northwestward, although none just like it occurs there in sight. Mr. Dwight in searching for an outcrop of such a *Solenopora* limestone in Canaan, found similar nodules in some of the limestone, but they failed of the columnar structure, and he is of the opinion, that the failure is due to incipient metamorphism; which is very probably the fact; for the first trace of metamorphic change would obliterate columns only 1-500th of an inch in diameter; and specimens thus changed he has found to be common near Poughkeepsie.

* Ibid., p. 248.

† This Journal, xxxi, 241, 1886.

Adding the discoveries in Canaan (Columbia County, New York), on the western side of the Taconic Range, to those of Vermont on the eastern side, and in Dutchess County to the south, the facts are enough to demonstrate the Lower Silurian age of the Taconic limestone, the eastern and western. A Cambrian limestone is in places included in the formation, and when so it is conformably to the other strata except where faults occur. Mr. Wing announced the limestone of Vermont to be a combination of limestones from Potsdam to Trenton inclusive; and Prof. Dwight has found the same to be true near Poughkeepsie.

I have not felt at liberty to adduce as additional evidence to that from the Canaan limestone, the discovery of Lower Silurian fossils in the "Sperry" limestone of Hoosac, thirty miles north of Canaan, which Prof. Hall stated, at the meeting of the American Association in 1885,* that he made more than forty years since, because Prof. Hall has never mentioned this discovery in any of his published writings, and has not yet announced the kinds of species or the particular locality. Science cannot rightly use the facts before these details are made known. The existencè of fossils in the Hoosac limestone is not at all improbable.

[To be continued.]

The Views of Prof. Emmons on the Taconic System.

The announcement has been very recently made that Prof. Emmons admitted that the age of the western (Sperry) Taconic limestone was Lower Silurian in his second report on the Taconic System, that of 1844:—issued first in a quarto pamphlet, and in 1846 incorporated with his Report on the Agriculture of New York. Since my writings on the subject will need some correction in case this is a right interpretation of his report, I have been again over his statements, and give here the result.

The announcement appears in a paper by Dr. T. Sterry Hunt, in the February number (pp. 114--125) of the *American Naturalist* (issued near the close of March).† It is stated that Prof. Emmons in 1842, in his first detailed publication on the Taconic system (Report on the Geology of New York, 1842), pronounced the Transition or Sperry limestone, like the rest of the Taconic, to be older than the lowest member of the New York Lower Silurian (or Champlain Division), but that in 1844, 1846, "he made one important and significant change," "acquiescing in the judgment of Eaton" ["of 1832"] he "now declared that the upper portion of the Taconic system—namely, the great belt of slates with limestones, sandstones and conglomerates—designated by him in 1842 as the Taconic slate, and including both the Transition Greywacke and

* This Journal, III, xxxi, 248, 1886.

† The title of the paper is, "The Taconic Question Restated."

the Sparry lime-rock of Eaton, was the stratigraphical equivalent of the lower part of the Champlain division, and in fact a thickened and modified form of the Calciferous sandrock, which was now said to be in its eastern extension 'protean' in its character and to include a great variety of rocks." Besides this, we find also in the same paper, the idea that Professor Emmons "came forward in 1842 as the champion of the views of Eaton," and this idea is repeated afterward in other championing words in which the first correct announcement of the age of the Taconic System is traced to Eaton.

Since it is established, by the facts already presented in this memoir, that Emmons's Sparry or western limestone, and his Stockbridge limestone (the eastern) are one in mass, any argument sustaining the Calciferous age of the Sparry limestone sustains the same for the Stockbridge limestone. But that Professor Emmons suggested the Calciferous as the age of either of these limestones, or of the "Taconic slate," in his memoir of 1844 and 1846, or was a "champion of the views of Eaton," I have been able to find no proof.

The "Champion of the views of Eaton," Professor Emmons, has these three sentences relating to Professor Eaton in his Report on the Geology of New York (1842).

On page 19, speaking of previous geological work in northern New York, he says: "Previous to the year 1837, nothing exact was known of the geology of the northern district. Mr. Eaton, who was the oldest laborer in geology in New York, had not extended his observations far into this field. He had, however, represented the McCombe Mountains as composed of ranges of gneiss, extending from the valley of the Mohawk to the Provincial line, and the intermediate valleys, of limestone extending along their bases and around their northern extremities; and the whole section as being composed of two principal formations, a Carboniferous slate, denominated Primary, and a calcareous formation, denominated Secondary. It is sufficiently evident that all this was imaginary; it is even difficult to conceive how imagination could have carried even a partial observer so far from the truth."*

Two lines below, on the same page, we have: "In this paper [by Mr. Finch] there is a brief account of the rocks of this county [St. Lawrence]; the Potsdam sandstone was spoken of as a Transition rock, and the Calciferous sand-rock of Eaton as a siliceous limestone."

On p. 280: "The mass of grit is the greywacke of authors; some portions are brecciated, or belong to that variety denominated *rubble* by the late Professor Eaton."

* In this Journal, III, xix, 270, 1880, Dr. Hunt says that the lithological characters of the primary gneissic formation of northern New York "were clearly defined by Eaton, who under the name of the Macomb Mountains, described what have since been called the Adirondacks," etc.

These are all the sentences in the volume that contain the name of Eaton or relate to his views.

Professor Emmons, on the second page of his chapter VII on the TACONIC SYSTEM, has the heading, "*Persons who have Contributed to our Knowledge of the Taconic rocks,*" and under it the "champion of the views of Eaton," should of course have something about the views of Eaton. The first two paragraphs are as follows:

Page 136. "By reference to the early numbers of the *Journal of Science*, it will be seen that Profs. Dewey and Hitchcock early turned their attention to the rocks under consideration. The former, distinguished for his scientific attainments, gave an elaborate essay, wherein the rocks were described as fully as was possible in the infancy of geology in this country; in fact, so far as mere description is concerned, very little remains to be added. In 1829, the history of Berkshire was published, the matter of which was contributed by the clergymen of the several parishes in the county. In this work an abridgment of Professor Dewey's former essay appeared, so that a general account of these rocks has been widely circulated. Prof. Hitchcock has at various times furnished many important facts in regard to the geology of Berkshire, but, as appears from his publications, has relied mainly upon the information derived from Professor Dewey's labors, especially in his elaborate and excellent work on the rocks of Massachusetts.* To these gentlemen, therefore, we are principally indebted for the facts which have been placed before the public."

Page 125. "The limestones of Berkshire have been fully and ably treated of by Professors Dewey and Hitchcock."

Page 151. Speaking of the Sparry limestone, he says: "This limestone is called Transition limestone upon the geological map contributed by Professor Dewey for illustrating the geology of Berkshire county, Massachusetts."†

In this mention of early workers, there is not a word about Eaton anywhere. Dewey made his investigations eight to fifteen years before Professor Eaton's work of 1832 was published. Eaton made no observations on the Taconic rocks, and honorably gave credit for all he knew (see page 270 of this volume) to Prof. Dewey. According to the facts, consequently, "the persistent war waged" against "the views of Amos Eaton" (p. 121 of the *Naturalist*)—till now an unheard of war—was begun by his pupil, Professor Emmons. Eaton was a man of great energy and enthusiasm; but his was the beginning-time in American geology; and little credit is to be given either to him or to Dewey for their adoption of the term Transition from European writers, or for any ideas on the age of the rocks.

Professor Emmons is charged (on p. 120 of the paper and be-

* These remarks with reference to Professor Hitchcock relate evidently to his earlier report, that of 1835, on the Geology of Massachusetts, and not to his later quarto report of 1841.

† This *Journal*, vol. viii. 1824. Emmons dedicates his "*American Geology*" to Dr. Dewey.

yond) with "contradictions" and "perplexing discrepancies" in his volume of 1842; and in a note at the bottom of the page, "pages 121, 124, 125, 280-282, and further, p. 147," are referred to for testimony on this point. Only one of these pages is in the chapter on the Taconic system—the "and further p. 147." I find no "contradictions" or "perplexing discrepancies" in that chapter, or in anything relating to the Taconic system.

Professor Emmons does not merit the condemnation thus made; for he is clear and consistent throughout.

As to the change of opinion asserted, I find, as I had done before, that in 1842, Professor Emmons, contrary to the idea conveyed on page 123 of the paper in the *Naturalist*, made the Sparry or western limestone *older* than the Stockbridge limestone, because the western dipped eastward beneath it; he commences his paragraph on the subject of relative age (Rep. Geol. N. Y., "and further, p. 147,") with the sentence "there seems to be no valid reason against the opinion that the most western belt of limestone is, after all, the oldest of the Taconic limestones."

In 1844, 1846, speaking, in his Memoir, of the Taconic rocks, he says, p. 63 of the *Agricultural Report* and 19 of the 1844 pamphlet): "I shall describe the rocks in the *descending order*," and this is the order:

First. "THE BLACK SLATE" (on pp. 63-65), described as affording at Bald Mountain, Trilobites.

Second: "THE TACONIC SLATE WITH ITS SUBORDINATE BEDS" (on pp. 65-72); of which he says: "Occupies almost the whole of Columbia, Rensselaer and Washington Counties" (p. 72); "extends from Lansingburgh to the Sparry limestone in the eastern part of Hoosic near the western bounds of Bennington in Vermont—at least 20 miles in a direct line" (p. 72); "It crosses the [Hudson] river near Poughkeepsie, ranging southward so as to underlie the belt of country to the west of Newburgh for six or eight miles" (p. 103). In these and other statements he gives the Taconic slate a wide range, and includes under it slates near Poughkeepsie that in recent years have afforded Hudson River brachiopods. He makes it older than the Black Slate.

Third: The "SPARRY LIMESTONE" (on pp. 72-74): of which he says, "Occupies the belt of country comprising the eastern part of Dutchess, Columbia, Rensselaer and Washington counties (p. 73); "not far west of the dividing line between Massachusetts, Vermont [on the east side] and New York [on the west]" (p. 74); "through Ancram, Hillsdale, Canaan, New Lebanon, Berlin, Petersburg, Hoosic, Whitecreek," etc. (p. 74). In the account of this limestone I find nowhere, any more than in that of the Taconic slate, the slightest intimation of a change in his opinion as to its age. All the rocks of the Taconic series are made unequivocally older than the Potsdam sandstone.

As above indicated, Professor Emmons did make one change in 1844, and a wise one. In 1842 he argued from the eastward dip, as I have shown, that the Sparry limestone was the oldest of the

Taconic limestones. In 1844, 1846, he dropped the argument and the conclusion, and showed, by sections, how through flexures the order of original superposition might be reversed. This change left the Sparry limestone and Taconic slate older, as before, than the Potsdam. Further, he added the Black slate of Washington Co., N. Y., with its trilobites, and made this the *upper* or newer member of the series, on account of the fossils, with the other members following in the descending order above given,—the quartzite at the bottom.

Professor Emmons was right in his Berkshire stratigraphical observations. He drew chronological conclusions on data that we now know to be too uncertain for any safe inference, and on lithological data extended his system beyond its true limits; but in those decisions at that early time there is nothing to his discredit, while his investigations are greatly to his honor.

It is a fact of historical importance in the Taconic controversy, that the writings, on the subject, by Professor Mather, the Professors Rogers, Dr. D. D. Owen and Professor E. Hitchcock, the early questioners or opponents of the Taconic system, do not contain a discourteous word. Their criticisms are such as give life and progress to the science. Professor James Hall, whatever opinions he may have had or may have orally expressed, has nowhere in his notes on the fossils of the Taconic slate (Black slate), an offensive remark; and these are all of his writings on the subject. Logan, after the Quebec discoveries of the Canada survey, put a few lines in his Canada Report—a very few, in all not over twenty; he did it courteously and not even controversially. He afterward made examinations in Vermont, Massachusetts and New York which gave him confirmatory conclusions, but personally he wrote nothing on these conclusions.

The writer's acquaintance with the subject began in 1843, after an absence abroad of four years; and for many years afterward he was learning, but published nothing. After the discoveries of fossils in Canada, and the announcements of the Canada Geological Survey, I adopted Logan's opinion; and this is presented in my *Manual of Geology*, published first in 1863. It appeared at the time to be the generally accepted opinion. My investigations in Berkshire were commenced in July of 1871, in order to get at the truth, without any feeling of opposition to Professor Emmons.

Dr. T. Sterry Hunt was one of the strong and active opponents of the Taconic system between the years 1849 and 1875. The Report of the American Association for 1850 has his decision that "The results of the [Canada] survey have shown, as I had the honor to state at the last annual meeting at Cambridge [in 1849], that the Green Mountain rocks are nothing else than the rocks of the Hudson River Group with the Shawangunk conglomerates, in a metamorphic condition;" and in his address before the same Association for 1871, he stated, as he had done many times in the interval, that the conclusion of Rogers and

Mather, referring the Taconic System to the "Champlain Division" of the New York rocks had been sustained by subsequent observations. Further, his "Chemical and Geological Essays" published in 1875 (see Title-page) contains the Association address of 1871, and the same remarks on the Taconic. Here are *twenty-five years* of opposition to Professor Emmons, in a number of papers, and never once a hint that Emmons agreed with him in the Calciferous age of either of the rocks. The account of the investigations of Logan and Hall in Dutchess County, New York and elsewhere, bearing against the Taconic system, as published in this Journal for 1865, has attached to it Dr. Hunt's name as he was the writer. Dr. Hunt's opinions were not always couched in courteous language. In 1861, he makes the Taconic, exclusive of the slates, equivalent of the Calciferous, adding: "It remains to be seen whether Dr. Emmons can retain, from the wreck of his system, the lower slates as a Taconic formation older than the Potsdam." This sounds like "persecution;" and the series of papers like "persistent war waged against Ebenezer Emmons." Now, the Restatement indicates for its author a return to the idea of the Calciferous age of some of the Taconic rocks.*

* The continuation of the "Taconic Question Restated," to be found in the March number of the *Naturalist* (pp. 238-250), has been published since the above was put in type—the number having been received at New Haven April 13th. It calls for no further remarks. But as it will aid in clearing away doubts, and give a fuller view as to what have been, as the author expresses it (p. 248), "my own teachings," I cite a few more sentences from his papers during the 25-year period of *opposition*, and others from two of those of the subsequent period of *agreement*.

Review of the Progress of American Geology, in this Journal, II, xxxi, 402, 1861. "The Quebec group with its underlying shales is no other than the Taconic system of Emmons.

"*Review of Mr. Barrande, On the Primordial Zone in North America*," in the *Canadian Naturalist*, 1861, and this Journal, II, xxxii, 427, 1861. "Dr. Emmons claims that the whole of his Taconic system is inferior to the Potsdam sandstone, which is the admitted base of the Champlain division, but we have already shown that the whole of his system, with the probable exception of these slates [the black slates] is of the age of the Calciferous sandrock, the second member of that division." "The fossils of the Quebec group show it to be the paleontological equivalent of the Calciferous sandrock. The Stockbridge and Sperry limestones with their accompanying slates (excepting only 7 and 8 [the Taconic slate and black slate]), we conceive to be no other than the Quebec group."

Address to the American Association, August, 1871. Salem, 1871.—p. 15, "The Taconic system, as defined by him [Emmons] may be briefly described as a series of uncrystalline fossiliferous sediments reposing unconformably on the crystalline schists of the Green Mountains, and partly made up of their ruins; while it is, at the same time overlaid unconformably by the Potsdam and Calciferous formations of the Champlain division, and constitutes the true base of the paleozoic column,—thus occupying the position of the British Cambrian." Hence in 1871 the author had not made the discovery that Professor Emmons referred any part of his Taconic system to the Calciferous.

History of the Names Cambrian and Silurian in Geology; published in the *Canadian Naturalist*, for April and July, 1872.—p. 36, "Emmons, misled by stratigraphical and lithological considerations, complicated the question in a singular manner, which scarcely finds a parallel except in the history of Murchison's Silu-

In view of these twenty-five years of opposition, and of present indications, it is of interest to read again (if already once read) the pathetic remark on page 122 of the paper in the *Naturalist*.

"There is a painful resemblance in many respects between the story of Emmons and of his opponents and that of the warfare waged against Sedgwick by Murchison and his allies in the famous Cambrian and Silurian controversy, as set forth by the present writer in 1874 in his *Chemical and Geological Essays* (pp. 364, 365):" the same volume that contains Dr. Hunt's Association Address.

A note to "opponents" in this sentence states a further incident in the "persecution" from a letter by Professor Emmons, in which Professor Emmons says, that "the *editor of the American Journal of Science* refused to publish my remarks upon Logan's Report when he [Logan] announced his Huronian System, though their tenor was courteous in the extreme; I claimed that the Huronian was only the Taconic System." The refusal was on the ground that the "remarks" contained no facts sustaining the opinion, and that opinions on such a point without facts were of no value to the science. The Huronian region and the Taconic were remote from one another, and Logan's discoveries of fossils in Canada seemed to be too decisive to be so set aside.

But this instance of "persecution" occurred far back in that

rian sections. Completely inverting, as I have elsewhere shown, the order of succession in his Taconic system, estimated by him at 30,000 feet, he placed near the base of the lower division of the system, the Stockbridge or Eolian limestone, including the white marbles of Vermont, which by their organic remains have since been by Billings found to belong to the Levis formation [Quebec group].

The following are those on the other side.

On the *Azoic Rocks of Southeastern Pennsylvania*, Report E. of Geol. Survey 1878, pp. 206, 207. "We have given reasons for regarding the Lower Taconic, or the Primal and Auroral strata of the great Appalachian Valley as the equivalents of the similar series in southern N. Brunswick and of the Hastings series in Ontario with its Scolithus and Eozoon. While it has been shown, in a preceding chapter, that the Upper Taconic includes the organic remains of the European Cambrian at least as low as the Menevian, it is by no means certain whether the Lower Taconic series is to be regarded as the equivalent of the still lower beds of the Cambrian of Great Britain and Sweden. In this uncertainty it is deemed well to preserve for this series the original name of Taconic."

"*The Taconic Question*," 84 pp. 4to, published in the volumes of the Transactions of the Royal Society of Canada for 1883 and 1884. In the "conclusions" the author says (pp. 149, 150): "There exists in eastern North America a great group of stratified rocks, consisting of quartzites, limestones, argillites and soft crystalline schists, which have altogether a thickness of 4000 feet or more, and are found resting unconformably upon various more ancient crystalline rocks from the Laurentian to the Montalban inclusive. This series called Transition by Maclure . . . is the Lower Taconic of Emmons." This series which I have preferred to call Taconian is essentially one of Transition crystalline rocks."—p. 151, "The Taconian, as I have suggested, may constitute a link between the older Eozoic groups and those of Paleozoic time."—p. 151, "the Upper Taconic group, the First Graywacke of Eaton, the Potsdam and Quebec groups of Logan (which include a large part of what was described by Mather and by Logan as Hudson River group) we have seen to be the Appalachian representative of the Cambrian group."

If any one doubts whether the author of the preceding extracts and of the article in the *Naturalist* is one and the same person he must investigate for himself.

interval of twenty-five years during which Dr. Hunt was one of the persecutors if there were any such—an interval, moreover, which was continued, without any abatement in the opposition on Dr. Hunt's part, for twelve years after Professor Emmons's decease.

I think I have stated facts enough to end the Taconic controversy. The work which Professor Emmons did in the stratigraphical geology of the Taconic region and his discoveries in Paleontology will in the main stand; while no effort can keep life in wrong conclusions, whatever the source.

GEOLOGICAL MAP
—OF—
Middle and Northern Berkshire,
—BY—
JAMES D. DANA.