THE TACONIC SYSTEM OF EMMONS, AND THE USE OF THE NAME TACONIC IN GEOLOGIC NOMENCLATURE.

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WITH PLATE III.

field Professors Dewey and Amos Eaton had studied more or less of the Taconic region, and the data obtained by them were of material aid to Dr. Emmons.

Among others who have examined portions of the area studied by Dr. Emmons previous to 1844, are: Dr. W. W. Mather, of the geological survey of New York, who made a reconnoissance of the portion within New York State (Geol. N. Y., Rep. First Geol. Dist., 1842); Professor James Hall, who examined a section crossing from the Hudson River to the Green Mountains (Proc. Assoc. Am. Geol. and Nat., p. 68, 1845), and the Professors W. B. and H. D. Rogers who studied a section extending from the Massachusetts side of the Taconic area to the Hudson River (loc. cit., p. 67: also, Proc. Am. Phil. Soc., vol. ii, pp. 3 and 4, 1841). The Professors Edward and C. H. Hitchcock described and mapped the strata referred to the "Taconic System" in Vermont, and discussed the question of their geologic age (Geol. Vt., 1862). Subsequently, Professor C. H. Hitchcock made a series of sections, crossing the "Taconic System" in Vermont (Bull. Am. Mus. Nat. Hist., vol. i, 1884). The observations made by Mr. S. W. Ford, from 1874 to 1886, in the counties of Rensselaer and Columbia, N. Y., have furnished important data on the formations examined by him that will be referred to again. Some of the results obtained by the geologists mentioned will be spoken of under the head of "Comparison and Discussion."

Dr. T. Sterry Hunt, Professor Jules Marcou and Professor N. H. Winchell have all written at length upon the "Taconic System," but I have been unable to discover that either of these gentlemen have made any field observations in the typical Taconic area *

In searching for data to aid me in forming an opinion respecting the value of the name Taconic in American geologic nomenclature, I found that there was such a wide divergence of opinion among the geologists who had studied the "Taconic System" in the field and those who had formed opinions upon it from partial observations in other areas, and the data given by Dr. Emmons and the Professors Hitchcock and Professor Dana, that there seemed to be no way to settle the questions at issue except by investigating the original Taconic area and identifying and mapping all the formations within it except the areas mapped by Professor Dana and the Professors Hitchcock. The necessity of ascertaining the age of the different

* Dr. Hunt's later opinions appear to have been influenced by his geologic observations in Pennsylvania, and by certain theoretic views founded on the lithologic characters of the "Lower Taconic" rocks. Professor Marcou examined the extension of the "Upper Taconic" strata in Northern Vermont and Professor Winchell appears to have studied the publications of Messrs. Emmons, Marcou and Ford.

formations by paleontologic evidence, was also imperative, as their lithologic characters were of little comparative value outside of the Taconic area owing to local differences in the original sedimentation and to the subsequent alteration of the strata by metamorphic agencies.

With the assent of the Director of the Geological Survey I began field work during the season of 1886 and continued it until the close of the field season of 1887. A few of the results of this work were given in a paper entitled "Geologic Age of the Lowest Formations of Emmons's Taconic System," and read before the Philosophical Society of Washington, January 15th, 1887, a brief abstract of which was published (this Journal, vol. xxxiii, p. 153, 1887). On the 22d of April, 1887, I read a paper before the National Academy of Sciences, at Washington, bearing the title: "The Taconic System of Emmons." In it were given the results of my studies up to that date; and I exhibited a geologic map, and a cross-section, of the Taconic area. As I was soon to return to the field this last mentioned paper was not published.*

Previous to studying the geology of the Taconic area I worked during portions of the field seasons of 1883–4 on the "Upper Taconic" strata of Northern Vermont and published a part of the results in the introduction to Bulletin Thirty of the U. S. Geol. Survey, 1886.

GEOLOGY OF THE TACONIC AREA AS KNOWN AT THE PRESENT TIME.

The section (see map)† crossing the Taconic area shows the general position and relation of the strata, and their geographic distribution is given on the map. In a report on the geology of Washington County, N. Y., I shall describe the geologic section in detail. For the present purpose, however, the section and map, supplemented by notes on the geologic formations, will I think give the data required for a clear understanding of the geologic terranes. Beginning on the east, the terranes will be mentioned in the order they are met with in passing westward from the pre-Cambrian crystalline gneisses of the Green Mountains to the Hudson River, and each will be given a number by which to identify it in subsequent references.

One of the best localities to see the contact between the pre-Cambrian crystalline gneiss and the overlying, bedded quartzite

* A short abstract of it was sent, June 8th, 1887, to Professor N. H. Winchell, reporter on the lower Paleozoic rocks to the American Committee of the International Congress of Geologists, and was subsequently withdrawn owing to the field work of the season of 1887 having negatived and rendered obsolete several of the conclusions therein expressed.

† To be inserted with the second part of this paper.

is on the western crest of Clarksburg Mountain, northeast of Williamstown, Mass. It is one of Dr. Emmons's typical localities, and it has also been examined by Professor C. H. Hitchcock, who, in speaking of the relations of the quartzite to the Green Mountain gneiss, says:

"3. Still more decisive is the fact that the lowest layer of the quartzite has been derived from the ruins of the gneiss. This stratum is a conglomerate, containing many pebbles of a peculiar blue quartz, and has been observed at Clarksburg, Mass., Sunderland, East Wallingford, Ripton, and in Lauzon conglomerate, at Bristol. (The Geology of Northern New England: royal 4to, p. 2, 1870).

When making observations during the summer of 1887 on Clarksburg Mountain, I found the unconformity between the quartzite and gneiss to be well marked. The lower layers of the quartzite series contain shales and thin beds of conglomerate, and there are no passage beds between the quartzite series and the gneiss in the localities where the bedding of the gneiss and quartzite series appears to be conformable. In accordance with this, the unconformity has been represented in the section.

The quartzite, including certain minor beds of schistose shale, conglomerate and limestone, I will call terrane number one.

Terrane No. 1.—Professor James D. Dana, in describing the Quartzite series, in a paper on the Geology of Vermont and Berkshire, says "Associated with the limestone belt and following mainly its eastern border there is a *quartzyte* series, consisting in Vermont of quartzyte and crystalline slate or schist (hydromica slate, sometimes chlorite slate), and rising at intervals into mountain ridges. This quartzyte formation commences just abreast of the northern limit of the 'Eolian limestone' in Vermont: and it follows it southward through Massachusetts, and into Connecticut, being, throughout, its close attendant" (Amer. Jour. Sci., vol. xiii, p. 38, 1877). And on p. 204: "(4) The age of the Quartzyte formation, and its relation in position to the adjoining limestone.—The quartzyte formation includes, as has been explained, strata of quartzyte and schists—sometimes one predominating, and sometimes the other. The special age of the formation is in doubt, equally with that of the eastern limestones. There may be quartzytes of different periods of the Lower Silurian: and so with the schists. The question of age can be positively answered only by the discovery of decisive fossils in the quartzyte of Vermont: and so many imperfect forms have already been brought to light (besides the unsatisfactory worm-burrows, and Fucoids or worm-tracks) that we feel sure the future will clear away the doubts."

Professor Dana considers that the evidence proves the existence of a limestone beneath the quartzite, in some sections,

but in Vermont Mr. Wing makes the limestone superjacent to the quartzite (loc. cit., p. 204).

As all observers agree on the stratigraphic position of the quartzite series the paleontologic evidence of the age of the terrane, formed by that series, will be now considered.

The Professors W. B., and H. D. Rogers, Edward, and C. H. Hitchcock, James Hall, Dr. W. W. Mather and Professor Jas. D. Dana have all held the opinion that the quartzite (Terr. No. 1) should be referred to the Potsdam horizon and, from its stratigraphic position, the tentative reference was in accordance with the facts known; but, as Professor Dana has said (*ante*), the question of age can only be answered by decisive fossils in the quartzites of Vermont.

During the progress of the geological survey of Vermont, a few fossils were found in the quartzite. On page 356, of the Geological Report, vol. i, 1862,* it is stated: that besides Scolithus, a straight-chambered shell occurs in a hyaline quartz, on the west side of Lake Dunmore, and a species of Lingula in Starksboro, near Rockville; and, on page 357: "In the southwestern part of Woodford there seem to be traces of organisms resembling bivalve shells, about the size of a three-cent piece." I have, through the courtesy of Professor Dana, examined two of the specimens referred to, that are now in the collection of the Peabody Museum, at New Haven, and I find the "Modiolopsis-like shell" to be *Nothozoe Vermontana*, and the straight-chambered shell to be, to all appearances, a cast of *Hyolithes communis*, a Middle Cambrian species.

Professor B. K. Emerson kindly sent to me for examination the specimens from the Amherst college collection mentioned in the Geology of Vermont, and which were collected at Salisbury, Vt. I find one to be *Nothozoe Vermontana* and the other species to be a cast of *Hyolithes communis*, or a closely allied species. In a small collection of fossils, received from Professor H. M. Seely, of Middlebury college, Vermont, who found them in quartzite bowlders on the west slope of Sunset Hill, near Lake Dunmore, there occurs the *Nothozoe Vermontana* described as "from the Potsdam sandstone,"† and, with it, heads of a species of Olenellus undistinguishable from *O. Thompsoni* of the Georgia formation in Franklin County, Vermont; and in other specimens of the quartz rock, collected at the same locality and containing *N. Vermontana* and *O. Thompsoni*, a species of Hyolithes occurs that is undistinguishable from *H. communis*.

An investigation of the reported localities of fossils, made by the writer in June and July, 1887, resulted in the discovery

* Dated 1861, but issued in 1862.

† Bull. Am. Mus. Nat. Hist., vol. i, p. 145, 1884.

that only the Scolithus had been found *in situ.* Professor H. M. Seely had traced the Rockville "Lingula" to a bowlder, taken from a stone wall, and also the reported Lake Dunmore specimens to bowlders on Sunset Hill: no fossils being found *in situ.* In company with Professor Seely, I visited the Lake Dunmore locality, and found fossils in rounded quartz bowlders, but the quartz ledges gave no traces of them. The Woodford locality was too indefinitely described to be found; but as transported bowlders afforded me Nothozoe and traces of trilobitic remains, similar bowlders were probably the source of the specimens mentioned. In Sunderland, east of Arlington, on Roaring Branch, Scolithus occurs abundantly *in situ*, in the quartzite; and angular blocks of quartzite were found, one mile up the ravine, that contained Hyolithes and fragments of trilobites; but they were not traced to the beds from which they were derived. Two miles east of Bennington, however, success attended my search for fossils *in situ.* The section begins in the woods on the west slope of the mountain on the old Weeks farm north of the old Windham turnpike.

Wooded slope, above pasture	75 feet.
1.—Light-gray, nearly white, compact, fine-grained massive-bedded quartzite, with alternating beds of hyaline quartz. Dip 0° to 5° S. E.; strike, N. 35° E. (magnetic)	35 "
2.—Light-colored, bedded quartzite, with brown spots; showing grains of sand and fossils: the latter also in the compact rock. Fossils: Nothozoe, Hyolithes and Olenellus*	40 "
3.—Alternating bands of layers of light-gray and hyaline quartzite, becoming more massive near the summit	325 "
The dip increases from 5° to 10,° 15° and up to 25° S. E., on the line of the section, and a little farther south, to 45° S. E. Strike, N. 45° E. (magnetic)	
	400 feet.

The quartzite was traced north into the valley of Roaring Branch, and it is a continuation of the deposit on the western slope of Bald Mountain; to the south it extends along the west side of the ridge leading to Dome Mountain, in Pownal, northeast of Williamstown, Mass. It caps the latter and crosses the narrow valley on the south to the Clarksburg group of mountains, along the slopes of which it extends to a point opposite Williamstown, where it bends eastward along the south face of

* I have shown elsewhere that the genus Olenellus is characteristic of the Middle Cambrian horizon, over wide areas in North America, and that it is a pre-Potsdam type. (Bull. U. S. Geol Survey, No. 30, 1886.)

the mountain, reaching into the valley north of North Adams-Mass. On the western summit of the mountain, toward Williamstown, the quartzite series come in unconformable contact with the pre-Cambrian gneiss; and fragments of a trilobite, apparently the genus Olenellus, were found about one hundred feet above the contact.

As a result of the discovery of fossils, *in situ*, in the quartzite east of Bennington, the fossiliferous bowlders are given a value, as they were undoubtedly derived from the quartzite formation, and were distributed in the valley to the west during Quaternary time and even at the present by floods occurring in the gorges and valleys that cut through the quartzite. It is now a question of search to trace the fossiliferous horizon in the quartzite from Starksboro, to Bennington, Vt. and to Dutchess County, N. Y., where Dr. Mather considered the "Quartzite" metamorphosed Potsdam sandstone, and he so called the compact sandstone of Stissing Mountain, in the northeastern part of Dutchess County, N. Y. (Geol. N. Y.; First Geol. Dist., p. 418, 1843). During the field season of 1886, I had the opportunity of visiting the Stissing Mountain sandstone locality, in company with Professor W. B. Dwight, and we found *Hyolithellus micans* in the limestone layers, resting immediately on the sandstone; and the heads of *Olenellus Thompsoni* in the sandstone, fifty feet or more below the limestone. *Hyolithellus micans* is known only in the Georgia terrane of New York, Vermont and Canada. A species of Triplesia is associated with the Olenellus at Stissing Mountain, but it has little value in the correlation of strata.

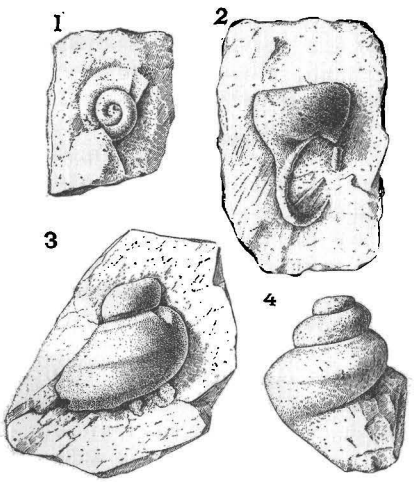
If we now turn to the geologic map, we find that all the localities I have mentioned are on the line of outcrop of the quartzite (Terr. No. 1).

Résumé.—The stratigraphy shows the quartzite series (Terr. No. 1) to be the oldest of the Paleozoic sediments known on the eastern side of the Taconic area, and the contained fauna correlates it with the middle division of the Cambrian, but not as low in position as the fauna of the lower strata of the Georgia Terrane. (See Terr. No. 5.)

Terrane No. 2.—Dr. Emmons, when describing the sections of Graylock (Am. Geol., vol. i, pt. 2, p. 17, paragraph 16), states that the "rock overlying the quartzite is again talcose slate, siliceous at its base, but purely a talcose slate as a mass and which requires no further description. It is between 400 and 500 feet thick and extends up the limestone which constitutes the seventh member of the Lower Taconic system." It is this belt of shales that I have numbered 2 on the sections: and it is assumed to represent, at this point, the Potsdam sandstone of the western side of the Champlain basin. This ter

rane is so much more extensively developed farther west, in the section, that I will omit its description until passing down the western side of the synclinal formed by terrane number three. (See Section on the map.)

Terrane No. 3.—This is the limestone and marble belt that outcrops both on the eastern and western side of the Taconic range. Its distribution is shown on the map and in the section, and I think it unnecessary to restate the evidence given by Professor Dana to prove that this limestone belt is the representative of the limestones of the Trenton-Chazy-Calciferous series of the western side of the Champlain basin. His conclusions are based on the stratigraphy, supported by paleontologic evidence,* discovered by Messrs. Wing, Dana and Dwight on the western side of the Taconic range, north and south of the typical area. The fossils have been referred, however, to the sparry limestone or "Upper Taconic" by those writers who favor the view of the pre-Cambrian age of the "Lower Taconic." Prior to August 5th, 1887, determinable fossils had not been found in the limestone series *east* of the Taconic range. At that date, I found, in the eastern limestone, in the town of Pownal, Vt., about half a mile north of the Massachusetts line, a number of fossils that were weathered out in relief on the surface of a compact, clouded marble. The collection gives Euomphalus? (fig. 1); the lower whorl and aperture of a shell like *Murchisonia bellicincta* (fig. 2); two whorls of a form identical or closely allied to *Murchisonia Milleri* (fig. 3). (fig. 4 is a cast of *Murchisonia Milleri*, from the Cincinnati formation, for comparison with fig. 3): a cross-section and lower whorl of a Raphistoma-like shell, and a large, crushed gasteropod shell. The fauna belongs to the Trenton terrane, and, by it, we can correlate the Eastern with the Western limestone.†



In September, 1887, I found fossils in the limestone on both

* See Professor Dana's papers in Am. Jour. Sci., 1872 to 1887.

† Paper read before the American Association for the Advancement of Science, August, 15th, 1887: "Discovery of Fossils in the Lower Taconic of Emmons."—C. D. W.

the eastern and western side of Mt. Anthony, on the line of strike of the Taconic range. The strata of Mt. Anthony are conformable and form a southwardly-sloping synclinal of limestone and marble, carrying, above, a considerable thickness of shales. On the west side the limestones dip eastward and are well exposed one mile south of the Hoosic post office, N. Y. About 400 feet of limestone are shown in the section, and, near the upper part of it, shales appear which have a schistose structure. The shales are in thin beds alternating with the limestones at first, and then they increase until the interbedded limestone disappears and the typical Taconic "talcose slates" of Emmons are the prevailing rock. In the limestones, nearly 200 feet below the shales, a stratum of limestone from two to four feet in thickness is crowded with shells of the genera Maclurea and Murchisonia. The limestone is compact and hard, so that sections only of the shells could be secured. To any one conversant with the Trenton-Chazy limestones of Washington County, N. Y., both the lithology and fossils of the Mt. Anthony limestone, at this point, would prove the geologic horizon to be that of the Trenton-Chazy. Crossing the mountain to the eastern side, at a point three miles south of Bennington Centre, Vt., abundant fragments of crinoids occur in a dark bituminous limestone, above a band of clouded marble. In fig. 5, a few sections of a column is shown and also the calyx and portions of the arms of a crinoid, allied to *Homocrinus gracilis* of the Trenton limestone of New York. Above the dark shale and dipping westward with it, there is a band of arenaceous limestone upon which I noticed a fragment of an Orthoceras, an Euomphalus-like shell and sections of what appeared to be a Rhynchonella. This limestone is lithologically similar to that conformably overlying a bed of marble that dips toward and passes beneath Mt. Anthony at a quarry, two miles west of Bennington Centre.

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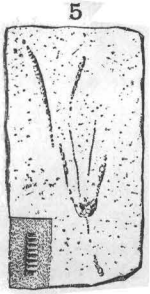

I next visited the limestone at the entrance of the Hopper on the north side of Graylock peak, a typical locality of Dr. Emmons's. The limestones and marbles are of the same lithologic character as those of Mt. Anthony with the exception of the bituminous limestone, carrying the crinoids. Several traces of fossils were observed, but only one that could be recognized. It appears to be the inner whorl of a gasteropod related to Euomphalus or Maclurea (fig. 6).

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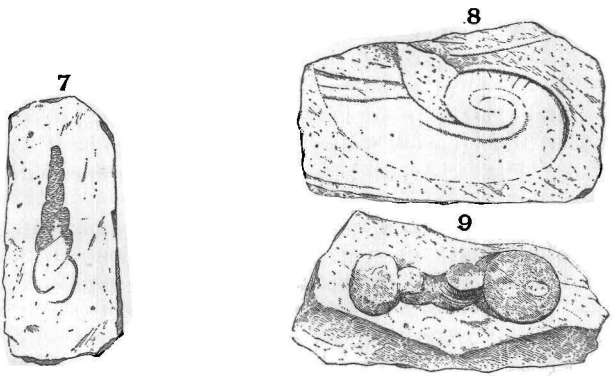
Having verified the stratigraphy as published by Dr. Emmons and Professor Dana, and having found Trenton-Chazy fossils in the marble belt, I crossed the Taconic range to its

western base, in the town of Berlin, N. Y. The schists of the range dip to the eastward, have a greenish color, feel talcose to the touch, and appear unlike the dark shales of the Hudson Terrane. Continuing on over the range and down the western slope, I found that the schistose character of the rock was gradually disappearing and that it was becoming more shaly. The greenish color continued, but, toward the western base of the range, a mile north of the village of Berlin, the color began to change, the green and dark shales appearing in the same stratum, and even in hand specimens, and soon the dark shale of the Hudson Terrane was the prevailing rock. A little lower down, the characteristic brown sandstones of the Hudson Terrane began to appear in the shales; and, just east of Berlin village, the limestones appeared from beneath the shales. In other words, it is a repetition of the Graylock and Mt. Anthony sections with the exception of less alteration in the lower part of the shales, and in the limestones. One mile south of South Berlin post office, on the eastern side of the valley, the limestones dip to the east and northeast. At the base of the section there is a considerable thickness of dark argillaceous shale, upon which the limestone rests conformably. Continuing up the west slope of the mountain, more or less impure limestones are met with in which I found *Solenopora compacta*, plates of crinoidal columns, *Murchisonia gracilis?* (fig. 7), and fragments of indeterminable gasteropods. The



Lituites sp?

fossil-bearing limestone is subjacent to, and interbedded with, shales that are succeeded by arenaceous limestones which, in turn, are conformably subjacent to the shales and schists of the Taconic range.

The next locality examined was one described by Dr. Emmons as showing fossiliferous limestones of the Champlain series, resting unconformably upon the "Taconic" schists (Am.

Geol., pt. 2, pp. 73–77, 1856). He studied the section, where it is very much broken and disturbed, and found evidence that sustained his view. If he had gone a mile to the north, he might have discovered that the shales pass conformably beneath the limestone and, also, that shales occur conformably above it. Fossils were abundant at a point one mile north, northwest of Hoosick Falls, and the following species were recognized: *Solenopora compacta*, *Maclurea* sp.?, *Lituites* sp.? (figs. 8 and 9), and *Orthoceras* sp. undet.

On the map the localities, where fossils have been found in this terrane, are indicated by the letter F.

Résumé.—The stratigraphic and paleontologic evidence unite to prove that the limestones and marbles of Terrane No. 3 are the geologic equivalent of the Calciferous-Chazy-Trenton limestones of the Champlain and Hudson valleys, and belong to the system of strata characterized by the second fauna of Barrande.

Terrane No. 4.—This terrane directly overlies and rests in synclinals of the limestones of Terrane No. 3, at Graylock and at other points; and there is no apparent reason to differ from Professor Dana in referring it to the Hudson Terrane.

In regard to the graptolites found in it, near Hoosick, N. Y., I wish to state that I visited that locality and collected specimens of the flattened and distorted graptolites from the smooth shales. On comparing the specimens with those of *Diplograptus pristis*, from the Hudson Terrane, at Fort Edward, N. Y. and, also, from the Hudson Terrane in the western part of the township of Greenwich, Washington County, N. Y., I fully concur with the opinion given by Professsor James Hall, in 1847 (Pal. N. Y., vol. i, pp. 321, 322, pl. 72), that the Hoosick shale graptolite is identical with the *Diplograptus pristis* found in the Hudson Terrane, within the Hudson valley.

Terrane No. 2.—In speaking of this terrane as the shale above the quartzite of Terrane No. 1 and beneath the limestone of Terrane No. 3, it was assumed that it represented the Potsdam horizon (*ante*); and we now have to search for the evidence of that horizon between the recognized Georgia horizon of Terrane No. 1, and the Chazy-Trenton horizon of Terrane No. 3. Unfortunately, on the east and west sides of the synclinal, on the line of the section, the shales beneath the limestones are unfossiliferous; but, from the data afforded by the Potsdam or Upper Cambrian strata of Saratoga, Dutchess and Washington counties, N. Y., we obtain a fairly satisfactory identification of the Potsdam horizon in the Taconic area.

In Saratoga County a section occurs where a pure limestone, carrying a well-marked Potsdam fauna, rests directly on a mas-

sive-bedded sandstone.* The sandstone is of Potsdam age, and contains typical fossils in its extension north in the valley of Lake Champlain: in Washington County I found, at Dewey's Bridge, south of Whitehall, fossils in the Potsdam sandstone, and at Whitehall, numerous Potsdam fossils in the limestone layers resting upon the sandstone and beneath the Calciferous formation. The Calciferous formation was subjacent to the Chazy limestone.

In Dutchess County Professor Dwight found the Potsdam fauna in a limestone, three species of which are identical with those at the Saratoga and Washington County localities. This proves the presence of the Potsdam fauna in Dutchess County, not far distant from the sandstone and limestone carrying the Georgia fauna. Although no direct stratigraphic connection is yet known at this point between the limestone carrying the Potsdam fossils, and the limestone resting on the the sandstone carrying the Georgia fossils, there is little doubt, from the known succession of faunas elsewhere, that the Potsdam formation was deposited in its usual position, between the Georgia and Calciferous formations, and that it has been displaced by the subsequent faulting of the strata.

In Saratoga County, the Calciferous-Trenton terranes are superjacent to the Potsdam, and, also, in Dutchess and Washington counties. In all the sections given in Bulletin 30, U. S. Geological Survey, the Potsdam is superjacent to the Georgia Terrane; and I find that Terrane No. 5, beneath the 2,000 feet of greenish schistose shales of Terrane No. 2, is characterized by the Georgia or Middle Cambrian fauna. I think, then, that we may conclude that Terrane No. 2 represents the Potsdam horizon: also, that the latter may be represented in part by sandstone or quartzite on the west side, near the limestones, or, if the same conditions prevail as in Dutchess County, the lower portion of the limestone; the shales and schists beneath the limestone all belong to the Middle Cambrian. To the east of the limestone, the Potsdam Terrane may be represented in part by either (1) the upper part of the quartzite of Terrane No. 1, (2) the lower part of the limestone of Terrane No. 3, or (3) the hydromica shale between the quartzite and limestone, or Terrane No. 2, or by the combination of two or more of these parts.

Terrane No. 5.—In my field work of 1886–'87, I studied with care the slates, shales and interbedded limestones and sandstones that form Terrane No. 5. On the map an interruption is shown midway, by the presence of a broad belt of

* Bull. U. S. Geol. Survey, No. 30, pp. 21, 22, 1886.—I found several species of this same fauna (Dicellocephalus, Ptychaspis, etc.) in sandstone in the upper beds of the Potsdam sandstone, in the vicinity of Chateaugay Chasm, Franklin County, N. Y.; also in a calciferous sandrock of the Potsdam Terrane, at Whitehall, N. Y.

the Hudson Terrane (No. 6), but I did not find that the two parts of Terrane No. 5 are a repetition of the same strata except possibly for a short distance, near the break between them. The upper or eastern portion is formed of green, purple and drab slates, with thin interbedded limestones, carrying characteristic Middle Cambrian fossils; the lower and western part consists of dark and drab shales with interbedded sandstones, calcareous sandrock and limestones that contain Middle Cambrian fossils. About 2,000 feet from the base, the fauna begins to show the presence of the Lower Cambrian or Paradoxides fauna, but not in sufficient force to overbalance the predominating assemblage of Middle Cambrian species.—(See this Journal, vol. xxxiv, p. 188, 1887). Fossils occur more or less abundantly at over 100 localities as now known to me within the typical Taconic area, and they are distributed at various horizons throughout the 14,000 feet or more of strata referred to this Terrane.

An examination of the sections and the faunas of Terrane No. 1 and Terrane No. 5, shows that the former is stratigraphically and faunally the equivalent of the upper or eastern part of Terrane No. 5, Terrane No. 1 being the sandy deposit of the shore line, and No. 5, the off-shore accumulation of finer sediment.

Terrane No. 5, like No. 1, is referred to the Middle Division of the Cambrian.

Terrane No. 6.—This is a belt of red, black and green slates, cherts and sandstones faulted in between the two parts of Terrane No. 5. The contained graptolites show it to be a portion of the Hudson Terrane. Its distribution and relation to the other terranes is shown on the map and in the section.

Résumé.—I have briefly noticed the strata included within the Taconic area with the exception of the beds west of the great fault line, separating Terrane No. 5 from the recognized strata of the Calciferous-Chazy-Trenton and Hudson terranes. Along the line of the fault, the strata of Terrane No. 5 are usually thrust against, and, sometimes, over and upon, the latter, but in no instance have I been able to find an unconformity by original deposition between the strata of Terrane No. 5 and the strata of any of the superjacent terranes. This will be more fully described later under the head of Comparison and Discussion.

In the preceding pages, the strata of the Taconic area are grouped under six terranes and identified as follows.

Terranes Nos. 1 and 5=Middle Cambrian.*

Terrane No. 2=Upper Cambrian.*

Terrane No. 3=Calciferous, Chazy and Trenton limestones.

Terranes Nos. 4, and 6=Hudson shales, sandstones, etc.

[To be continued.]

* For a description of the term Cambrian as used in this paper see this Journal, III, vol. xxxii, pp. 138–157, 1886.

[From the American Journal of Science, Vol. XXXV, April, 1888.]

ART. XXVI.—*The Taconic System of Emmons, and the use of the name Taconic in Geologic nomenclature;* by CHAS. D. WALCOTT, of the U. S. Geological Survey. With Plate III.

(Continued from page 242.)

GEOLOGY OF THE TACONIC AREA AS KNOWN TO DR. EMMONS.

(1). The strata referred to the "Taconic System;" (2). The stratigraphic position of the "Taconic System."

Dr. Emmons began the study of the Taconic area in Berkshire County, Mass., and from there extended his investigations, to the north, into Bennington County, Vt., and to the west, into Washington and Rensselaer counties, N. Y.† In 1842,‡

* Ch. News, x, 263, 1864. Phil. Mag., IV, xxix, 475.

† "My first business is to sketch a picture of the oldest of the sediments, as they are exhibited in a series which collectively constitute the Taconic System and as it is developed in the Taconic ranges of Berkshire and the adjacent country immediately north and south." (Am. Geol., pt. 2, p. 5, 1856).

‡ Geol. N. Y., pt. 2, p. 144, 1842.

he proposed the Taconic System, with the statement that it was composed of five different rocks, as follows:

"1. A coarse granular limestone of various colors which I have denominated *Stockbridge limestone*," etc.

"2. *Granular quartz* rock, generally fine-grained, in firm, tough, crystalline masses of a brown color, but sometimes white, granular and friable."

"3. *Slate*, which for distinction I have denominated *Magnesian slate*," etc.

"4. *Sparry limestone*, generally known as the sparry lime-rock."

"5. A slate, which I have named *Taconic Slate*, and which is found at the western base of the Taconic range. It lies adjacent to the Lorraine or Hudson River shales, some varieties of which it resembles," etc.

A section is given on page 145, fig. 46, to show that the "Taconic System" embraced all the strata between the gneiss on the east and the "shales of the Champlain group" on the west. The latter are represented as unconformably superjacent to the "Taconic slate."

His second memoir appeared in 1844* as a pamphlet, published in advance of vol. i, of the Agriculture of New York, in which, in 1847, the subject matter was reprinted without change. The changes from the stratigraphic scheme of 1842 consist in placing the granular quartz at the base of the system, with the Stockbridge limestone conformably resting upon it. A theoretical section† is given to show the relation of the various formations. The crystalline gneiss is represented with (1), the Granular Quartz or brown sandstone resting upon it; then, in turn (2), the Stockbridge limestone; (3), Magnesian slate; (4), Sparry limestone; (5), Roofing slate; (6), coarse brecciated bed; (7), Taconic slate, and (8), Black slate. On the following page, the section shown by fig. 7 represents these beds as all having a high and uniform dip to the eastward,‡ and with the Hudson river shales (9), unconformably superjacent to the Taconic slate (8).

When speaking of the lithologic characters of the system, Dr. Emmons says: "Taking one broad view of the whole system, it may be described as consisting of fine and coarse slates,

* Agric. N. Y., vol. i, pp. 45-112, 1847. The pamphlet of 1844 is very rare, as few copies were issued, and I shall make all references to its contents as reprinted in the volume of 1847, combining the dates as 1844–'47.

† Loc. cit., p. 62, fig. 6.

‡ This is corrected for the "Lower Taconic" rocks in the Section published in 1856 (Am. Geol., vol. i, pt. 2, p. 19), but all the strata of the "Upper Taconic" are considered superior to the Stockbridge limestone.

with subordinate beds of chert, fine and coarse limestone, and gray, brown and white sandstone.*

The geological map, prepared to accompany the memoir of 1844–'47, bears the date of 1844 and is a reprint of the Geological Map of New York, issued in 1842, with additional data on the geology east of the Hudson and Champlain valleys. The long, narrow range of the "Taconic System" is colored drab in its extension from Canada to Westchester County, N. Y. There is no reference to the "Taconic System" in the legend on the map, and the formations composing it are not distinguished by different colors, the reason for which is explained in the description of the map, published on page 361 of the Agriculture of New York, vol i, 1847.†

In 1856,‡ Dr. Emmons divided the "Taconic System" into an upper and a lower division: the upper division taking the formations 4 to 8 of the section of 1844–'47, and the lower division the formations 1 to 3; an arrangement that was repeated in 1859 (Manual of Geology), when the name "Magnesian slate" was replaced by that of "Talcose slate." In the diagram, fig. 10, the formations are represented in the order of succession given in 1856; and, on the map, the geographic area is given within which the typical localities of the various formations occur and also the extension of the latter to the north and south. This is the stratigraphic scheme of the "Taconic System" as arranged by its author from the results of his latest field observations.§

"*Granular Quartz*" (Terrane No. 1, of section on side of map and fig. 10).—Dr. Emmons calls the "Granular Quartz" the basal member of the "Taconic System," and, in his opinion, the base of the Paleozoic sediments on the North American continent. He describes its occurrence in Vermont and follows it, with interruptions, across Massachusetts into the northeastern part of Dutchess County, N. Y., and also south into Putnam and Westchester counties.‖ The stratigraphic

* Loc. cit., p. 61.

† The copy I have of this map was purchased by me from a second-hand book dealer, in 1876. I have reason to state that 3000 copies were originally delivered to the Secretary of State, of the State of New York, by the printers, and I think that copies can still be obtained from the said Secretary's office, despite the published statement that the edition was stolen or destroyed. (See letter of Dr. Emmons to Prof. Jules Marcou: Am. Acad. Arts and Sci., vol. xii, p. 188, 1885, also copied by Dr. Hunt, Am. Nat., vol. xxi, p. 122, foot note 3, 1887).

‡ The first part of this volume is dated 1855. The second part, containing the description of the "Taconic System," was issued in 1856.

§ I shall not comment on the so-called Taconic rocks, as identified by Dr. Emmons in Canada, Maine, Rhode Island, Michigan, and the southern Appalachian region. All those determinations rested on lithologic characters; and the strata referred by him to the "Taconic System" range from pre-Cambrian to the Niagara of the Silurian.

‖ Agric. N. Y., vol. i, p. 86, 1847.

position was determined by its relation to the crystalline rocks beneath and the superjacent strata, as no fossils were known by him from the formation. A talcose conglomerate that is treated as a subordinate member of the "Granular Quartz series" is described as occurring between the quartzite and Primary, in several localities.

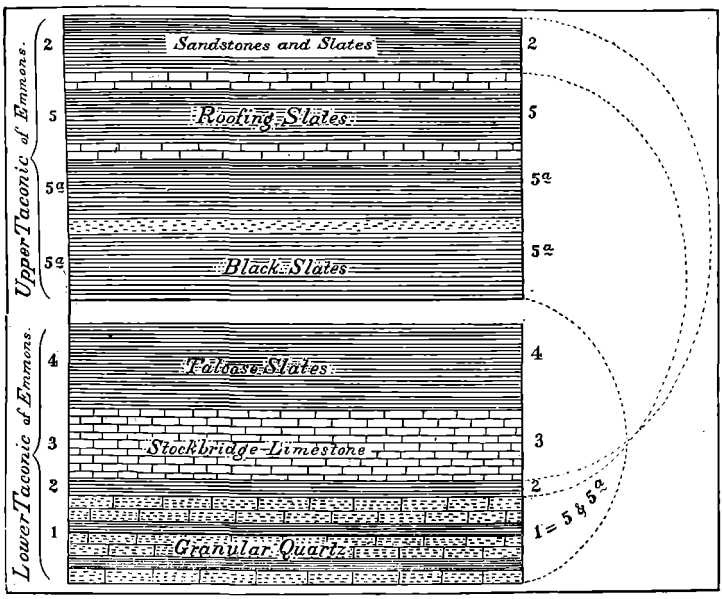


Fig. 10.—A tabular view of the strata as arranged by Dr. Emmons.
The figures placed at the sides are equivalent to those used on the section on the side of the map. The dotted lines on the right side show the relation of the "Upper Taconic" to its geologic equivalent the "Granular Quartz."

Conformably resting on the "Granular Quartz," on the north side of Graylock Peak, at the Hopper, he found a bed of "talcose slate," 400 to 500 feet thick, which is represented in the table (fig. 10) by number 2. It appears to be the extension of a formation of more than 2,000 feet in thickness that occurs on the western side of the Taconic range. (See section on the map.)

Stockbridge limestone (Terr. No. 3 of Section and fig. 10).—Upon the slates of Terrane No. 2 a series of limestones and marbles are conformably superimposed that are called by Dr. Emmons the "Stockbridge limestone." This includes all the limestones, "good and bad, in connection with the bed known as marble." A good description of this terrane is given in the memoir of 1844–'47, and again in 1856. It is assigned a thickness of 500 feet, in Saddle Mountain, Mass.

Talcose Slates (Terr. No. 4 of Section and fig. 10). — These slates, which are called "Magnesian slates" in the reports of 1842–'44–'47, were given the name "Talcose slates" in 1856. A thickness of 2000 feet is assigned to them on the Taconic range and they are represented as conformably superimposed upon the Stockbridge limestone.

"*Upper Taconic.*"—In the scheme published in 1844–'47 the Magnesian slate is succeeded by the Sparry limestone, Roofing slate, a coarse brecciated bed, Taconic slate, and Black slate, and on p. 13, Am. Geol., pt. 2, 1856, this succession is recognized. On page 49 (loc. cit.), however, the entire scheme is changed; the Black slate is placed at the bottom of the series and then, in succession, siliceous slates: slates and sandstones, with thin-bedded blue limestones succeeded by thicker beds of sandstone; blue, green, purple and red roofing slates, coarse sandstone and shale passing into conglomerates and brecciated conglomerates. "The latter terminate the series eastward, and geographically near the Hoosick roofing slates. In the foregoing brief enumeration in the ascending order, the rocks follow each other in a conformable position, and beginning with the thin black slates, end in thick bedded sandstones and conglomerates," (loc. cit., p. 50).

In this re-definition of the "Upper Taconic," the Sparry limestone is no longer considered as belonging to it, and I have failed to find it mentioned subsequently as a distinct formation of the "Upper Taconic." The sparry limestone spoken of in describing the "Upper Taconic" section crossing Washington County, refers to the thin interbedded sparry limestones, in which I have found Olenellus and other Middle Cambrian fossils. The sparry limestones west of Hoosick Falls are referred to the Lower Silurian and removed entirely from the "Taconic System."

As is shown by Professor Dana, Dr. Emmons, in 1842, called the Sparry limestone the oldest of the Taconic limestones, and, in 1844, he placed it beneath the Taconic slate and above the Stockbridge limestone.* In 1856,† however, a section was published showing the Taconic Range by C and, at its western base, the limestone (2) is identified with the Stockbridge limestone (2), of B (Graylock Peak). What Dr. Emmons intended by this, and why he did not mention the change in the text, is not explained by him. Professor Dana called my attention to it by letter, and says that he accepts the evident meaning given by the section, which is, that Dr. Emmons identified the Sparry and Stockbridge limestones as one formation. With our present knowledge, this explanation is the only one open to us.

* This Journal, III, vol. xxxiii, pp. 415, 416, 1887.
† Am. Geol., vol. i, pt. 11, p. 19, fig. 2.

In 1859 the section is republished,* but the numbers are omitted from all the formations except those of Graylock Peak. Whether the omission was by design or accident is unknown.

In the black slates, at the summit of the "Taconic System" of 1844–'47 and at the base of the "Upper Taconic" of 1856, Dr. Asa Fitch found a few fossils which he gave to Dr. Emmons, who described two species in the memoir of 1844–'47, under the names of *Elliptocephala asaphoides* and *Atops trilineatus*. In 1859 Dr. Emmons compared these fossils with the Primordial fauna of Barrande, and established their position in the stratigraphic series on paleontologic evidence.† Their reference to a pre-Potsdam horizon, in 1844–'47 and 1856, was on the supposed stratigraphic position of the beds in which they occurred.

Résumé.—It is not necessary to repeat the full and accurate lithologic descriptions of the five terranes (fig. 10) mentioned by Dr. Emmons in 1844–'47 and 1856. They are grouped in fig. 10 to represent his view of their succession within the "Taconic System."

2. *Stratigraphic position of the "Taconic System."*—Dr. Emmons founded the "Taconic System" under the belief that it was composed of older formations than those of the New York Lower Silurian, the base of which was then the well-known Potsdam sandstone. In the memoir of 1842, he says: "But I have, at the head of this section, asserted that the slates and masses of the Taconic System are not related to, or connected with those of the Champlain group. By this I mean that they are not the same rocks in another condition."‡ Again he says: "They are to be considered, however, as furnishing us with a knowledge of that state which immediately preceded the existence of organic beings."§ After further field study his views became more positive in regard to the relation of the Taconic to the Lower Silurian rocks. He says: "I shall take the broad and distinct ground that the Taconic System occupies a position inferior to the Champlain division of the New York system, or the Lower division of the Silurian system of Mr. Murchison."‖

"1. *Position.*—It rests unconformably upon primary schists, and passes beneath the New York system, the oldest and inferior members of the latter being superimposed unconformably upon the Taconic slate."¶ These views were sustained in his publications of 1856, 1859 and 1860.

On the section, accompanying the memoir of 1844–'47, pl. 18, Section I, the strata of the "Taconic System" all dip con-

* Manual of Geology, p. 85, fig. 60.
‡ Geol. N. Y., pt. 2, p. 138, 1842.
‖ Agric N. Y., vol. i, p. 55, 1847.
† Manual of Geology, p. 87, 1859.
§ Loc. cit., p. 164.
¶ Loc. cit., p. 108.

formably to the eastward. On the east they rest unconformably on the primary and, on the west, the Calciferous and Hudson terranes are represented as unconformably superjacent to the Taconic slates. Dr. Emmons says: "This section may be regarded as one of the best for exhibiting and proving the entire independence of the Taconic System from the Primary below and the New York system above." *

Two sections published in 1859 † may be taken as expressing his latest views of the relations of the different parts of the "Taconic System," in its typical area, with the exception of the "Upper Taconic" and the Lower Silurian (Ordovician), on the western side. In these sections, the "Lower Taconic" forms a synclinal with the "Granular Quartz" at the base and then the Stockbridge limestone and Talcose slates, respectively superjacent, the "Upper Taconic" being entirely disconnected from the latter. He held the view, from the first, that the eastward dip of the greater part of the strata of the "Taconic System" resulted from successive uplifts, "which, in consequence of the confined position of the rocks, have often produced local foldings and plications of the strata." ‡ His view of the extent and character of the uplifts was subsequently changed, as is shown by his representation of the position of the sparry limestone in 1842,§ 1844§ and 1855.

In the memoir of 1856 several sections were illustrated and described to show the unconformity between the Taconic slate and the Calciferous sandrock, and thus establish the inferior position of the "Taconic System" to the Lower Silurian (Ordovician) strata. These sections will be spoken of again, under the head of "Discussion and Comparison."

Dr. Emmons correlated the "Taconic System" with the Cambrian system of Sedgwick, in his first memoir of 1842, in the following words: ‖ "The Taconic rocks appear to be equivalent to the Lower Cambrian of Prof. Sedgwick, and are alone entitled to the consideration of belonging to this system, the upper portion [of the Cambrian—C. D. W.] being the lower part of the Silurian System." ¶

Again, in the memoir of 1844–'47, he says, when speaking of the proposed abandonment of the Cambrian System by English geologists: ". . . . were it not for a single fact, the

* Loc. cit., p. 366.

† Manual of Geology, p. 85, figs. 58 and 60.

‡ Geol. N. Y., pt. 2, p. 142, 1842.

§ See Professor Dana, this Journal, 3d Ser., vol. xxxiii, p. 415.

‖ Geol. N. Y., pt. 1, p. 163, 1842.

¶ Dr. T. S. Hunt (Am. Nat., vol. xxi, p. 124, 1887) interprets this passage to prove that Dr. Emmons in 1842 correlated the upper portion of the Taconic with the Lower Silurian of Murchison, but, as I read it, Dr. Emmons refers the Upper Cambrian, not his Taconic, to the Lower Silurian.

writer would freely acquiesce in the decision, so far as the British rocks are concerned. This fact is found in the existence of peculiar fossils on both sides of the Atlantic, which, so far as discoveries have been made, are confined to the slates of the Cambrian and Taconic systems; and now the great object of the writer is to show that the above question has not been settled right, or according to the facts; or, in other words that the Taconic rocks are not the Hudson River slates and shales in an altered state, or that all the Cambrian rocks are not Lower Silurian." *

In the following pages observations and deductions therefrom are given to support the above statement in relation to the "Taconic System," but nothing further is said of the fossils from the Cambrian system, and I am at a loss to know to what species the author referred. Reference is made to the Cambrian sections of Sedgwick, in 1856, to show that although the Cambrian slates are conformably beneath the Coniston limestone bearing Lower Silurian fossils, and hence may be referred to the Silurian, the Taconic rocks are unconformably beneath the equivalent Calciferous sandrock of the New York series and cannot be included with the Lower Silurian.†

Among the letters of Dr. Emmons, published by Prof. Jules Marcou,‡ is one, dated November 19, 1860, in which he says:§

". . . . I do not think him [referring to Barrande] right in maintaining that his Primordial group is a part or parcel of the Silurian: . . . . the Lower Silurian is strictly unconformable to every part of my Taconic series, and this series is . . . . separate and distinct from Silurian."

On the same page, in a letter dated November 20th, 1860, he says: "On reading his [Barrande's] papers, I found that, after all, his Primordial group is *only Lower Silurian*. I conceive we have exactly his *Primordial group* in the band of slates containing the *Paradoxides*. But this band is only a very narrow belt of beds."

In a letter dated December 28th, or 29th,‖ he says, when speaking of the announcement of the *Huronian* System by Logan: "I claimed that the *Huronian* was the *Taconic* System . . . Are you aware that most, if not all, of those beautiful graptolites Mr. Hall refers to the Hudson River group belong to the Taconic System?"

Again, in a letter dated January 23d, 1861:¶ "The acknowledgment of the *Primordial of Barrande in this country* is really one of the finest and best facts in geology, making a *coördination of American and European rocks so complete and harmonious.*"

* Agric. N. Y., vol. i, p. 49, 1847.
† Am. Geol., vol. i, pt. 2, p. 90, 1856.
‡ Proc. Am. Acad. Arts and Sci., vol. xii, 1885.
§ Loc. cit., p. 186.
‖ Loc. cit., p. 188.
¶ Loc. cit., p. 190.

In commenting upon Professor Marcou's reference of the Potsdam sandstone to the "Taconic System," he objects to such references on stratigraphic grounds, as is shown by his letter of January 28th, 1861.

These later letters of Dr. Emmons prove that he considered the "Taconic System" to include the Huronian of Logan and the graptolite-bearing shales of the Hudson valley, from his letter of November 20th, 1860, he also included the Paradoxides beds of the "Upper Taconic" which equal the Primordial group of Barrande, which "is *only* Lower Silurian," and declared that "the Lower Silurian is strictly unconformable to every part of my Taconic series."

Despite the statements made in the preceding paragraph, I think we may say that Dr. Emmons regarded the original "Taconic System" as stratigraphically unconformable and subjacent to the Potsdam sandstone of the Lower Silurian of the New York section and believed it to rest unconformably upon the crystalline gneiss at its base and to form a great system of sedimentary rocks between the gneiss and Potsdam sandstone.

Comparison and Discussion.

Comparison.—A comparison of the geology of the Taconic area as known at the present time with the geology of the same area as known to Dr. Emmons develops several points of agreement. His lithologic descriptions are usually easily verified; and the general dip and arrangement of the strata within the "Taconic System" are the same with the exception of the relations of the strata referred to the "Lower" and "Upper Taconic."

The points of disagreement are: the identification of the geologic age of the formations of the "Lower Taconic;" the stratigraphic relations of the "Lower" and "Upper Taconic;" the stratigraphic relations of the "Upper Taconic" and the superjacent Silurian formations, and the value of the stratigraphic and paleontologic identifications of the age of the "Upper Taconic" slates.

1. Dr. Emmons considered the "Lower Taconic" to be composed of three non-fossiliferous pre-Silurian formations—"Granular quartz, Stockbridge limestone and Talcose slates" (see fig. 10) that were unconformably superjacent to the crystalline gneisses beneath and conformably subjacent to a great series of slates, forming the "Upper Taconic," that, in turn, were unconformably subjacent to the lowest of the Lower Silurian formations, the Potsdam sandstone.

We now know that the base of the "Taconic System," the "Granular Quartz," contains fossils that prove it to be the geologic equivalent of the greater portion of the "Upper Ta-

conic;" also, that it is the arenaceous deposit that accumulated along the pre-Paleozoic shore while the siliceous, argillaceous and calcareous muds, now forming the "Upper Taconic," were being deposited to a greater depth off the immediate shore line. This entirely negatives the conclusion of Dr. Emmons, that the "Upper Taconic" slates were superjacent to the "Lower Taconic" rocks.

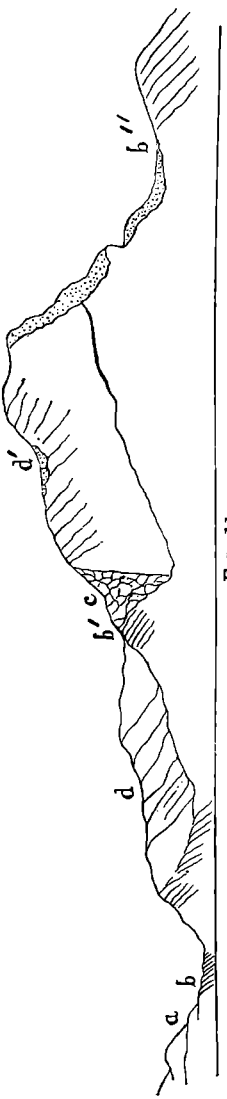


FIG. 11.

2. The second formation, the "Stockbridge limestone," has afforded fossils that prove it to be the equivalent of the Trenton, Chazy and Calciferous limestones of the Lower Silurian of the New York section, and it is not, as claimed by Dr. Emmons, a peculiar pre-Silurian deposit of limestone.

3. Conformably resting upon the "Stockbridge limestone" the "Talcose slates" (Terr. No. 4) occupy the stratigraphic position of the Hudson Terrane, in the New York section, and a species of graptolite, abundant in the Hudson Terrane, occurs in the "Talcose slates" near Hoosick, N. Y.

We have next to consider the relations of the "Upper Taconic" slates to the superjacent Silurian formations and the value of the stratigraphic and paleontologic identifications of the age of the "Upper Taconic."

In the first published section* of the "Taconic System," the "Shales of the Champlain Group" are represented as resting unconformably against, and on, the Taconic slates. This is repeated in the section published in 1844–47.† These two sections are largely theoretic, but, on page 89 (loc. cit.), Dr. Emmons gives a section of Bald Mountain, in the town of Greenwich, Washington County, N. Y., which is here reproduced (fig. 11).

This section is intended to show the unconformity between the Taconic slates, *b*, *b'*, *b''*, and the Calciferous formations, *d*, *c* and *d'*, it being assumed by Dr. Emmons that the slates, *b*, *b'* and *b''*,

* Geol. N. Y.; Rep. Second Geol. Dist., p. 145, fig. 46, 1842.
† Agric. N. Y., vol. i, p. 63, fig. 7, 1847.

were identical, and that *d'* was a mass of the Calciferous sandrock of the New York section, and, also, the mass represented by *c*. I began the investigation of this section, in 1887, by searching for fossils in the various formations, and then studied its stratigraphy. The result is given in the section represented by fig. 12. I found that the blue limestone, *c*, of figs. 11 and 12, extends beneath the shales and limestones capping the mountain and that it is interbedded in the shales and considerably broken and displaced on the south edge of the mountain, toward the fault line, as shown in fig. 12. *Leperditia fabulites* was found in it, on both the west and south side of the mountain. The true *Calciferous sandrock*, of the New York section, is shown at E, interbedded in the shales, S and X. In the limestones, *d*, forming the summit of the mountain, in fig. 11, I found *Lingulella cælata*, *Linnarssonia Taconica*, *Obolella* sp. undet., *Hyolithellus micans*, *Microdiscus speciosus* and *Olenellus Thompsoni:* all of which are Middle Cambrian species and characteristic of the slates, *b''*, in fig. 11, east of the mountain. Dr. Emmons identified this mass of strata, *d'*, with the Calciferous sandrock on lithologic characters, overlooking the fact that a similar rock might occur in his Taconic series. Two miles to the north, on the farm of D. Walker Reid, this belt of calciferous rock is over 600 feet thick, it contains a characteristic Middle Cambrian fossil, *Hyolithellus micans*, and is conformably subjacent and superjacent to shales and limestones, containing over fifteen characteristic species of Middle Cambrian fossils.

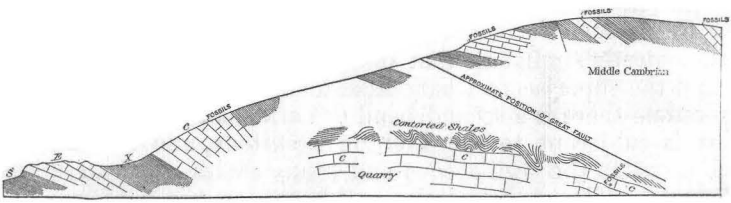


FIGURE 12.—Section of Bald Mountain from the south. The profile of the mountain and position of the Cambrian and Lower Silurian rocks are taken from a photograph. The "Upper Taconic"=Cambrian slate, sandrock and limestone are shown to the right of the fault, and *c*=Chazy limestone; *x*=dark shales, interbedded between *c* and the Calciferous sandrock, E; *s*=dark argillaceous shales beneath the Calciferous sandrock.

The section of Bald Mountain proves that the strata of the "Upper Taconic" are there pushed over on to the Chazy Terrane, and that the "Upper Taconic" is not unconformably subjacent to the latter or to the Calciferous sandrock.

To the north of Bald Mountain, about two miles, a somewhat similar mass of limestone to that of *c* is adjacent to the fault

line and contains: *Orthis testudinaria*, *Strophodonta alternata*, Maclurea and other gasteropods, *Calymene senaria* and fragments of *Asaphus platycephalus*. Details of all the exposures observed where the "Upper Taconic" shales and the rocks of the Lower Silurian come in contact will be given in a report on the geology of Washington and Rensselaer counties.

Another section,* taken by Dr. Emmons just east of the village of Whitehall, is reproduced in fig. 13. The object of this is to show the presence of a mass of calcareous sandrock, *d'*, resting unconformably upon the Taconic slate, which Dr. Emmons identified as the Calciferous formation of the Lower Silurian. I studied the section in 1886, also in 1887, and found Cambrian fossils, represented by the heads of the Olenellus and fragments of Ptychoparia, imbedded in the sandrock, *d'*, and also found the strike and dip of the sandrock and shales to

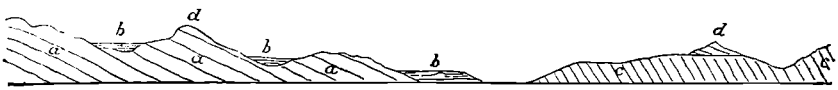


FIGURE 13, *a*, *a*.—Easterly prolongation of the mountain, which is surmounted by the Calciferous sandrock: *b b*, Tertiary clay; *c*, *c*, Taconic and black slate; *d*, *d*, Calciferous sandstone, unconformable to the Taconic slates, and dipping southeast at an angle of 40–45°. (After Emmons.)

be conformable. Another section on the same page† is entirely within the Champlain series on my map and west of the great fault line. It is 30 miles north of Bald Mountain and in the township of Whitehall. I found the Potsdam sandstone at its base, in the village of Whitehall, and then, superjacent to it, the Calciferous Terrane, with a band of dark argillaceous shale, lithologically similar to that of the Hudson Terrane, between it and the superjacent Chazy limestone. Resting on the Chazy limestone there is a second band of dark shales, 175 feet thick, that is subjacent to the Trenton limestone, and the latter is subjacent to the argillaceous and sandy shales of the Hudson Terrane. The strata of the entire section are conformable; and the limestones were identified by contained fossils. East of the shales of the Hudson Terrane, the existence of the great fault line is shown by the presence of strata, resting against, and on, the Hudson Terrane, that carry Middle Cambrian fossils. These interbedded shales, between the limestones, and, also, the Hudson shales, were considered, by Dr. Emmons, to be of Taconic age, and the limestone to lie unconformably above them.‡

* Agric. N. Y., vol i, p. 56, fig. 2, 1847. † Loc. cit., p. 56, fig. 3.

‡ One fact, not recognized by Dr. Emmons at Bald Mountain or along the great fault line, is that in many localities belts of dark argillaceous shale occur between the Calciferous, Chazy and Trenton limestones; that, in others, one or more of these formations is entirely a shale formation, and that the Potsdam Ter-

Another illustration of the supposed overlap of the Champlain upon the Taconic Terrane is given in the American Geology, pt. 2, p. 72, fig. 12. It is in the township of Greenbush, opposite Albany, N. Y., on Cantonment Hill. There a mass of the Trenton limestone is caught on the line of the great fault separating the Champlain and Cambrian strata, as at Bald Mountain and other places in Washington county, and, also, in Vermont. The strata of the Hudson and Trenton Terranes are broken and displaced, but there is no evidence that the Trenton was deposited upon the upturned edges of the Cambrian or "Upper Taconic" slate; and, on the line of the same fault, 20 miles to the south, in the township of Schodack, Mr. S. W. Ford discovered an unconformable contact between the dark-drab siliceous and micaceous shales of the Cambrian and the dark argillaceous shales of the Hudson Terrane.* Mr. Ford kindly took me to the locality which he has so well described, and I saw the "hade" of the fault, the slickensides on the opposing surfaces, and broke out graptolites from the Hudson shales beneath, and within six inches of, the fault line. A short distance south the limestones interbedded in the dark-drab shales gave us an abundance of characteristic Middle Cambrian fossils. For the details of this overthrust of the Cambrian upon the Hudson Terrane, see Mr. Ford's paper.

Dr. Emmons illustrates another section† that shows the same errors of observation as in the figure of the section at Cantonment Hill. Again, in fig. 22,‡ of the section at Snake Mountain, in Vermont, the error made at Bald Mountain is repeated, for it is now well known that the supposed overlying Calciferous (?) sandrock ("Red sandrock") is a stratum of the Cambrian pushed over on to the Lower Silurian Terrane,§ and not a Lower Silurian formation, unconformably superjacent to the "Upper Taconic" strata.

All the overlying limestones that he mentions as unconformably overlying the Taconic rocks, with the exceptions noted, where they contain Middle Cambrian fossils, are west of the

rane, off shore, was originally deposited either as a calcareous or argillaceous mud. It was owing to this oversight that he frequently identified the shales of the Champlain series as those of the Taconic. Another phenomena not understood by him, was the creeping or protruding of shales from beneath heavy masses of limestone, on account of the pressure squeezing the shales out and turning them up. In this way many of his non-conformities of dip appear to have been erroneously observed. In many instances he did not recognize the lithologic differences between the great mass of his Taconic slate and that of the Hudson Terrane. The black shale (marked "Taconic," in the Bald Mountain section, *b*, *b'*, fig. 11) is not similar to the shale containing the trilobites, east of the great fault, yet he identified them as lithologically the same formation.

* This Journal, vol. xxix, p. 16, 1885.

† Am. Geol., vol. i, pt. 2, p. 79, fig. 14, 1856.

‡ Loc. cit., p. 87.

§ This Journal, III, vol. xiii, p. 413, 1877.

fault line separating the Cambrian and Silurian Terranes; and the shales west of the fault belong to the Silurian, not to the "Upper Taconic" Terrane. The line of outcrop of the Cambrian Terrane is well marked, and I have endeavored to locate it accurately on the map. The great Appalachian fault separates the Potsdam and other Silurian rocks from the Cambrian; and nowhere on the western side of the Cambrian Terrane, to my knowledge, either in New York or Vermont, is there a deposition contact, either conformable or unconformable, between the rocks of the "Taconic System" and the Potsdam or other Silurian terranes. I have examined all the localities cited by Dr. Emmons and, later, by Professor Marcou and, in every case, the great fault separates the strata of the two systems. In fact, the Taconic usually rests on the Silurian strata as the result of the overthrust from the east; and, as will be shown in my report on Washington County, N. Y., the strongest proof of the presence of a fault line is shown by the mechanical disturbance of the Cambrian strata, on the eastern side of the fault.

That the Taconic slates are unconformably pre-Potsdam, is yet to be proven in any area known to Dr. Emmons, either in New York or Vermont. Where they pass beneath the shale representing the Potsdam horizon, beneath the Stockbridge limestone in the Taconic Range, they are conformably pre-Potsdam, but this fact was unknown to Dr. Emmons.*

Résumé.—As the result of these comparisons, we find that the "Lower Taconic" is essentially a repetition of the lower Silurian (Ordovician) section of the Champlain valley. It differs in lithologic details and in having a less abundant fauna in the typical Taconic area

The "Upper Taconic" is found to be conformably subjacent to the "Stockbridge" limestone of the "Lower Taconic," and to include the Potsdam horizon at or near its upper portion. Its base is not unconformably subjacent to the Lower Silurian Terrane, as maintained by Dr. Emmons and Professor Marcou.

The value of the paleontologic identification by Dr. Emmons of the "Upper Taconic" slate as a pre-Potsdam formation will now be considered.

* Professor Henry D. Rogers, in his address before the meeting of the Association of American Geologists and Naturalists, held at Washington, in May, 1844, said, when speaking of the unconformity claimed by Dr. Emmons between the Champlain and Taconic rocks: "I must take the liberty of expressing my disbelief of any such unconformity, and of observing that in the prolongation southwestward of this altered and plicated belt as far as the termination of the Blue Ridge in Georgia, a distance of 1000 miles, no interruption of the general conformity of strata has ever met the observation of my brother or myself."—(Amer. Jour. Sci., I, vol. xlvii, p. 152, 1844).

On page 63, of the Agriculture of New York (vol. i), under the heading "Black Slate," Dr. Emmons says: "I shall describe the rocks in the descending order: and by so doing, I commence with the mass of which there is some doubt whether it ought to be considered as a distinct rock or merely the upper portion of the Taconic slate; still I am disposed to regard it now as a separate and distinct rock, forming, so far as examinations have been made, the highest member of the Taconic system. Circumstances which have led to the separation of this from the rock referred to are of an interesting character; interesting particularly as being connected with the discovery of crustaceans where they were least expected."

Dr. Asa Fitch found the fossils from the "Black Slate," in 1843, and gave them to Dr. Emmons, who described two species of trilobites under the names of *Atops trilineatus* and *Elliptocephala asaphoides;* the first he thought to be an intermediate genus between the Calymene and Triarthrus; of the second, *Elliptocephala asaphoides*, he compared parts with similar parts of the *Asaphus tyrannus*, of the Lower Silurian of England.*

On page 68 of the same memoir, under the head of "Fossils peculiar to the Taconic Slate," he describes two species of Annelid trails: one from the Green Taconic slate, and the other from the sandstone in Washington County. He follows this with a description of nine species of what appeared to be trails from the slates of Waterville, Maine. It appears from this that Dr. Emmons considered these various trails to be "fossils peculiar to the Taconic slate," and that the trilobites which he described he did not consider, at that time, as typical of the "Taconic System," for he says (loc. cit., p. 64), in speaking of the "Black Slate:" "Assuming that its fossils are distinct from the fossils of this and other systems," etc.

In his conclusions, he says:† "The Nereites and other fossils of the Taconic slate are unknown in any of the members of the Champlain group. In addition to which, it is important to bear in mind the fact that in this group the Mollusca of the New York system are also wanting."

In 1856,‡ he referred the Black slates to a position above the Talcose slates of the "Lower Taconic," thus making them the base of the "Upper Taconic" series. On page 98, loc. cit., the argument is made that the "Taconic System" is peculiar in its contained organisms, and that he has the right to consider the absence of certain Silurian fossils as evidence that the Taconic was not of Silurian age. As has been shown in the first part of this paper, the limestones of the "Lower Ta-

* Loc. cit., pp. 64, 65.

† Loc. cit., p. 108.

‡ Am. Geol., pt. 2, p. 49, 1856.

conic" carry characteristic Lower Silurian (Ordovician) fossils, as, also, do the shales overlying the limestones.

In 1859 (Manual of Geology, p. 87), Dr. Emmons for the first time compared his *Elliptocephala asaphoides* with the genus Paradoxides, of Barrande's Primordial Zone, stating that the Taconic Paradoxides is also Silurian, and hence it is shown that the Primordial Zone, in Bohemia, is in coördination with the upper series of Taconic rocks. This statement is the first known to me upon which, either by paleontologic or stratigraphic evidence, Dr. Emmons could base his assertion that any portion of the "Taconic System" was of pre-Potsdam age.

The want of clearness in his views is well shown by the extract already quoted from his letter of Nov. 20, 1860, published by Prof. Marcou. "His [Barrande's] Primordial group is *only Lower Silurian.* I conceive we have exactly his *Primordial group* in the band of slates containing the Paradoxides."—What becomes of the stratigraphic break between the Lower Silurian and Taconic rocks if the "Black slates" are still retained in the "Taconic System," remains unexplained. If removed the fossils go into the Lower Silurian with it.

Dr. Emmons described several species of graptolites* from the "Taconic System," the majority of which are now known to also occur in the Hudson Terrane, in the valley of the Hudson. On the map, I have given the distribution of the Hudson Terrane in the Taconic area, as determined by stratigraphic and paleontologic evidence. It is in the central belt, carrying the red slates, that the graptolites occur which led Dr. Emmons to include, as a matter of necessity, if he put the red slates in the Taconic, the dark, argillaceous shales of Hudson Terrane at Troy, Albany, and Baker's Falls, in the Hudson Valley, for they contain the "beautiful graptolites"† referred to by him in 1860. At Albany, N. Y., however, the graptolite beds contain a characteristic Trenton-Hudson fauna.‡ This removes a considerable portion of the "Upper Taconic" strata from the "Taconic System."

* Am. Geol., vol. i, pt. 2, pp. 104–111, 1856.

† See letter to Prof. Jules Marcou; Proc. Am. Acad. Arts and Sci., vol. xii, p. 188, 1885.

‡ Mr. C. E. Beecher found three of the same species of graptolites (*Climacograptus bicornis*, *Dicranograptus ramosus* and *Diplograptus mucronatus*) as those found by me in the "Taconic Slates" of Washington and Rensselaer counties, associated with Brachiopoda, 5 species; Lamellibranchiata, 16 species; Pteropoda, 2 species; Gasteropoda, 3 species; Cephalopoda, 2 species; Annelid, 1 species; Crustacea, 1 species, and Trilobita, 2 species. For names of species, see Mr. Beecher's paper. (Thirty-sixth Ann. Rep. N. Y. State, Mus. Nat. Hist., p. 78, 1884).

Résumé of the Paleontologic Evidence.

(1.) The trilobites described in 1844–47, from the "Black Slate," were referred to the highest member of the "Taconic System," on stratigraphic evidence.

(2.) The same trilobites were referred to the lowest member of the "Upper Taconic," on stratigraphic evidence, in 1856.

(3.) In 1859 they were for the first time referred to a pre-Potsdam position by comparison with a fauna whose position had been stratigraphically determined in relation to the Silurian fauna.

(4.) The Nereites and other trails with the exception of the two from Washington County, N. Y., described as typical of the "Taconic System," have not yet been stratigraphically located in the geologic series.

(5.) The graptolites referred to the "Taconic System" form a portion of the fauna of the Hudson Terrane.

Discussion.—There is not much opportunity for a discussion of the geologic age and position of the "Lower Taconic" rocks. The thorough work of Professor Dana practically settled those points before I began my investigation. Dr. T. S. Hunt opposed Professor Dana's conclusions, basing his dissent on the result of his own studies of the geology of southeastern Pennsylvania and, on his acceptance of certain theoretic views in regard to the lithology of the "Lower Taconic" rocks. He argued that the "Lower Taconic" was the typical Taconic System and of Archean age,* and that Professor Dana's interpretation of the stratigraphy was not sufficient, without the aid of fossils, in the typical Taconic region, to establish the Lower Silurian age of the Stockbridge limestone or the crystalline marbles of the Lower Taconic. With the facts presented in this paper, however, I do not think that Dr. Hunt can claim support for his views without first substantiating them by researches in the Taconic area, a matter that he has apparently not given his attention, † heretofore.

*("Taconic Question in Geology;" Min. Physiology and Physiography, p. 582, paragraph 92, 1886). "92. Considering the pre-Cambrian age of the Lower Taconic to be established, as well as its distinctness alike from the older crystalline rocks below and from the Cambrian series above, to which Emmons had given the name of Upper Taconic—it was proposed by the writer, in 1878, to restrict the term Taconic—for which the alternative name of Taconian was then suggested,—to the Lower Taconic of Emmons." For other views held by Dr. Hunt, see Am. Jour. Sci., 3d ser., vol. xxxiii, pp. 417, 418, 1887.

†Some of Dr. Hunt's errors consist: 1. In relying upon a lithologic theory based upon observations made far distant from the Taconic area 2. His acceptance of Dr. Emmons's theory of the stratigraphic position of the "Lower Taconic" strata without personal investigation when it was well known that *all* of Dr. Emmons's contemporary geologists opposed the "Taconic" theory. 3. His assuming that it was largely personal opposition to Dr. Emmons that led all geologists who investigated the Taconic area to decide against the "Taconic" theory. 4. His ignoring all stratigraphic and paleontologic evidence published by Professor

Professor Dana was in accord with the opinion of Professors W. B. and H. D. Rogers, Edward and C. H. Hitchcock, W. W. Mather and James Hall, as well as with the results of his own field studies, when he called the "Granular Quartz" Potsdam, the "Stockbridge limestones, Lower Silurian (Calciferous-Chazy-Trenton) and the overlying "Talcose" shales the Hudson River formation. He held the opinion that the "Lower Taconic" was the typical "Taconic System," as first defined in 1842, but as that was proven to be Lower Silurian in age the "Taconic System" could not longer be recognized. In opposition to this Professors Marcou and Winchell argue that if the "Lower Taconic" was of Lower Silurian age the "Upper Taconic" contains Primordial fossils and is, therefore, equivalent to the Cambrian; and, as the discovery of fossils in the "Upper Taconic" was made before typical Primordial fossils were published from Sedgwick's Cambrian System, the name Taconic had priority over that of Cambrian and should be used in place of it to designate the strata containing the First or Primordial fauna of Barrande.

I was influenced by the statement made by Dr. Emmons that the slates of the "Upper Taconic" were unconformably beneath Lower Silurian strata, and, also, by the views of Professors Dana and Marcou when, in 1885, I wrote my observations, "On the Use of the Name Taconic," in the introduction to Bulletin 30, of the U. S. Geological Survey. I was satisfied from the evidence presented by Professor Dana, that the limestones of the "Lower Taconic" belonged to the Calciferous-Chazy-Trenton Terrane, and that the overlying schists were properly referred to the Hudson Terrane. The reference of the quartzite beneath the limestone to the Potsdam horizon, also appeared to be consistent with the data known to him. I was but partially convinced, however, from the evidence presented by Dr. Emmons and Professor Marcou that the "Upper Taconic" slates were stratigraphically pre-Potsdam, or that there was a valid claim for the substitution of the name Taconic for that of Cambrian.

Professor Jules Marcou, although a persistent advocate for the use of the name Taconic, did not go to the typical Taconic area to study the "Taconic System," but studied the extension of the "Upper Taconic" slate and shales in northern Vermont, and identified the "Upper Taconic" as the true "Taconic System." I have carefully examined the localities where he describes the occurrence of a non-conformity between the Georgia slates and the superjacent so-called Potsdam sandstone and at none of them

Dana and others within the past fifteen years on the ground that the writers were putting forth the "old metamorphic hypothesis" of Mather, Rogers, etc. (See Am. Nat., vol. xxi, pp. 114–320, 1887).

could I find a trace of the Potsdam sandstone. The sandstone referred to the Potsdam is of Middle Cambrian age and, at Parker's farm contains two of the same species of fossils that occur in the slates conformably subjacent to the sandstone. The only non-conformity found is formed by the overthrust of the Georgia or Cambrian strata upon the Lower Silurian Terrane, just as at Bald Mountain in Washington County, N. Y., Snake Mountain in Vermont and all along the line of the great fault, wherever outcrops of the two systems occur.

His extension* of the "Taconic System" to include the Potsdam sandstone is in opposition to all of Dr. Emmons's views of the relations of the Taconic and Potsdam strata, as Dr. Emmons founded the "Taconic System" largely on the belief that a great stratigraphic break existed between the Potsdam and Taconic, and that the fauna of the Taconic was unlike that of the "Champlain group," of which the Potsdam formed the base.

Dr. Emmons's errors are nearly all traceable to his trust in the lithologic characters of the various formations within the Taconic area. He established the "Taconic System" in 1842, on the differences in the lithologic characters of the Taconic rocks and those of the New York 'Lower Silurian.' The unconformity between the "Taconic System" and "Champlain" series, announced in 1844–'47, was primarily based on the similarity of the lithologic characters of the Calciferous sandrock of the Lower Silurian and the calciferous sandrock of what we now know to be, from its contained fossils, a part of his "Upper Taconic" series. Again, when the latter (calciferous sandrock of the Cambrian) was pushed over on to the dark shales of the 'Lower Silurian,' on the line of the great fault, he identified the latter shales with the "Upper Taconic" shales, and thus obtained an unconformity, as at Bald Mountain, between the Lower Silurian and Taconic strata. He failed to recognize the fact, shown along an outcrop of a hundred miles or more, that the Potsdam and, frequently, the Calciferous Terranes were represented in the geologic sections by a shale undistinguishable from the shale of the Hudson Terrane; also, that the same conditions occur in the Champlain valley, in the towns of Fort Ann, Kingsbury, and Hartford, Washington County, N. Y., and that, in several localities, the Trenton limestone is replaced by shale. This explains much of the confusion in his stratigraphy and, also, in that of Professor Jules Marcou, in northern Vermont, who was misled in the same manner. The shales containing the Primordial fauna are usually lithologically dissimilar from the dark argillaceous shales of the Lower Silurian,

* Proc. Bost. Soc. Nat. Hist., vol vii, p. 371, 381, 1860.

but, as Dr. Emmons included the dark graptolitic-bearing shales of the Hudson Terrane, within the Taconic area, in the "Upper Taconic," he necessarily compared and identified the black shales of the Lower Silurian with the "Black Slate" of the "Upper Taconic." He could scarcely do otherwise, when the stratigraphy along the western side of the "Taconic System" supported his theory, if such an identification of the shale was made.

The fact that the Potsdam sandstone, as a lithologic formation, is a local deposit in the immediate vicinity of the Adirondack mountains and that the sediments being deposited at the other localities at the same time, embedding similar organic remains, were argillaceous, siliceous and calcareous muds, does not seem to have impressed him, although he devotes many pages of his various memoirs to the description and discussion of the lithology of the Taconic and Lower Silurian rocks.

Dr. Emmons was not a collector of fossils, or he would have found them in nearly all the formations within the Taconic area; and I think that no student conversant with the faunas of the Lower Silurian and Cambrian terranes will long hesitate in concluding that he did not have sufficient critical knowledge of the faunas to which the fossils belonged that he did obtain, to identify the strata from which they came on paleontologic evidence otherwise he could not have so confused them.* When Dr. Fitch gave him the fossils that he had found in the "Black Slate," two miles north of Bald Mountain, in 1843, he at once referred them to a pre-Potsdam horizon, on *stratigraphic* evidence, without making any comparisons with a fauna which he knew to be pre-Potsdam at some other locality. In fact, no such data were at his command at that time, and the reference of the fossils to a pre-Potsdam horizon was based entirely upon the fact that they were in strata which he considered to be situated unconformably beneath the Potsdam sandstone or, in its absence, the Calciferous sandrock.

I wish to mention here that, in 1847, Dr. Emmons did not consider the two species of trilobites as characteristic of the true Taconic slate, but of the overlying "Black Slate," which he considered to be pre-Potsdam, from the evidence of the Bald Mountain section. I also call attention, again, to the fact that there was no valid stratigraphic evidence of the pre-Potsdam age of the "Black Slate;" moreover, as I have shown, the "Black Slate" is the lowest member of the "Taconic System" and not the highest, as stated by him, in 1847, or next above

* It is not practicable for me, owing to want of space, to give a full analysis of the paleontologic work done by Dr. Emmons in connection with his argument for the Taconic system. This will appear in my report on the geology of Washington County, N. Y.

the "Lower Taconic," as stated in the scheme of 1856. (See fig. 10.)

The comparisons made by Dr. Emmons between the fossils of the "Black Slate" and the Primordial fauna of Barrande, in 1859, came too late to anticipate the identification of the Primordial fauna in the Cambrian of Sedgwick, for the Cambrian System, as used by me, was correctly identified, paleontologically, by M. Barrande, in 1851.*

As I have repeatedly stated, Dr. Emmons assigned the two species of fossils described by him from the "Upper Taconic" slates to a pre-Potsdam horizon, on stratigraphic evidence that, on investigation, proves to have been based on errors of field observation. Such being the case, there was no proof of the position of the fauna, as he had no means for comparison with a similar fauna that had been stratigraphically located elsewhere in the geologic series. It was a *fortunate happening* that the "Upper Taconic" fossils proved to be of pre-Potsdam age, and not a scientific induction based on accurate observations or comparisons.

M. Barrande visited England in 1851 and determined the age of the Primordial fauna found in the typical Cambrian area of Wales before he knew of the existence of the vestige of the Primordial fauna published by Dr. Emmons. Subsequently, upon the evidence of Dr. Emmons's published stratigraphic sections, showing that he, Dr. Emmons, knew the fossils to be stratigraphically pre-Potsdam, M. Barrande was misled into crediting him with a discovery (in 1859) that was based on errors of field observation, and I did the same thing in the introduction to Bulletin 30, U. S. Geological Survey, in 1885.

* January 20th, 1851, M. J. Barrande read a paper before the Geological Society of France, upon the "Silurian Terrain of England." He presented a sketch of a section from Wales showing the Archean and, resting upon it, the stages corresponding to the stages C and D, of the Bohemian section, or the strata of the First or Primordial fauna and the Second or Lower Silurian fauna. Above the Lower Silurian the Upper Silurian is shown as resting unconformably upon the latter. In this paper the Lower Cambrian of Sedgwick is identified by organic remains, through comparison with the established succession of fossils in the Bohemian Basin. (Bull. Soc. Géol. de France, t. viii, pp. 207–212, 1851).

[To be continued.]

[From the American Journal of Science, Vol. XXXV, May, 1888.]

Art. XXXIII.—*The Taconic System of Emmons, and the use of the name Taconic in Geologic nomenclature;* by Chas. D. Walcott, of the U. S. Geological Survey. With Plate III.

(Continued from page 327.)

Nomenclature.

I. Use of the name Taconic. II. Use of the name Cambrian. III. Classification of North American Cambrian rocks.

Use of the name Taconic.—To the writer the evidence presented and referred to in the preceding pages proves that the "Taconic System" was founded on errors of stratigraphy of such character and magnitude that the name Taconic has no claim upon the geologist for recognition in geologic nomenclature.

I endeavored to make, in 1886, an argument for the use of the name Taconic for the Middle division of the Cambrian System, but it failed in the light of later results of field work; and now I think that geologic nomenclature will be benefited by dropping the name entirely. Based on error and misconception originally, and used in an erroneous manner since, it serves only to confuse the mind of the student, when applied to any formation or terrane. There are several reasons for the foregoing conclusions that perhaps it is best to here state:

1st.—The name is not applicable. The Taconic range, from which the "Taconic System" was named, is not known to contain a fossil of the First fauna or a formation that contains one elsewhere. The "Upper Taconic" slates lie west of the range, and the "Granular Quartz" series east of it; and the range is formed of strata of the Trenton-Hudson Terrane.

2d.—The "Taconic System" was considered pre-Potsdam, on two suppositions: (*a*) that the Calciferous sandrock of the Lower Silurian is unconformably superjacent to the Taconic slates, on the west; (*b*) that the variation of the lithologic characters of the Lower Taconic rocks, from the New York Lower Silurian, indicates a distinct system of rocks. We find that the unconformity (*a*) was based on errors of field observation, and (*b*), that the "Lower Taconic" rocks are of Lower Silurian age, with the exception of the lower quartzite, which is Cambrian and *conformably* subjacent to the Lower Silurian.

3d.—The claim of priority of discovery of the Primordial fauna is invalidated by the fact that the fossils found in the Taconic slate were referred to a pre-Potsdam horizon on an erroneous interpretation of the stratigraphy and not from comparison with a known fauna that had been stratigraphically located in any clearly defined geologic section.

4th.—It is only a fortunate happening, and not a scientific induction based on accurate stratigraphic or paleontologic work, that any portion of the "Taconic System" is found to be where Dr. Emmons placed it.

5th.—The application of the principles stated at the beginning of this paper rules out the name Taconic from geologic nomenclature.

6th.—The term Cambrian antedates Taconic for a stratigraphic system and, also, as a correctly-defined faunal definition.

It was stated under "Discussion" that Professor Dana held the opinion that the "Lower Taconic" was the typical "Taconic System," as first defined in 1842, but as that was proven to be Lower Silurian in age, the "Taconic System" could not longer be recognized.* For a time I was inclined to disagree with this view, but as I approach the end of this investigation I am convinced, after a full consideration of all the circumstances, that the position taken by Professor Dana is the correct one.

The first published section of the "Taconic System" gives *all* the rocks included within it in 1842.† The gneiss is represented on the extreme east and the "Taconic slate" on the extreme west and the "shales of the Champlain group" as resting unconformably on the "Taconic slate." This section includes *all* the strata of the "Taconic System," as then known to Dr. Emmons, and agrees with the description, in the accompanying text, of the rocks of the System.‡

Five additional sections are given on Plate XI, four of which are in the typical area and agree with the section in the text (loc. cit., p. 145, fig. 46). The latter section and the first four sections of Plate XI do not extend west of the area of Hudson slate on the line of Hoosick Falls in Rensselaer Co., N. Y. (see map). They all limit the "Taconic System" at this belt of the Hudson Terrane, and the accompanying text corroborates the view expressed in the sections. A glance at the map shows that not one single outcrop of rock of the "Upper Taconic" was included in the "Taconic System," as originally proposed, with the exception to be noted of Section 5, Plate XI, and not until 1887 was it proven that any portion of the original Taconic System was older or subjacent to the horizon of the Potsdam sandstone. As is mentioned in the 1st reason given for rejecting the name Taconic, there is not a known stratum of rock in the Taconic range that is of the geologic

* This Journal, III, vol. xxxi, pp. 241–244, 1886.
† Geol. N. Y., pt. 2, p. 145, fig. 46, 1842.
‡ Loc. cit., pp. 144, 145.

age assigned to it by Dr. Emmons. In 1844 he incorporated a great series of slates and shales belonging to another geologic system by extending his sections across the western belt of the Hudson Terrane, that limited the section of 1842, and on west to the next line of outcrop of Lower Silurian rocks. This addition gave the opportunity to separate off the "Upper Taconic" in 1856. I have shown that all his reasons for calling this series pre-Potsdam were based on errors of stratigraphy; and that it was a fortunate happening that any portion of the "Upper Taconic" rocks occur where he placed them in his stratigraphic scheme. Even if there were no errors to vitiate Dr. Emmons's argument for the pre-Potsdam position of the "Upper Taconic," that portion of his system could not retain the name "Taconic;" for it belongs to a different stratigraphic system from that to which the strata of the Taconic range belong and to which he gave the name "Taconic."

Section V, of Plate XI, represents a section of strata a few miles south of Burlington, Vt., and includes, not the "Taconic System" of the first five sections and the text by Dr. Emmons in 1842, but strata entirely disconnected from the original Taconic, which, nineteen years later, was proven to belong in part to the "Upper Taconic." This section is not mentioned in the text, but it is evidently considered as exhibiting the same relative geologic section as the other sections, a view that is substantiated by the name "Taconic slate" being given to the strata referred to the "Taconic System." There is not any stratigraphic connection between the Vermont section (No. 5) and the sections in the Taconic area (see map), and until 1859 there was not any paleontologic evidence that the slates of section 5 were or were not of the same geologic age as the "Taconic slates" of the five other sections and the text. In 1859 the publication of the Olenellus fauna by Professor Hall, proved that Dr. Emmons was mistaken in referring the Vermont slates, of section 5, to his Taconic System of 1842. I do not think that we can admit as evidence in favor of the strata of the "Upper Taconic" having been described in the original work of 1842, such an erroneous identification of a section that had at the time no stratigraphic or paleontologic connection with the original Taconic System.

It was not until the field work, in the fall of 1887, was concluded that I arrived at the above conclusions. Professor Dana reached it long before, and Dr. T. S. Hunt holds that the "Lower Taconic" is the typical Taconic. It matters not whether geologists agree to restrict the test of what the original Taconic was to the original Taconic of 1842 or hold that Dr. Emmons had the right to add the strata separated off into

the "Upper Taconic" in 1856, the name Taconic does not appear to have any place in the geologic nomenclature of to-day.

The following tabulation of the successive phases of the Taconic system viewed in the light of present facts is instructive. It was proposed in a letter from Professor Dana to the writer:

PHASE I, 1842.

	"Taconic System"	True order begins.	
	6. Stockbridge limestone	II.	Lower Silurian limestone.
	5. Magnesian slate of Graylock	III.	Hudson slate.
*	5. Granular quartz	I.	Cambrian.
	4. Limestone	II.	Lower Silurian limestone.
	3. Magnesian slate of Taconic mountains	III.	Hudson slates.
	2. Sparry limestone	II.	Lower Silurian limestone.
	1. Taconic slate	III.	Hudson slates.

PHASE II, 1844.

5.	*a.* Black slate. Fossiliferous	I.	Cambrian.
	b. Taconic slate "		Mostly Hudson slate.
4.	Sparry limestone	II.	Lower Silurian limestone.
3.	Magnesian slates	III.	Hudson slates.
2.	Stockbridge limestone	II.	Lower Silurian limestone.
1.	Granular quartz	I.	Cambrian.

PHASE III, 1855.

I.	*Upper Taconic.*		
2.	Black slate	I.	Cambrian.
1.	Taconic slate	III.	Mostly Hudson slate.
II.	*Lower Taconic.*		
3.	Magnesian slate	III.	Hudson slate.
2.	Stockbridge limestone and Sparry limestone	II.	Lower Silurian limestone.
1.	Granular quartz	I.	Cambrian.

Use of the name Cambrian.—There is no necessity for reviewing the Silurian-Cambrian controversy. All the facts, as understood by many writers, are accessible to the student of English geologic literature. It is my opinion that the name Cambrian should be used for the system of strata characterized by the "First Fauna."

The Cambrian System was correctly established on a stratigraphic basis in 1835, and included the same relative geologic terranes as the "Taconic System," with the exception of going a little lower in the section containing the Primordial fauna. Like the Taconic, it included the Lower Silurian (Ordovician) System, a fact noted and corrected by Dr. Emmons, *for the Cambrian*, in 1842. The Cambrian section stands intact to-day, and, on faunal evidence, separates into two great divisions, the lower of which is the Cambrian System, as used by many

* Made equivalent to the lower unfossiliferous part of Sedgwick's Cambrian as known to Dr. Emmons at that time.

writers for the system of strata characterized by the "First Fauna," and the upper the Champlain of Emmons, the Lower Silurian of Murchison, or the Ordovician of some more recent authors.

Classification of North American Cambrian Rocks.

In the classification of the fossiliferous sedimentary rocks of all countries it becomes more and more evident that the great systems—Cambrian, Silurian, Devonian, etc.—must rest on the broad zoologic characters of their included faunas and not on stratigraphic breaks between the systems, and that geologists will need to recognize the fact so well stated by Lapworth, that "we have no reliable chronological scale in geology but such as is afforded by the relative magnitude of zoological change—in other words, that the geological duration and importance of any system is in strict proportion to the comparative magnitude and distinctness of its collective fauna."* In pursuance of the above principle I have separated the Cambrian System in North America from the Lower Silurian. In the magnitude of sedimentation and extent of the fauna it ranks with the other great geologic systems, and we cannot unite it with the Lower Silurian except from reasons that, if followed out, will unite all the systems from the Cambrian to the Quaternary.

In arranging the different strata composing the Cambrian System three primary divisions are distinguished by the predominence in each of a fauna that, in assemblage of genera and species, may be separated from others whenever two or more of them occur in the same stratigraphic section. This extends to the identification of the relative geologic horizon by the fauna when its vertical or geographic connection with other faunas is not preserved. The three divisions of the table have been recognized to a greater or less extent in all the sections of Cambrian strata studied in North America, and all the observed Cambrian faunas come within their limits.

The second column in the table gives local names that have been applied within certain geologic provinces, where the fauna and the sedimentation indicate a greater uniformity of conditions than existed throughout the larger areas outlined by the first three divisions. The right-hand column gives the names of local subdivisions where the conditions of sedimentation and of life were still more restricted.

The table is a correlation of the various sections described in the introduction to U. S. Geological Survey Bulletin No. 30, and hence is tentative. It is the expression of my present knowledge and opinion. All who use it in geologic work

* Geol. Mag., vol. vi, p. 3, 1879.

should refer to the data given in that Bulletin, and decide individually upon the value of the correlations made in the table.

	Lower Calciferous.	Lower portion of the Calciferous formation of New York and Canada. Lower Magnesian of Wisconsin, Missouri, etc.
UPPER CAMBRIAN.	Potsdam. Knox. Tonto.	Potsdam of New York, Canada, Wisconsin, Texas, Wyoming, Montana and Nevada; Tonto of Arizona; Knox Shales of Tennessee, Georgia and Alabama. The Alabama section may extend down into the Middle Cambrian.
MIDDLE CAMBRIAN.	Georgia. L'Anse au Loup. Prospect.	Georgia and "Granular Quartz" formations of Vermont, Canada, New York and Massachusetts. Limestones of L'Anse au Loup, Labrador. Lower part of Cambrian section of Eureka and Highland Range, Nevada. Upper portion of Big Cottonwood Cañon Cambrian section, Utah.
LOWER CAMBRIAN.	St. John. Braintree. Newfoundland. Uinta?	Paradoxides beds of Braintree, Mass., St. John, New Brunswick, St. John's area of Newfoundland; Lower portion of Big Cottonwood Cañon Cambrian section, Utah. Uinta? (The Ocoee conglomerate and slates of East Tennessee are doubtfully included.)

DESCRIPTION OF THE MAP AND SECTION.

The map shows the geographic distribution of the strata referred to the "Taconic System" in eastern New York and western Vermont, Massachusetts and Connecticut. The data for it are taken from the Geological map of Vermont and New Hampshire, by Professor C. H. Hitchcock, 1877 (Geol. Northern New England); the maps published by Professor Dana, on the geology of the region studied by him in western Massachusetts and Connecticut, and eastern New York; and the map of southwestern Vermont, published by Professor Dana on the result of Rev. A. Wing's field studies (Am. Jour. Sci., 3d ser., vol. xiii, 1877); and for Washington and Rensselaer Counties, N. Y., as mapped from field work done by myself in 1886–87.

The line of contact of the Cambrian and pre-Cambrian rocks on the east, in Vermont, is tentative, as it is known to be incorrect in details; the data for correcting it have not been obtained.

Certain changes in the identification of the strata, as compared with the older maps, have been rendered necessary by the correlations made in this paper; and the shales, in the vicinity of the limestones south of the Rensselaer county line, have not been colored, as it is yet undetermined whether they belong to the Hudson or Cambrian Terrane. The shales immediately beneath the limestone (3) are shown as a distinct

terrane (2) in the section but on the map they are merged with the Georgia terrane (5).

The exact localities of fossils within the typical Taconic area are shown by the letter F. Many localities to the north and south are not indicated.

Section.—The geologic section crosses the Taconic area on the line marked A, B, on the map, which is very near the line of the original section published by Dr. Emmons in 1847 (Geol. N. Y., pt. 1, pl. xviii, Sec. 1). On the line C, D fossils have been found more abundantly on the eastern side, and the structure is found as in Dr. Emmons's section of 1856.

1. Cambrian quartzite—Terrane No. 1.
2. Hydromica (Potsdam ?) shales—Terrane No. 2.
3. Trenton, Chazy and other limestones of the Lower Silurian —Terrane No. 3.
4. Hudson (hydromica) shales of the Taconic range and, in the Hudson valley, the Hudson terrane—Terrane No. 4.

4*a*. A belt of strata of the Hudson terrane, faulted in between Cambrian rocks—Terrane No. 6 of text.

5, 5*a*. Slates, with interbedded limestones and sandstones of the Georgia Terrane, of the Cambrian—Terrane No. 5.

6. Pre-Cambrian (Agnotozoic) or Archean rocks. *a*, *b*, *c*, *d*, fault lines, known to the writer, in Washington County, N. Y. The hade of the Ball Mountain fault (*a*) is approximately correct (see fig. 12) while that of the other faults is probably much more oblique or inclined to horizontal than as represented. They are drawn to show where they occur and not to indicate the hade or angle of the faults. The minor undulations, faults and displacements that occur on the east side, between 3 and the gneiss are not represented.

Comparing this with Dr. Emmons's sections, we find a difference in the arrangement of the strata in the eastern half. The "Lower Taconic" embraced the strata from Terrane No. 1, on the east, to Terrane No. 3, on the west side of the Taconic range, and included *all* the strata of the original "Taconic System" as known and defined by Dr. Emmons in 1842. The "Upper Taconic" included the strata of terranes Nos. 2, 4, 4*a*, 5, and 5*a*, west of the Taconic Range, which was added to the original "Taconic System" in 1844.

I have not attempted to show that the quartzite contains interbedded limestones and schists in some localities, nor that the limestone series (3) is broken by interbedded schists or arenaceous beds; nor that, as at Graylock, the quartzite (1) extends completely beneath the synclinal of the limestone (3) and appears on the western side. It is only the illustration of the

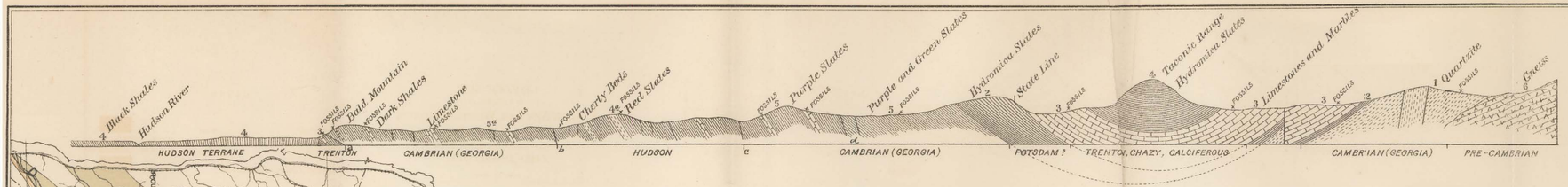
general relations of the quartzite, limestone and schists to each other that is attempted.

To the west of the Taconic Range the section passes down through the limestone (3) to the hydromica schists (2), and thence to the great development of slates and shales with their interbedded sparry limestones, calciferous and arenaceous strata, all of which contain more or less of the Olenellus or Middle Cambrian fauna.*

No. 2 occupies the stratigraphic position of the Potsdam formation elsewhere; and 5 and 5*a* by contained fauna and stratigraphic relations, are correlated with the Granular Quartz series (1) and referred to the horizon of the Middle Cambrian, as the latter is defined in Bulletin 30, U. S. Geological Survey, and in the table of classification (*ante*).

Between the limestone (3) and the slates (5) there are several displacements, but none to displace the strata sufficiently to bring rocks of other formations in sight, and so break the section that the general relations of 3, 2 and 5 can be interpreted by me in a different manner from that given in the section.

* Thirty-five species in Washington County, N. Y., as known to date. (See thios Journal fr, September, 1887).



GEOLOGIC MAP

OF PORTIONS OF

EASTERN NEW YORK, WESTERN VERMONT,
WESTERN MASS. AND NORTH WESTERN CONN.

COMPILED UNDER THE SUPERVISION OF

CHAS. D. WALCOTT

SCALE OF MILES

0 5 10 15 20 25 30

LEGEND

Quaternary	Drift		
Hudson	Brown Sandstone, dark shales, green and red coating slate		4
Trenton, Chazy, Calciferous			3
Potsdam	Sandstone		2
CAMBRIAN		Shales, Limestones etc.	5
Georgia		Limestone red sandrock	1
		Quartzite	1
PRE-CAMBRIAN			

JULIUS BIEN & CO. PHOTO-LITH.