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ART. XLIII.—*An account of the Discoveries in Vermont Geology of the Rev. AUGUSTUS WING; by JAMES D. DANA.*

[Continued from page 347.]

IN the preceding part of this paper the discoveries have been announced of *Trenton fossils* in crystalline limestone in North Castleton, Hubbardton, and Sudbury, within the area of the "great central slate-belt;" in East Cornwall just east of the belt; east of the village of Shoreham; in Eastern Orwell; in Middlebury, and north of East Cornwall—indicating a north-and-south area of Trenton limestone either side and underneath the slate, and showing the slate to be probably the Hudson River shales; of *Chazy fossils* at West Rutland; in East Cornwall; northeast of the village of Orwell; in West Cornwall; in North Cornwall at Ellsworth Ledge; at Weybridge Upper Falls northwest of Middlebury; of *Quebec fossils*, south of the East Cornwall locality of Trenton fossils, and in North Cornwall at Ellsworth Ledge; of *Calciferous fossils* near the borders of West Cornwall at Bascom's Ledge; in Northeastern Shoreham at Mutton Hill, and also in another fold near by (affording a small species of *Orthoceras*, etc.); near the border of West Cornwall at Bascom's Ledge, and at Barbour's Ledge in South Bridport.

The Eolian limestone extends north through Middlebury and New Haven and terminates in Monkton, and affords other fossils in its northern portion.

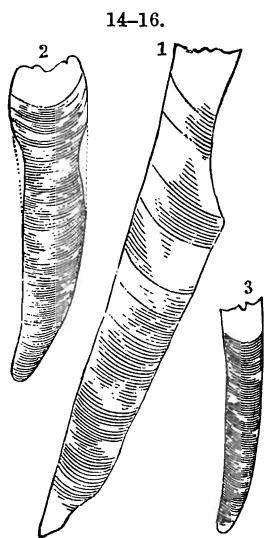
6. *Northern Middlebury, New Haven, Monkton.*

About two miles north of Middlebury, a few rods east of the road running by Messrs. Hammond's to the Severance (or Old

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Middlebury) Marble Quarry, half a mile west-by-south from the quarry, across a small stream, there is a thin bed of limestone dipping to the east 70° or 75° , underlain on the west by six or eight feet of dark fine-grained quartzite holding *Scolithi*. At this place ten or twelve specimens of a small *Orthoceras* occur, weathered out over the exposed surface of limestone near the place of contact with the quartzite. The *Orthoceras* are tapering in form, three to five lines in diameter and one to two inches long, and have very fine close septa. The species is very much like the *Calciferous Orthoceras* figured by Hall in the New York Report.

I visited this locality, on my excursion with Mr. Wing, and found his description right; the specimens are beautifully distinct although only worn sections. Expecting that Mr. Wing would describe the *Orthoceras*, and also hoping that I should receive from him a specimen (which only long working with a quarryman's tools could safely dig out), I took no satisfactory notes at the time. Through the kindness of Professor H. M. Seely, I have had "squeezes" from three of the specimens, showing well the character of the septa, and have further learned that the number of septa is from ten to thirteen in a quarter inch, that is forty to fifty-two in an inch; and I have also received drawings made on the spot by Miss Parker. The accompanying three figures are from these drawings and the squeezes. They are natural size; and Professor Seely observes that there are indications, though doubtful, that the upper end of No. 1 may have been half an inch longer. The figures are restora-



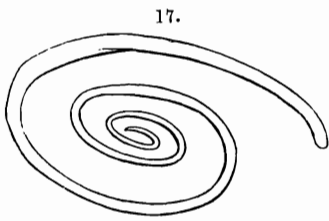
tions only in having part of the septa more entire than in the specimens.

They show that the species is much like *Orthoceras primigenium* Hall, but that part have a slight curve. Mr. Wing's earliest notes on this locality among those in my hands, occur in a letter dated October, 1867.*

Half a mile northwest of the *Orthoceras* locality and two and a half miles northeast of Middlebury village, and apparently in the same formation with the last, there are specimens resembling *Ophileta compacta*; there was also found here a

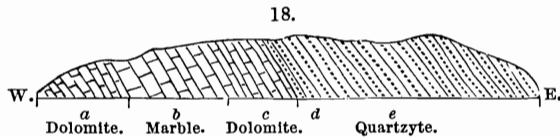
* I repeat here that the paragraphs in smaller type consist of remarks by the compiler of this paper, and of facts from other sources.

large *Maclurea*. "The figure here given is correct as to size and general form, though not having the grace of the original."



About a mile southwest of the Middlebury quarry and thirty or forty rods west of Mr. E. Kirby's residence, in an old orchard, several distinct convoluted shells were seen on a dark siliceous limestone dipping west. The beds are probably Calciferous.

The quartzite near the old Middlebury Marble Quarry above-mentioned extends northward into the town of New Haven to New Haven River, a distance of about two miles. The following figure represents a section taken south of New Haven River on the southern border of



Section south of New Haven River on the southern border of New Haven town.

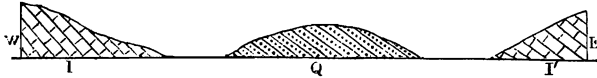
the town of New Haven. There are in succession, going eastward along the lines of section, 150 feet of dolomite (*a*); 200 feet of marble (*b*); 150 feet of dolomite (*c*); 10 feet of gray quartzite (*d*); 800 feet (*e*) of buff and reddish quartzite with some slate. The quartzite has been made the overlying rock in the view of Mr. Wing by an overthrow fold. This quartzite belt, with the limestone west of it, stops at New Haven River. But, 80 to 100 rods to the west, another belt begins which stretches northward, passing just east of New Haven village (four miles from New Haven River), and finally joins the Red Sandrock of Monkton.

At a place two and a half miles south of New Haven village, in a field belonging to Mr. J. Brown, a small *Orthoceras* was found over the weathered surface of the dolomite just west of the quartzite, which was apparently identical in species with those of the locality above-mentioned. The *Orthoceras* is closely like that of Shoreham (figured on page 342), which was found in limestone adjoining the underlying sandrock. The quartzite at Mr. J. Brown's, two and a half miles north of New Haven village, is 400 to 500 feet thick, dips eastward at an angle of 50° to 60°, and contains "numerous Fucoids and obscure Scolithi."

This locality is one of those I visited with Mr. Wing. The quartzite is situated between limestone on the east and west, all dipping alike. The dolomitic limestone to the east has a reddish

color seamed with white, somewhat brecciated, and resembles much the red Winooski limestone (Primordial). The quartzyte ridge was nearly half made up of hydromica slate.

19.



Section near Mr. J. Brown's.

For a mile northeast of the Weybridge Upper Falls, across the railroad, the "striped stratum" is seen in short anticlinals without fossils; but in a fold skirting the western foot of Town Hill, near an old lime-kiln, on the farm of A. Lorraine, three miles southwest of New Haven village, *Rhynchonellæ* were found. The same formation extends on and contains fossils in Brookville, and "in northeastern Middlebury east of Chipman Hill, a little north of Mr. Foot's residence, just east of the road going to Mr. Hammond's."

In the northwestern part of the town of New Haven, one and one-half miles north of New Haven depot, a few rods west of Mr. Charles Mason's residence, the road to Monkton cuts through the western border of a low quartzyte anticlinal, having an eastward and westward dip in the opposite directions. Following the quartzyte northward twenty-five or thirty rods, *Fucoids* and *Scolithi* are found in it. The quartzyte to the west and east dips under heavy beds of "dolomitic siliceous limestone." Farther east there is a thick stratum of white crystalline limestone or marble; next, beds of "sandstone" and concretionary limestone; next, a coarse "sandstone" conglomerate; next, limestone. "Obscure *Orthocerata*, convoluted shells and an *Orthis* were seen," and they appear to be fossils of the "Ophileta beds" or Upper Calceiferous. "The limestones end in Monkton not half a mile north of this place," the rock beyond being the Red Sandrock, with its *Scolithi* and *Fucoids*. The Calceiferous formation is thus traced to the northern limit of the Eolian limestone.

At my visit to the quartzyte anticlinal just described, I found that there was a small cross-gorge in the quartzyte, showing that the quartzyte had little thickness and that it overlaid a stratum

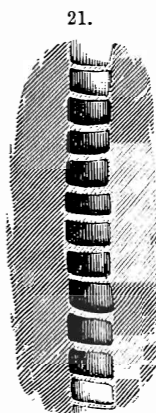
20.



Section of Quartzyte Anticlinal.

of limestone, probably dolomitic, twenty feet in height of which were exposed to view. The beds at this place have only a small dip. The general relations of the beds are shown in the above section.

The quartzite is in most parts a little slaty in structure, and in limited portions a shining grayish-black slate. In places over it there are areas of sub-concentric conchoidal lamination, looking somewhat as if examples of the flow-and-plunge structure, but more probably a result of concretionary consolidation. To the latter cause I attributed some forms that looked exceedingly like casts of a *Pleurotomaria* and a *Murchisonia*, and of a valve of *Orthis lynx*. Others of these imitative forms over the surface were semi-cylindrical and chambered, as if worn casts of long crinoidal stems; yet having the chambers too large and irregular for any known crinoidal forms. A portion of one of them is here figured natural size; its total length was over ten inches. These simulations of Crinoids may also be due to a concentric structure in the slaty portion of the rock; yet how, it is not easy to understand.



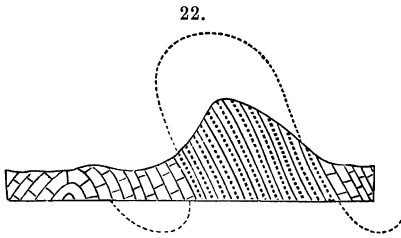
7. *Eastern portion of the Eolian Limestone belt, and the Quartzite adjoining.*

In this eastern portion of the Eolian limestone, constituting one-fourth to one-third of the whole breadth, no fossils have been found. The more crystalline character of the rock accounts for the absence of fossils. Conclusions as to its age and that of the quartzite have to be based on other considerations. This evidence of intenser metamorphism on going eastward is apparent beyond the limits of the limestone region, to and beyond the Green Mountain axis.

The interstratification of the quartzite and Eolian limestone is illustrated in the section given on page 340, in which two bands of dolomite are included between belts of the quartzite.

In July, 1875, Mr. Wing made, along with Professor Seely, a special examination of the quartzite mountain called the "Hogback," forming the northern terminus of the Vermont Quartzite range, and lying near the western foot of the Green Mountains. At the north end of the Hogback a low hill, situated north of the road to Starksboro, is of hard grayish quartzite, while the main range south is brownish and distinctly stratified, with the dip 70° to 75° to the eastward. North of this low quartzite hill, the quartzite extends on northward in narrow masses, and is directly overlaid on the northeast by dolomite and bounded by the same dolomite around the whole northern end. The dolomite on the west was not seen in immediate contact with the quartzite; but at the nearest point, "some rods distant," it seemed to dip east at a high angle, while a few rods to the west it had a decided westward dip. On the east side of the quartzite at this northern end of

the range, and also south to Starksboro, there is another north-and-south range of limestone (dolomite), having an eastward



Mr. Wing's section through Hogback.

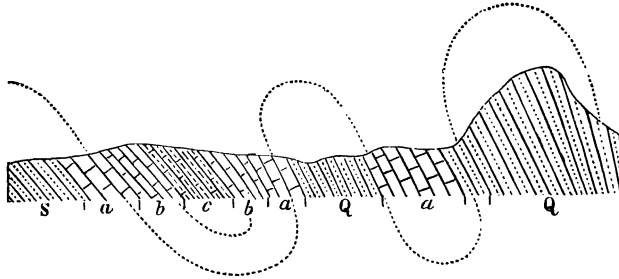
dip conformable to the quartzite (as represented also in the Vermont Report, p. 346). The figure here given (copied from Mr. Wing's note book) gives his view of the stratification.

At Starksboro, *east* of the dolomite, there is a quartzite ridge which "for a height of 3,000 feet seemed to be an immense flag-stone quarry; the rock is quarried for flagging farther north. It may be called brown quartzite; it is within the 'Talcose Conglomerate' area of the Vermont Geological Report." The layers are nearly vertical, having a very high eastward dip, conformable with the dolomite and with the quartzite lying west of the dolomite. The whole valley between the two ranges of quartzite,—a nearly level strip of country "embracing two or three villages, excellent farms and farm-houses,"—seems to have been made by erosion, the dolomitic and slaty strata having been worn away faster than the quartzite of Hogback on the west and the Flag-stone ridge on the east. The only fossils of the quartzite are the *Scolithi* and *Fucoids* observed elsewhere, and these are the same with those of the Red Sand-rock.

The conclusion given in the notes of this excursion in 1875 is,—that "all the rocks in Bristol north and east of Mr. Oaks's residence (on the road next west of Bristol village), all in Monkton and in Starksboro, are older than the Calciferous; the dolomites belong to the Red Sandrock series, or that of the quartzite, and in some places appear to be 400 to 500 feet thick; and they overlies the quartzite, being beneath because of an overturn anticlinal." These dolomites here referred to the Red Sandrock series are those called "Subcrystalline limestone" on page 343, which contain the Calciferous *Orthoceras* at Mutton Hill and are there referred to the Lower Calciferous. The following section (from the letter of 1872,) represents the rocks between the Red Sand-rock west of New Haven (see map) and the quartzite at the village of Bristol, and Mr. Wing's view as to the folds. *a*, The Red Sand-rock dolomite or "Subcrystalline limestone;" *b*, The "Ophileta beds" or Calciferous; *c*, The "Conglomerate" or "Trilobite bed" or "siliceous limestone greatly resembling it," underlying to the south on the strike, "Rhynchonella beds" containing fossils;

Q, quartzite. Adjoining the Red Sandrock on the west is No. 2 of the section on page 343, a "dolomitic sandstone."

23.

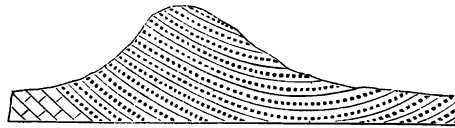


Mr. Wing's section from the Red Sand-rock west of New Haven to the Quartzite at Bristol village.

In the excursion with Mr. Wing we passed along by the western foot of the Hogback range, north of the village of Bristol. At one point the limestone stratum was seen to form the lower part of the quartzite bluff, and to dip beneath the quartzite at a small angle, as if actually an underlying stratum. Mr. Wing spoke of this limestone at the time as part of the Primordial or Red Sand-rock series.

A section of Hogback in the Vermont Geological Report, taken along a line south of the region examined by Mr. Wing, between Bristol and Lincoln, makes the limestone at the *west* base

24.



Section of Hogback, from Vermont Report.

of Hogback dip eastward 45° or so beneath the quartzite. To the eastward of Hogback along this section no limestone is represented in the figure; but the Report says (p. 346): "in the valley of the north branch of New Haven River, passing up to Starksboro, there are ledges of limestone occasionally seen, interstratified with the quartz rock, nearly as far as Starksboro village; and there is reason to believe that it may extend to meet a narrow belt of limestone running south from Hinesburgh."

In my examination of the limestone and quartzite ridge northeast of Rutland, I found that the dip in both was eastward; but the nearest outcrops of the two were too remote to make it sure that they were conformable. They are conformable according to the section through Rutland and Mendon given in the Vermont Geological Report. The quartzite in Vermont is in many places interstratified with, and replaced by, hydromica slate (sometimes

chloritic), or a hydromicaceous quartzite or conglomerate—a fact dwelt upon in the Vermont Geological Report, which says as follows, when describing sections across the eastern quartzite range. In Sunderland the quartz-formation includes, with quartzite, talcose schist [that is, hydromica slate] (p. 614). In Wallingford the quartzite and quartz conglomerate are interstratified with talcose schist (p. 627). “Talcose schist is associated with the quartz-rock of Mendon” (p. 634). In Goshen “the quartz-rock formation is composed of hyaline quartz, talcose schist, and argillo-talcose schist” (p. 640). In Ripton “the quartz-rock is composed of ten bands of different rocks, viz: hyaline quartz, compact sandstone, talcose and chlorite schist” (p. 645). Speaking of the belt of “talcose conglomerate” it says that it includes sandstones, breccias, quartzite, coarse conglomerates, talcose schist, novaculite schist, and “talcose schist is the most common rock in the belt” (pp. 386, 387).

I have examined this association of hydromica slate and quartzite in the quartzite ridge northeast of Rutland (the ridge making the western boundary of the town of Mendon). Having on my second visit struck the ridge at a different point from that examined on my first visit, I was perplexed by finding hydromica slate in place of true quartzite; but afterward reached an explanation on observing the gradations of one rock into the other. The Geological Chart of the Vermont Report does not generally represent this interstratification of the quartz and hydromica slate, as the Report observes, because the details were not separately made out owing to the intimate relations of the two. It is shown, however, in Section VIII, where, near Ripton, occurs the remark “Quartz rock interstratified with talcose schist;” and bands of color in the colored section represent the fact.

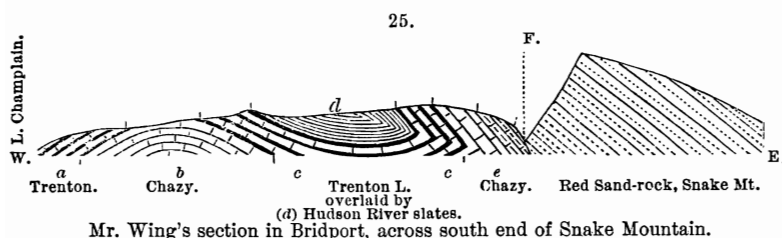
8. “*Great Fault of Western Vermont.*”

Snake Mountain is a north-and-south ridge of Red Sand-rock several miles long, situated to the west of Middlebury, within seven miles of Lake Champlain. It has a steep western face, and gradual eastern slopes—the former across the stratification, and the latter nearly conforming with it. This western side is the course of a great fault.

The rock of Snake Mountain east of the fault is the Red Sand-rock of the Vermont Report, and this continues to be the surface rock eastward to Otter Creek. At the southern extremity of the mountain, in Bridport, west of the mountain, there are the successive Lower Silurian formations, but in an inverted position. The following section gives the order and position of the beds observed at this place.

The first and uppermost rock west of the fault containing fossils is the Chazy; below this comes the Trenton, and next the Hudson River, so that the Chazy and Trenton have been folded

back for two or three miles upon the slate. This arrangement in the main prevails along the west front of Snake and Buck Mountains to near Vergennes.



Mr. Wing's section in Bridport, across south end of Snake Mountain.

"Along the highest part of Snake Mountain no slate or limestone is seen at all. At the north end of the mountain the Red Sand-rock has been lifted until it is 700 feet above the level of the Hudson River slates to the west, while at the south end, four or five miles distant, it is much less elevated. Around its northwest end, only the Hudson River slate is seen. Then the Chazy comes in behind the Trenton, and both are folded over on the slate. The Chazy, Trenton, and the Hudson River slate disappear in the same order farther south. The Red Sand-rock (Potsdam) appears to have been pushed up and thrust west over these other formations; and so far over, opposite the highest part of the mountain, as to conceal first the Chazy, the Trenton and the Hudson River beds; then, farther north, leaving the Hudson River beds, Trenton and Chazy, along the lower parts of the mountain."

The Chazy beds on the west of the fault afford large *Maclurea*, one or two species of *Orthoceras*, an *Orthis*; the Black River limestone, *Columnaria alveolata* in great masses, besides other species; the Trenton, *Trinucleus concentricus*, and various other fossils, and the Hudson River slate its characteristic species.

This fault continues south through Bridport, Eastern Shoreham and Orwell to Orwell village and beyond, "but with some irregularity of direction, it following neither a meridian nor the line of a belt or fold."

"Two or three miles south, half a mile west of the village of Shoreham, and south by Sisson's Hill and Barnum's Hill, in the south of Shoreham, the Potsdam proper is folded over on to the Hudson River slate." "Six miles south, $1\frac{1}{2}$ miles west of the valley of Orwell, at Chittenden's Mills, in a deep gorge made by the stream, the Chazy, holding large *Maclurea*, is seen folded over the Hudson River slate, etc." Mutton Hill adjoins the fault. Again in Waltham, eight or ten miles north of Bridport, the Red Sand-rock is brought up against the Trenton.

Prof. Emmons describes the fault at Snake Mountain and gives a section in his *American Geology* (vol. I, Part 2, p. 87, 1855); but his section seems to have been taken north of the point described by Mr. Wing; the place is not stated. It makes the formations to the west of the fault lie in regular instead of inverted order. Professor Emmons supposed the rock of Snake Mountain, raised by the faulting, to belong to his Taconic System and therefore pre-Silurian. Prof. Hitchcock, in the Vermont Geological Report, gives a section which represents the mountain *without the fault*.

9. *Conclusions of Mr. Wing as to the Geology of the part of Central and Southern Vermont investigated by him.*

1. The hydromica slates, clay slates, Eolian limestone and quartzite, with the so-called talcose conglomerate on the east, are all of Lower Silurian age, and conformable in superposition.

2. The Eolian limestone is not Taconic, as made by Prof. Emmons; nor of some one formation, as implied in statements in the Vermont Report and in the name it gave it; nor of the Quebec group, as inferred by Logan; it includes Lower Silurian limestones of various periods, the Upper Potsdam or Lower Calcareous, Calciferous, Quebec, Chazy, Black River, and Trenton.

3. The Red Sand-rock on the west of the Eolian limestone—admitted to be Potsdam or Primordial in age—and the Quartzite on the east which often rises into mountain ridges, are of the same formation, and come nearly or quite together in Monkton, on the northern limits of the limestone area.

4. These rocks—the Red Sand-rock and Quartzite—are the western and eastern borders of a great abraded synclinal, the axis of which in its northern part has a slight northward rise (or southward dip), the sides there coming together; and which also has both the eastern and western sides of the fold eastwardly inclined, the dip of the beds being generally eastward. Between its borders there are, in some parts, subordinate longitudinal abraded anticlinals and synclinals.

5. The slates of the "great central belt" are of the age of the Hudson River slates (or that of the Cincinnati group), for the reasons stated on page 345—which are briefly these: (1) the slate-belt is bordered in several places on both the east and west sides by limestone affording Trenton fossils (*Trinucleus*, etc.), and no where else have Trenton fossils been found in the Eolian limestone; (2) there are also narrow north-and-south outcrops of limestones containing Trenton fossils over the interior of the slate-belt, as if brought up from beneath by anticlinals; (3) the slate-belt is plainly underlaid by the limestone at its north end; (4) in Whiting the Trenton limestone of the Sudbury area has a direct connection, across the slate area, with the limestone of Otter Creek valley, east of the belt, which also is Trenton in age—the slate being interrupted "for forty or fifty rods."

The Trenton limestone has been identified west of or within the "central slate-belt," at localities but a few miles apart, in all the towns north of Castleton (the most southern on the map illustrating this paper, p. 335), including, in succession, Hubbardton, Sudbury, Whiting, Shoreham, Cornwall, Weybridge; and east of the slate-belt, in Leicester, Eastern Cornwall and Middlebury. The Chazy limestone adjoins the "central slate-belt" in West Rutland.

6. The several Lower Silurian limestone formations lie in north-and-south belts, with the lowest—the Potsdam and Calciferous—nearest to the Red Sand-rock, or to the Quartzyte, and the upper—the Trenton or Chazy—nearest to the "central slate-belt." This view is presented in the section from East Shoreham to East Leicester on p. 340.

This is confirmed as regards the Trenton limestone, "Sparry limestone," by the list of its localities just mentioned. The Chazy ("Rhynchonella beds") so well represented by fossils at West Rutland, has afforded fossils also in Leicester, East Cornwall, Middlebury, and the same fossils have been found on the east, as on the west, of the "central slate-belt;" while the "striped stratum," which is a marked feature of the Chazy,— "a way-mark by which the rock can be recognized without its fossils," occurs also in Middlebury, in the western part of Brandon by the Burgess Field farm and along the quarries of this part of the town, in the western part of Pittsford, and in Northern Salisbury; and "doubtless it reaches the marble quarries of West Rutland, and continues south through Tinmouth and the whole State; and in this formation is embraced the Birdseye and Black River limestones." "On Crown Point, Lake Champlain, these 'striped beds' are largely developed at the old Forts, and are perhaps 100 yards beneath the Black River limestone—whether in the Chazy or Birdseye is not known. There is a stratum of seemingly pure sandstone, resembling the Potsdam, overlying them at Crown Point. These facts may help to solve the age of the same 'striped beds' in Addison County."

The groups affording the lowest Calciferous fossils on the west of the "central slate-belt" occur next to sandstones of the Red Sandstone formation; and also at two localities north of Middlebury, adjoining beds of quartzyte, or where the limestone and quartzyte come together. The "Ophileta beds," or those referred to the Upper Calciferous, come next, being more remote from the sandstone or quartzyte, as found to be true in Shoreham, Western Cornwall, Weybridge, Middlebury and New Haven.

The beds occur, with their fossils, in Salisbury, Leicester and Brandon.

The eastern range of limestone, or that forming the eastern margin of the great Eolian belt, a mile in width in many places

but narrower to the north, is concluded to be Calciferous or Upper Potsdam, because it adjoins the quartzite, and is dolomitic, the limestone nearest to the outcrops of quartzite in Northern Middlebury and New Haven being proved by its *Orthocerata* to be—like that nearest the Red Sand-rock to the west of Shoreham—of Calciferous age, if not Upper Potsdam.

The localities affording the Calciferous fossils (*Ophileta* beds) in Salisbury, Leicester and Brandon lie a little to the west of the great marble formation; and this marble formation is considered the equivalent of the western "Subcrystalline limestone" just above the fucoidal sandstones or Upper Potsdam. The dolomites farther east belong to the Upper Red Sand-rock series, or else the bottom of the Calciferous, as has been elsewhere stated.

The later formations extend less far north than the older because of the inclined axis of the great abraded synclinal: "the Hudson River slates (those of the "central slate-belt") reaching central Weybridge; the Trenton, about a mile farther; the *Rhynchonella* beds five or six miles farther north; and finally these disappear, owing to the rising into view of the Red Sand-rock."

7. The quartzite of the eastern range, with that also of the local belts in the Eolian limestone area, is regarded as Potsdam (or Primordial) in age, because it contains in many places *Scolithi* (worm-burrows) and *Fucoids* like those found in the Potsdam sandstone; because also it adjoins Calciferous limestone beds at the localities just mentioned in North Middlebury and New Haven; and because it joins the Red Sand-rock in Monkton, and one rock has in many places the character of the other, although not commonly alike in color, and showing differences explainable on the ground of the greater metamorphism of the quartzite. "In Monkton, the Red Sand-rock and the Quartzite meet in a succession of short anticlinals, thus cutting off to the north the great trough or synclinal;" and "the Red Sand-rock absolutely overlies the beds of Red Sand-rock in one anticlinal and the quartzite in another anticlinal, and both hold *Scolithus linearis*."

8. The quartzite belt of Rutland Center (just north of Rutland), with the associated slate, extends north by Sutherland Falls nearly to Forestdale, and it runs south of Rutland Center into Clarendon and Tinmouth. It lies throughout within the Eolian limestone area. But it is seen on the map that the area is on the line of strike of the quartzite-range north of Pittsford. This quartzite is regarded as Potsdam; and the limestone which lies directly to the west of it (half way from Rutland to the West Rutland valley) is supposed to be possibly the "*Ophileta* beds" or Upper Calciferous, and the "Conglomerate" or Quebec

group. "But this narrow valley is a very disturbed region, and the limestone seems to be greatly compressed between the quartzite belt on the east and the slate belt on the west (separating it from West Rutland valley)." "The region was studied farther south in the valley as well as to the north, to ascertain what rocks occurred, and the conclusion was that nearly all the formations found in other places here occur; that is, the older on the east against the quartzite (No. 1), and then the others in succession, with the Trenton against the slate bounding the limestone on the west, while the slate is No. 8 or the Hudson River slate." No fossils were found in it.

10. *Historical Note.*

The preceding notes have been taken chiefly from the letter from Mr. Wing to me dated August 9, 1872. They show that his view, that there are Hudson River slates in the Eolian limestone region, antedates my own; for my paper on the subject was not published until 1873, and there had been no communication between us before then on the subject, or on any subject. Moreover, my own views as to the age of the Berkshire rocks were based chiefly, as I stated, on Mr. Wing's discoveries in Vermont. I cite the following from a letter to me, of May 8, 1875, written soon after he had first seen my paper on the subject—a letter never, however, received by me until his papers were recently put into my hands. It shows that his conclusions date as far back as 1866.

"When, in 1866, the *Trinucleus concentricus* and other Trenton fossils were found first in Sudbury, underlying on the west side the great central mass of slate running south from Weybridge through the State, embracing the "Talcoid schists" capping Dorset and Manchester Mountains, Mount Anthony in Bennington, and also Graylock in Massachusetts, I reached the conclusion at once that all these slates in Southwestern Vermont and Southwestern New England were neither of the Quebec group, nor Taconic, but of the age of the Hudson River slate. In the progress of my investigations, I assumed, and I often expressed in correspondence with Mr. Billings, that the 'Eolian limestone' of the Vermont Geological Report embraced not only the Trenton and Hudson River beds, but all the formations of the Lower Silurian as well, and even limestones and dolomites of the Red Sand-rock series. I was wrong at first in assuming that these same slates overlying the Trenton and Chazy limestones along this central belt extended also west to the Hudson River and were all of the same age. For the Primordial fossils recently collected at Bald Mountain, Washington Co., and east of Troy, New York (both of which places I have visited), have modified my view as to the western extent of the Hudson River slates. But they have not weakened my belief in their existence in Southwestern Vermont and New England."

From the preceding account of Mr. Wing's discoveries it is evident that he performed well the task he laid down for himself in 1865—the determination of the age of the Eolian limestone. Knowing that fossils were the only sure criterion of geological age, he searched, and he found them, and thus reached sure conclusions. For the western portion of the Eolian limestone and more than half the eastern (that of Otter Creek Valley), the special geological age was thus determined, and the several Lower Silurian formations identified. He further made a right use of the facts, when, in view of the Trenton and Chazy age of the fossils in limestone along the borders of and within the "central slate-belt," and the observation that the beds more remote are successively older—he deduced that the slates were younger than the limestones holding the Trenton fossils, and therefore, in all probability, of the Hudson River (or Cincinnati) group, and that they lay in a synclinal with Trenton and older limestones beneath and on either side.

The more highly metamorphic condition of the limestones making the eastern border of the Eolian limestone prevented his giving to the geology of this part of the region the same positive basis from fossils which he had obtained for the rest.

The Quartzyte also proved almost barren, yielding him only *Scolithi* and *Fucoids*, neither of which serve to fix positively the age of the beds. His argument with respect to it from the well-defined Calciferous fossils found adjoining quartzite at three different localities on the west and north is however a strong one, and seems to set the question at rest for those outcrops. The Vermont Geological Report states that the eastern Quartzite range, near Rockville in Starksboro, has afforded a *Lingula*—the specimen containing "scores of fossils but none very distinct"—which Prof. James Hall "regards as a new species related to one in the Medina sandstone," and as evidence "though unsatisfactory" that the quartzite is of the age of the Medina. From the same Quartzite range farther south, in the vicinity of Lake Dunmore, Prof. C. B. Adams, as it states, found a shell near a *Modiolopsis* in form; also a tapering shell looking like an *Orthoceras*. Yet the determinations of all these fossils are admitted to be doubtful, and the question of age is still an open one.

One of the most important points established by Mr. Wing is the conformability of the Lower Silurian formations throughout the region. From the Red Sand-rock, or Primordial, upward they make one consecutive series, and all are involved, as Mr. Wing urges, in one system of synclinals and anticlinals. The quartzite, hydromica slates, and limestones, associated on the eastern border of the region, and the great bands of limestone, hydromica slate and clay slate (or roofing slate), with some quartzite, making the center and western portion, are of one system, and took, together, their present positions. The great fault which made Snake Mountain was simply one of the breaks and displacements attending the mountain-making movement, as shown years since by

Logan. The observations of Mr. Wing afford nothing to sustain the view that there was an epoch of disturbance in the region at the close of the Primordial or Cambrian period, but, on the contrary, they prove that the rocks went on forming in regular succession nearly or quite to the close of the Lower Silurian; and that then followed, as Mr. Wing concludes, the epoch of upturning and metamorphism. The making of the Green Mountains has for many years been referred by some geologists to this epoch, on the basis of the fossils in the limestones of Vermont. These fuller developments leave no doubt that this view is right, at least, so far as the Eolian limestone of Vermont and the associated schists and quartzite are concerned.

In another number of this Journal I will close this subject by stating the bearing of the Vermont facts on the geology of Berkshire.