ART. XLII.—*A brief history of Taconic ideas;* by JAMES D. DANA.

As the Taconic controversy is now nearing its end, a brief review of the progress of ideas relating to the various sides of the subject from the time of the earliest discussions to the present will be found instructive.*

* A historical account of the Taconic, especially of the views of Taconic advocates, entitled "The Taconic System and its position in Stratigraphical Geology," by Mr. Jules Marcou, is contained in the Proceedings of the American Academy of Sciences, vol. xii, 1884, 1885, pages 174 to 256. It relates mainly to the "Upper" Taconic, and makes little mention of facts or observations of the thirty years past connected with the "Lower" Taconic rocks in the southern half of Vermont, Massachusetts with its typical Williamstown Taconic section, and in eastern New York from Rensselaer Co. southward; all which have a profound bearing on the question of age, and on the true relation of the "Upper" and "Lower" sections. No account is given of the Taconic system of 1842, in the detailed presentation of which Prof. Emmons states its fundamental and distinctive

1818 to 1828.—The name Taconic first came into topographical geology through Professor Chester Dewey, who made the earliest geological map of the region, observed the general arrangement and eastward pitch of the beds, and called the rocks in the style of the time, Transition rocks.*

Prof. Amos Eaton gave credit in 1820 to Prof. Dewey for the chief part of his knowledge of the Taconic rocks;† but, by 1828, this pioneer in American geology had made fifteen sections of the rocks from the Hudson River to the Taconic mountains, in order to ascertain, as he says, their conformability and true order of succession.‡

1836 to the close of 1841.—Prof. Emmons, whose department in the New York Geological Survey covered the northern and northeastern part of the State, and who was already acquainted with the adjoining region of Williamstown in Massachusetts, continued his survey into Williamstown. But in the New York Annual Reports no mention is made of the Taconic system either by him or by any other of the New York geologists. This is true even of the latest—the fifth—annual Report, that for 1840. Prof. Emmons, in his part of this Report, under the date of transmittal of Feb. 1, 1841, says on page 94:

"The Granular quartz of Bennington, which occurs also in Dutchess Co., N. Y., I believe to be Potsdam sandstone in a metamorphic form, and the granular limestone associated, to belong to the same geological epoch." I believe "that the rocks from Lake Champlain, along the eastern part of the counties of Washington, Rensselaer, Columbia, Dutchess, all of Putnam, Westchester, great part of Rockland and southeast part of Orange are metamorphic and intruded rocks, and I would suggest that all the rocks from the New York state line to the Connecticut valley are similar. The talcose and micaceous and talco-micaceous divisions of the Green Mountain range in Vermont, Massachusetts and Connecticut have a strong analogy to the metamorphic slates of the east part of Washington, Rensselaer and Columbia Counties, but are traversed by large granite veins and are interstratified with intrusive rocks which might be expected to produce a greater change in mineral constitution."

characteristics, and to which alone the discussions in 1842 to 1844 by Rogers, Mather, Hall and Hitchcock had reference. Mr. Marcou's own special Taconic investigations were made in northern Vermont and its vicinity, a region barely alluded to as Upper Taconic by Prof. Emmons.

* C. Dewey, this J., i, 337, 1819; ii, 246, 1820; viii, 1, 240, with the map, 1824.

† A. Eaton, Index to the Geology of the United States, 1820.

‡ A. Eaton, this J., xiv, 147, 1828, where he says: "I have traversed the Transition range from Massachusetts line to Hudson River in fifteen places, since the first part of my survey was published, for the purpose of ascertaining the true superposition of rocks in this most complicated and difficult geological theatre." Prof. G. H. Cook recently drew my attention to this statement of Prof. Eaton which I had previously overlooked.

As late, then, as February, 1841, there was no indication that the Taconic system had taken shape in the mind of Prof. Emmons, although pretty well stored with Taconic facts. In opposition to the ideas of the Taconic system of 1842, the quartzyte is spoken of as the "Potsdam sandstone" in a metamorphic state, and the associated granular limestone as of "the same geological epoch."

In 1842, the quarto Report on New York Geology by Prof. Emmons appeared, with its letter of transmittal dated January 1, 1842; and in this volume the account of the Taconic system as a new system of rocks in American geology covers pages 135 to 164, thirty quarto pages. The germinant period was, consequently, between February 1, 1841, and January 1, 1842.

Another fact brings us closer to the time of first announcement. The system became a subject of special discussion, as I am told by Prof. James Hall, at the meeting of the American Association of Geologists and Naturalists held early in April, 1841, at Philadelphia. This narrows down the germinating period to the two months between February 1 and April 10 of 1841.

Those who took a prominent part in this first discussion were Professors Henry D. Rogers, Edward Hitchcock, Wm. W. Mather, Mr. James Hall and Mr. Lardner Vanuxem. Prof. Rogers was interested in the subject because of his elaborate geological study of the Appalachian Mountain system on which he reported at length to the Association the following year; Prof. Hitchcock, because the heart of the Taconic region was within his own field of study—the state of Massachusetts,—his final report on which he already had in the press; Prof. Mather, because part of the Taconic rocks west of Massachusetts were very largely within his section of the survey of the State of New York; Prof. Hall, because of the bearing of the facts on the system of New York rocks. Prof. Vanuxem, also one of the New York State geologists, had under his charge only southern New York west of the Taconic area and had given the rocks no study.

Although we have no report of the discussions,* we learn from later publications that Professors Hitchcock, Rogers, Hall and Mather objected to the views of Prof. Emmons, and Mr. Vanuxem † favored them.

* The Proceedings of the meeting in this Journal, xli, 158, 1841, and in the Trans. Assoc. Am. Geol. and Nat., 1840–42, contain no allusion to the discussion, discussions being, as the Preface of the Transactions states, "imperfectly reported in these pages." The only fact of any Taconic interest mentioned in the Proceedings of the meeting for 1841 (Proc. Assoc., 1883, p. 16, and this J., xli, 163), is that of the occurrence of impressions of Annelids in the slate of Waterville, Me., by Prof. O. P. Hubbard—the fossils and slates being afterward (1844) claimed for the Taconic by Emmons. Prof. Wm. B. Rogers did not become a member until 1842.

† Mr. Vanuxem has a page on the subject in his N. Y. Geological Report, p. 22.

The comparison of views at the meeting resulted in inducing Prof. Rogers and Prof. Hall to take the field for the study of sections over the Taconic region. The season had just passed when Prof Rogers made a report on his results to the American Philosophical Society at Philadelphia,* sustaining the views which Hitchcock, Hall, Mather and himself had before favored, namely: that the rocks were Lower Silurian (as the term was then used) from the Potsdam upward, but much flexed and disguised by partial metamorphism. Prof. Emmons mentions in his Report of 1842, on p. 147, that "Professors Hitchcock and Rogers" were prominent objectors to his views. We learn that Prof. Mather's views were essentially those of Prof. Rogers from his New York Geological report published in 1843. In his Preface he gives an interesting account of the discussion. The Dr. Dana he refers to was Dr. Samuel L. Dana, of Lowell, Mass.

1842 to the close of 1844; Phase I.—Such was the state of opinion when Prof. Emmons's full report on the Taconic system was published in 1842.

The Taconic system of this report comprised the rocks from the Hoosic Mountains westward, passing over the Hoosic Valley, Saddle Mountain (which included Greylock), and also over the high ridge of granular quartz, Oak Hill, just north, the Williamstown plain, the Taconic Mountains next west on the Massachusetts boundary, and the eastern border of New York west of this boundary to the Hudson. Beginning on the east, the rocks were: (1) the "Stockbridge limestone," (2) the "Granular quartz" and the "magnesian slate" of Greylock, which are topographically north and south of one another, (3) the limestone of Williamstown plain, (4) the "magnesian slate" of the Taconic mountain, (5) the "sparry limestone" west of the latter, and farther west, (6) the "Taconic slate." The following, commencing at the bottom, is the chronological order according to Emmons, and in a parallel column, are given the true equivalents (the Roman numerals giving the order of age) as established by the latest investigations.

Taconic System of 1842.	*Equivalents.*
6. Stockbridge limestone.	II. Lower Silurian.
5. *a.* Magnesian slate of Greylock, perhaps a repetition of No. 3.	III. Hudson slate.
b. Granular quartz.	I. Cambrian.
4. Limestone.	II. Lower Silurian.
3. Magnesian slate of Taconic Mountain.	III. Hudson Slate.
2. Sparry limestone.	II. Lower Silurian.
1. Taconic slate.	III, I. Hudson slate and Cambrian.

* Proc. Amer. Phil. Soc., Jan., 1842.

The order of succession adopted by Emmons was the order of superposition, as he states, with arguments in its favor, on page 147 of his report, the idea of flexures being rejected. The granular quartz he says (p. 138) "lies between two masses of limestone,"—which is topographically a fact.

The idea of the pre-Potsdam age of the beds was based on the absence of fossils; on the difference in the kinds of rocks, and in their succession, from the lower rocks in the New York series; also on supposed unconformability, no special case however being mentioned. He says, with reference to the distinction in kinds of rocks (p. 139), "As a general rule, certain minerals are found in particular rocks; and may not a similar rule or law prevail where a system of rocks is concerned?"

Early in May of 1844, two years after the appearance of Prof. Emmons's Report and over half a year before his second presentation of the system, Professor H. D. Rogers brought the Taconic question into his Presidential address before the "Association of American Geologists and Naturalists," and reiterated his former conclusions.*

1844 to the close of 1849; Phase II.—In December, 1844, appeared as a pamphlet in 4to—the preface bearing the date December 2, 1844—Prof. Emmons's revision of the Taconic system, with additions and an extension of its limits; and in 1846, the same was published as a chapter in his N. Y. Report on Agriculture. The prominent changes are the following: (1) the system is, for the most part, turned the other side up, Rogers's views being adopted as to flexures and overthrust folds. (2) It is made in part fossiliferous, and the fossiliferous part is put at the top under the idea that the fossils proved it to be the newer part. (3) The granular quartz is placed at the bottom.

The order of the strata in the Report, and the equivalents, are as follows:

Taconic System of December, 1844.	*Equivalents.*
5. *a* Black slate (Bald Mt.)	I. Cambrian.
5. *b* Taconic slate.	III, I. Hudson slate and Cambrian.
4. Sparry limestone.	II. Lower Silurian.
3. Magnesian slate.	III. Hudson slates.
2. Stockbridge limestone.	II. Lower Silurian.
1. Granular quartz.	I. Cambrian.

* H. D. Rogers, this Journal, xlvii, 137, 247, 1844. The address is a discussion of geological views, and is of permanent interest. His remarks on the Taconic system occupy pages 150 to 153; and he ends them with the suggestion that the Taconic system, instead of belonging exclusively to the Champlain division, may "include also some of the sandy and slaty strata here spoken of as lying beneath the Potsdam sandstone," referring to his own observations in Virginia and East Tennessee.

The system thus had Cambrian at top and Cambrian at bottom. In the chapters on the granular quartz, doubts about its true position are admitted; but the decision as to its being the oldest in the series is not recalled.

The Report has an appendix on pages 109–112; and its closing sentences, which show wavering opinions, are important in the history. After saying that in this system of beds, made when the earth's condition earliest admitted of it, "we find the earliest beings which had life and vitality," he adds (p. 112): "We do not feel confident that it is in the earliest of these deposits that we have discovered fossils. Mr. James Hall, however, informs me that he found the *Scolithus*, a tubular polyparian, in the most easterly mass of the granular quartz. On visiting the place as described to me, I was not successful in my search for this fossil, but *at another locality I found what appears to be an orthoceratite.* The fossils, however, are more abundant in the newer rocks of this system; and they belong to beings of an extremely delicate construction, as the reader may see by reference to our description in another part of this report." The orthoceratite is not figured or again mentioned.

Prof. Emmons was led to make the "Black slate" of Bald Mountain either "a distinct rock, or merely the upper portion of the Taconic slate" by his discovery "during the early part of September," 1844, of a fossil "which resembles closely an Annelide," and the finding at the same place by Dr. Finch of two species of trilobites. The trilobites were named *Atops trilineatus* "evidently allied to *Triarthrus Beckii*, so abundant in the Utica slate" and *Elliptocephala asaphoides*, and figures are given on pages 64, 65. The "Taconic slate" of eastern New York, including the Hoosic slate, and occupying, as he says, "almost the whole of Columbia, Rensselaer and Washington Counties and reaching to St. Albans," was also put with the upper fossiliferous part of the system (pp. 67 to 71), because of the discovery of Annelid markings chiefly, *Nereites* and *Myrianites.*

These new New York fossils had claims to a place in the first volume of Prof. Hall's Paleontology of New York, which was published nearly two years later, the preface bearing the date September 1, 1846. The author made the *Atops* identical with *Triarthrus Beckii* and hence referred both trilobites, together with the slates, to the Hudson river group; and the Elliptocephalus was referred to the genus *Olenus.* In the same month, the question of identity was discussed at the meeting of the Association of Geologists and Naturalists and a committee of investigation appointed for its consideration

and at the following meeting in 1847, Mr. S. S. Haldeman, the chairman of the committee, made an adverse report.* A reply from Mr. Hall appeared in this Journal in 1848.†

The discussion was continued at the first meeting of the American Association for the Advancement of Science (an expansion of the Association of American Geologists and Naturalists), in 1848, when Prof. Emmons read a paper entitled "On the identity of the *Atops trilineatus* and the *Triarthrus Beckii*, with remarks upon the *Elliptocephalus asaphoides*," in which he gives a full comparison of characters and also points out the differences between the latter species and either of the allied genera *Olenus* and *Paradoxides*.‡

The following year, 1849, a new advocate of the views of Rogers and Mather, in opposition to Emmons, appeared, in Mr. T. S. Hunt, then of the Geological Survey of Canada, who presented that year to the American Association for the Advancement of Science, at its second meeting in Cambridge, an abstract of the Geological Report of Canada for the year 1847–8.§ But it does not appear that either Mr. Hunt, or any one connected with the Canadian survey, had made the Taconic region a subject of investigation.

1855 to 1859; Phase III.—In the year 1855, Prof. Emmons made, in his new volume entitled "American Geology," his *third* presentation of the Taconic System.‖ The chief changes introduced are the following: (1) The fossiliferous portion of the system is now called the *Upper Taconic*, and the rest the *Lower Taconic*; (2) the Sparry and Stockbridge limestones are brought together as one formation; (3) the synclinal character of Greylock is first recognized and figured; and (4) extensions of the system to new localities are mentioned.

The order of succession in this third phase of the system and the true equivalents are as follows:

Taconic System in 1855.		*Equivalents.*
Upper Taconic.	2. Black slate of Bald Mountain.	I. Cambrian.
	1. Taconic slate.	III, I. Hudson slates and Cambrian.
Lower Taconic.	3. Magnesia slate.	III. Hudson slates.
	2. Stockbridge limestone.	II. Lower Silurian.
	1. Granular quartz.	I. Cambrian.

* S. S. Haldeman, this Journal, II, v, 117, 1848. At the same meeting, in 1847, Prof. C. B. Adams, of the Vermont Geological Survey, read a brief note on the Taconic rocks of Addison County, Vt., in opposition to the system.

† James Hall, this Journal, II, v, 322, 1848.

‡ E. Emmons, Proc. Amer. Assoc. for 1848, vol. i, p. 16.

§ T. S. Hunt, Proc. Amer. Assoc. for 1849, vol. ii, p. 325, and this Journal, II, ix, 12, 1850.

‖ Occupies pages 1 to 122 of Part II of the American Geology, 8vo, Albany, 1855.

This system of 1855, like that of 1844, has a top and bottom of Cambrian rocks. The succession of rocks in the "Lower" Taconic—which, it should be remembered, were the only rocks in the system when Rogers wrote in 1841 and 1844 and Mather in 1843—coincides with the views early set forth by Rogers, and with the order established by the most recent discoveries of fossils.

Professor Emmons, on page 70 of the American Geology, earnestly sustains the *azoic* character of the "*Lower*" Taconic, and particularly that of the slates of Saddle Mountain or Greylock. But the sentences about the occurrence of fossils in other parts of the "Lower" Taconic are left ambiguous. Speaking of the Taconic system as a whole on the closing page (p. 122) he says: (3) "It is a vital system, having been deposited during the period when organisms existed." (6) It "carries us back many stages farther in time when life gave vitality to its waters than the Silurian." He also says: "(1) Its series, divided into groups, are physically unlike the Lower Silurian series." "(2) It supports unconformably at numerous places the Lower Silurian rocks." Again on page 49: This group, "the 'Lower' Taconic, is mostly anterior to the Organic period." No locality of Taconic trilobites is mentioned in the chapters except that of Bald Mountain in Rensselaer Co., N. Y., and one of much interest in Augusta Co., Virginia, which had afforded Professor Emmons the small species he named *Microdiscus quadricostatus.*

In 1854 or 1855 new Trilobites, related to those of Bald Mountain, were found in the Black Slates of West Georgia, Vermont, within the range of beds referred to the "Upper" Taconic. Passing into the hands of Mr. Zadock Thompson, who had been assistant in the Geological Survey of the State under Professor C. B. Adams, the specimens were sent to Professor Hall, and in 1859, they were figured and described by him as "Trilobites of the shales of the Hudson River Group," under the names *Olenus Thompsoni*, *O. Vermontana* and *Peltura holopyga*, and the beds were thus made equivalents of the Bald Mountain slates.* Although these fossils

*J. Hall, Twelfth Annual Rep. N. Y. State Cab. Nat. Hist., pp. 59–62, 1859. Also Vol. III, N. Y. Paleontology, 1859, p. 325; Rep. Geol. Vermont, p. 367, where the two species of Olenus are *united* under the name *Burrandia Vermontana.* In Vol. III of the Paleontology, Professor Hall says, on page 94, "In the western flank of the Green Mountain range, the great variety of schists, designated as talcous, mica, gneissoid mica, hornblende and calcareous mica slates are all results of metamorphism of Silurian strata;" and on p. 83: "It is now many years since the belt of the country was regarded as one great Primary mass. Later observers began to yield a little and contented themselves with a Primary axis; and now we have the evidence, derived from fossils occurring at intervals over much of the area between the Hudson and the Connecticut rivers, as well as

were not formally claimed as Upper Taconic by Professor Emmons, they have passed as such. His Manual of Geology, the preface of which bears the date May 1, 1859, contains a good figure of a large trilobite under the name *Paradoxides brachycephalus*,* which (as first suggested by Professor C. H. Hitchcock in 1861† and is recently recognized by Mr. Walcott)‡ is identical with Hall's *Olenus Thompsoni*; and it was evidently so named before the publication of Prof. Hall's paper, though whether *published* before is not certain. Unfortunately, Professor Emmons failed to mention the locality of his specimen. On page 87, he makes the following judicious remark: "According to Barrande, the *Paradoxides* and

from the geological structure of the country, that these rocks all consist of strata lying between the base of the Silurian and the beginning of the Coal-measures."

On page 94, in a note, occurs the statement—of historical interest and therefore here cited—that staurolite and some other minerals "mark with the same unerring certainty the geological relations of this rock [a mica schist passing through central New England] as the presence of *Pentamerus oblongus*. *P. galeatus*, *Spirifer Niagarensis*, *S. macropleura*, and their respectively associated fossils, do the relations of the several rocks in which they occur." It was a valuable suggestion at the time, but one that the establishment of the facts just cited from p. 83 has now set aside.

In 1857, two years before the publication of Vol. III of the N. Y. Paleontology, cited from above, Professor Hall delivered an address before the American Association at Montreal. The writer was absent and never learned anything about its contents; it was never published. In 1882, only six years since, appeared a pamphlet, of forty pages, entitled "Contributions to the Geological History of the American Continent. The Address of the retiring President delivered before the first Montreal Meeting of the American Association for the Advancement of Science, August, 1857, by JAMES HALL." A note to the title is appended in which the author says: "The original manuscript of his Address" "has been copied without any supervision by him or any changes suggested by him." This publication of the Address cannot claim to have historical value and hence demands no notice here; for it came out *twenty-five years after date*. It has no scientific importance; for the subjects presented are much more fully and more satisfactorily discussed in the 96 quarto pages of the valuable Introduction to Vol. III, above mentioned, all of which is Professor Hall's, and besides is two years later than the Address. In the Appendix to this pamphlet on p. 68, it is stated that "the Address has been facetiously criticised as proposing a system of mountain-making with the [origin of the] mountains left out" Accordingly, the *Address*, although it had never been published, had on one subject been "facetiously criticised." The critical remark referred to occurred in volume xlii (1866, p. 210) of this Journal, in a note on views published by Professor Hall *in his Volume III*, as is stated in the note, and had no reference to the unpublished and wholly unknown Address. Some officious friend has made a slip here; Professor Hall could not have so forgotten himself. The pamphlet closes, following this, with two pages of "Notes on Professor James Hall's Address by T. Sterry Hunt."

* Manual of Geology by E. Emmons, 290 pp. 8vo. Philadelphia, 1860; see p. 88. Also C. D. Walcott on Cambrian Faunas, 2d paper, Bull. No. 30, U. S. G. S., 1886. p. 167. The name *Paradoxides asaphoides* is given by Professor Emmons for the figure on page 87, as if his first intention was to have inserted his old figure of *Elliptocephalus asaphoides*, but afterward decided to insert a figure of the new species. The name *P. brachycephalus* is changed to *P. macrocephalus* in a second issue of the Manual (1860), both under the cut on page 88 and in a note to page 280, and the corrected name is cited by Mr. Walcott.

† Rep. Geol. Vermont, p. 367.

‡ Bull. U. S. G. S., No. 30.

Olenus belong to his Primordial zone or are Sub-silurian in Bohemia. In this respect our Paradoxides are also Sub-silurian: and hence it has been shown that the Primordial zone in Bohemia is in coördination with the upper series of the Taconic rocks." Professor Emmons's letters to Mr. Marcou written in 1860 and published by the latter in the Proceedings of the American Academy for 1884, show that he meant here to emphasize "Upper" Primordial; for he protests that only a small part of his system is coincident with Barrande's Primordial.

1860 to 1863.—The years 1860 to 1863 were epochal in Taconic History. Great light was let in upon the system by letters of August, 1860, from Barrande, the eminent paleontologist of the Silurian of Bohemia, addressed to Professor Bronn of Heidelberg and Mr. Marcou of Cambridge, Mass., and also from a memoir read by him before the Geological Society of France. Having before him the figures and descriptions of the Georgia trilobites, referred to above, received from Mr. Billings, he pronounced them unquestionably Primordial, thus confirming the decision of Professor Emmons just mentioned.

But Barrande, adopting in his Memoir in full the views of Emmons on the Taconic system, and regarding the Primordial fossils as really characteristic of a great Taconic system of rocks extending far below the Olenus or Paradoxides zone, speaks of the Taconic as the American Primordial—his own system under unusual development—a view not satisfactory to Professor Emmons, for he had in contemplation for his Lower Taconic much greater depths, something like the unsounded Huronian, equivalency with which he thought he could make out.* And thus confusion was introduced by Barrande along with the

* Barrande's letters are addressed—Paris, July 16, 1860, to Professor Bronn of Heidelberg, and August 14th, 1860, to M. J. Marcou. They were read before the Boston Soc. Nat. Hist. in October, 1860, and are published in the Proceedings, vol. vii, 371; also in this Journal. II, xxxi, 210, 1861, with an omission of Mr. Marcou's name because of its unmentioned omission on the part of the sender (from Canada) of the communication; also in the Geol. Rep. Vermont (with the same omission) p. 377; and also, with other letters, in Mr. Marcou's paper in the Proc. Amer. Acad., vol. xii; see page 411. In this Journal and in the Vermont Report the letters are followed by letters to M. Barrande from Logan and from Hall; also in the Boston Proceedings, vol. vii, and also vol. viii, 239, by remarks of Mr. Marcou, giving his view of the bearings of the facts on the Taconic system of Emmons, with some additional facts. Barrande's Memoir referred to above is entitled, "Documents anciens et nouveaux sur la Fauna primordiale et le Système Taconique en Amérique," and was presented to the Geological Society of France, Nov., 1860, and Feb., 1861.

Barrande's letters appeared also in the Canada Nat. and Geol. for 1861. The facts show that some person connected with the Geological Survey of Canada is accountable for the "omission" above referred to. Mr. Marcou's paper of 1884 gave the editors of this Journal their first knowledge of it.

light. It would not have been so, we are sure from his careful Bohemian work, had he been within reach of the stratigraphical problem, for he would have withheld his general conclusion until he had investigated the region of the Taconic rocks.

Trouble came in 1860 again through the recognition by Logan of the Quebec Group in Canada—based on fossils from the vicinity of Quebec that corresponded in age apparently to the combined Calciferous and Chazy Groups.* For this step was followed by Logan's announcing, without previously making a careful stratigraphical study of the region, that the Taconic slates and limestone were, for the most part at least, of the Quebec Group.

Light came in again through the Vermont Geological Survey;† (1) by the discovery of fossils of undoubted Silurian age at several localities in the Stockbridge (Eolian) limestone of Vermont, the Report says (p. 421) Silurian, Devonian, and possibly Carboniferous); (2) by the exhibition of the topographical relations of the rocks on the colored geological map of Vermont; and (3) through the stratigraphical sections across the limestone and slates, making in Mt. Anthony, Mt. Equinox, Spruce Peak, Mt. Eolus or Dorset and Danby Mountain the slates to lie in synclines with the limestone underneath, precisely as had been proved for Greylock by Emmons. Here at one stroke, Emmons was sustained in his stratigraphy as regards his "Lower" Taconic, and shown to be probably wrong in his conclusion as to the pre-Potsdam age of the limestone, and part at least of the slates. No definite conclusion was reached by the survey as to the age of the quartzyte, opinion varying between Potsdam and Medina.‡

* Sir Wm. Logan, Remarks on the Fauna of the Quebec Group of Rocks and the Primordial Zone of Canada, Jan., 1861, Letter to Barrande, this Journal, II, xxxi, 216, 1861; Considerations relating to the Quebec Group, Can. Nat. and Geol., p. 199, May, 1861.

Mr. Billings first observed the peculiar features of the fossils of the so-called Quebec Group in May, 1860 (Geol. Rep. Can., 1863, p. viii), and the Canadian Nat. and Geol. for 1860 contains his earliest descriptions of the fossils, afterward given in full, with an account of the rocks by Logan in the Can. Geol. Rep. for 1863, and more completely in Billings's Palæozoic fossils, vol. 1.

† Rep. Geol. Vermont by E. Hitchcock, E. Hitchcock, Jr., A. D. Hager and C H. Hitchcock, 1861. In a note published in the Proceedings of the Boston N. H. Soc., vol. xxiv, 1888, Prof. C. H. Hitchcock states that the printing of the Report commenced in 1861, and was all completed that year, excepting the Appendix on "Lower Silurian fossils" by E. Billings.

‡ Ibid., pp. 356, 500. On the latter page, the opinion is cited from Professor Hall, based on the discovery of a species of Lingula, that the quartzyte is "of the age of the Clinton Group or of the Medina Group," Upper Silurian formations. Bearing on the history we find in the Proc. Boston Soc. N. H., vii, 237, 1860, a note by Professor W. B. Rogers, in which, in view of the reference to the Medina group, he cites approvingly, from a manuscript paper of his written in 1851, paragraphs sustaining the Medina age of the Vermont Quartzyte and Red Sandrock. The latter rock Emmons never included in the Taconic.

But along with the light from Vermont, doubts entered through the reference of some of the fossils of the limestone to the Upper Silurian and perhaps Devonian, and the use made of the few fossils of the Quartzyte. The facts were partly righted in 1862 by Mr. Billings, the paleontologist of Canada, who reviewed the Vermont Report in this Journal, and claimed that "the evidence of the fossils furnishes no reasonable ground for placing the formation above the Lower Silurian."*

Accepting the stratigraphical sections in the Vermont Report as teaching what they appear to teach, and recognizing the Lower Silurian age of the fossils from the limestone, and accepting also Barrande's confirmation of Emmons's decision as to the Primordial relations of the "Black slate" trilobites, the general bearing of the facts made known, during this epoch of progress and drawbacks, could hardly be mistaken.

At this time the first edition of the writer's Manual of Geology † was published. The preface bears the date of the close of the printing, November 1, 1862. The Potsdam period in American Geology had already become expanded into the Primordial by the discovery, six years before, near Boston, of specimens of *Paradoxides Harlani* ‡ and by facts received from abroad; and it is designated in the work (pp. 169, 171) the "POTSDAM OR PRIMORDIAL PERIOD," and made the equivalent of the era of the Paradoxides and other Primordial beds of Scandinavia and Bohemia, as well as of that of the Lingula Flags and underlying Cambrian of Great Britain. Moreover, *Paradoxides*, *Olenus*, and other Lower Cambrian genera are cited, and *P. Harlani* appears among the figured species. Barrande's determinations of the Georgia Slate Trilobites, making them and the beds containing them Primordial, are recognized by mentioning the beds and fossils among the facts of the "Potsdam or Primordial Period"—conforming in this to the decision of Emmons as well as Barrande.

The Vermont discoveries of fossils in the Eolian limestone had proved that the limestone and the overlying slates were

* E. Billings, this J., II., xxxiii. 416, 1862.

In 1870 the chief divisions in the geology of Vermont were briefly stated by Prof. C. H. Hitchcock in a folio of six pages bearing the date of March 1st. His further study of the State, in connection with the work of the Canadian Survey, had led him to refer at this time the Eolian or Stockbridge limestone and associated slates to the Quebec group, and the Quartzyte, Red Sandrock and the Georgia slates and Black slate to the Potsdam or Primordial, the last-mentioned the oldest.

† Manual of Geology by James D. Dana, 798 pp. 8vo, illustrated by a chart of the world and over 2000 figures. Philadelphia, 1863.

‡ W. B. Rogers, this J., II, xxii, 296, 1856, from a letter to J. D. Dana of August 13. Prof. Rogers compares the fossil with the *P. spinosus* of Barrande, and identifies it with the *P. Harlani* of Green. Mr. Green's cast of a specimen of unknown locality, had been widely distributed, and had reached Barrande. He also shows by Green's description of the rock, that his specimen was probably of the same locality.

later rocks than the Primordial, at least as late as Lower Silurian; and hence the term Taconic could not have been substituted for Primordial, as only a small part of the system was Primordial: the name belonged by first right to the original Taconic of 1842. The Primordial addition to the top of the Taconic column made by Emmons in 1844 was rectified by simply recording the facts in their proper places. The Eolian or Stockbridge limestone and other "Lower" Taconic rocks are mentioned in the Manual under the Calciferous (pp. 175, 176) in connection with remarks on the Quebec group; but it is added that "fossils probably of the Trenton period occur in the Vermont limestone"; and on p. 391, evidence in favor of a Trenton rather than a Calciferous or Quebec age is presented, based on the facts from the Vermont Geological Survey and the remarks by Billings.

By the close of the year 1862, therefore, the Black slates of the "Upper" Taconic had reached their right place in a Geological Manual. There remained however to be yet made out their particular horizon in the Cambrian, the particular periods of the Lower Silurian represented in the Stockbridge limestone, and the age of the quartzyte.

1865 to 1872.—In May, 1870, Rev. A. Wing, of Vermont, collected fossils from the limestone at West Rutland "not 100 yards from an abandoned marble quarry," which were sent a year later (June, 1871), to Mr. E. Billings, of Montreal, who reported upon them in this Journal for 1872, pronouncing them probably Chazy.* Mr. Wing had been exploring since 1865, in order to "ascertain if possible the geological age of the limestones, slates and quartzite," and relied on Mr. Billings for the determination of his fossils.† In 1867, Mr. Billings identified for him *Asaphus canalis*, two or three species of *Bathyurus*, *Maclurea matutina*, from the limestone in Cornwall, Vt., and made the species *Calciferous*. The same year he found the Trenton fossil *Trinucleus concentricus* in place "in great abundance" in Sudbury; also about this time or between it and 1872, he found "*Bathyurus Saffordi*, a Quebec Group trilobite" in East Cornwall; *Bathyurus extans*, a Birdseye species, *Columnaria alveolata*, a Black River species, and the *Trinucleus*, east of Shoreham; and confirmatory species as to the Calciferous as well as the later periods from other localities.

By 1872,‡ Mr. Wing had established one of the points he had in view, that the limestone was not, as Logan had held, of the Quebec group, or of Calciferous and Chazy only, but embraced the Trenton also, and apparently all the Lower Silurian forma-

* E. Billings, this J., III, iv, 133, 1872.
† A. Wing, this J., II, xiii, 332, 405, 1877.
‡ This J., III, iv, 1872; and for his conclusions, p. 414.

tions from the Calciferous to the Trenton; and, consequently, he had made it certain that whatever slates were really overlying were of Utica or Hudson age.

In 1869, an article by Prof. J. B. Perry appeared in this Journal, sustaining, by the results of his observations in Vermont, the Taconic system as presented by Emmons. As its principal stratigraphic points have now been disproved by the discovery of fossils, and evidence of the existence of faults and flexures which he misunderstood, it need not be noticed here.

1872 to 1886.—In 1871 the writer entered the field, believing that the Chazy fossils of West Rutland—the only part of Wing's discoveries then published—and the earlier discoveries of the Vermont Survey, made the region a good and certain base for a determination of the age of the Massachusetts and more southern portions of the Taconic rocks, as well as of the Vermont portion, and, thence, of the age of the schists throughout the Taconic Range. My purpose was (1) to prove the continuity from north to south of the three *associated* Taconic formations, the quartzyte, the limestone and the slates or schists; also (2) to work out the system of flexures; (3) to ascertain whether the Taconic Mountains were generally or not of synclinal structure, as they were made by Rogers, Mather and Hall, and in 1864 by Logan;* (4) to settle the question as to continuity from east to west of the limestone of the different north-and-south belts; (5) to apply the evidence from fossils, making them the sole basis for fixing the age of the beds; and finally (6), to use the evidence of the age, thus obtained, for the determination of the age of the hydromica schists, chloritic schists, garnetiferous and staurolitic schists, and other rocks of the Taconic Mountains, and thus test the value of, or give greater precision to, the assumed "lithological canon" first propounded by Prof. Emmons (p. 414). My work was continued in Western New England and Eastern New York at intervals from 1871 to the close of the season of 1886. In 1876 I accompanied Mr. Wing on a Vermont excursion, visiting besides other places, the West Rutland region of fossils in the limestone; a locality of small Orthocerata, apparently Calciferous, in the limestone two miles north of Middlebury, which Mr. Wing figured;† and the region of the Snake Mountain overthrust fault which he well understood.‡

By 1878, the problem began to receive new light from the discoveries of fossils outside of Vermont. In 1878, Mr. T. N. Dale announced Brachiopods of the Hudson Group in the Poughkeepsie Taconic slate.§ In 1878, Professor Wm. B. Dwight

* This J., II, xxxix, 96, 1865.

† A. Wing. this J., III, xiii, 406, 1877, where the Orthocerata are figured.

‡ Ibid., p. 413.

§ Dale, this J., III, xvii, 57. 1879.

began his numerous discoveries of Trenton and Calciferous fossils in the belts of "Sparry limestone" of Dutchess Co., N. Y., which he has continued to 1888;* and in 1885 and 1886 made other discoveries in the "Sparry limestone"—strictly the southern part of the Eolian—in Canaan, Columbia Co., N. Y., just west of the Taconic Range.† Thus the evidence of the Lower Silurian age of the limestone and slate went on accumulating. Further, both Hudson River and pre-Potsdam Cambrian fossils were reported by Mr. S. W. Ford from the east border of the Hudson near Schodack landing,‡ and Upper Cambrian by Professor Dwight near Poughkeepsie,§ both being cases of the uplift of Cambrian beds along a fault. Professor Dwight found the Hudson shales to be the prevailing rock in Dutchess County; also that it was intersected by numerous faults: Potsdam occurring faulted against Trenton, against Calciferous and against Hudson shales; and the Calciferous against Trenton and Hudson shales. Again, in 1886, Mr. I. P. Bishop, of Chatham, Columbia Co., N. Y., eight miles southwest of Canaan, announced‖ the occurrence of Hudson group graptolitic schists and fossiliferous Trenton limestone at that place, and the continuation of the beds northward to the borders of Rensselaer Co., N. Y., and south to Ghent—facts that bore on the age of the "Taconic slate" of Emmons not only for Columbia County but also for the region north.

My papers appeared in this Journal in 1872, 1873, 1877, 1879, 1880, 1884, and finally in 1885 and 1886, the series was continued, with new results, and the completion of a geological map of the limestone areas of the Taconic region east and west of the Taconic Range from Northern Bennington in Vermont to the southern limit of Canaan and Salisbury, Conn. It is not necessary to mention here conclusions. I was slow in reaching any positive conclusion about the age of the quartzyte because of the non-discovery of fossils, which I made the only reliable evidence of age. But in 1884 discovering chondroditic limestone in eastern Berkshire as evidence of the presence of Archæan, I made out an eastern quartzyte as Potsdam or Cambrian, leaving the quartzyte that alternates with the schists and limestone in the center of the Taconic limestone region, still in doubt. But the evidence was not sufficient to prove that there was a continuous belt of Archæan along eastern Berkshire and the Green Mountain Range to the north, so that

* W. B. Dwight, this J., III, xvii, 389, 1879, xix, 50, 451, 1880, xxi, 78, 1881, xxvii, 249, 1884.

† W. B. Dwight, this J., xxxi, 248, 1886.

‡ S. W. Ford, this J., III, xxviii, 35, 206, 242, 1884, xxix, 16, 1885.

§ W. B. Dwight, this J., III, xxxi, 125, 1886, xxxiv, 27, 1887.

‖ I P. Bishop, this J., xxxii, 438, 1886.

part of the mica schist and gneiss remained in doubt, as, for example, that of Hoosic Mountain east of North Adams, and that of Mt. Mansfield in the Green Mountains,* not knowing whether to pronounce them of the age of the Taconic Greylock schists which they closely resemble, or of that of the schists in the Quartzyte formation, or of Archæan age—thinking the last the least probable.†

In 1884 Professor C. H. Hitchcock published an account of new sections made by him across Vermont and New Hampshire, sustaining essentially his former conclusions as to the Lower Silurian age of the limestone and slates, making the Eolian limestone Lower Silurian.‡

Other papers, besides those that have been mentioned, appeared during the thirty years from 1855 to 1886, but none of importance that were the direct result of investigation of the Taconic region apart from what appeared on Northern Vermont and Canada. Articles on the Taconic system by Dr. T. Sterry Hunt have come out from time to time since his first in 1849 giving the views he had adopted ; views that were strongly opposed to Professor Emmons for nearly thirty years, and for the last ten, from 1878 to 1888, as strongly or a little more so, in favor of the Taconic system and in contest with the facts that were fast accumulating against it. As the arguments and conclusions presented were at no time based on his own investigations in the Taconic region there has been no occasion to cite from his papers.

1887, 1888.—In 1886 Mr. Charles D. Walcott, the excellent paleontologist of the United States Geological Survey, commenced the study of the Taconic slates, limestone and quartzyte of Northern and Southern Vermont and the adjoining counties in New York ; and in 1887, he continued his work southward into Williamstown in Massachusetts and to Berlin, southwest of Williamstown, in eastern New York. He added largely to the number of known Cambrian fossils of the Georgia region in Vermont and of Washington County in New York besides studying the stratigraphy; made many new discoveries of fossils in southern Vermont, finding in the

* Mt. Mansfield is the only peak of the Green Mountains which I have ascended.

† The quartzyte regions of (1) Washington, Mass., southeastern Pittsfield and eastern Lenox, (2) the eastern border of Tyringham, Mass., (3) the southern border of Canaan, Ct., adjoining Cornwall, and (4) the northern border of high eastern Sharon, Ct., near Salisbury, where there are quarries, are among the best localities for the study of transitions in the quartzyte toward gneiss; they were to have been my field of work in 1887, and failed to be so because of my sudden move to the Hawaiian Islands.

‡ C. H. Hitchcock, 34 pp. 8vo, with 2 plates, Concord, N. H., 1884. Bull. Amer. Mus. N. Hist., i, no. 5, p. 155, 1884; a note to the title says, "This article was prepared in 1882."

Stockbridge (Eolian) limestone Trenton fossils within half a mile of the Massachusetts line in Pownal; other Lower Silurian fossils on both sides of Mt. Anthony, three miles south of Bennington, a Trenton crinoid included; Trenton fossils in Williamstown, at the Hopper, at the west foot of Greylock and others in Berlin south of South Berlin; and at Hoosic Falls in Rensselaer Co., New York, west of Bennington, Trenton fossils again.*—The results warrant full confidence, he says, in the Calciferous-Trenton age of the limestone. Further, in the slates at Hoosic he obtained Graptolites, as had long before been found, of Hudson age. In the study of the quartzyte of Vermont, specimens in the Amherst cabinet (Amherst, Mass.) afforded him the species *Nothozoe Vermontana*, *Olenellus Thompsoni* and *Hyolithes communis;* the quartzyte mountain, two miles east of Bennington, Vt., gave him specimens of *Nothozoe*, *Olenellus* and *Hyolithes*, and the quartzyte of the west summit of Clarksburg Mountain or Oak Hill, on the borders of Williamstown, an *Olenellus*. These discoveries were preceded in 1886 by finding, along with Professor Dwight, *Hyolithellus micans* in the limestone resting on the quartzyte of Stissing Mountain in Dutchess Co., N. Y. (the quartzyte referred to by Professor Emmons), and heads of *Olenellus Thompsoni* at the same place in the quartzyte itself.

The colored map accompanying his paper in volume xxxv (1888) of this Journal has the above mentioned localities of fossils indicated, and also those of Cambrian age within the area of the Taconic slates over eastern New York and the borders of Vermont. The fossils are positive evidence of the age of the slates at the localities where they occur. But how far the slates away from the localities are Cambrian, or how far they are, instead, of the Hudson group, with faults here and there bringing up Cambrian, in Eastern New York, as in Dutchess County, remains yet to be ascertained. The doubt does not affect the general conclusion from the facts. Further, Mr. Walcott made out that the quartzyte formation, and the Bald Mountain and Georgia slates were alike in belonging distinctively to the Olenellus section of the Cambrian.

These discoveries of Mr. Walcott afford the first demonstration of the age of the quartzyte, and give new precision to our knowledge of the age of the Georgia, Bald Mountain and associated slates. Besides this, they give full completeness to the proof, that had been for years accumulating, of the Lower Silurian age of the Taconic limestone. They show, moreover, that the Primordial beds constituting Emmons's "Upper" Taconic, on account of which the terms Primordial and Taconic have by some been thought to be rightful synonyms, are

* C. D. Walcott, this Journal, III, xxxiv, 187, 1887, xxxv, 229, 307, 394, 1888.

only outcrops of the Cambrian formation of the "Lower" Taconic; that the "Lower" Taconic includes the "Upper" and is therefore all there is of Taconic.

It is thus finally made positive that the Taconic system is not a pre-Silurian system, and that the claiming for its equivalency with the Huronian was but a leap in the dark. It is manifest, in fact, that "Taconic system" is only a synonym of the older term "Lower Silurian," as this term was used by geologists generally, twenty, thirty and forty years since, and by many writers till a much later date.

It is almost fifty years since the Taconic system made its abrupt entrance into geological science. Notwithstanding some good points, it has been, through its greater errors, long a hindrance to progress here and abroad. It has also been a promoter of investigations of wide bearing and influence. But, whether the evil or the good has predominated, we may now hope, while heartily honoring Professor Emmons for his earnest geological labors and his discoveries, that Taconic ideas may be allowed to be and remain part of the past.

1841-1888.