

THE  
"TACONIC SYSTEM"  
AND ITS POSITION  
IN  
STRATIGRAPHIC GEOLOGY.

BY  
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## XI.

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## I. INTRODUCTION.

DE VERNEUIL has wittily said, that "the primordial fauna of Bohemia has made a fortune; one might also say, that the Taconic fauna in America has not made a fortune"; although Barrande's conclusion on the matter is thus stated: "Simple and impartial witness of the discussions of American geologists, we recognize in the Taconic fossils the same order of succession as that which is established in the palæozoic regions of Europe."\*

The publication of this memoir will not cause all opposition to the "Taconic System" to cease. When we remember the favorite dogma of mud-currents and gigantic waves of water in the transportation of erratic boulders, and the lively and passionate opposition that was made to the glacial theory of Agassiz and to the ice age, we see that an opposition of forty years' standing is "hard to die." Though the dogma of the transportation of boulders by water has been again and again demolished for fifty years past, it every now and then reappears dressed up anew, as a fresh contribution to geological progress.

Two sorts of manifestations are made against the Taconic system which escape refutation by their intangible nature. One is, simply to

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\* See "Documents anciens et nouveaux sur la Faune primordiale et le Système Taconique en Amérique," par J. Barrande, pp. 225, 228, and 238 (Paris, 1861).

write the "so-called Taconic system," — this expression containing the knowledge of the writer on the question. The other is, carefully to avoid naming the Taconic, even in the manuals destined to present to the public the actual condition of American geology.

In the same way one hears geologists say, "I do not believe in the doctrine of colonies"; or, "I do not believe in the passage of one or more species from one system of strata to another." To deny facts does not suppress them. They are there, in the field, and the only answer is, that those who do not see them are unfortunate.

"Geological theories, instead of being rigid and irrevocably fixed in their principles, should be framed with great elasticity, to embrace, if need be, unexpected facts. Geology is far from being complete for us, and is slowly forming itself, surmounting the difficulties of observation, and also painfully freeing itself from the hindrances that our limited human intelligence creates for itself by preconceived theories."\*

Geology is not a science to be studied in laboratories, nor by manuals; it is by work in the field, in deciphering the manuscript that the earth spreads everywhere before us, that a knowledge of it is attained; and certain more difficult pages of this terrestrial book require many years, and often several generations of geologists, to be correctly interpreted. In the end, the truth is always victorious, in spite of opposition and obscurity, and therefore the future of the "Taconic System" is fully assured.

## II. HISTORIC: 1837-1881.

**1837.**—The "sandstone of Potsdam" was first recognized and named by Dr. Ebenezer Emmons in 1837. In his "Second Annual Report" as Geologist of the Second Geological District of the State of New York (Albany, Feb. 15, 1838, p. 214), this name first appears, with a description of the quarries of Racket River, near Potsdam village, in the county of St. Lawrence. "Potsdam Sandstone," the designation of a group of rocks since become so celebrated in geology, was first printed on page 217 of the same Report.

**1838-42.**—The first appearance of the "Taconic System" is in the "Final Report on the Second District of New York" (Albany, Jan. 1, 1842), of which it constitutes Chapters VII., VIII., and IX. Dr. Ebenezer Emmons says: "A group or system of rocks which belong evidently to a position between the primary of the Atlantic

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\* Barrande, *Défense des Colonies*. IV. p. 79 (1870).

ranges of mountains and the New York system. In these remarks the writer does not expect to be able to give full justice to the subject on which he is about entering; the merit, to a certain extent, of removing some of the obscurities which envelop this system of rocks, is all that he would claim." A very modest estimate, certainly.

"The Taconic System, as its name is intended to indicate, *lies along both sides of the Taconic range of mountains*, whose direction is nearly north and south, or for a great distance parallel with the boundary line between the States of New York, Connecticut, Massachusetts, and Vermont. The counties through which the Taconic rocks pass are Westchester, Columbia, Rensselaer, and Washington; and after passing out of the State they are found stretching through the whole length of Vermont, and into Canada as far north as Quebec. It is, however, in Massachusetts, in the county of Berkshire, that we find the most satisfactory exhibition of these rocks. They form a belt whose width is not far from fifteen miles along the whole western border, and which extends clearly to the western part of the Taconic range."\*

He divides the rocks composing his Taconic system into five groups, in the following ascending order: 1. Stockbridge limestone; 2. Granular quartz; 3. Magnesian slate; 4. Sparry limestone; and 5. Taconic slate. Insisting more especially on the "liability to mistake some of the slates and limestones for those which belong to other systems." Emmons demonstrates that the Taconic system is "not connected with or related to the slates and shales of the Champlain group (Utica slate and Lorrain shales)." Finally he says: "These rocks are entirely destitute of fossils"; and "appear to be equivalent to the Lower Cambrian of Prof. Sedgwick."

In the following passage Dr. Emmons gives the exact time from which dates the Taconic system: "When, in 1836, I determined that in New York the Potsdam sandstone was the base of the Silurian system, it seemed that we had at that time the base of the sediments; but when, two years subsequently, I had observed the same base resting on sediments still older, as those along the eastern side of Champlain and elsewhere, it became evident that there was still a series older than the Silurian. The proof of this has been accumulating ever since; and the Taconic system is found to rest upon primary rocks without an exception; and it has now been observed through the whole length of the States, from N. E. to S. W. It is worthy of note,

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\* Geology of the Second District of New York, p. 136.

that through this whole extent the base is continuous. The most northeasterly point at which I have observed this system is at the Fox Islands, off the coast of Maine; but I have good reason to suspect its existence in Newfoundland. If so, it ranks among the most persistent geological formations of this country.\*

1844-46. — The quarto volume published in Albany, 1844, entitled, "The Taconic System, based on Observations in New York, Massachusetts, Maine, Vermont, and Rhode Island," is the work that has best made known this new system of rocks. Resuming his "Final Report" of 1842, Dr. Emmons here develops largely his first views, and extends them by explorations and observations throughout New England. The indication of fossils, all of them figured, is the most important part of the work, as follows: two Trilobites, *Atops trilineatus* and *Elliptocephala asaphoides*, found by Dr. Fitch near Bald Mountain, in Washington County, New York; several *Nereites* from Maine; and some *Graptolites* (fucoides) from the flagging-stone of Hoosick.

This memoir, except the Preface, is exactly reproduced in "Agriculture of New York," by Ebenezer Emmons, Vol. I. (Albany, 1844, 4to), with an Appendix of four pages. It constitutes the fifth chapter, from page 45 to page 112 inclusive.

1855-56. — Dr. Emmons gives a new statement of the documents relating to his Taconic system in his "American Geology," Vol. I. Part II. pp. 1 to 122 (Albany, 1855, 8vo). Here are a few quotations: —

"*The Taconic period one of animal and vegetal life.* — This system is not less thoroughly peculiar in its organisms than in its physical characteristics. It is true that the number of its fossils is small when compared with the Silurian period; but, as far as they go, they stamp upon it a distinctiveness which is as marked as that of the Silurian and Carboniferous. . . . As a general rule, however, the fossiliferous bands occupy nearly the same horizons, and they are so rarely absent that the palæontologist always expects to find them. It is not so, however, in the Taconic system; *there is a general barrenness of life* and vitality, which is not accounted for, unless it is regarded as due to the period in which the rocks were deposited. . . . While the Silurian carries its characteristic fossils for more than a thousand miles, the Taconic system is equally comparatively barren for the same distance. Again,

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\* American Geology, Part II. The Taconic System, (Albany, 1855,) pp. 5 and 6.

the scarcity of fossils cannot be explained on the ground that the rocks have not been examined. This series of rocks have been under the eyes of geologists since 1817; they have been examined minutely in Rensselaer and Washington counties, New York, and Berkshire, Massachusetts, and with more or less care over the whole area of western Vermont. A few fossils only have been discovered over this large area. Of the fossils which these rocks have furnished, marine vegetables are the most common, but they are limited to a few obscure species; the thickness of the bed in which they occur is at least 2,000 feet. Graptolites rank next in numbers; they even exceed the marine plants in the number of species which have been found. In addition to the foregoing, there are three species of Trilobites and some four or five of mollusca."

Dr. Emmons describes four marine plants, twenty-one Graptolites, six Mollusca, and three Trilobites. Of the Mollusca he says, "Most of the mollusca of this system belong to the family of Brachiopods, all of which are so minute that it is difficult to discover their most important characters." And of the Trilobites he observes, "*The species, however, are unknown in the Silurian period.*" Finally, Emmons summarizes the Taconic system in the following manner.

"The Taconic system rests, then, on the following points:—

"1. Its series, divided into groups, are physically unlike the Lower Silurian series.

"2. It supports unconformably at numerous places the Lower Silurian rocks.

"3. It is a vital system, having been deposited during the period when organisms existed.

"4. As a natural history system, it is unlike the Lower Silurian; first, in containing fossils yet unknown in the Lower Silurian; and, second, in the absence of the typical forms which are prevalent in the Lower Silurian.

"5. In the Taconic system we have the palæozoic and sedimentary bases; the former comes in far above the latter, or at a long period subsequent to the time when deposits began to be formed.

"6. The Taconic system carries us back many stages farther in time, when life gave vitality to its waters, than the Silurian. It represents a period vastly longer, though it may occupy a less superficial area."\*

In Chapters X., XI., and XII. of his "Geological Report of the Midland Counties of North Carolina," (Raleigh, 1856, 8vo.) Dr. Em-

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\* American Geology, Part II. The Taconic System, p. 122.

mons gives a description of the Taconic system in that State. He points out the existence of fossil corals in the lower Taconic series near Troy, in Montgomery County, and describes and figures them, pages 62 and 63, under the name of *Paleotrochis major* and *P. minor*. There are some doubts as to their organic character, and it is possible that like *Bozoön* they belong to the mineral kingdom.

1859-60. — In his "Manual of Geology," first published in 1859, and a second edition in 1860, (New York, 8vo,) Prof. Emmons describes the Taconic system in Chapter XI. pp. 81 to 89. "This system is subdivided into a *Lower* and *Upper*; the first consists of a conglomerate at the base, succeeded by silicious talcose beds of considerable thickness, in which there are frequently pebbles; next above, are three thick beds of sandstone, separated by talcose slates; these are succeeded by the Stockbridge limestone. This is the marble of Berkshire County, Massachusetts, which extends from the State of Vermont to Georgia. The Stockbridge limestone is succeeded by a mass of slate of great thickness, the upper part of which is suitable for roofing. The greatest thickness of the Lower Taconic rocks is about 5,000 feet. . . . *Upper Taconic rock* consist of numerous beds of slate alternating with shales, thin-bedded sandstone, some of which are coarse and brecciated, thin-bedded bluish limestone, more or less cherty and checked with seams of white calcareous spar, and red, brown, and purple roofing-slates. . . . According to Barrande, the *Paradoxides* and *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 co-ordination with the upper series of the Taconic rocks." A most important remark, at a time (1859) when every geologist and palæontologist in America except Colonel Jewett and Billings, were against the existence of the Primordial zone in the Taconic system.

Finally, Emmons, in a note at the end of the second edition, 1860, of his Manual of Geology, page 280, says: "The slates or shales referred to (in the Regent's Report of New York for 1859), in Northern Vermont, as constituting a new series above the so-called Hudson River group, instead of ranking thus high in the geological scale, are really sub-silurian, as is fully proved by the overlying calciferous (red sand-rock) sandstone. . . . We now know the following Trilobites, all of which belong to a slate beneath the calciferous," (Emmons called the red sand-rock of Vermont, which is since proved to be identical with the Potsdam sandstone, *Calciferous sandstone*,) "viz.: *Atops punctatus*, *Eliptocephalus* (*Paradoxides*) *asrphoides*, *Paradoxides Thompsoni*,

*Par. Vermonti*, *Par. macrocephalus*, *Par. (Pagura) quadrispinosus*, and *Microdiscus quadricostatus*."

This finishes the list of documents published by Dr. Emmons. In September, 1860, he went to North Carolina as State Geologist, and continued within the enemy's lines during the civil war until he died, in 1863, at his plantation in Brunswick County, on the 1st of October. Notwithstanding the difficulty of his position, he received the first memoir published in his favor by Barrande and Marcou at the end of December, 1860, and the following extracts are from his last letters.

We must remember that a powerful, systematic opposition, verging on persecution, had been at work from the beginning against the Taconic system and its author. This is necessary in order to follow clearly the progress and development of the Taconic system question. Its adversaries pretended that the strata in the northern part of New York State, placed beneath the Potsdam sandstone by Emmons, were the beds of *Lorrain Shales*, above the "Utica Slate," these being called *Hudson River group* for the eastern region of the State; that farther east these beds of the Hudson River group were followed in concordant superposition by *metamorphic* rocks, which were, according to them, the "Upper Silurian" and even "Devonian." In a word, the Potsdam sandstone was the base of the sedimentary rocks, the most ancient group of all, resting directly upon the gneiss and granite; and even sometimes, as in the Highlands, the Potsdam sandstone was altered and "becoming gneissoid and granitic."

The positions were well taken. On the one side, Dr. Emmons described strata thirty thousand feet in thickness as a special system of rocks having a well-defined stratigraphy, its own lithology, and containing its own fossil organized remains, constituting the most ancient and the most important system in the stratigraphic series. On the other hand, his adversaries denied all this *in toto*, using the very elastic word *metamorphism* to explain everything.

1859-60. — "The Twelfth Annual Report of the Regents . . . of the State Cabinet of Natural History" of New York, dated March 15, 1859, Albany, contains (p. 59) a notice under the title of "Trilobites of the Shales of the Hudson River Group."

There are only three fragments of Trilobites described by Prof. James Hall, under the names of *Olenus Thompsoni*, *Olenus Vermontana*, and *Peltura (Olenus) Holopyga*.

The description of these fossils collected from the schists "in the town of Georgia," and presented as coming from the shales of the *Hudson River group* of Vermont, ends with the following note: "In



addition to the evidence heretofore possessed regarding the position of the shales containing the Trilobites, I have the testimony of Sir W. E. Logan that the shales of this locality are in the *upper part of the Hudson River group*, or forming a part of a series of strata which he is inclined to rank as a distinct group *above* the Hudson River proper. It would be quite superfluous for me to add one word in support of the opinion of the most able stratigraphical geologist of the American continent."

This little notice had the privilege of drawing the attention of Joachim Barrande, "the inventor of the primordial fauna," as he was happily styled by D'Omalus d'Halloy, and here follow, in the order of their dates, the correspondence and publications brought about by the intervention of Barrande.\*

"PARIS, 28 Mai, 1860.

"MON CHER MONSIEUR MARCOU :—

". . . Si vous voyez le Prof. W. B. Rogers, je vous prie de lui dire, que je suis très reconnaissant des trois belles photographies de *Paradoxides Harlani* Green, qu'il a eu la bonté de m'envoyer. Elles ont beaucoup intéressé notre société géologique à laquelle je les ai montrées, en constatant que cette espèce est identique avec *Parad. spinosus* de Bohême. C'est un fait très important, et qui doit avoir d'heureux résultats, pour établir les relations d'âge entre les formations les plus anciennes des deux continents.

"Par occasion, je désirerais beaucoup savoir par le Prof. Hitchcock, géologue de Vermont ou par tout autre savant qui aurait étudié le terrain :—

"1°. Quels sont les fossiles qui se trouvent dans les mêmes couches qui ont fourni les trois trilobites récemment d'écrits par J. Hall dans le *12th Annual Report of the Regents of the University of New York*, p. 59, sous les noms de *Olenus Thompsoni*, *Ol. Vermontana*, et *Peltura (Olenus) Holopyga*.

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\* Colonel E. Jewett, Curator of the State Cabinet of Natural History of New York at Albany, "during the numerous excursions he had made over the disputed territory, had arrived at the conclusion, from his own observations, that Dr. Emmons was, upon the whole, correct in his views," and Billings, "on the 25th of April, 1860, . . . sent a copy of Prof. Hall's pamphlet, containing the figures and descriptions (of the three Vermont Trilobites) to Barrande, then in Paris," and said, "I referred him to these three trilobites, as an example of a group of primordial fossils, in rocks which were considered by American geologists to be of the age of the Hudson River formation."—Remarks on the Taconic Controversy, by E. Billings, in "The Canadian Naturalist," New Series, vol. vi. pp. 315 and 317 (Montreal, 1872).

“ Ces trois fossiles auraient été trouvés dans les schistes de la ville de Georgia admis comme recouvrant le groupe de Hudson River ; d'après l'autorité de Sir W. Logan, invoquée par J. Hall.

“2°. Sur quelle sorte de preuve repose la détermination de cet horizon ?

“ Le terrain de ce pays est-il tellement simple et clair dans sa constitution stratigraphique, qu'on ne puisse avoir aucun doute sur cette détermination ? ou bien, y a-t'il des accidents locaux qui pourraient faire hésiter sur le véritable horizon auquel on doit rapporter les schistes de Georgia ?

“ Le fait est que ces trois *Olenus* seraient fort surprenants dans une formation au dessus de ' Hudson River group.'

“ D'un autres côté nous avons deux exemples assez remarquables des rectifications que la paléontologie, bien entendue, peut faire dans les travaux purement stratigraphiques. D'abord au sujet des collines de Malvern en Angleterre, qui nous offre réellement la faune primordiale au lieu de celle de Caradoc que le *Geological Survey* y avait déterminée. En second lieu au sujet de la chaîne Cantabrique où la même faune primordiale vient d'être reconnue en contact immédiat avec la faune dévonienne avec laquelle elle avoit été confondue par tous les géologues. . . .

“J. BARRANDE.”

“ PARIS, 14 Août, 1860.

“ MON CHER M. MARCOU : —

“ Votre aimable lettre du 30 Juin dernier m'est parvenue le 17 Juillet, lorsque j'avais déjà écrit la lettre à M. Bronn, dont la copie est ci-jointe. Vous jugerez aisément, que la question est importante et fort intéressante, lors même qu'elle ne serait soulevée qu'à l'occasion des trois *Olenus* de Georgia. Mais elle prend subitement une grande extension par suite d'une lettre de M. Billings que je viens de recevoir. M. Billings m'annonce qu'il vient de recueillir, aux environs de Québec, dans des schistes et calcaires considérés comme formant la prolongation de ceux de Vermont en question, une suite de près de 100 espèces, presque toutes nouvelles. Dans ce nombre, 26 qui proviennent d'un calcaire *blanc*, lui semblent être de véritables représentant de la faune primordiale ; et il cite parmi elles des *Conocephalites*, *Arionellus*, *Dikelocephalus*, etc., c'est-à-dire des formes qui sont en effet très caractéristiques de cette faune. Dans un autre calcaire, qui est *gris*, il trouve 39 espèces, toutes différentes des premières citées, et représentant, au contraire, les types les plus prononcés de la faune

seconde. Enfin les schistes noirs lui fournissent des *Graptolites*, des *Lingules*, etc., c'est-à-dire des formes dont la première vue ne peut pas déterminer l'horizon, parcequ'elles se trouvent sur divers horizons siluriens.

“Quant à l'ordre de succession des roches diverses, renfermant ces trois groupes différents de fossiles, M. Billings ne s'explique pas, ou ne se prononce pas encore, car le fait est tout récent et doit être à l'étude.

“Mais, en attendant que les relations stratigraphiques très obscures, soient débrouillées, et sans engager en aucune façon M. Billings, qui doit conserver toute l'indépendance de son opinion, je crois pouvoir vous exprimer ma manière de voir, toute personnelle, et dont je dois en ce moment prendre seul la responsabilité. Je pense donc, que cette région des schistes et calcaires de Vermont, du *Taconic system*, en d'autres termes, reproduira en Amérique ce qui a eu lieu en Angleterre pour les collines de Malvern ; c'est-à-dire que la faune primordiale, après y avoir été méconnue, y reprendra ses droits et sa place, usurpée par la faune seconde.

“Vous voyez que c'est une grande et belle question, dont la solution finale complétera les importantes harmonies, qui existent déjà entre la série des faunes paléozoïques d'Amérique et celle des faunes contemporaines d'Europes, en laissant à chacune l'empreinte particulière à son continent.

“Je conçois très bien d'après les positions antérieurement prises par nos savants confrères américains, au sujet du *Taconic system*, que la solution finale dont je parle ne sera pas obtenue sans contestations et peut-être sans quelques froissements d'amour propre, car il faudra abandonner quelques opinions qui paraissent être dominantes. Mais l'expérience m'a enseigné qu'en pareil cas, ce sont toujours les esprits les plus élevés qui s'ouvrent les premiers à la lumière, et qui se mettent en tête du mouvement de réforme.

“Ainsi lorsque en 1850 j'ai reconnu la faune primordiale dans les collines de Malvern, où l'on n'avoit vu que la faune seconde, Sir Henri de la Bèche et Sir Roderick Murchison ont les premiers adopté mes vues, auxquelles se sont ralliés peu à peu les autres géologues officiels. Edouard Forbes n'a pas hésité à se ranger publiquement à mon opinion, dès 1853, lorsque d'autres hésitaient encore, dans le *Geological Survey*. Aujourd'hui il n'y a plus aucun opposant à ce sujet.

“Je me figure qu'il en sera à peu près de même en Amérique, et que d'ici à peu d'années l'opinion des savants aura subi une profonde modification, en ce qui touche cette question.

“ Si le Dr. Emmons fait encore de la géologie, c’est pour lui une belle occasion pour reproduire ses anciennes observations et ses idées, avec plus de succès qu’en 1844. Le connaissez vous ? Pourriez-vous l’instruire de ce qui se passe ? en lui communiquant ma lettre à M. Bronn.

“ Comme j’ai envoyé copie de cette lettre à Sir W. E. Logan, en le priant de la transmettre à Mr. J. Hall, vous sentez que la communication à d’autres personnes est maintenant bien permise, et par conséquent vous pouvez faire de cette lettre l’usage que vous jugerez à propos, et même la *publier* s’il y a lieu.

“ Dans tous les cas, je vous prie de la montrer à M. Agassiz. Par la même occasion, vous pouvez lui dire qu’il peut compter sur la parole que je lui ai donnée, au sujet de mes *duplicata*, dont j’ai déjà préparé une partie à son intention. Mais, au milieu de mes occupations et affaires, il m’est difficile de consacrer à ce travail minutieux tout le temps qu’il exige pour être fait convenablement. . . .

“ J. BARRANDE.”

Part of this letter and one paragraph of the letter of May 28 were published in the Proceedings of the Boston Society of Natural History, Vol. VII. pp. 369 to 375, December, 1860. The letter to Prof. Bronn of Heidelberg, referred to, was also translated by Mrs. Marcou, and published in a communication made before the Boston Natural History Society, October 17, 1860, under the title, “ On the Primordial Fauna and the Taconic System, by Joachim Barrande ; with additional Notes, by Jules Marcou.” (Vol. VII. p. 371.) It was also published in German and in French, at Stuttgart and Paris.

“ ALBANY, September 1, 1860.

“ TO PROF. J. MARCOU.

“ MY DEAR FRIEND, . . . I shall, and do now hope that I may enlist you in the controversy respecting *the Taconic rocks*, and I want exceedingly to show you places of importance and of great interest, and I know what your opinion will be beforehand, though now you may, and probably do, entertain views directly contrary to my own. I have forborne to bring the question relative to the existence of the Taconic system before you, for it was not the time ; but as you must now be an American geologist, I hope all American questions will be entertained and investigated by you. Yet it is not an American question exclusively, for the upper part of the Taconic is equivalent to Barrande’s *Primordial Group*. . . .

“ E. EMMONS.”

“MONTREAL, October 30, 1860.

“TO M. JULES MARCOU.

“MY DEAR SIR, . . . I have read your Geological History (in ‘Geology of North America,’ p. 99, Chapter IX., 4to, Zurich, 1858) with great pleasure. That work contains many views which are precisely in accordance with those which I have long entertained, but never saw in print before. Professor Dawson informs me that you are about to investigate the Primordial Zone of North America, or the Taconic system of Emmons. I am glad that you have taken up this subject. . . . I have been attached to the Geological Survey of Canada only four years, and the Taconic question, so far as it has been investigated here, was settled long before I ever saw either Professor Hall or Sir W. E. Logan. Hall, although not on the Survey, was the palæontological adviser, and he decided that the Quebec rocks were Hudson River, because they contained Graptolites. Taking these rocks as a starting point, Sir William, with immense labor, traced out the geographical distribution and physical succession of all the others in the disturbed region of Canada East. You will see that, if there has been any mistake made, it originated in Hall’s determination of the fossils of the Point Lévis or Quebec Graptolites. Hall’s mistake, I think, is partly due to his ignorance of the geology of Europe. He has always been of opinion that in Europe Barrandé’s Primordial Zone overlies the Lower Silurian. You will see by reference to Foster and Whitney’s ‘Report on Lake Superior,’ page 318, in the comparative table which he gives on the European and American formations, that he places the ‘alum schists and argillaceous schists of Northern Europe with *Graptolites*, *Olenus*, *Ampyx*, etc.,’ above the ‘Orthoceratite limestone.’ Now, it is well known that the ‘alum slates’ of Sweden constitute the *Primordial Zone*, or Angelin’s *Regiones A*, *B*, and also that they underlie the ‘Orthoceratite limestone.’

“Emmons is the man who actually made the discovery of the Primordial Zone on this continent, and who is entitled to the credit; and when we consider that he has stood alone against all the leading geologists of America for more than twenty years, it would be hard if his . . . opponent were to come in and share the honor with him.

“I made the above statements upon the supposition that it will be proved by physical geology that the ‘Champlain series,’ from the Potsdam upwards, do overlie the Taconic rocks. I have examined the fossils only, and such as I have seen appear to me to represent in part the fauna of Angelin’s *Regio B C*, and in part the Primordial

Zone. I have become of late very deeply interested in this question, and would like to see it settled; but I do not, owing to my peculiar relations with others, desire to be recognized publicly in the matter. It is on account of my interest in the question, and because I like your writings, that I take the liberty of communicating thus freely with you, although you are a stranger to me, and may feel surprised that I should take such freedom.

“Yours, with the greatest respect,

“E. BILLINGS.”

“RALEIGH, N. C., November 6, 1860.

“PROF. JULES MARCOU.

“MY DEAR SIR, . . . . But of all the erroneous opinions ever published in this country, are those adverse to the *Taconic system*, a system which stands out as boldly in our system of rocks as the Carboniferous. . . . .

“E. EMMONS.”

“RALEIGH, November 19, 1860.

“PROF. J. MARCOU.

“MY DEAR SIR, . . . . I am right in the Taconic system! and of [*sic*] that, though it may not be so clear in the book [referring to his *Manual of Geology*], is clear as daylight in the field. But (*inter nos*) I do not think Barrande goes far enough; and I do not think him right in maintaining that his Primordial group is a part or parcel of the Silurian. And if you have taken that view you will have to back out, for the Lower Silurian is strictly unconformable to every part of my Taconic series; and this series is *sui generis*, one *geologically, stratigraphically, and palæontologically*, with a host of other long words, separate and distinct from Silurian.

“E. EMMONS.”

“RALEIGH, November 20, 1860.

“PROF. JULES MARCOU.

“MY DEAR SIR, . . . . I sent, three or four weeks ago, all my publications to Barrande, who has written me, though they had not reached him. Perhaps yesterday I did Barrande injustice, if a person in my position and acquirements can do so. On reading his 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.

"I need not dwell on this point. We can discuss this question when face to face. Only my remarks are not intended to convey the slightest disparagement of his discoveries in that particular, and I believe, if he was here, he would no longer maintain the doctrine that this group is Silurian. I shall wait with anxiety the reception of your promised paper. You have already, as Colonel Jewett tells me, stirred up my opponents, one of which took the Colonel to task a few days ago for his belief in the 'Emmonsian myth.'

"E. EMMONS."

The promised paper spoken of in this last letter of Emmons was my communication to the Boston Natural History Society, 17th October, Vol. VII. of the Proceedings, pp. 357 and 369, under the title of "On the Primordial Fauna and the Taconic System, by Joachim Barrande; with additional Notes by Jules Marcou." A very short *résumé* only appeared in the proceedings of the meeting of October 17. However, the priority of the discoveries of Emmons was stated; also, that "the Taconic system is equivalent to the Primordial fauna of Barrande"; and "Mr. Marcou considers this [the Potsdam sandstone] not the first fossiliferous stratum, but the last of a series containing the Primordial fauna." Finally, the memoir was accepted for publication, and it was placed among the proceedings of the next meeting, November 7.

These statements were the starting-point, and the pivot on which the evolution of the views regarding the Hudson River group as the last and uppermost division of the second fauna revolved; and the Taconic system was again brought forward.

Here follow, successively, and in their order of dates, the most important letters and notes.

"MONTREAL, December 21, 1860.

"M. JULES MARCOU.

"MY DEAR SIR, — I have seen your paper in the Proceedings of the Boston Natural History Society.\* I think you are right when you say that Emmons should have included the Potsdam in the Taconic. . . . I very much wish this question [of the Taconic and Primordial zone] was settled, but I think it will be two or three years before any conclusions that will satisfy all parties will be arrived at.

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\* The signature of the sheet of the Proceedings is 24 December, 1860. So copy or copies were sent, without my knowledge, to Montreal, as early at least as the 19th of December.

"I beg to state that the limestone at the top of the fall at Montmorency is Trenton limestone, and full of fossils. I have collected a good many there myself. I did not examine the rocks at the foot of the fall, as I had no idea when I was there that any question as to its age would ever arise.

"E. BILLINGS."

"RALEIGH, December 28 or 29, 1860.

[Postal mark, December 29.]

"PROF. J. MARCOU.

"MY DEAR SIR,—I thank you for your pamphlets, and am exceedingly gratified with the view you have taken of the question. It is presented in an unanswerable form. I have dwelt more upon the stratigraphical relations of the two systems; because, to ordinary readers, that is perfectly obvious. I insisted, however, upon the palæontological view, the palæontological evidence; and said often, that, if this was rejected, then ought all of this kind of evidence to be rejected elsewhere. Mr. J. Hall insisted upon the identity of the *Atops* and *Triarthrus*; notwithstanding the decision years ago by a committee of the American Association, of whom [*sic*] Conrad was a member, was against Hall.

"I made and published with my Report while in the survey of New York a modified map of the State, which showed the extent of the Taconic rocks in New York. The three thousand copies were stolen or destroyed by persons unknown, so that they were never issued with the proper volume. The rocks illustrating the Taconic system in the State Cabinet were all taken out by order. . . . My existence as one of the State geologists was ignored at the last meeting of the American Association at Albany. In fine, the persecution I suffered for opinion has been rarely equalled. . . . The editor of the American Journal of Science refused to publish my remarks upon Logan's Report, when he announced his Huronian system; though they were courteous in the extreme. I claimed that the *Huronian* was only 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? Nothing of the kind occurs in the Lorrain slates, or the shales about Rome, where the rocks are undisturbed; there are probably two species in the Trenton and the slates above. No more.

"I shall be very much obliged to you for six more copies of your paper.

"E. EMMONS.



"P. S. As it regards the Potsdam sandstone I think you right, so far as Owen's discoveries are concerned. It is a point I have not thought of, and is new to me. The suggestion is a good one, and must be met."

"RALEIGH, December 30, 1860.

"PROF. J. MARCOU.

"MY DEAR SIR,— I wish, if not inconvenient, you would send three or four copies of your pamphlet to Colonel E. Jewett, Curator of the State Cabinet of Natural History, Albany. He is now one of the strongest friends I have, and will do much to disseminate the truth. . . . I have no doubt that, for fossils, the Taconic is the best field for work which remains, though it may not prove to be productive in numbers.

"E. EMMONS."

"RALEIGH, January 23, 1861.

"PROF. J. MARCOU.

"MY DEAR SIR,— I am under the highest obligations to you for the decided part you have taken in the question respecting the Taconic system. Your example and decision, and judicious statements, have effected a revolution in opinion quite remarkable. I should not forget Mr. Billings; for, placed as he was, he must have run great risks in the course he took; but no man is good for anything unless *he dare express an opinion* when he has formed one. . . . It was ten years ago, I think, when I claimed Logan's Huronian system as nothing more than the Taconic. . . .

"It is really a matter for wonder that Sir Wm. Logan has conceded as much as he has. I am told he has not done the thing *very* gracefully. But the case was one that there was no way to get around it, nor over it, nor through it; sooner or later, the acknowledgment must be made, and the sooner was the wise course. I have not yet seen what he answered to Barrande.

"Colonel Jewett is a capital man. He is not afraid to speak what he thinks.

"When once the Primordial group is recognized, the rest follows necessarily, unless an older system is called up and a new name given.\*

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\* Dr. Emmons has evidently no idea that a part of the Primordial zone will be called "Quebec group," and placed above the Potsdam sandstone, and as a substitute to the Calciferous, the Chazy, and the Trenton groups. An expedient so contrary to what exists in the field never came into his mind.

The idea of Prof. Hitchcock that the Berkshire marbles are *Devonian* is a great way from the truth; because, in the range of mountains between New York and Massachusetts, this limestone lies below the slates which run up into those containing the primordial trilobites.

"The acknowledgment of the *Primordial of Barrande in this country* is really one of the finest and best facts in geology, making a *co-ordination of American and European rocks so complete and harmonious*; I think of nothing I have said or done in this matter; I look upon the harmony of the systems; they are truly worth dwelling upon; and a great deal more is yet to come out.

"I want much to see you when I get to Albany in the spring, to look over with me my fossils from the Trias and Dyas. — By the way, this puts me in mind of the *Dyas* controversy with Murchison; and I think you have got the better of the old Dictator; and the Dyas must stand and take the place of Permian.

"E. EMMONS."

"RALEIGH, January 28, 1861.

"PROF. J. MARCOU.

"MY DEAR SIR, — You will excuse me for addressing you at this time, or again, inasmuch as my letters, I fear, may get to be troublesome. But I wish to say two or three things about your proposition to place the Potsdam sandstone at the top of Barrande's Primordial group or my Taconic system. Let me declare, once for all, that I have not the slightest objections to your view; as if when established it would diminish aught of the importance of my views; but simply to present something for your consideration before the Potsdam rock, as I established it in 1836-37, is abandoned as the base of the Silurian system.

"In St. Lawrence and Jefferson Counties, where first observed, it is underlaid by beds of *coarse granitic conglomerate*, and then graduating into a fine even-grained sandstone, and then the sandstone graduating again into the Calciferous sandstone above, the latter of which is perfectly conformable,\* so that there is no line really of demarcation between the Potsdam and the Calciferous. Now in the region I have named I see no possibility of excluding the Potsdam from the Silurian system, and there are no fossils except a single *Lingula*

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\* It is a mistake. I have observed since at Chazy and Potsdam a discordance of stratification of 15° between the Potsdam sandstone and the Calciferous sandrock. — J. M.

scarcely differing from the one in the Calciferous.\* So much for the St. Lawrence region.

“But now as to Iowa and the West, I understand Owen to say, that far below what he would call the Potsdam proper, there are beds with Primordial fossils (he does not use the word, but we may). Here, then, we have got down to another series, which no doubt appears to be conformable with the Silurian, but with peculiar fossils and in abundance. These no doubt should be regarded as the upper part of the Primordial series, and it may be contain sandstones. I have not Owen’s book to refer to. Again, not having seen these beds, I have no satisfactory knowledge how they lie; but those sandstones may be placed as you suggest. And I go further, and say, if you believe you can make out a good case with the Potsdam anywhere, I never shall object, for I have no wants except truth.

“But the break, or the heavy conglomerate at the base of the Potsdam in St. Lawrence County, seems to me to favor the position I took, that the sandstone and conglomerate beds are at the base of the Silurian. I merely suggest these facts for your consideration.

“In conclusion, allow me once more to thank you for all you have done in American geology, and especially for the benefit you have been to your servant,

“E. EMMONS.”

This letter is the last I received from Emmons. After the breaking out of the civil war, I was unable to send either the memoir of Barrande, “Documents anciens et nouveaux sur la Faune Primordiale et le Système Taconique en Amérique,” or my observations and pamphlets of 1861 and 1862, entitled, “The Taconic and Lower Silurian Rocks of Vermont and Canada” (Proceedings Bost. Soc. Nat. Hist., Nov. 6, 1861), and “Letter to M. Joachim Barrande on the Taconic Rocks of Vermont and Canada” (Cambridge, 1862). The impossibility of reaching him left Dr. Emmons partly in ignorance of the efforts made in favor of his “Taconic system.”

These last letters, the two dated in January, 1861, are given to show his opinions at the moment of the change made in the official classification of the geological survey of Canada. They were written in ignorance of the printed letter of Logan to Barrande, and it is doubtful if Dr. Emmons ever saw it.

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\* Several fossils have been found since in the Potsdam sandstone near Keeseville, besides the *Lingula* (*Obolella*) *prima*, such as *Lingulepsis minima*, *Conocephalites minutus* and *C. Verrucosus* Whitf., entirely Primordial fossils.

The letter of Billings, 21 December, shows an acquaintance with the memoir containing extracts from three letters of Barrande; the official date of this memoir is 24 December, 1860, printed at the foot of the page, and its having been sent to Montreal before its issue at Boston, and before I had seen it even, is a sufficient proof of the interest excited by it; it was in part reprinted immediately in several scientific journals.

**1861.** — Logan could hardly delay any longer his answer to Barrande's letter of 1860, containing a copy of the letter to Prof. Bronn. The publication of this letter in English rendered it necessary for him to make a decision. After great hesitation he decided to write a printed letter, entitled, "Remarks on the Fauna of the Quebec Group of Rocks, and the Primordial Zone of Canada, addressed to M. Joachim Barrande." 31 December, 1860, is the date of the letter; the date of the impression is 3 January, 1861, and it was distributed and sent from Montreal on the 12th of January. This document of five pages is the letter of a diplomatist rather than of a geologist.

The explanation of the stratigraphy of Point Lévis is unintelligible; so much so, that some months later he was unable to explain it to me on the map made by himself of Point Lévis; and that on the ground, after two successive studies made in 1861-62, I was unable to make this explanation agree with what exists at Point Lévis.

The principal concession of his letter is the existence of what he erroneously calls the "Quebec group" (it is in reality the "Point Lévis group"), of a thickness of perhaps some 5,000 or 7,000 feet, which he regards as equivalent to, and on the horizon of, the two divisions of Chazy limestone and Calciferous sandrock with points of "overturned Trenton" from time to time framed therein, in Vermont, but not in Canada. Further, he thinks the "*Olenus* shales of Georgia" are interposed in the strata of the Quebec group, and that the whole rests upon the "Potsdam formation," which, according to him, forms the "New Primordial zone in Canada." A paragraph is given to Lake Superior, where he looks upon the sandstone as Chazy, Calciferous, and Potsdam, or the equivalent of his Quebec group; and the rocks containing copper as belonging to his Huronian system.

Finally, he admits that Prof. Emmons was certainly right to maintain that the rocks in Vermont are older than the Birdseye formation; and that Billings regards the trilobites of the Quebec group as indicating that this group is nearly at the base of the second fauna. The last phrase declares Georgia to be a constituent part of the Primordial zone, contrary to what he had said a few paragraphs back.

This letter does not allude to the memoir published a fortnight previously at Boston, which he had received, as appears from the letter of Billings.

Three communications were made by M. Barrande to the Geological Society of France at the meetings of the 5th and 19th of November, 1860, and the 4th of February, 1861, which appeared under one title, as "Documents anciens et nouveaux sur la Faune Primordiale et le Système Taconique en Amérique." This memoir, so remarkable for its clearness, impartiality, and the opinions it contains, is an admirable justification of the "Taconic system." We can only regret that Emmons only knew of its existence, without being able to see it.

Several unpublished letters of Barrande, of January, 1861, and later, are given as important in showing the progress accomplished by his intervention.

From far distant Bohemia, where he had studied with the greatest care, first the stratigraphy and then the palæontology of a very small geologic basin in the centre of Europe, Barrande recognizes that Emmons is right in placing the strata of the eastern part of Lake Champlain below those of the other side of the lake on the western shore in the State of New York; that he is correct in placing below the second fauna a Primordial fauna contained in beds that constitute the Paleozoic base, and a wholly new system justly called by him the "Taconic system"; that the opposition to these views for twenty years past is not only unjust, but erroneous, and that his adversaries have only to change their base and adopt more correct ideas. At so great a distance, he cannot enter into details; these he leaves for those on the ground, who study the stratigraphy of these regions, contenting himself with having brought forward the "Taconic system," and shown all its value and importance.

"PARIS, 20 Janvier, 1861.

"JULES MARCOU, ESQ.

"MON CHER CONFRÈRE,—J'ai successivement reçu vos deux lettres du 16 et 24 Décembre avec vos deux envois de brochures, comprenant 20 exemplaires, outre la première épreuve, et la note de notre ami M. Agassiz sur l'origine des espèces.

"Votre long silence ne m'a pas étonné et je l'avais même interprété assez justement, car je m'étais figuré que, ne pouvant obtenir à Boston, des documents assez positifs sur le terrain Taconique, vous aviez pris le parti d'aller en personne sur les lieux. Je supposais que vos explorations avaient exigé tout ce temps et j'attendais patiemment vos

résultats. Je ne m'étais pas trompé en principe, puisque votre lettre du 16 Décembre me fait part de vos projets d'excursions et des circonstances contraires, qui les ont fait ajourner à l'année prochaine. Je ne puis que louer vos résolutions à ce sujet et j'espère que vous ne quitterez pas la contrée Taconique sans avoir résolu les divers problèmes géologiques auxquels elle a donné lieu. Vous avez toutes les qualités nécessaires pour ces explorations, qui exigent l'intelligence, l'indépendance, et un véritable dévouement à la science.

"Je vois par vos lettres que vous avez pris la bonne méthode dans les discussions qui ont eu lieu aux réunions de votre Société d'Histoire Naturelle [Boston Soc. Nat. Hist.]. Il ne s'agit pas de théories, qui ne mènent à rien, mais bien de faits positifs sur lesquels il paraît que les explorateurs du pays sont encore un peu en arrière puisqu'aucun d'eux ne présente des sections dont il puisse garantir l'exactitude.

"Dans ma position lointaine, je distingue deux questions très différentes. La question stratigraphique qui est jusqu'ici la moins claire, est entièrement hors de ma portée. La question paléontologique est beaucoup plus simple, et bien que les éléments de la faune Taconique soient encore très incomplets, quelques uns d'entre eux sont assez clairs pour qu'un observateur même éloigné soit frappé par les analogies qu'ils présentent avec la faune Primordiale. Je veux parler surtout des trois *Olenus* de Georgia et de quelques fragments publiés par le Dr. Emmons. M. Angelin qui a passé ici quelques mois, et à qui j'ai montré tous ces documents, partage entièrement mon opinion à cet égard et m'a autorisé à publier son assentiment.

"Remarquez bien que je n'ai pas déterminé le genre de ces Trilobites, par la simple raison qu'ils sont encore incomplets. On pourra même leur donner tous les noms nouveaux qu'on voudra, ils n'en resteront pas moins des formes d'apparence primordiale.

"Les livres du Dr. Emmons ne circulent pas sur notre vieux continent, et s'il n'avait pas eu l'aimable attention de m'en envoyer quelques uns, il m'eût été impossible d'exposer ses idées, que je ne connaissais guère, d'après les ouvrages qui sont entre mes mains.

"Je vous suis très reconnaissant des traductions aussi élégantes qu'exactes de mes diverses lettres. Vous avez bien exposé la question et vous avez fait une intéressante excursion dans le Canada (1849) où la question Taconique se présente sous des apparences aussi compliquées que dans la région typique. Il faut vraiment que vos notes de voyage soient bien fournies et votre mémoire bien sûre, pour que vous ayez pu vous retrouver ainsi sur les bords du St. Laurent.

"Une lettre du Prof. Phillips (Oxford) que je reçois, me porte à

croire qu'il a déjà lu votre publication, car il pense comme nous sur le système Taconique.

“ Vous me dites que notre ami M. Agassiz et Mr. Albert Ordway, après avoir comparé douze exemplaires de *Paradoxides Harlani* avec *Par. spinosus* observent entre eux des différences assez marquées et constantes, pour croire que ce sont deux espèces distinctes. Je trouve ce jugement très convenable, car je sais que M. Agassiz a toujours maintenu l'espèce dans des limites très étroites. Quant à moi au contraire, je prends des limites beaucoup plus larges et j'y suis forcé sous peine d'être entraîné à distinguer six ou huit mille espèces dans mon petit bassin de Bohême, au lieu de deux mille trois cents que je suppose exister. J'ai par exemple telle espèce d'Orthocère, qui pourrait bien en fournir une dizaine à divers paléontologues. Mais plus j'étudie, plus je vois la nécessité de prendre mon parti en pareille matière, sans quoi la science des fossiles paléozoïques deviendrait un dédale inextricable.

“ Je vous dirai qu'à mon point de vue personnel, le groupement des formations, sous des noms de systèmes ou autres, me paraît d'une importance secondaire et transitoire. J'admets, donc volontiers des grandes divisions qui me semblent suffire pour le moment, mais je crois que peu à peu toutes ces classifications seront remaniées et transformées par les progrès de la science. La chose la plus importante doit être de bien étudier dans chaque pays la succession des faunes et de bien définir les éléments dont elles se composent. Nous ne savons pas bien encore, jusqu'à quel point chacune d'elles pourra être définie entre des limites verticales fixes. C'est là justement ce qui résultera de nos études comparées sur les deux continents. Pour moi, je me borne aux trois faunes siluriennes de la Bohême, parce que le sujet est déjà assez vaste pour absorber tout mon temps.

“ Il paraît que les indications des étages par des lettres vous semblent difficiles à retenir. Cette méthode a cependant un grand avantage, c'est d'indiquer immédiatement l'ordre de succession et la superposition. C'est pour cela que je l'ai adoptée. Du reste, pour fixer mieux les idées, j'accompagne ordinairement, dans le texte, chaque lettre par une autre définition. Ainsi, je dis par exemple : *Etage des quartzites D.* — *Etage calcaire inférieur E*, de sorte que le lecteur n'est pas en face d'un signe abstrait. Mon terrain ne se prête pas à l'emploi des noms de localités ; et si j'avais voulu par exemple dire : — *Calcaire de Konieprus*, il y aurait eu un malentendu continuel, parce que cette localité présente deux étages de calcaires, différents d'âge, et tous les deux bien développés. Il en est de même dans la plupart de mes

localités importantes. J'ai donc dû éviter d'employer leurs noms. Lorsque je lis les ouvrages américains sur le terrain paléozoïque, cette longue série de noms de localités, qui vous paraît si claire et si simple, m'embarrasse toujours, et je me vois obligé de consulter de temps en temps le tableau de superposition, pour bien fixer mes idées. Je crois donc que chaque système de notation a ses avantages et inconvénients et je trouve tout naturel que chacun préfère le système auquel il est le plus habitué.

“J. BARRANDE.

“P. S. 5 Février. — Cette lettre ayant été interrompue à plusieurs reprises, représente un couple de semaines. Je suis heureux de ne l'avoir pas expédié plutôt, afin de pouvoir vous annoncer que je viens de recevoir la Notice de Sir W. E. Logan, intitulée, *Remarks on the Fauna of the Quebec Group of Rocks, and the Primordial Zone of Canada*, etc. Le Prof. Emmons doit être satisfait du paragraphe qui le concerne. Il me tardera de savoir comment cette déclaration de M. Logan sera acceptée à Albany. Je remarque que le nom du Prof. J. Hall y est à peine mentionné.

“Il est clair que les environs de Québec présentent des difficultés stratigraphiques considérables, pour reconnaître l'ordre de dépôt des couches indiquées par  $A_1 - A_2$ , etc.,  $B_1 - B_2$ , etc. Mais cette classification n'est que secondaire.”

“PARIS, 7 Février, 1861.

“MON CHER MONSIEUR MARCOU: —

“Je viens de recevoir votre lettre du 21 Janvier. Je vois que les *Remarks on the Fauna of the Quebec Group, etc., addressed to Mr. Joachim Barrande*, de Sir W. E. Logan, ont produit sur vous les mêmes impressions que sur moi. Puisqu'il a si galamment pris sa résolution, vous dites très bien qu'il serait inopportun de s'appesantir sur les questions accessoires, qui demandent encore à être éclaircies. Chacun apportant dans ces débats l'amour pour la vérité et la bienveillance pour les personnes, tout finira par s'éclaircir à la satisfaction générale.

“Avant d'avoir reçu votre dernière, c'est-à-dire lundi 4 courant, j'ai communiqué à la Société Géologique de France, d'abord la Notice sur laquelle vous avez bien voulu mettre mon nom avec le vôtre (*On the Primordial Fauna and the Taconic System*); et ensuite les *Remarks on the Primordial Zone of Canada* de M. Logan. Les observations que j'ai faites à cette occasion, dans le même sens que celles que vous avez présentées à la Société d'Histoire Naturelle de Boston, ont été bien



accueillies. — Je les ajouterai à mes communications de Novembre, 1860, — de sorte que tout cela ne fera qu'une seule notice.

“ Je vous ai dit, dans ma précédente lettre, que les revirements de nomenclature ne peuvent avoir aucune influence sur les faits, et vous le sentez tout comme moi.

“ Adieu, mon cher Monsieur Marcou, et agréez avec tous mes remerciements l'expression de mes sentiments très distingués.

“ J. BARRANDE.”

“ PARIS, 27 Mars, 1861.

“ M. JULES MARCOU.

“ MON CHER CONFRÈRE, . . . Sans vous je n'aurais pas reçu de longtemps le *Thirteenth Annual Report of the State Cabinet of Natural History of New York*, qui n'ajoute pas beaucoup à la connaissance des trois Trilobites (de Georgia) en question, mais qui constate que ces fossiles peuvent être nommés *a primordial type*. C'est là le fait important qui restera toujours et dominera la discussion, car je considère les noms génériques *Olenus, Paradoxides*, etc., comme très peu importants. Nous devons donc regarder cette déclaration paléontologique . . . comme nous dispensant à l'avenir de toute discussion oiseuse sur cette matière.

“ Je sais vraiment gré au Prof. J. Hall de cette déclaration, qu'il répète de la manière la plus positive par deux fois sur la page 221 de sa *Letter to the Editors of the Amer. Jour. of Sc.* (Sill. Journal, March, 1861) que je viens de recevoir. Je pense que ce numéro du Journal, auquel je ne suis point abonné, m'a été directement adressé par les éditeurs.

“ . . . Je trouve d'ailleurs dans l'ensemble de cette lettre, un ton très modéré et que je dois louer, surtout en comparant ce document avec l'annonce de son opposition, qui avait été publiée dans le numéro de Janvier.\* Reconnaître qu'il reste à résoudre une grande question dans

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\* “ It is plain to all who take an interest in the progress of geology in the United States, that an active discussion is now imminent on the questions touching Barrande's Primordial zone. In this discussion the Taconic system of Emmons so long suppressed will probably be again put forward. Already the contestants are sharpening their weapons; and we will not anticipate the discussion farther than to intimate that the views of the distinguished French geologist will find a warm opposition at the hands of the New York State Palæontologist, and probably also with some of the gentlemen of the Canadian Survey. The subject is already before the Boston Society of Natural History, where Mr. Marcou appears as the advocate of the Taconic system. . . . The Introduction [Prof.

la classification des premières faunes paléozoïques, c'est certainement une grande concession de la part de celui qui ne semblait auparavant admettre en aucune façon, que ses propres idées pouvaient être modifiées. Il faut donc que la conviction antérieure et si positive de J. Hall ait fait place à un doute. En fait de doctrine un doute est déjà un acheminement vers une doctrine nouvelle.

“ En ce qui touche le groupe de Québec, nous pouvons aussi nous féliciter du grand pas qui a été fait, puisque ce groupe est reporté du sommet à la base de la faune seconde par Sir W. E. Logan. On voit bien par la lettre du Prof. J. Hall, que cette transposition ne lui est pas sympathique. Cependant, il n'exprime pas nettement une négation contraire à cette nouvelle classification. Toute sa discussion paléontologique se borne à démontrer qu'il existe dans l'ensemble des fossiles de la Pointe Lévis, un grand nombre de types de la faune seconde avec quelques types primordiaux. En cela il a parfaitement raison, et il répète pour ainsi dire, mot à mot ce que j'ai dit dans ma seconde lettre à Bronn, publiée dans le 7<sup>ème</sup> numéro du *Jahrbuch* de Leonhard et Bronn, terminant l'année 1860.

“ Il est bien certain, que tout n'est pas encore clair aux environs de Québec ; mais les points obscurs ne peuvent être éclaircis que par des études de détail, qui peut-être demanderont beaucoup de temps.

“ En rendant compte, le 4 Février dernier, à la Société Géologique de France, de la lettre (imprimée) de Sir W. E. Logan, j'ai insisté principalement sur ces deux points : 1°. Que le groupe de Québec est placé à la base de la faune seconde, à cause de ses affinités paléontologiques ; — 2°. Que l'ordre stratigraphique des couches indiquées par A — A<sub>1</sub> — A<sub>2</sub>, etc., B<sub>1</sub> — B<sub>2</sub>, etc., n'est pas encore déterminé. Tant que l'ordre de superposition de ces couches ne sera pas clairement établi, on pourra faire bien des suppositions, que je trouve complètement inutile de discuter en ce moment ; car le fait seul peut nous éclairer un jour et faire disparaître toutes les difficultés actuelles.

“ . . . Je pense d'ailleurs comme vous, qu'il serait inutile en ce moment de discuter ces petites questions de détail, lorsque nous avons déjà obtenu des concessions si considérables et si peu attendues, dans le peu de temps qui s'est écoulé depuis l'origine de ce débat. Vous

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Hall's third volume on the Palæontology of New York] handles with masterly skill the difficult subjects connected with the proper classification of the lower horizons of life in our planet. A review of this important chapter with reference to the views of Barrande will probably appear in our next.” — *The American Journal of Science*, January, 1861, p. 125.

avez remarqué comme moi ces paroles qui terminent les *Introductory Remarks* dans l'article du Journal de Silliman (Correspondence of Joachim Barrande, etc.) du mois de Mars, p. 212, 1861 : 'It seems probable that the sequence contended for by Emmons will turn out to be at least for the greater part the true one.' Quel contraste entre cette conclusion et l'article de Janvier (p. 125 du même Journal) que vous m'aviez signalé et dans lequel le *Taconic system* était indiqué comme *so long suppressed*. Lorsqu'on voit des dispositions semblables et un changement total de doctrines, dans les savants qui paraissent auparavant si fermement décidés dans leur opposition, il faut avoir de la patience.

“Attendez les résultats des nouvelles recherches, qui semblent devoir occuper à la fois beaucoup de géologues. Je suis charmé de voir, que vous êtes toujours disposé à consacrer une partie de votre temps à cette grande question : et j'espère que vous contribuerez plus que tout autre à élucider les points sur lesquels nous attendons la lumière. Je serai charmé que cette lumière vienne de vous, précisément à cause de tout ce qui s'est passé. Il serait bien loin de ma pensée et de mes sentiments de regretter de vous avoir pris pour correspondant et pour coopérateur dans cette œuvre purement scientifique. Je ne suis pas de ceux qui peuvent sacrifier leurs sentiments et des relations honorables, à un avantage quelconque. Voilà soixante ans que je pratique cette doctrine, et je ne vois pas de motifs pour faire une exception à votre égard. Je ne veux donc rien changer à nos relations, et j'espère même que ceux qui vous sont le plus opposés comprendront à la fin que, dans les questions scientifiques, il ne faut pas mêler les questions de personnes. J'ai bien remarqué dans l'article du Journal de Silliman (*Correspondence of Joachim Barrande, Sir William Logan, and James Hall, on the Taconic System and the Age of the Fossils found in the Rocks of Northern New England and the Quebec Group of Rocks*, March, 1861, p. 210) qu'on avait mis de côté votre nom.\* C'est une petite faiblesse. . . . Je suis bien persuadé que lorsque vous apporterez de nouveaux faits et des lumières nouvelles dans la question, on sera bien forcé de reconnaître votre existence scientifique et la valeur de vos travaux.

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\* The title in the American Journal is, "On the Primordial Fauna and the Taconic System of Emmons, in a Letter to Prof. Bronn of Heidelberg" (Proc. Bost. Soc. Nat. Hist., vol. vii., Dec., 1860, p. 371); instead of, "On the Primordial Fauna and the Taconic System, by Joachim Barrande; with Additional Notes, by Jules Marcou."

“ Aussitôt que le tirage à part de mes *Documents . . . . et le Système Taconique en Amérique* me sera livré, je vous en expédierai un bon nombre d'exemplaires afin que vous puissiez les distribuer à vos amis. Vous trouverez dans mes *Documents, etc.*, un chapitre intitulé, *Transposition verticale de la Faune Primordiale de Suède, par J. Hall*. C'est la rectification d'une grave erreur énoncée par ce savant dans le *Report on the Geology of the Lake Superior Land District*, by Foster and Whitney, p. 318, 1851. J. Hall a essayé en effet dans ce Rapport, de placer les schistes à *Olenus* de Suède au niveau des schistes de Hudson River, ce qui concordait parfaitement avec la transposition du système Taconique. Je ne pouvais pas laisser sous silence une erreur si grave et qui compromettait tous les résultats de mes travaux. J'ai donc démontré qu'il y avait absence complète de tout fondement pour soutenir cette opinion du Prof. J. Hall.

“ M. Angelin n'a publié que deux livraisons de sa *Palæontologica Scandinavica*. C'est un ouvrage purement paléontologique et malheureusement beaucoup trop laconique pour les descriptions. Il est tout en latin. La seconde livraison commence par une courte esquisse géologique des étages ou *Regiones* constituant le terrain. Cette esquisse occupe à peine neuf pages. Du reste, bien que cet ouvrage soit important à mes yeux, à cause des faits qu'il constate, beaucoup de géologues seraient disposés à faire des reproches à l'auteur, d'une côté parce que ses descriptions sont très incomplètes, et de l'autre parce que les figures qu'il donne, laissent beaucoup à désirer. Pour moi, qui connais M. Angelin, pour avoir passé avec lui plusieurs mois à Prague, en 1855, et à Paris, en 1860, j'excuse volontiers ces deux défauts et même un certain manque d'ordre, en considération des circonstances difficiles qui pèsent sur lui, et aussi de la confiance qu'on doit avoir dans sa conscience scientifique, qui est très droite. Vous verrez dans mes *Documents, etc.*, que, dans diverses circonstances, il a voulu que son opinion fut publiée comme en parfaite harmonie avec la mienne, notamment en ce qui touche les Trilobites de Georgia et la transposition verticale des schistes à *Olenus* de Suède, dont j'ai parlé plus haut.

“ J'estime beaucoup, comme vous, le Colonel Jewett que je connais depuis longtemps, par les témoignages de M. de Verneuil. Je lui ai récemment écrit pour le remercier d'avoir bien voulu me transmettre les ouvrages du Prof. Emmons. Je suis charmé de vos bonnes relations avec lui, et je crois que s'il voulait sortir de son rôle trop modeste, sa voix ne manquerait pas d'avoir une grande influence dans l'importante question qui occupe en ce moment les esprits.

“Je vous prie d'exprimer plus particulièrement à Madame Marcou mes sincères remerciements pour ses traductions\* aussi élégantes que fidèles. Agréez mon cher confrère l'expression de tous mes sentiments très distingués.

“J. BARRANDE.”

After this successful beginning, the Taconic question demanded minute and careful study in the field in order to be fully decided. Its adversaries had conceded something; it became necessary to pursue the research, and to clear up the stratigraphy of the borders of Lake Champlain and the environs of Quebec. Urged by Colonel Jewett, Barrande, Agassiz, and Billings to undertake this work, as an extract from a letter of Billings to Colonel Jewett will show, I resolved to devote myself to this difficult and ungrateful task; and in September, 1861, I started for Vermont.

“MONTREAL, July 30, 1861.

“MY DEAR COLONEL JEWETT.

“. . . I send you by express to-day a Trilobite from the Red Sandrock of Vermont. It is a *Conocephalites* allied to *C. minutus* of the Potsdam, but still a distinct species. This Trilobite proves very clearly that the Red Sandrock of Vermont is either the Potsdam or the base of the Calciferous. The genus *Conocephalites* is a true Primordial type. No species of this genus is found above the base of the Lower Silurian. This puts an end to the idea that the Red Sandrock is the *Medina sandstone*. Besides, I have other evidence. I lately spent three weeks at Phillipsburgh on Missisquoi Bay examining into the age of this formation. At Phillipsburgh the Calciferous † is laid bare over an area of eight miles in length by about three in width. Along the shore of the bay it forms a precipice, from fifty to one hundred feet high, for three miles. The base of the cliff is composed of slate as at Sharp Shins. The Calciferous rests upon the slate unconformably. [This is a mistake, for the limestone is enclosed in the slates. — J. M.] I found here (in the Calciferous) about forty species, most of them new. Of the described species I

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\* Mrs. Marcou translated into English the three letters of Barrande of the 29th May, 16th July, and 14th August, 1860, published in the Proc. Bost. Soc. Nat. Hist., vol. vii. p. 369.

† The Calciferous does not exist at Phillipsburgh. Billings took the Phillipsburgh group, which corresponds to the Point Lévis group, for the Calciferous of Chazy Village, a synchronism which cannot be maintained after a visit to the two places. — J. M.

found *Maclurea matutina* and *M. sordida* in great abundance; also the species figured by Hall under the name of *Turbo dilucula*. *Euomphalus uniangulatus* occurs here but rarely. I shall describe them all shortly. Not a vestige of any Medina sandstone or Middle Silurian species is to be seen. I followed the Calciferous back three miles, and then came on the Red Sandrock. The two formations are in contact, but I could not ascertain which is the uppermost, on account of the disturbed state of the strata. I then traced the Red Sandrock down into Vermont. Hearing that Dr. Hall of Swanton had found Trilobites in it, I called upon him, and he accompanied me to the place. It is just two miles south of the Province line, and about one mile or a little more east of Highgate Springs. It is in a hill about a hundred and fifty yards east of the house of a man by the name of Church. We found a number of specimens and a small *Theca*. They are exactly such forms as I expected to find. I believe these are the only fossils found in the Red Sandrock, and as they prove this rock to be the base of the Lower Silurian, what are we to call the immense formation of slate that lies beneath it? Surely not Hudson River group.

“In about three weeks I intend to go out to the Eastern townships again, and will let you know the results. You say that Prof. J. Hall ‘still declares that the position of Sir William Logan does not affect the stratigraphy in the least.’ Sir William’s position brings down the Quebec rocks from the top of the Lower Silurian to the bottom. It makes all those rocks in Vermont (called Medina sandstone) either Potsdam or Calciferous, and consequently the slates which can be seen lying below them at Snake Mountain, at Sharp Shins, and at Phillipsburgh are older than the Lower Silurian.

“It is upon the age of these Vermont rocks that the whole Taconic question depends. If they are Medina sandstone, and if the slate beneath them is Hudson River, then there is no Taconic system. But if the Red Sandrock of Vermont is Calciferous or Potsdam, then Emmons is right. Sir William concedes to the fullest extent that they are of the age of the Calciferous or Potsdam, and therefore he admits all that Emmons requires. If that does not affect the stratigraphy, I do not know how it can be affected. As I have often stated in my former letters, it will be some time before all will be cleared up.

“It is unfortunate that in New York there are no active and unprejudiced geologists to enter into this vast field of research. All that has been done during the last two years (I mean in the way of publication) has been effected in a roundabout way through foreign geologists. It should have been done in New York. I hope Jules Marcou

will soon take up the subject. He should examine Snake Mountain, Sharp Shins, the Red Sandrock at Highgate, and the cliff along the shore from Phillipsburgh to the mouth of Rock River on Missisquoi Bay.

"I could publish a great deal myself, but cannot well do so. You are an old officer, and know well what *subordination* means. I fear I have made this badly written letter too long.

"Yours very sincerely,

"E. BILLINGS."

The principal results of my first exploration, in September and October, 1861, were, 1st, a complete confirmation of the *Taconic system*; 2d, the absence of metamorphic rocks in the upper Taconic from Snake Mountain and Georgia, Vermont, to Point Lévis; 3d, the creation and exact position of the divisions of the "Georgia slates" and "St. Albans group" at the base of the upper Taconic; 4th, the maintaining the Potsdam sandstone in the upper Taconic and the Primordial fauna which it covers, as I had proposed in the first notice published jointly with M. Barrande.

These views were presented to the Boston Society of Natural History at the meeting held November 6, 1861, and a notice, entitled, "The Taconic and Lower Silurian Rocks of Vermont and Canada," was published in the Proceedings, vol. viii. p. 239, November, 1861, which sums up the facts obtained.

Mr. Barrande wrote me the following letter in regard to my researches at Point Lévis and Georgia.

"PRAGUE, 9 Nov., 1861,

Kleinseite, No. 419 Choteksgasse.

"MON CHER MONSIEUR MARCOU :—

"J'apprends avec beaucoup de plaisir par votre lettre du 2 Octobre, que vous avez fait votre voyage d'exploration dans le Vermont et dans le Canada, avec succès et satisfaction. Je suis à votre disposition pour présenter à la Société Géologique de France le mémoire que vous vous proposez de rédiger cet hiver, sur vos observations.

"Si vous établissez nettement la succession des formations de la Pointe Lévis, ce sera un point fort important. La succession des formations observée à Belle Isle, par Mr. Richardson vient fort à propos pour confirmer toutes nos vues. C'est magnifique, suivant votre expression, et la lumière se fait de plus en plus, avec une rapidité que

nous n'avions pu espérer. Je pense que Mr. Billings me donnera quelques détails sur cette suite de fossiles de Terre-Neuve.

“ Je viens de lire un *Review* de mes *Documents*, etc., par Mr. Sterry Hunt, qui me l'a adressée avec quelques mots de politesse. Elle a paru dans le *Canadian Naturalist*, 10 pages. Le grand fait de la faune Primordiale en Amérique n'est plus contesté, mais on voit qu'on accorde avec regret à Mr. Emmons le mérite de l'avoir devinée, tandis que le premier paléontologue américain l'a méconnue. Il faut bien cependant se résigner devant les faits historiques. Il paraît que mon chapitre sur la *Transposition verticale de la Faune Primordiale par le Prof. Hall*, a touché un point sensible, puisque Mr. Hunt croit devoir reproduire l'excuse que j'ai mentionnée en faveur de son ami.

“ Vous savez sans doute que le Prof. Geinitz de Dresde vient de publier le premier volume (fossiles) du *Dyas*. Ainsi voilà votre *Dyas* installé en Allemagne.

“ J. BARRANDE.”

One important palæontological memoir by Billings appeared in August, 1861, (*Canadian Naturalist and Geologist*, vol. vi. p. 310, Montreal,) entitled, “On some of the Rocks and Fossils occurring near Phillipsburgh, Canada East.” In this work, as in his memoir “On some new Species of Fossils from the Limestone near Point Levi, opposite Quebec,” August, 1860, he considers both faunæ as very similar, and having even thirteen identical species, and both as indicating the lower part of the “Calciferos sandrock.”

1862. — I give here extracts from Barrande's letters written during the first eight months of 1862.

“ PRAGUE, 3 Mars, 1862.

“ MON CHER MONSIEUR MARCOU : —

“ . . . Je ne comprends pas pourquoi Mr. Billings, qui auparavant m'adressait de longues lettres, a complètement cessé de m'écrire depuis un an. Il ne m'a pas même accusé réception de mes *Documents*, etc. Sir W. Logan s'est retranché de même dans le silence. Je ne crois pas cependant avoir démerité en rien de ces Messieurs, puisque vous trouvez que j'ai beaucoup trop fait valoir les travaux du *Geological Survey of Canada*.

“ En compensation, et à ma grande surprise, j'ai reçu il y a peu de temps une lettre de J. Hall. Je ne m'attendais pas à cette communication, après la lettre publiée l'an dernier par lui dans le *Silliman's Journal*, vol. xxxi. p. 220, March, 1861. En effet J. Hall paraît avoir



fait depuis lors de très louables réflexions, et il m'exprime le regret d'avoir écrit cette lettre, qui contraste beaucoup avec les opinions très nettes qu'il professe aujourd'hui. Il est du même avis que moi, non seulement sur la nature primordiale des Trilobites de Georgia, mais encore sur la position stratigraphique que doivent occuper les roches de cette localité dans la série verticale. Il renonce donc complètement à ranger ces roches dans l'Hudson River, et il reconnaît qu'elles doivent être reportées vers la base de toute la série. En même temps, il m'envoie deux sections gravées, présentées par lui à l'Association of American Geologists and Naturalists, en 1845-46. Or ces sections indiquent les schistes de Georgia comme immédiatement superposés au grès de Potsdam, et en stratification concordante avec ce dernier. C'était le résultat d'explorations faites par J. Hall en 1844-45 et concordantes avec les vues de Eaton sur ces contrées. J. Hall me dit qu'il n'avait abandonné ces opinions primitives, résultant de ses propres observations sur le terrain, que par déférence pour l'autorité de Sir William E. Logan et de Mr. Hunt, qui lui ont persuadé que tout le groupe de roches en question se trouvait au niveau du groupe de Hudson River.

“Voilà donc l'assentiment de J. Hall sur les deux points principaux en question. Quant aux points secondaires que vous débattiez, il est aussi à espérer qu'on finira par s'entendre de même.

“J'ai étudié votre notice du 6 Nov., 1861 (*The Taconic and Lower Silurian Rocks of Vermont and Canada*, in Proceed. Boston Soc. Nat. Hist., vol. viii. p. 239). Tout ce qui regarde le Vermont me paraît très clair, et du point où je suis placé il n'y a pas la moindre observation à faire sur la succession verticale que vous indiquez. Seulement, j'aurais été porté à maintenir les *Lingula flags* (Highgate Springs) avec le Potsdam, par ce que ce dernier a toujours été caractérisé par ses Lingules. En ce qui touche les environs de Québec, votre notice est trop concise pour que je me figure bien la succession verticale; notamment au sujet de la colline de la Redoute. Vos profils nous expliqueront cela, je pense; et c'est très nécessaire de l'expliquer, si c'est possible, après les indications si incomplètes de Sir W. Logan.

“Mille choses aimables à notre ami Mr. Agassiz. Je pense souvent que la guerre civile doit beaucoup le contrarier pour la publication de son grand ouvrage (*Contributions to the Nat. Hist. of the U. S.*), et je partage bien toutes ses contrariétés à ce sujet. Je vous prie aussi de le remercier pour l'envoi de ses deux notices au sujet des *Homologies des Radiaires* qui m'ont beaucoup instruit.

“J. BARRANDE.”

“ P. S. Le second volume du *Dyas* de Geinitz, qui doit exposer la partie stratigraphique n'a pas encore paru. Il y a avec lui d'autres collaborateurs, dont l'un a étudié le terrain en Russie.”

“ PARIS, 3 Mai, 1862.

“ MON CHER MONSIEUR MARCOU : —

“ . . . Le lundi, 28 Avril, jour de la séance de la Société Géologique, j'ai fait une courte communication au sujet de la lettre de James Hall dont je vous avais parlé dans ma dernière du 3 Mars. J'en ai exposé le contenu en quelques mots, en rappelant que l'année dernière, j'avais communiqué une autre lettre du même savant, sur le même sujet, et dans un sens très différent. J'ai fait remarquer que J. Hall, en reconnaissant aujourd'hui que les couches renfermant les Trilobites primordiaux doivent être rapportées à la base du Silurien Inférieur et non au Groupe de Hudson River, a réellement mis fin à la discussion de la question principale. Cette question étant la seule dans laquelle un géologue qui n'a jamais vu le terrain, puisse exprimer une opinion, il me semble qu'à l'avenir mon rôle doit se borner à être simple spectateur des différences d'opinion qui peuvent encore exister au sujet des questions secondaires. La faune Primordiale étant reconnue par tout le monde, et attribuée à son véritable horizon, en Amérique comme en Europe, ceux qui comme moi portent intérêt à ce grand fait, doivent patiemment attendre que les recherches locales jettent la lumière nécessaire sur les divers points contestés.

“ À ce sujet, j'ai naturellement mentionné vos travaux récents et votre voyage dans le Vermont et le Canada, dans le but d'établir l'ordre de succession des formations fossilifères les plus anciennes. J'ai cité les sections que vous avez données dans votre communication du 6 Novembre, 1861, à la Société d'Histoire Naturelle de Boston, et je reproduirai au moins celle de Vermont dans ma notice (*Bulletin Soc. Géol. France*, 2<sup>ème</sup> série, vol. xix. p. 721, Paris, 1862).

“ . . . Comme il n'existe pas de Graptolites dans la faune Primordiale d'Europe, la présence et la grande fréquence de ces fossiles dans la faune Primordiale d'Amérique, doit être constatée de la manière la plus authentique. Vous ne paraissez pas douter de ce fait, d'après vos indications, et en cela vous vous trouvez d'accord avec le Prof. J. Hall, qui m'exprime la même opinion dans sa lettre. Vous savez qu'en diverses circonstances j'ai signalé le privilège d'antériorité de la zone silurienne du nord, et plus spécialement de l'Amérique, par rapport à la zone du centre de l'Europe. Le développement des Graptolites dans la faune Primordiale viendrait fort à propos pour confirmer ces

vues, qui ont déjà été adoptées par beaucoup d'autres géologues. Vous concevrez aussi que des faits de cette nature confirment naturellement et d'une manière très générale ma doctrine des Colonies.

"M. Delesse a eu la complaisance de me remettre votre *Carte Géologique de la Terre*; je vous en suis très reconnaissant. C'est un immense ouvrage, par les recherches qu'il a dû exiger dans toute la littérature scientifique. Nous profiterons tous, pour notre instruction, de votre beau travail.

"J. BARRANDE."

"PARIS, 24 Juin, 1862.

"MON CHER MONSIEUR MARCOU:—

". . . Vous verrez en lisant ma brochure, *Défense des Colonies*, II.; que MM. les géologues de Vienne ne se sont pas gênés pour faire une carte géologique fantastique, ou en d'autres termes, pour altérer les faits et les accommoder à leurs idées préconçues. Au fond de tout cela il y a de tristes préoccupations, et je ne puis me dissimuler que je constitue par ma personne la *Colonie* qu'on avait le plus en vue dans cette attaque. On croyait sans doute que je ne retournerais plus en Bohême, après une absence de plus de dix-huit mois, mais je montrerai de la manière la plus incontestable, que le système des plis imaginé contre les Colonies repose uniquement sur des faits controvés ou altérés.

"Je vois que vous admettez le renversement des couches du Tacouique et que vous considérez le grès de Potsdam comme se présentant sous forme de couverture brisée et en échellons. Il paraît que cette disposition n'est pas vue de même par tout le monde, et notamment par Mr. Billings qui indique à l'Est de Swanton une localité où l'on voit les schistes noirs à *Paradoxides* (*Olenellus*) alternant conformablement avec le *Red Sandrock*. Il y aura donc à ce sujet discussion prolongée tant que cette contrée ne sera pas étudiée et décrite avec tous les documents désirables. Je pense que c'est à cela que vous travaillez, puisque vous avez différé la publication de votre travail, afin d'avoir le temps de revoir les localités de Georgia et de Québec. Une si grande question dont la solution embrasse une si vaste surface de terrain, demande certainement beaucoup de temps et d'étude.

"J. BARRANDE."

"PARIS, 26 Août, 1862.

"MON CHER MONSIEUR MARCOU:—

"Je pars après demain, pour aller me reposer à Prague de toutes mes fatigues dérivant soit de mes affaires à Paris, soit de mon séjour d'un mois à Londres, d'où j'arrive.

“Ce voyage en Angleterre n'a été que très accessoirement scientifique, par ce que je ne l'ai fait que pour accompagner Monsieur le Comte de Chambord à la grande Exposition Internationale. J'ai cependant vu quelques géologues. Sir W. Logan avait quitté Londres la veille de mon arrivée. Il m'a envoyé ici 464 pages de sa *Geology of Canada*, 1862. L'ouvrage n'est pas achevé, mais le sera bientôt sans doute. Au sujet du groupe de Québec il reproduit ce qu'il a déjà dit, en indiquant que le sujet est encore à l'étude. Je pense que le dernier mot dépendra des documents fournis par Mr. Billings, qui continue à distinguer ses calcaires Nos. 1, 2, 3, 4, dans ses *new species* en attendant sans doute ses études stratigraphiques sur les lieux. Il serait fort à désirer que vous puissiez vous entendre avec lui, car le fractionnement des opinions ne peut qu'entraver la solution finale des questions à résoudre, à l'appui de la grande question déjà résolue.

“Je suis charmé que vous ayez fait de bonnes études sur les lieux, et j'admire beaucoup la conviction qui a surgi subitement en vous, au sujet de la doctrine coloniale. Depuis que j'ai énoncé cette doctrine, si contraire aux idées reçues, je me suis bien gardé d'en presser l'adoption, même dans l'esprit de mes amis. Les faits et les observations doivent seuls amener la croyance, pour qu'elle soit solide. Si vous lisez la seconde brochure de ma *Défense des Colonies*, vous verrez que par la multitude de faits nouveaux que j'indique dans le bassin de la Bohême ; que je ne m'étais nullement hâté de donner à mes amis, pas plus qu'à mes adversaires, la connaissance de tous les documents qui ont servi de bases à ma doctrine. Par suite de la polémique engagée, je suis obligé de dévoiler successivement ces faits, et je n'en suis pas encore au bout. J'en ai assez dit pour montrer que les prétendues études de mes contradicteurs ne sont autre chose que des combinaisons arbitraires, qui manquent à la fois de fondement réel et de sincérité. À la suite de ces débats, je ne doute pas que l'idée des Colonies ne soit adoptée dans la science, comme la faune Primordiale, les métamorphoses des Trilobites, etc., qui ont aussi soulevé bien des contradictions.

“Il est fort possible que certaines Colonies représentent des centres de création. En indiquant cette conception, je me suis décidé pour l'immigration à cause des circonstances propres à la Bohême. Je ne suis pas juge pour les autres pays ; et mon choix du nom de *Colonies* ne peut être apprécié que d'après mon point de vue, auquel il m'a paru logiquement adopté.

“J. BARRANDE.”

The experience of 1861 had convinced me of the need of very close and careful study on several chosen points in order to reach any precise results as to the strata existing between the "schists of Georgia" and the "Utica slate." The exploration of this year was therefore devoted to Swanton, Phillipsburgh, and Chazy on Lake Champlain, and to Point Lévis near Quebec. First, each bed at Point Lévis was studied with care, at the east of the village and near the railway station; and in the month of July I was convinced that what had been considered as *beds* of limestone and conglomerate were only *lentils* enclosed in the schist. This discovery explained several outcroppings of magnesian limestone which had embarrassed me the preceding year at St. Albans Bay, at Swanton, and at Highgate.

Dr. Emmons and Colonel Jewett had considered similar formations in the neighborhood of Troy, New York, used for making lime, and also those along the line of the Upper Taconic from Canada to the Hudson River, as *bags* of Silurian limestone (Trenton or other) which were deposited in *holes* or *cracks* of the black Taconic slate. They had seen that, at several of these quarries, the lime was exhausted, there being no more limestone. For them these bags of limestone were the remains of the Lower Silurian which had extended thus far at the time of the deposit, but which subsequent denudations had carried off, leaving these bags of limestone to witness to their former extent. Some rare and badly preserved fossils were found in these bags of limestone, identical with, or at least very similar to, six or eight Silurian species from the groups of Chazy and Trenton.

The proof once reached, that the limestone lentils of Point Lévis were of the same age with the schists which enclosed and shut them in too surely to admit the doubt of a later deposit, I went directly to Swanton, seeking to verify the same fact in the limestones of this eastern shore of Lake Champlain. I drafted exactly the surface appearances, and studied in detail several lime quarries, quite common in this region. I found everywhere that the limestones were *lenticular masses*, some very limited in size, like boulders; and others, on the contrary, having the characteristic form of lentils; and all so well enclosed in the schists that they were penetrated by them, or they were thrust into them like wedges.

Further, I found these limestone lentils scattered at all levels of the Upper Taconic, from its base in the schists at the east of the town of St. Albans, to the borders of Lake Champlain in the schists of Swanton; they were singularly placed, sometimes isolated, sometimes in large

agglomerations, and sometimes absolutely wanting over large surfaces where the schists only were found.

The next step was to revisit with care the Isle La Motte, the peninsula of Alburgh, Chazy Landing and Village, Keeseville, and Potsdam. These typical localities of the Calciferous, of Chazy, Trenton limestones, and Utica slate, already visited by me in 1849, are very rich in fossils, and easy to study, and at a distance of only from three hundred yards to one mile from the Taconic region of the eastern part of Lake Champlain. When there I saw plainly the necessity of giving up all idea of identifying their strata with those of Georgia, St. Albans, Swanton, Highgate, and Phillipsburgh.

Near to Chazy and Potsdam, I observed that the Calciferous sandrock, and consequently all the Lower Silurian, rested in discordance of stratification on the Potsdam sandstone, — at least a discordance of sixteen degrees. I had foreseen and indicated this in the additional notes to the letters of Barrande in our memoir of 1860 (On the Primordial Fauna and the Taconic System, p. 380), in which I say: "I am not sufficiently acquainted with its (the Potsdam group) distribution and position in regard to the Taconic and the Calciferous sandrocks to give a decided opinion based on stratigraphical grounds, but from the description of Prof. Emmons in his *Taconic system*, and from what I have seen at Little Falls, the Calciferous sandrocks are certainly very differently distributed from the Potsdam, and a dislocation and disturbance of strata have taken place between the two groups."

It was a happy discovery, for with the palæontological proofs of the strictly primordial character of the small fossils found at Keeseville and Highgate, there was no longer a doubt that the Potsdam sandstone belonged to the Taconic, as the covering and last term of the Primordial Zone in America.

I published a letter addressed to Barrande, August 2, entitled, "Letter to M. Joachim Barrande on the Taconic Rocks of Vermont and Canada," with a plate of a "Comparative Tabular Section of the Upper Taconic Rocks in Vermont and Lower Canada." This letter for the first time mentions the existence of calcareous lentils or lenticular masses of limestone in the Taconic slate, encloses the "group of Phillipsburgh" and the "Swanton slates" between the "Georgia slates" and the "Potsdam sandstone," and contains the opinion that there are no Calciferous sandrocks either at Phillipsburgh or at Point Lévis. Finally, the calcareous lentils of Point Lévis and Phillipsburgh are spoken of as precursory centres, or Barrande Colonies; Colonies of the second fauna enclosed in the Primordial one.

There remained a very difficult question to settle, — the presence at Highgate Springs of a group of rocks, which palæontologists persisted in calling Lower Silurian, thus indicating the existence of Black River, Trenton, and even Utica slate.

I passed the autumn of 1862 in reviewing attentively the country from Phillipsburgh to Shoreham, Vermont, accompanied by the late Dr. Hall and the late Rev. J. B. Parry of Swanton, two skilful geologists, who spared me much time and fatigue, by taking me to the fossiliferous localities. In August, 1863, I again visited Point Lévis, Vermont, and the State of New York. Finally, in 1873 and 1874, I passed from four to five months at Highgate Springs, repeatedly studying every square yard of the ground, and at length determined that the rock between the Franklin Hotel and Lake Champlain was not a Silurian wedge driven into the Taconic, but an agglomeration of lenticular limestone with schists, containing the colonies of the Second fauna enclosed in the Primordial one.

But let us go back; for my memoir with a geological map of the Taconic of the borders of Lake Champlain was not published till 1881.

1863. — At the beginning of this year, I received from Barrande the following letter: —

“PRAGUE, 17 Janvier, 1863.

“MON CHER MONSIEUR MARCOU: —

“Je regrette beaucoup que ma lettre du 18 Octobre ne vous soit pas parvenue [a lost letter]. D’abord parce qu’elle exprimait mes remerciements pour votre brochure (*Letter to Joachim Barrande on the Taconic System*, etc.), et ensuite parce que j’y avais ajouté quelques observations qui me paraissaient importantes, avant la rédaction définitive du mémoire que vous voulez faire paraître dans le Bulletin de la Soc. Géol. de France. [It did not appear until 1881.]

“Le point important est celui-ci. Dans votre lettre imprimée du 2 Août, 1862, et dans les *Tabular Sections* qui l’accompagnent, vous indiquez un grand nombre de fossiles de la faune seconde trouvés dans les lentilles calcaires du groupe de Phillipsburgh, environ cinquante espèces. Parmi ces fossiles vous indiquez deux *Dikelocephalus* et un *Menocephalus* comme appartenant à la faune primordiale. Ce fait est certainement très intéressant, mais considéré seul, il pourrait être interprété simplement comme indiquant le passage successif et par voie ordinaire de mélange, entre la faune primordiale et la faune seconde.

“Pour que vos lentilles calcaires jouent le même rôle que mes colonies de Bohême, il faudroit encore montrer la faune primordiale continuant à exister et florissante, soit dans les schistes proprement dits

de Phillipsburgh qui enveloppent les lentilles, soit dans les schistes de Swanton qui sont au dessus.

“ Il y a bien des *Conocephalites* indiqués dans votre grès de Potsdam, mais c'est un horizon éloigné, et dont la position stratigraphique dans cette série pourra vous être contestée, autant que je puis en juger parceque vous en dites en peu de mots.

“ Peut-être avez-vous seulement omis de citer les espèces primordiales dans les schistes de Phillipsburgh et au dessus. Dans ce cas, la lacune de votre lettre sera aisée à combler. Mais dans le cas contraire, il serait bien important de découvrir quelques fossiles dans ces schistes, ou immédiatement au dessus pour établir la parité avec mes Colonies. Vous aurez remarqué que je définis mes Colonies comme une *apparition intermittante des avants-coureurs de la faune troisième au milieu de la faune seconde*. En effet, j'ai toujours montré à tout venant les fossiles caractéristiques de la faune seconde, en place, au dessus comme au dessous de mes Colonies. Tâchez donc de compléter ce point si cela vous est possible.

“ 2°. Les relations du grès de Potsdam avec les formations du système Taconique n'étant pas assez développées jusqu'ici, ne sont pas bien claires pour moi, et devraient être établies très nettement pour aller au devant de toute objection.

“ 3°. Le renversement général du système Taconique, que vous indique seulement en passant comme un fait hors de doute, aurait aussi besoin d'être éclairci; car c'est ce renversement qui rend plus difficile l'intelligence des relations du Potsdam avec la série inférieure.

“ 4°. Vous considérez vos lentilles calcaires comme des centres de création. J'admets volontiers cette interprétation comme très plausible, d'après nos idées actuelles de la succession des faunes.

“ Cela posé je vous prie de considérer que les espèces de la faune seconde qui font leur première apparition dans ces centres, disparaissent ensuite, de la contrée, durant une période de temps fort longue et représentée par les dépôt des schistes de Swanton et du grès de Potsdam. Si elles reparaisent dans les mêmes parages, c'est dans la faune seconde développée au dessus du grès de Potsdam. Cette longue disparition ou intermittence ne peut avoir eu lieu que par deux migrations successives, à deux époques très éloignées l'une de l'autre, savoir: d'abord après le dépôt des lentilles calcaires (départ du centre de création), et ensuite retour après la disparition de la faune primordiale.

“ On arrive donc toujours forcément à l'idée des migrations, qui sont implicitement exprimées dans la dénomination de Colonies, ainsi que je l'ai expliquée en diverses occasions.



“Je vous soumets amicalement ces observations afin que vous en fassiez l'usage que vous trouverez convenable.

“Vers la fin de Mars j'arriverai à Paris, et je m'occuperai des fossiles que vous m'avez expédiés par le Hâvre. Il est probable que la plupart des espèces ont été déjà nommées par Mr. Billings, ou le seront avant peu. Pour moi, je ne cours pas après cette conquête, car j'ai encore à moi plus de fossiles que je n'ai pu en étudier et nommer jusqu'ici. — Ce que j'espère, c'est de profiter de votre aimable communication pour bien apprécier les contrastes entre les faunes primordiale et seconde du Nord de l'Amérique; si toutefois ils existent comme en Bohême ce que j'ignore.\*

“Vous saurez que durant ces dernières années j'ai surtout travaillé à compléter la connaissance de la première phase de la faune seconde, — ma division *d*<sup>1</sup>.

“J'ai porté à quarante-huit espèces le nombre de ses Trilobites, qui n'était que de trois en 1852. Les autres fossiles sont relativement moins nombreux dans *d*<sup>1</sup>. Ainsi les Trilobites y prédominent comme dans la faune primordiale. Cependant malgré cette grande analogie dans leur composition zoologique; malgré la proximité stratigraphique, il n'a été découvert en Bohême aucune espèce commune à la faune primordiale et à la phase originaire de la faune seconde. C'est un fait très remarquable, mais, je le répète, je ne prétends pas et je n'attends pas qu'il se répète ailleurs.

“La polémique sur les Colonies n'a pas fait un pas, parce que mes contradicteurs n'ont pas encore répondu à mes deux brochures (*Défense des Colonies*, I. et II.). Voilà un an qu'ils méditent leur réponse. Il est difficile de répondre en effet, quant il s'agit de justifier de véritables faux en matière scientifique. Haidinger qui était si ardent, m'a écrit il y a quelques semaines, qu'il *avait des dispositions plus conciliatrices que belliqueuses*. Nous verrons comment il cherchera à concilier la vérité avec la fausseté. C'est difficile, et je ne me prête pas à des accommodements de vanité aux dépens de la vérité.†

“J. BARRANDE.”

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\* This large box of fossils from Georgia, Swanton, Phillipsburgh, Point Lévis, Braintree, and Newfoundland was never opened, and Barrande returned it to me in Paris, in 1867, having really no time to devote to it. The contrast between the primordial and the second faunæ does not exist in America, nor Scandinavia, nor England, as it does in Bohemia, where special circumstances have arrested life during the end of the deposits of the Taconic system. — J. M.

† This last phrase is very characteristic. Barrande was immovable when the truth was concerned, as well in science as in political affairs. — J. M.

In May, 1863, Sir William E. Logan published his "Geology of Canada, 1863. — Geological Survey of Canada; Report of Progress from its Commencement to 1863; accompanied by an Atlas of Maps and Sections." A large volume of more than 900 pages (Montreal, 8vo).

Let us notice first the contradiction between the text and the geological map.

"The Quebec Group," or Chapter XI., is placed in the description of the stratigraphic series between Chapter X., "The Utica and Hudson River Formations," and Chapter XII., "The Anticosti Group and the Guelph Formations"; that is, between the second and third faunæ. But in the text (p. 225) Logan says: "Although from their geographical position apparently superior to the Hudson River formations, these rocks belong in reality to an older group, which is developed to a great extent in Eastern Canada, and presents somewhat different characters in the various parts of its distribution. The rocks of this series are still under examination, and the descriptions now given may hereafter require to be somewhat modified."

Thus, in 1863, Logan reconsiders the opinions expressed in his letter to Barrande, of 1861, and his acquiescence in the opinions long maintained by Emmons. In the Geological Map of Canada, instead of placing the Quebec group above the Hudson River, as he does in the text, he places it below the Birdseye and Black River group; and even more, he identifies it with the Chazy limestone and the Calciferous group, an error as glaring as putting the Georgia slates with *Olenellus*, above the Utica and Lorrain groups.

In Chapter II., "Geological Nomenclature," (p. 20,) the Quebec group represents the Calciferous and the Chazy, and, further, the Calciferous is identified with the Lévis, and the Chazy with the Sillery; two errors as incomprehensible as the position of the *Olenellus* schists of Georgia at the top of the second fauna. Towards the close of the volume (p. 836), the supplementary Chapter XXII. gives the results of his researches in 1862 and 1863. The Quebec group is again described at length, from pages 844 to 880. In the Atlas accompanying, sections are given, and a geological map on a large scale, with the title, "Map showing the Distribution of Rocks belonging to the Potsdam, Quebec, and Trenton Group on the east side of Lake Champlain in the Neighborhood of the Line between Canada East and Vermont." In the explanation of the colors, there are only three divisions, the Trenton, the Quebec, and the Potsdam, arranged in their supposed order of superposition.

According to Logan the Potsdam includes not only the Red Sandrock, but the Georgia slates and the St. Albans group; an approximate thickness of from 3,700 to 4,000 feet. He also puts into it, between Swanton and Highgate Falls, schists with lentils of magnesian limestone of the Phillipsburgh group. It must be remembered that the Red Sandrock rests in discordant stratification upon the schists of Georgia, the group of St. Albans, and that of Phillipsburgh; thus giving to the Potsdam, as described by Logan, an extension and a mixed composition such as this group does not possess at Potsdam, nor anywhere in the State of New York, where it was created.

The Quebec group comprehends the Phillipsburgh group and that of St. Albans, beginning at Highgate Falls and rising towards the north. As this group is found throughout the region his map covers, below the Red Sandrock or Potsdam, he is obliged to see along the whole course of accidental contact a fault, recognized at certain points and supposed at others, where he inscribes *supposed fault*. In the western part no fault is seen, and he does not seek to explain why his Potsdam is there superposed upon the Quebec group. All the schists of Swanton and Highgate Springs are called "Trenton."

After a long and very detailed study of all the region represented on this map, I could not find a *fault* anywhere. There is discordant stratification between the Red Sandrock and all the other beds, which are all older; and I found neither Calciferous, Chazy, Trenton, nor Utica slate. The result of these studies was given in my "Carte Géologique des Bords du Lac Champlain entre Georgia (Vermont), Chazy (New York), et Phillipsburgh (Canada)." (See Bulletin Soc. Géol. de France, Tom. IX. Plate I., 1881, Paris.)

With these two documents any practical geologist can go upon the ground and form an opinion as to the value of these different investigations.

I have given more attention to this volume, "Geology of Canada, 1863," because Sir W. E. Logan, having recognized the value of the observations of Emmons in his Letter to Barrande, 31 December, 1860, here tries to suppress the *Taconic system*; first by creating the *Quebec group*, and then by giving to the *Potsdam sandstone* a much greater vertical extension than it possesses at Potsdam itself, and, lastly, by putting directly below and in contact with the Potsdam the *Huronian* series, created at the expense of the *Lower Taconic*.

**1863-1881.** — The palæontologists, while extending the primordial fauna above and below the Georgia slates, were always met by apparitions of certain forms of the second fauna which disconcerted them;

they seem from 1862 to 1881 to have remained stationary, while the old adversaries of the Taconic system, taking courage, have made great efforts to suppress it entirely. But as I have avoided citing the attacks and criticisms of the first period of the history of the Taconic system, I will not mention the numerous criticisms appearing from 1861 to 1881, as these publications have brought no new facts or elements into the Taconic question.

Justice should be rendered to the labors of the palæontologists, more especially those of Billings, S. W. Ford, Whitfield, Hart, and Matthews. Billings did not give all he promised. Placed in a subordinate position in the Geological Survey of Canada, and succeeding as palæontologist a *savant* with whom he disagreed almost from the beginning, — affected by a cruel malady that completely paralyzed his power of observation in the field, — he died at a comparatively early age, and was thus prevented from showing his full powers and doing what was to be expected from so good an observer. In truth, no American palæontologist has ventured to touch the stratigraphic question. No one has been willing to render palæontology subject to stratigraphy studied carefully on the ground. If Barrande had been like them, he would never have found his “Colonies”!

Stratigraphists are as subject to error as other men, without doubt; if they observe under the influence of a preconceived idea, they are often mistaken. This occurred in Bohemia to Lipold, Krejci, and Marr. But when, like Barrande, they study the ground with the sole object of finding the veritable structure of the rocks and their relative ages, that is, the truth as it exists, they are seldom deceived.

**1881.** — After twenty-one years of study in the field and researches in collections I published the result of my research on the upper part of the *Taconic system* or *Taconic* proper of the eastern side of Lake Champlain. The memoir appeared in the *Bulletin Soc. Géol. de France*, 3<sup>e</sup> Série, Tom. IX. p. 18, Paris, 1881, under the title of “Sur les Colonies dans les Roches Taconiques des Bords du Lac Champlain,” with a detailed map of the borders of Lake Champlain between Georgia (Vermont), Chazy (New York), and Phillipsburgh (Canada). This region includes the typical localities of Georgia, Swanton, Highgate, Phillipsburgh, and Chazy, and comprehends the two States of Vermont and New York, and reaches into Canada. I give here only the tabular view or theoretic vertical section, with its *résumé* of explanation, referring those who wish to know the details to the original memoir.

VERTICAL SECTION [LAKE CHAMPLAIN] IN VERMONT, CANADA,  
AND NEW YORK, 10,140 FEET.

Champlain Group, 1,050 feet.	Utica slate.	Feet 105	Thriarthrus Beckii, Graptolithus pristis.
	Trenton limestone.	360	Isotelus gigas, Illænus crassicauda, Calymene senaria, Ceraurus pleurexanthemus, Phacops, Trinucleus concentricus, etc., etc.
	Chazy limestone.	225	Isotelus canalis, Illænus, Asaphus, Maclurea magna, Scalites, Leptæna, Orthis, Atrypa, etc., etc.
	Calciferos sandrock.	360	Maclurea matutina, Ophileta, Orthoceras primigenium.
Upper Taconic, or the true Taconic System, 9,090 feet.	Potsdam sandstone.	300	Conocephalites Adamsi, C. vulcanus, C. minutus, C. verrucosus, Lingulepis minima, Obolella prima.
	Swanton slates, with lenticular masses of limestone.	2,400	No fossils, except <i>Graptolites</i> at Swanton Falls, at Point Lévis, Orleans Island, and River Ste. Anne. — Colonies of the second fauna at Highgate Springs, with <i>Trinucleus</i> , <i>Calymene</i> , <i>Ampyx</i> , <i>Orthis</i> , <i>Rhynchonella</i> , <i>Lingula</i> , etc.
	Phillipsburgh or Point Lévis Group, slates with lenticular masses of limestone.	3,000	<i>Dikelocephalus</i> , <i>Olenus</i> ? <i>Bathyrurus</i> , <i>Conocephalites</i> , <i>Monocephalus</i> , <i>Arionellus</i> , <i>Amphion</i> , <i>Cheirus</i> , <i>Asaphus</i> , <i>Illænus</i> , <i>Lituites</i> , <i>Nautilus</i> , <i>Orthoceras</i> , <i>Maclurea</i> , <i>Murchisonia</i> , <i>Metoptoma</i> , <i>Ecculiomphalus</i> , <i>Camerella</i> , <i>Leptæna</i> , <i>Orthis</i> , etc., etc. Prophetic types or forerunners of the second fauna at Phillipsburgh, Swanton, St. Albans Bay, and at Point Lévis.
	Georgia slates, with lenticular masses of limestone.	390	<i>Olenellus</i> Thompsoni, <i>O. Vermontana</i> , <i>Dikelocephalus</i> , <i>Angelina</i> , <i>Conocephalites</i> , <i>Orthisina</i> , <i>Obolella</i> , <i>Camerella</i> .
	St. Albans Group, slates with lenticular masses of limestone.	3,000	No fossils yet found <i>in situ</i> . The late Dr. G. M. Hall has signalized a fragment of <i>Bathyrurus</i> ? at Highgate Falls; and a very indistinct <i>Cephalopoda</i> ? or a <i>Pteropoda</i> ? Also the late Rev. J. B. Perry has signalized an <i>Olenellus</i> ? near Franklin, and another behind St. Albans; and finally <i>Salterella pulchella</i> Billings in the Dove or Winookski marble of St. Albans, but it was not found <i>in situ</i> by Billings.

NOTE. — Plane of unconformity indicated by double and triple dividing lines.

The section given is of the beds immediately above the chlorite schists, the conglomerates, and the talcose slates which form the upper portion of the Lower Taconic.

Here are schists with lentils of magnesian limestone of three thousand metres, or about nine thousand feet, in thickness, extending from the top of the most westerly range of the Green Mountains to the borders of Lake Champlain. With the help of the rare fossils to be found in them, I have for convenience established four divisions in these beds, making an upward series as follows:—

At the base the *St. Albans Group*, three thousand feet thick, in which only one or two fossils of uncertain determination have yet been found, because the specimens have been lost or imperfectly studied. The one found near the town of St. Albans, and also at Franklin, may be an *Olenellus* or a *Paradoxides*; the other, found at Highgate Falls, may be a *Pygidium* of *Bathyrurus*; also a fragment of *Cephalopoda*? or *Pteropoda*? Finally, *Salterella pulchella* was found in a fragment of Dove limestone near St. Albans, but not *in situ*.

2d. *Georgia slates*, or slates with *Olenellus*; they are about three hundred and ninety feet thick. Two small lenticular masses of blue and gray limestone, containing numerous fossils, are found at Swanton. At Parker's farm in Georgia a calcareous sandstone which contains iron geodes is found just above the *Olenellus* beds. The fossils are *Olenellus Thompsoni*, *Ol. Vermontana*, *Peltura holopyga*, *Angelina Hitchcocki*, *Dikelocephalus? Marcouï*, *Conocephalites Teucer*, *Obolella cingulata*, *Orthisina orientalis* and *festinata*, and *Camerella antiquata*.

3d. *Phillipsburgh or Point Lévis Group*.—Light black slates, containing now and then large lenticular masses of limestone. At Phillipsburgh the lenticular masses of limestone are very numerous and closely packed together, with only a sort of network of slates enclosing them, and forming, as it were, a frame or border. At Point Lévis the lenticular masses of limestone enclosed among the black slates are less numerous than at Phillipsburgh, and show a folding just at the chapel near the St. Joseph church. The thickness varies, but it cannot be less than three thousand feet. Fossils are numerous in some places, and at some special spots more or less limited. These are what Barande has called *Colonies* of the second fauna enclosed in the strata of the primordial fauna, and I have named them *precursory centres* of creation, or centres in which forerunning species or generic types appear, that obtain their full development only during the following great period of the second fauna.

The fossils belong to the following genera and species: *Olenus? Logani*; *Dikelocephalus magnificus*, *Dik. planifrons*, *Dik. megalops*, *Dik. Missisquoi*; *Conocephalites Zenkeri*; *Menocephalus Sedgwicki*, *Men. Salteri*; *Bathyrurus Saffordi*, *Bat. Cordai*, *Bat. bituberculatus*,

*Bat. oblongus*, *Bat. capax*; *Arionellus*; *Amphion Salteri*; *Cheirurus*, *Asaphus*, *Ulenus*; *Lituites Farnsworthi*, *Lit. imperator*; *Orthoceras Marcoui*, *Orth. Missisquoi*; *Nautilus Pomponius*; *Maclurea matutina*, *Macl. ponderosa*; *Ecculiomphalus canadensis*, *Ecc. intortus*, *Ecc. spiralis*; *Metoptoma Niobe*, *Met. Orithya*, *Met. Hyrie*, *Met. Augusta*; *Murchisonia Vesta*; *Pleurotomaria postuma*; *Camerella calcifera*; *Leptæna sordida*, *Lep. decipiens*; *Orthis gemmicula*, *Ort. Tritonia*; *Ort. Electra*, *Ort. Hippolyte*, *Ort. Endosia*; and *Stricklandia?* *Arachne*, *Acrotreta*, *Obolella*, and *Lingula*.

4th. *Swanton slates* formed of black slates interstratified now and then with thin layers of a marly limestone; they are about twenty-five hundred feet thick. A few lenticular masses of limestone are enclosed, containing at Highgate Springs and some other places colonies of the second fauna, with *Trinuclens concentricus*; *Calymene Blumenbachii*; *Ampyx Halli*; *Orthis lynx*; *Rhynchonella increbescens*; *Stenopora fibrosa*, *Sten. Petropolitana*; *Orthoceras*, *Murchisonia*, *Columnaria*, and *Lingula*.

The *Graptolite beds* so numerous near Point Lévis and at Swanton Falls are in this group.

A dislocation of great magnitude occurred at the end of the deposit of the "Swanton slates."

5th. *Potsdam sandstone*, with its well-known rocks, lies in discordance of stratification over these different groups, and is found in many places where it has not been entirely destroyed and washed away by erosion. At Lake Champlain the Potsdam has been much eroded, and we have only the lowest part of it, about three hundred feet thick. The fossils are: *Conocephalites Adamsi*, *Con. Vulcanus*, *Con. minutus*, *Con. verrucosus*; *Lingulepis minima*, and *Obolella prima*.

Another dislocation occurred at the end of the deposit of the Potsdam, but not so important as the preceding one of the "Swanton slates."

CHAMPLAIN SERIES OR GROUP.—Just alongside, not more than half a mile distant from this typical region of the "Taconic system" of the eastern shore of Lake Champlain, are the peninsula of Alburgh, the Isle la Motte, and Chazy Landing, forming Emmons's group of Lake Champlain, with all its rocks and characteristic fossils, so totally distinct from the Taconic system. The Champlain group rests in discordant stratification of about 15° or 16° upon the Potsdam sandstone, very near the village of Chazy, and also at one mile to the west of the village.

The *Calciferous sandrock*, 360 feet thick, contains *Maclurea matutina*, *Turbo obscura*, and *Orthoceras primigenium*.

Then the *Chazy limestone*, 225 feet thick, containing a great many of the following fossils: *Illænus arcturus*, *Ill. crassicauda*; *Asaphus obtusus*, *As. marginalis*; *Isotelus canalis*, *Is. gigas*; *Ceraurus*; *Maclurea magna*, *Macl. striatus*; *Scalites angulatus*; *Pleurotomaria*; *Murchisonia*; *Bucania* or *Bellerophon*; *Orthoceras rectiannulatum*, *O. subarculatum*, *O. tenuiseptum*, *O. moniliforme*; *Atrypa*; *Orthis*; *Leptaena*; *Actynocrinus*; *Retepora*; *Chætetes*, etc.

Above we have the "Trenton," with the subdivision of the "Birds-eye" and "Black River" limestone, 360 feet thick. The following are very common fossils: *Illænus crassicauda*, *Ill. latidorsata*; *Calymene multicauda*, *Cal. senaria*; *Isotelus gigas*; *Ceraurus*; *Phacops*; *Asaphus*; *Trinucleus concentricus*; *Orthoceras*; *Endoceras*; *Cyrtoceras*; *Bellerophon*; *Murchisonia*; *Pleurotomaria*, *Holopea*; *Modiolopsis*; *Tellynomia*; *Nucula*; *Atrypa*; *Spirifer*; *Orthis*; *Leptaena*; *Chætetes*, etc.

The "Utica slate," at Rouse's Point and Alburgh peninsula, with *Thriarthrus* (*Calymene*) *Beckii* and *Graptolithus pristis* most abundant, has a thickness of about 105 feet.

This section is the most complete that we have in America; even that of Nevada recently found at Eureka by Mr. Charles D. Walcott is less satisfactory for the Champlain series and the Potsdam sandstone. But there are two "gaps," to which I invite attention by trying to fill them without going far from Lake Champlain. These "gaps" are in the upper part of the Taconic, and are owing to the two "breaks" with discordance which took place before and after the deposit of the Potsdam sandstone.

But first I will give an extract from the last letter which I have received from the promoter of my researches on the Taconic system, my most regretted friend, Barrande.

"PRAGUE, 10 Mars, 1882.

"MON CHER MONSIEUR MARCOU.

" . . . Depuis que j'ai reçu, en Avril, 1881, votre beau mémoire *Sur les Colonies dans les Roches Taconiques des Bords du Lac Champlain*, il est resté sur ma table de travail. A diverses reprises je l'ai étudié pour bien apprécier vos observations et en rendre compte dans ma *Défense des Colonies VI.*, en préparation.

" Il m'est agréable de reconnaître, que vos nouveaux documents sont bien supérieurs à ceux que vous avez d'abord publiés et méritent toute considération. La multitude de mes occupations urgentes ne me permet pas aujourd'hui d'entrer dans la discussion des faits en question.



“Etant privé ici de beaucoup de ressources littéraires, je suis peu au courant de ce qui se passe en Amérique. J'ignorais qu'il fut de nouveau question de système Taconic.

“Je serai charmé de voir les figures des fossiles (de Georgia) que Mr. Whitfield va publier d'après vos matériaux.

“J. BARRANDE.”

### III. VERTICAL AND GENERAL SECTION OF THE TACONIC SYSTEM. — INFRA-PRIMORDIAL, PRIMORDIAL, AND SUPRA-PRIMORDIAL FAUNÆ.

The dislocation of strata which occurred at the close of the deposit of the “Taconic slates,” the last group of which I have called “Swanton slates,” is the greatest as regards the breaking, squeezing, and local folding which has ever occurred in North America. The lateral pressure came from the east-east-south and met the *massifs* of *terra firma* of the Laurentine and the Adirondacks; all the strata were pressed together and taken between the force which pushed them from the east and the resistance from the west-west-north. They were first raised to a vertical position, and then overturned in fanlike shape.

Such are the origin and the form of that local folding of the earth's crust called the Green Mountain Chain of Vermont. The upper part of the “Swanton slates” came up against and spread over the crystalline rocks of the Adirondacks and the Laurentines, forming small local folds. The denudation took place immediately after; then the sea flowed over the upper part of the Taconic, extending even farther west, over the crystalline group of the Adirondacks, forming a gulf, of which Lake Champlain is the last witness, because it occupies a small part of it. This gulf deposited the “Potsdam sandstone,” which covers a part of the Taconic. A new dislocation at the end of the Potsdam diminished the size of this gulf, reduced now to a sort of sound or fiord, in which the strata of the “Champlain series,” or the true “Second fauna,” were deposited, deposits which, added to the Potsdam, cover and hide entirely the upper part of the “Swanton slates.”

But where the sea which deposited the Potsdam did not reach, as along the Laurentines from Three Rivers to Quebec, St. Anne, and lower down along the St. Lawrence River, all the “Swanton slates” must be found complete, leaning against the crystalline rocks. It is so at Quebec, Charlesbourg, Indian Lorette, Montmorency's fall, and

on the coast of St. Anne, where there is a group of Upper Taconic slates corresponding to the "Swanton slates," but of a much greater thickness, — at least 5,000 feet, instead of the 2,400 feet of the environs of Swanton.

In the town of Quebec even, at the Saut du Matelot, at the citadel, at Beauport, at Charlesbourg, and below Montmorency's fall, the schists have the same aspect and composition with the "Swanton slates," black, sometimes gray, even reddish; they contain some layers of blue limestone, lentils or kidneys of limestone, enclosed in the schists, and which at the Saut du Matelot resemble erratic limestone blocks shut into the black schists. They seem to be almost entirely destitute of fossils, except near the base, where are found the celebrated compound *Graptolites*.

In order to complete the general theoretic section of the Taconic, 2,500 feet, that is to say double the thickness of the "Swanton slates" as they are seen at Swanton, must be added.

The dislocation of the Potsdam resulted in the isolation and uncovering of a certain surface of these deposits of sandstone, conglomerate, dolomite, and limestone. This uncovered portion has been exposed to the great denudation which took place afterwards; the lowest parts alone remain; all the rest have been carried off. This explains why the Potsdam, or "Red Sandrock," in Vermont is only the lowest part of the formation. But in certain isolated cases portions have been less denuded, protected by divers obstacles, varying according to the localities; and here and there the Potsdam or "Red Sandrock" is quite thick.

One of these uninjured portions, preserved one might almost say miraculously, is near Saratoga, where it has been discovered by Mr. C. D. Walcott, who has described a part of the fossils he discovered, in the Thirty-second Annual Report of the New York State Cabinet. This upper part of the "Potsdam group" is formed of a "massive limestone," according to Walcott, containing a primordial fauna analogous to the Potsdam of Wisconsin. These are some of the forms: *Lingula*, *Platyceras*, *Metoptoma*, *Crepicephalus*, *Lonchocephalus*, *Dike-locephalus*, and *Ptychaspis*. (See Science, Vol. III. No. 52, p. 136.)

This upper limestone of the Potsdam covers the sandstone of Keeseville (Au Sable Chams), and the red sandstone of Highgate (Church farm).

This important discovery in this typical region of the Taconic completes the series of all the beds of this great and important system. The objection of the non-existence of this limestone formation under

the strata of the Champlain series at the village of Chazy, and at Potsdam itself, is explained in two ways. First, there is sufficient distance between Saratoga and Chazy for a local deposit of limestone to be made in one place and not in the other. But it is still more important to observe that at Chazy and at Potsdam the Potsdam rock has formed a beach during the whole time of the Champlain deposits. The character of this beach has been preserved in so striking a manner, that one would think it had been abandoned by the sea but a few years, even in our own day; it was greatly eroded and all its upper beds were destroyed shortly after the dislocation, and before the first deposits of the "Califerous" and of "Chazy limestone."

It is almost certain that this important discovery by Mr. Walcott will not be the only one, and that this upper part of the Potsdam will be found along the line of the Taconic, from Lake Champlain to Alabama. It has been pointed out and described long since in Wisconsin and Minnesota.

If we complete the theoretic vertical section already given in 1881 for the Lake Champlain region, and taking account of the discovery of the zone of *Paradoxides* on the borders of the Atlantic, we have the following section.

TABULAR VIEW OF THE TACONIC SYSTEM IN EASTERN  
NORTH AMERICA.

Potsdam Group, 400 feet.	Saratoga limestone.	Feet. 100	Dikelocephalus, Lonchocephalus, Crepicephalus, Lingula.	Supra-Primordial fauna.		
	Red Sandrock of Vermont and Keeseville.	300	Conocephalites Adamsi, C. minutus, C. vulcanus, Lingulepis, Obolella prima.			
Swanton Slates, 5,000 feet. Zone of the Colonies of the second fauna.	Upper Swanton slates or Quebec group of the city and citadel of Quebec, Charlesbourg, and Montmorency's fall.	2,600	Almost destitute of fossils.			
	Lower Swanton slates or slates between Swanton's fall and the shores of Lake Champlain.	2,400	Graptolites at Swanton's fall, and at the ferry road of Point Lévis, River St. Anne, and Gros Maule (Canada). Colonies of the second fauna at Highgate Spring, with Trinucleus, Calymene, Ampyx, Orthis, Rhynchonella, etc.			
Zone of the prophetic types or precursors of the second fauna.	Phillipsburgh or Point Lévis Group.	3,000	Dikelocephalus, Olenus? Conocephalites, Arionellus, Bathyrurus, Menocephalus, Amphion, Cheirurus, Asaphus, Illænus, Lituites, Nautilus, Orthoceras, Maclurea, Murchisonia, Metoptoma, Ecculiomphalus, Camerella, Leptæna, Orthis, etc.			
Georgia slates, or Olenellus Zone.		400	Olenellus Thompsoni, Ol. Vermontana, Dikelocephalus? Angelina, Conocephalites, Orthisina, Camerella, Obolella.		Primordial fauna.	
St. Albans Group, 5,500 feet.	Paradoxides Zone.	St. John or Acadian Group (New Brunswick).	2,700			Paradoxides Acadicus, Par. Eteminicus, Par. lamellatus; Conocephalites (14 species), Agnostus (2 species), Microdiscus, Elliptocephalus, Lingula, Obolella, Orthis, Discina, Eocystites, Salterella, Hyolithes, and Orthoceras.
	Argillites of Brantree, Mass., and St. Mary's Bay, Newfoundland.	300	Paradoxides Harlani, Par. Bennetii, Par. decoris, Par. tenellus; Arionellus, Agrauios, Anapolenus, Obolella miser.			
	Eophyton sandstone of Great Bell Island (Newfoundland).	1,500	Eophyton Linnæanum, E. Jukesi, Arthraria, Lingula, Lingulella, Cruziana, Iphidea, Palæophicus.			Intra-Prim. fauna.
	Aspidella and Arenicolites slates of St. John's, Newfoundland.	1,000	Aspidella Terranova, Stenotheca, Scenella, Arenicolites spiralis.			

Greenish and bluish slates, quartzites, and conglomerates, trappean or diabase beds, and volcanic ash?

Let us remember that the St. Albans Group, even at St. Albans or in the neighborhood, has as yet brought nothing certain to palæontology, and that there are only doubtful indications which I have placed on the "Lake Champlain section" as a halting-point or query. Without doubt fossils are very rare, but let us hope that some day the cutting of roads and opening of quarries will lead to their discovery, especially in the zone which should represent there the *Paradoxides beds*.

In the eastern part of the great masses of crystalline rocks in New England and Newfoundland, the fossils of the Primordial fauna have been found, indicating always by their forms, and their stratigraphic positions in close proximity to the crystalline rocks, that they come from the lowest parts of the fossiliferous rocks of the "Taconic system."

If these localities are classed according to their faunæ, the only possible way, considering the absence of superposition and the great distance which separates them, they may be thus described in a descending series.

*St. John Group, or Acadian Group.*— In the town of St. John, New Brunswick, and also very near its suburb Portland, in the slates upon which these two towns are built, the Rev. C. R. Matthews found in 1862 fragments of trilobites, which have been since carefully studied and published by Mr. G. F. Matthews, under the title of "Illustrations of the Fauna of the St. John Group," in the Transactions of the Royal Society of Canada, 4to, Section IV., 1882.

The first discoveries have been much added to by several observers, and as the fossils have been gradually collected they have been published, first by C. F. Hart in the "Report of the Geological Survey of New Brunswick" (1865) carried on under Prof. L. W. Bailey, and in the "Acadian Geology" (1868) of Principal Dawson, then by Billings and Matthews. The following is the list of fossils.

*Paradoxides*, 7 species or varieties; *Conocephalites*, 14 species; *Agnostus*, 2 species; *Microdiscus*, 1 species; *Elliptocephalus*, 1 species; *Lingula*, *Obolella*, *Orthis*, *Discina*, *Eocystites*, *Salterella*, *Hyalithes*, and *Orthoceras*.

It is pre-eminently the Primordial fauna of Barrande, "Zone des *Paradoxides*," with the certain apparition of a Cephalopod well recognized by Prof. A. Hyatt. The thickness of the beds at Portland and St. John is about three thousand feet, composed mostly of slaty shales, flags, and quartzites, with red sandy shales and conglomerates at the base.

The fossils are found at two hundred feet from the base, and are

confined exclusively to the slates at different levels, in a height of twenty-seven hundred feet.

This "Group of St. John," also called "Acadian Group," must be regarded as the upper part of the St. Albans Group, for the fossils indicate a lower level than the fauna of the "Georgia slates" with *Olenellus*; but they are not far from these; the Brachiopods resemble them very much, and the Trilobites have affinities with them, while they have a *facies* of greater antiquity, because of the *Paradoxides* and a considerable number of *Conocephalites*.

As to the stratigraphy and the fossils, Mr. Matthews says: "No trace of a fossil could be seen in the black slate. But scattered at intervals through some of the bands of this slate were hard, compact masses of rock, which, when broken, were found to be packed with fossils. The spherical and elliptical masses, which varied in size from about a yard in diameter to nodules of one inch across, had the appearance of imbedded boulders, but the fossils in them were always parallel to the stratification, and similar fossils were subsequently found in irregular beds and lenticular bands of hard rocks. In the boulder-like masses there were numerous layers loaded with organic remains, which extended without diminution in the number of the fossils to the very edge of the block, where they suddenly disappeared, and not a trace of them could be found in the adjoining slate rock."\*

There is a repetition of what I have pointed out on the borders of Lake Champlain and at Point Lévis, only the lenticular masses are of smaller dimensions, and recall those of Scandinavia.

*Braintree, near Boston, Massachusetts.*—Ten miles south from Boston, in direct contact with the syenitic granite of Quincy, are several quarries of argillites, two of which contain two trilobites rarely to be found;—one very large, the head or cephalic shield reaching even a foot in width, the *Paradoxides Harlani* Green; the other very small, almost minute, *Arionellus quadrangularis* Whitf. Beside these, a Cephalopod perhaps and a marine plant. These fossils are only found within a space of a few square yards; much narrower limits than the fauna of St. John, New Brunswick, or any of the localities of the fossiliferous Taconic on the borders of Lake Champlain.

Braintree evidently belongs to the "Zone of Paradoxides," in the lower part of this zone, and I place it, until the contrary is proved, below the "Acadian Group" of St. John, and about the middle of the "St. Albans Group."

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\* Illustrations of the Fauna of the St. John Group, p. 90.

*Peninsula of Avalon, Newfoundland.* — The south-southeastern part of Newfoundland, between Cape Race, the Bay of Placentia, and Trinity Bay, is occupied by some outcrops of syenite and gneiss, which cut into and cross the argillites, slates, quartzites, and conglomerates.

The following fossils have been found at Branch, in St. Mary's Bay and at Chapel Arm, Trinity Bay, in an argillite analogous to that of Braintree, and also directly in contact with the syenitic granite: *Paradoxides Bennettii* Salt., *Parad. decoris* and *Parad. tenellus* Bill., *Agraulos socialis* and *Agr. affinis* Bill., *Solenopleura communis* Bill., *Anapolenus venustus* Bill., and *Obolella? miser* Bill.

The argillite of Newfoundland covers a much larger surface than that of Braintree; the *Paradoxides Bennettii* is almost as large as *Par. Harlani*. This small trilobitic fauna not only belongs also to the lower part of the "Paradoxides zone," but is very likely contemporaneous with that of Braintree. In the theoretic section these two faunæ are placed together in the middle of the St. Albans group and below the Acadian Group of St. John, New Brunswick.

In Conception Bay, to the east of Branch and Chapel Arm, at Great Bell Island, and at Topsail Head and Brigus, in sandstone conglomerate and argillite, the following fossils have been found: *Eophyton Linnæanum* Torell, *Eoph. Jukesi* Bill., *Arthraria antiquata* Bill., *Lingula Murrayi* Bill., *Lingulella spissa* Bill., and *Lingulella affinis* Bill., *Iphidea bella* Bill., *Cruziana similis* Bill., *Paleophycus*, and two or three new species of *Lingula*.

Lastly, in the argillite of the town of St. John's have been found *Aspidella Terranovica* Bill., *Stenotheca pauper* Bill., *Scenella reticulata* Bill., and *Arenicolites spiralis* Bill.\*

The absence of trilobites and the presence of such forms as *Eophyton* and *Arenicolites* found in Sweden below the Paradoxides zone, and other new or very ancient and very enduring forms, such as *Lingula* and *Lingulella*, seem to indicate a greater age for this fauna than that of the Paradoxides zone; that it corresponds to the divisions of "*Eophyton* and *fucoïd* sandstones" of Sweden, of Linnarson; and that we have there the oldest fossils, until now, found in the eastern region of North America.

This fauna, certainly more ancient than Barrande's typical Primordial fauna of Bohemia, and which I place at the lower part of the

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\* See Geological Survey of Newfoundland, Report of Progress for the Year 1881, p. 13, and Appendix (St. John's, 1882).

St. Albans Group, is in reality *Ante-Primordial*, or more exactly *Infra-Primordial*, and in future I will designate it by this name. I place in it, temporarily at least, the two fossils *Straparollina remota* and *Hyalithes excellens* Bill., found at Smith's Sound, in Trinity Bay, as well as *Agraulos strenuus* Bill., of Brigus and Topsail Head, Conception Bay.

I do not now refer to the regions of Newfoundland near the Straits of Belle Isle, where the Georgia Group with *Olenellus Thompsoni*, and the Group of Phillipsburgh and Point Lévis, have been found; nor to the determination of certain beds as being of the age of the Potsdam and of the Calciferous. The existence of the true Potsdam and the Calciferous is very doubtful, as no fossils identical with those of the typical localities of the State of New York have been found.

*Infra-Primordial, Primordial, and Supra-Primordial Faunæ.* — I have called the most ancient fossils of Newfoundland *Infra-Primordial*, in order to distinguish them from the true *Primordial*, as Barrande has characterized it in Bohemia, and which is represented in America by the zones with *Paradoxides* and *Olenellus*. But we have also in America a fauna which has no representative in Bohemia, where the overflow of porphyry put an insurmountable obstacle to marine existence. This fauna is found at Hof in Bavaria, at Vestfosen near Christiania in Norway, and elsewhere in Europe; declared by Barrande primordial at Hof, while Linnarson looks upon it as the second fauna; and Brögger calls it by the name of *Asaphus Etage* in Norway. It is formed of Primordial types united with types whose great development takes place in the second fauna, properly so called, and for these reasons I give it the name of *Supra-Primordial*.

So we have in America and in Scandinavia, and very probably elsewhere, three Taconic faunæ. 1st. The *Supra-Primordial*, which at Lake Champlain includes colonies of the second fauna, and is terminated by the "Potsdam sandstone," including the "Saratoga limestone," with primordial fossils discovered by Walcott. 2d. The true *Primordial* fauna, including the zones with *Olenellus* of the Georgia schists, that with *Paradoxides* of the St. John or Acadian Group, and the argillites of Braintree and St. Mary and Trinity Bays. 3d. The lowest Primordial fauna, or *Infra-Primordial*, still more sporadic, with more simple and primitive forms, of Conception Bay, Smith's Sound, and St. John's harbor, Newfoundland.



IV.—THE TACONIC OF EUREKA (NEVADA) AND OF THE GRAND CAÑON OF THE COLORADO RIVER (ARIZONA).

The important and unexpected discovery of the uppermost part of the Potsdam at Saratoga with the same fauna as the Upper Potsdam of Wisconsin, St. Croix River, Lake Pepin, and Trampaleau, is not the only one that American stratigraphy owes to Mr. C. D. Walcott. This *savant*, whose studies on the manducatory and ambulatory appendages of the trilobites are justly celebrated, has in the last three years, 1881, 1882, and 1883, made other discoveries of great value in the regions of the Grand Cañon, Arizona, and the Great Basin, Nevada. Mr. Walcott gives the following general and ideal section of the Taconic strata of the Grand Cañon of the Colorado River.

GENERAL AND IDEAL SECTION OF THE TACONIC ROCKS OF THE GRAND CAÑON (COLORADO).

Tonto Group. 1,000 feet.	Upper sandstone, shales, and limestone.	Feet. 700	Dikelocephalus, Conocephalites, Crepicephalus, Iphidea, Lingulepis, Cruziana.	Saratoga and Wisconsin division.	Potsdam Sandstone Group.
	Coarse sandstone.	300	No fossils.	Red Sandrock of Vermont.	
Pre-Tonto Group. 10,000 feet.	Chuar Group.	5,000	Only three fossils have been found yet: first, a small Discinoid shell; second, a pteropod allied to <i>Hyolithes triangularis</i> ; and third, an obscure <i>Stromatopora</i> .		Infra-Primordial fauna or lower part of the St. Albans Group.
	Grand Cañon Group.	5,000	No fossils.		

Crystalline rocks.

NOTE.—Plane of unconformity indicated by double dividing line. No trace of the Primordial fauna, and of the Supra-Primordial fauna, except in the upper part, or Saratoga and Wisconsin subdivision.

The upper part is formed of sandstone, shales, and limestone, 1,000 feet thick. Major J. W. Powell has called it the "Tonto Group." *Tonto* means *stupid*; it is the name the Mexicans give to the Indians of that region. The fossils are found in the middle and upper part of the group, and belong to the genera *Dikelocephalus*, *Crepicephalus*, *Conocephalites*, *Iphidea*, *Lingulepis*, and *Cruziana*. They indicate the Upper Potsdam of Wisconsin, and of Saratoga County, New York. The fauna of the Lower Potsdam of Keeseville, New York, and of Highgate, Vermont, has not been found in the Grand Cañon.

There is a slight line of unconformity between the upper part of the Potsdam or "Tonto Group" and the Devonian, which rests directly upon the Taconic.

The Potsdam rests unconformably on 10,000 feet at least of strata called "Pre-Tonto, or Chuar and Grand Cañon Groups." The first 5,000 feet constitute the "Chuar Group," and are formed of sandstone, argillaceous shales, and limestone, resembling in texture and composition the Trenton limestone and Utica slate.

After very careful researches, prolonged for two months and a half, Mr. Walcott was only able to collect three species of fossils, — a small Discinoid shell, a Pteropod allied to *Hyolithes triangularis*, and an obscure *Stromatopora*. Evidently fossils are very rare, and those found indicate an Infra-Primordial fauna below the zones with trilobites, and recalling the fauna of Conception Bay and Smith's Sound, Newfoundland.

In the 5,000 feet of the "Grand Cañon Group" formed of sandstone interposed between "flows of greenstone-lava beds," as Walcott calls them, no fossils have been found; and one reaches, at last, quartzites crossed by veins of granite.

To resume. This section of the Grand Cañon only shows the base and the summit, that is, the first and last group of the Taconic system. All the middle parts are wanting. As there has been a very marked break, before the deposit of the Potsdam or "Tonto group," we may think that the upper portions have been destroyed by erosions, or are thrown to the right or left of the very narrow region of the Grand Cañon of the Colorado River.

A little farther north, in the Eureka district, and even already in the ranges of highlands in Eastern Nevada, and of Oquirrh in Utah, the middle portions of the Taconic system have a superb development of beds and of fossils, which fully completes the Taconic in the western regions of North America.

*Eureka.* — At Pioche City, the able geologist, Mr. E. E. Howell, has found the zone with *Olenelli*, or "Georgia Group," well characterized; and Mr. S. F. Emmons has recognized this zone with *Olenelli* a little farther north in the Oquirrh Mountains. Longer and more detailed researches have been made in the mining district of Eureka by Messrs. Arnold Hague and C. D. Walcott, and I will give the section of Eureka recently published in the "Abstract of Report on the Geology of the Eureka District, Nevada," by Arnold Hague (Third Annual Report of the United States Geological Survey, 1881-82, p. 253, Washington, 1884). I give here less than half this section as having relation to the Taconic.

Lower Part of the Eureka Section, Nevada, 12,700 feet.			Eastern N. America.		
Cambrian or Champlain.	Lone Mountain limestone.	1,800	Isotelus gigas, Trinucleus concentricus, Illænus, Leptæna, Ceraurus, Orthoceras, Cytoceras, Chætetes.	Champlain Group or Cambrian.	Second fauna.
	Eureka quartzite.	500	No fossils yet found.	Potsdam sandstone?	
* Taconic System, 10,900 feet.	Pogonip limestone.	2,700	Blue limestone with distinctly bedded structure; containing colonies of the second fauna, mingled with and among primordial fossils, Dikelocephalus! Crepicephalus Gallatinensis!!! Agnostus, Acrotreta, Obolella, Lingula manticula!! Lingulepis, Illænus, Bathyrurus, Asaphus, Amphion, Cystolites, Orthoceras, Maclurea, Orthis, Chætetes, and a Graptolites.	Swanton slates.	Supra-Primordial fauna.
	Hamburg shale.	350	Dikelocephalus! Conocephalites, Crepicephalus Gallatinensis!!! Agnostus, Kutorgina, Obolella, Lingula manticula!! Lingulepis.	Phillipsburgh or Point Lévis Group.	
	Hamburg limestone.	1,200	Dikelocephalus (2)! Conocephalites (4), Crepicephalus Gallatinensis!!! and 5 others, Chariocephalus, Oxygia, Agnostus (4), Hyolithes, Kutorgina, Acrotreta, Iphidea, Lingula manticula!! Lingulepis.		
	Secret Cañon shale.	1,600	No fossils in shale; a few imperfect fragments in calcareous beds.		
	Prospect Mountain limestone.	3,050	300 ft. of shaly beds with fossils: Dikelocephalus! Conocephalites, Crepicephalus Gallatinensis!!! Agnostus, Lingula manticula!! Obolella.		
			2,000 ft. of Magnesian limestone. No fossils.  Conocephalites Prospectensis, Dikelocephalus! Agnostus, Scenella.		
	Prospect Mountain quartzite.	1,500	No fossils.	500 ft. of Magnesian limestone and shales in lenticular or wedge-shaped bodies. No fossils.	Georgia slates or Olenellus zone.
100 ft. of red arenaceous shale or Olenellus shales. Olenellus Barrandi, O. Iddingsi, O. abnormis, Conocephalites, Acrotreta.					
				St. Albans Group.	No trace of the Infra-Primordial fauna.

Granite below the quartzite.

NOTE. — Plane of unconformity indicated by double dividing line.

\* Very likely a break or unconformity of some kind exists here.

A very thick solid mass of conglomerates, micaceous shales, and specially quartzite, of at least 1,500 feet, without fossils, rests upon the granite which is visible at but one point; this group is called "Prospect Mountain quartzite." (All the names of groups given by Messrs. Walcott and Hague are names peculiar to the region of Nevada and Eureka.) This group without fossils corresponds stratigraphically to the "St. Albans Group."

Directly above is the "Prospect Mountain limestone," which begins by a bed, 100 feet thick, of shales with *Olenelli*. The authors have united and confounded this very important horizon of the zone of *Olenelli* with a great mass of limestone, from which it is doubly distinct,—first by its lithology, and secondly by its palæontology. I have shown this on the section by a line. In these shales there are three species of *Olenellus*, a *Conocephalites*, and a brachiopod *Acrotreta*. This little fauna corresponds so well with that of Georgia, that it is needless to insist on the affinities which connect them. So the zone with *Olenelli*, or "Georgia slates," are strongly marked in Nevada. Above are 500 feet of bluish limestone without fossils. Then we come to a horizon of fossils belonging to the genera *Dikelocephalus*, *Conocephalites*, and *Agnostus*. Higher up is an enormous mass of 2,000 feet of metamorphosed and broken up limestone without fossils; and the last 300 feet, at the upper part, containing quite a large number of fossils belonging to the genera *Dikelocephalus*, *Crepicephalus*, *Conocephalites*, *Oxygia*, *Agnostus*, *Orthis*, *Lingula*, *Obolella*, etc. On the whole, a fauna resembling that of Point Lévis in Canada, and already Supra-Primordial.

Then comes a mass of slates 1,600 feet thick, without fossils, or having only imperfect traces of fossils badly preserved, called "Secret Cañon shale."

At the top of this group are the "Hamburg limestones," 1,200 feet thick, with numerous fossils, belonging to the genera *Dikelocephalus*, *Crepicephalus*, *Conocephalites*, *Oxygia*, *Agnostus*, *Hyalithes*, *Kutorgina*, *Iphidea*, *Lingula*, *Lingulepis*, etc.,—a fauna having all the characters of the Supra-Primordial.

Then come 350 feet of the "Hamburg shale," with a fauna almost identical with the preceding one in genera and species; the whole is really but one group, the "Hamburg Group," which, added to the "Secret Cañon shale," and to the "Prospect Mountain limestone," from which we must take 100 feet at the base where are the "Georgia slates" with *Olenelli*, represents in Nevada the "Phillipsburgh and Point Lévis Group" of Vermont and Canada. At Eureka

this group does not seem to show the types prophetic of the second fauna, so remarkable at Phillipsburgh.

For Messrs. Walcott and Hague, the Cambrian ends with the "Hamburg shale," without a break in the stratification and without a well-marked palæontologic horizon, since the species pass into the higher group which they call "Pogonip limestone." These *savants* have been influenced by the apparition of forms of the second fauna, and place themselves at a point of view entirely palæontologic, although quite open to discussion, even palæontologically. They have drawn there a strong line of separation between two geologic ages, which they call "Cambrian" and "Silurian."

The "Pogonip limestone," 2,700 feet thick, gradually passes into the "Hamburg shale" in concordant stratification, and contains a fine fauna, a decided mingling of species of primordial and second fauna forms, exactly the same as at Hof in Bavaria, and at Christiania, Norway. Mr. Walcott gives a list of sixteen species which he recognizes as common here and in the beds beneath, which he calls "Cambrian." They are *Dikelocephalus*, *Crepicephalus*, *Arethusina*, *Agnostus*, *Acrotreta*, *Obolella*, *Lingula*, and *Lingulepis*.

Towards the middle of the "Pogonic group" are found *Bathyurus*, *Amphion*, *Asaphus*, *Illænus*, *Maclurea*, *Orthoceras*, *Orthis*, etc. All these forms exist at Point Lévis, Phillipsburgh, and Highgate Springs; and at Eureka and in Nevada we have the same mixture and the same associations as in Vermont and Canada.

One single Graptolites has been found in Nevada, and it is in the "Pogonip group."

By its position above the beds with *Dikelocephalus* of the "Hamburg and Prospect Mountain Groups," and its mixed fauna, it is evident that here are the Colonies of the second fauna in the primordial fauna, as in the "Swanton slates" of Lake Champlain; and I do not hesitate to consider the "Pogonic limestone" as representing in Nevada the "Swanton slates."

Above we have the "Eureka quartzite," 500 feet thick, in which, unhappily, as yet no fossils have been found; but we must remember, that many years had passed before the discovery of the small *Conocephalites Adamsi* and *C. minutus* at Highgate and at Keeseville, and that we may hope for a like success at Eureka. In position and lithology the Eureka quartzite recalls the "Red Sandrock" of Vermont and the "Potsdam" of Keeseville, Chazy, and Potsdam. Further, although Messrs. Hague and Walcott have not recognized a discordance between this group and the "Pogonip," the excellent Geological

Map of the Eureka District accompanying the memoir of Arnold Hague shows the "Eureka quartzite" either seeming to overlap, or lying in direct contact with, all the different groups of Primordial, except the "Secret Cañon shale," which can only be explained by a transgressive discordance or a different geographical distribution of the level of the sea. It is probable that the great break of the Green Mountains, the most important as breaking and dislocation of strata that has ever happened in North America, was felt in its effects in this Nevadian fiord of the Upper Taconic by a slight change in the level of the sea, sufficient to produce a geographical distribution special and peculiar to the deposits of sand which form the "Eureka quartzite."

In order to show the numerous points of resemblance and the multiple relations existing between the "Eureka quartzite" and the "Red Sandrocks" or "Potsdam sandstone" of Vermont, New York, and the Grand Cañon of Arizona, I will add that there has been at Eureka a break between the quartzite and the following formation, the "Lone Mountain limestone." An unconformity exists between the two formations, and a denudation or erosion has destroyed the upper part of the "Eureka quartzite." As we know now that it is the upper part of the Potsdam which contain fossils, the lower having furnished in all America but six or eight species, we can understand why no fossils have yet been met with in the quartzites occupying the place of the "Potsdam sandstone" at Eureka.

The "Taconic System" in Nevada is finished with the "Eureka quartzite." The second fauna is above, analogous to that of the "Champlain division" of Emmons, and the "Lone Mountain limestone," from 1,800 to 2,000 feet thick, represents the true "Cambrian," from the "Calciferous," "Chazy," and "Trenton," even to the "Utica" and "Lorrain shales." It is nearly double the thickness of the typical series of New York.

Messrs. Walcott and Hague make one system only of the five lower divisions, "Prospect Mountain quartzite and limestone." "Secret Cañon shale," and "Hamburg limestone and shale," they call "Cambrian." Then uniting the "Pogonip limestone" with the "Eureka quartzite" and the "Lone Mountain limestone," they have made a second system of 5,000 feet, which they call "Silurian." It is an entirely palæontological classification, which follows only uniformist preconceived opinions. It pays no attention to discordances of stratification, nor to Primordial forms, especially the Primordial species, some of which are found from "Prospect Mountain" to "Pogonip limestone," such as *Lingula manticula* and *Orepicephalus Galati-*

*nensis*. If the beds are classed after the principal genus found in them, as has been done in Scandinavia, where the divisions or groups are called "zone of *Paradoxides*," "zone of *Olenelli*," "zone of *Asaphus*," &c., there are at Eureka two well-marked zones, — the "zone of *Olenelli*" at the base of the "Prospect limestone," and the "zone of *Dikelocephali*," reaching even the "Eureka quartzite." The genus *Dikelocephalus* is one of the most constant and the most universal in the Supra-Primordial of North America.

Thus it will be seen that the "Taconic System" is perfectly developed, as well at the Grand Cañon as at Eureka; and that all the horizons, or palæontologic zones, have been found there of the typical Atlantic regions of the Taconic in America, as I have shown them in the general and theoretic section. One alone has not been recognized, — the "zone with *Paradoxides*" of Braintree, St. Mary's Bay, and St. John, New Brunswick. But the Infra-Primordial is well represented in the "Chuar group" of the Grand Cañon; the Primordial, in the zone with *Olenelli* at Eureka, Pioche, and Oquirrh; and the Supra-Primordial in the zone with *Dikelocephali*.

These divisions terminate, as at Lake Champlain and Saratoga, with a covering in discordant stratification of a mass of sandstone identical with the "Red Sandrock" or "Potsdam sandstone," which Mr. Walcott calls "Tonto Group" and "Eureka quartzite."

The classification here given only differs in the groupings and denomination of the systems. I will give my reasons later for not using the terms "Cambrian" and "Silurian" as they are used by Messrs. Walcott and Hague; but the divergence of opinion on the general classification and the use of names does not at all diminish the value of the remarkable observations in the region of the Great Basin and the Grand Cañon made by these *savants*. Their researches and discoveries are of great importance, and their value cannot be too highly appreciated.

#### V. GEOGRAPHICAL DISTRIBUTION OF THE TACONIC. — NORWAY.

It is not necessary to review all the localities and regions of America where the Taconic System and the Primordial fauna have been discovered; it is sufficient to say that America has far more than the Old World of depositions already described, and of variety in the fossils collected; and it appears from what we know, that life was manifested in the New World under forms which have preceded the apparition of similar ones in Europe. We may say with confidence that from Newfoundland and Belle Isle to Eureka and the Grand

Cañon of the Colorado River towards the west, and to Alabama and Texas on the south, there are almost continuous lines of the outcropping of the Taconic System; and that the only point in the southern hemisphere where the Primordial fauna has been yet certainly found is in the Argentine Republic at Salta and Jujuy.

I must make a reservation as to the "Lake Superior sandstone" and "Keweenaw series" of eruptive rocks. No proof whatever, palæontological,\* stratigraphical, or lithological, has been given of their being of the age of the "Tonto Group" (Potsdam sandstone), or of the "Grand Cañon and Chuar Series" of the Colorado River; and their synchronism is merely a speculative supposition. The identification of those sandstones with the Potsdam of New York, which was based on the discovery of a great quantity of *Lingula prima* at Tequamenon Bay, has long been given up. They came from a small boulder of the glacial deposits. Dr. C. Rominger says, "There is no record of any instance in which recognizable fossils were found *in situ* in the Lake Superior sandstone."† Dr. R. V. Irving says, "The horizontal sandstone of the south shore of Lake Superior belongs unquestionably to this formation (Potsdam sandstone), though it is a matter of doubt whether the two sandstones do or ever did connect."‡

All the eruptive rocks, melaphyrs, and a part of the diabases and porphyries containing native copper and zeolites are similar and identical with the same rocks in Connecticut, Pennsylvania, and Nova Scotia on this continent; and with the rocks containing copper in Thuringia, where they belong to the Kupferschiefer and Rothliegende of the Dyas (Permian). If lithology has a meaning with regard to the age of rocks, the copper-bearing rocks of Lake Superior are Dyasic, while the Lake Superior sandstone of Sault Ste. Marie, Gros Cap, La Pointe, and Bois Brulé River belongs to the Bunter Sandstein of the Trias.

As to the existence of the Taconic System in the Lake Superior region, it is very possible that the slates of Kakabeka Falls, and some slates, conglomerates, diabases, and gabbro found on the edge and even in the interior part of the crystalline rocks forming the centre

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\* Several specimens having a decided *Orthoceratites* form have been found in the melaphyr and diabase of Point Keweenaw since 1848, a fact similar to the discovery of undoubted pieces of *Orthoceratites* in the diabase of Bohemia, and this goes far to confirm the Post-Silurian age of the copper-bearing rocks of Lake Superior.

† Geol. Surv. of Michigan, Vol. I. Part III. p. 80, 1873.

‡ The Mineral Resources of Wisconsin, p. 11, 1880.



of the highlands between Lake Superior, the Upper Mississippi, and Green Bay, belong to it, but as yet palæontological proofs are entirely wanting. Mr. A. R. C. Selwyn considers the columnar trap or diabase which forms the summit of Thunder Cape, Pie Island, and McKay's Mountain as contemporary with the black slaty shales of Kakabeka Falls, called "Animikie Group"; and not belonging to the "crowning overflow" of the melaphyr copper-bearing rocks. My own observations, made in 1848, coincide with this view; and I am led to think that the diabases of this region, northwest of the lake, are identical with those of Etchemin and Chaudière Rivers near Quebec, and of Bel Ciel, Montarville, and Rougemont near the Richelieu River; and that the black slates of Kakabeka Falls belong to the "Swanton slates" of the Upper Taconic.

In Australia, notwithstanding the discovery of compound *Graptolites* in the province of Victoria, one group of fossils alone, and of so low an order, will not suffice us to decide upon the positive existence of the Taconic System, although it appears very probable.

In Africa no Primordial fauna has as yet been found.

In Asia, China only has furnished certain proof, at Liau-Tang, that the Taconic System is well developed.

In Europe, Barrande has had the honor of first establishing, and then pointing out, the Primordial fauna and the Taconic System in Bohemia, in Great Britain, in France, in the Iberian peninsula, in Sardinia, in Bavaria, and in Scandinavia.

The development of the strata of the Taconic System, and the forms and number of fossils in the classic countries of the Primordial, England, Bohemia, and Scandinavia, are inferior to the American series on both these points.

In Bohemia, according to Barrande, there was an irruption of porphyry, which prevented any marine life, and placed a complete barrier between the primordial and the second fauna. We may say, further, that these porphyries arrested the development of the primordial fauna, which presents in Bohemia only the lower portion, or "*Paradoxides* zone," of the Primordial properly so called, without any trace of the Infra- or of the Supra-Primordial faunæ. There we have only the zone with *Paradoxides* represented in America by Braintree, near Boston; St. Mary, near St. John's, Newfoundland; and the environs of St. John, New Brunswick.

The result of this interruption of life in Bohemia between the "*Paradoxides* zone" and the second fauna, is the incompleteness of the palæontologic series, and an absolute limit to the passage of any

species; and hardly any genera exist between the primordial groups and those of the second fauna. In a word, the record of the palæontologic register of Bohemia is incomplete. It is evident that, although the development of life was interrupted in Bohemia, it must have continued elsewhere; for, once begun, nothing short of the destruction of the earth could stop the evolution of living forms. Thus, a fauna was shortly found not far from Bohemia, composed of the true primordial types, with a mixture of forms whose extended development was only reached during the existence of the second fauna. Dr. Gümbel, director of the geological survey at Hof, in Bavaria, in 1862 found this intermediate fauna. Studied by Barrande in 1863, this *savant* recognized that, beside the primordial types, such as *Olenus* and *Conocephalites*, there are forms of the second fauna of Bohemia, as *Asaphus*, *Calymene*, and *Cheirurus*, but belonging to different species. Then, supporting himself on the absence of the *Paradoxides* type at Hof, he concludes "that the fauna of Hof is posterior to the primordial fauna of Bohemia." And he adds: "Thus the fauna of Hof appears to correspond to an intermediary epoch between our primordial fauna and that of the first phase of our second fauna. This intermediary age is not represented by any fauna in our basin [Bohemia]. But it is natural to conceive that it corresponds to the time during which the masses of porphyry overflowed into the Silurian sea of Bohemia, which are intercalated between the strata enclosing our first two faunæ. In effect, the plutonic phenomena which introduced these rocks into our formations must have made the sea of these regions uninhabitable to the contemporary faunæ."\* However, the deposit at Hof is isolated, and in direct contact with the Devonian.

In Scandinavia the strata of the lower palæozoic rocks are of much less thickness than in Bohemia, in Great Britain, and especially in America. They average only about one thousand feet for the whole series of the primordial and second fauna, instead of the ten and twenty thousand feet of the English and American series. Further, these strata have suffered numerous dislocations and breaks, which have parcelled them out in small groups, on divers points, at some distance from each other. And to add still more to these difficulties, great denudations, carrying after them enormous quantities of materials transported by the great glaciers of the glacial epoch, have destroyed or covered up all the strata, leaving merely some outcroppings here and there, very difficult to class and to connect certainly with each other.

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\* Faune Silurienne des Environs de Hof en Bavière, pp. 56, 57 (Prague, 1868).

In Sweden Linnarson has succeeded in giving a more complete classification than his predecessor, without being able to clear up certain obscure points of superposition and of succession.

Here is the *résumé*:—

TABULAR VIEW OF THE LOWER PALÆOZOIC ROCKS OF SWEDEN.

Silurian System.	Klinte sandstone of Scania. Upper Graptolites shales. Brachiopod shales.		Silurian System.	
Ordovician * System.	Trinucleus shales. Chasmops limestone. Middle Graptolites shales. Orthoceras limestone.	} Second fauna.	Cambrian System.	
	Lower Graptolites shales. Ceratomyge limestone.			} Supra-Primordial fauna.
Cambrian System.	Dictyonema shales	} Primordial fauna.	Taconic System.	
	Olenus shales. Paradoxides beds.			} Infra-Primordial fauna.
	Fucoid sandstone. Eophyton sandstone.			

Compared with the section of the Taconic System, the two lower divisions represent the two groups with *Eophyton* and *Arenicolites* of Newfoundland, or the lower part of the St. Albans Group,— the Infra-Primordial fauna.

The "*Paradoxides* beds," with the six subdivisions that Linnarson has found there, represent the zone with *Paradoxides* at Newfoundland, Braintree, and St. John, New Brunswick. The "*Olenus* shales" correspond to the Georgia slates with *Olenelli*, and these two zones together form the true Primordial fauna.

Then the "*Dictyonema* shales," added to the "*Ceratomyge* limestone" and the "*Lower Graptolites* shales," represent the Supra-Primordial, or the Groups of Phillipsburgh, Swanton, and Potsdam.

It must be remarked that Linnarson, in placing the "*Ceratomyge* limestone" and the "*Lower Graptolites* shales" in his "*Ordovician* System," had reached the conclusion that the fauna of Hof was not Primordial, contrary to the opinion of Barrande; and according to his memoir it ought to belong to the second fauna.

NORWAY.—The environs of Christiania in Norway present an uninterrupted series of the Taconic System, much more complete than that of Sweden.

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\* From *Ordovices*, a people inhabiting the northern part of Britannia Secunda, or Cambria, now Wales.

Here is the general theoretic section given by Messrs. Kjerulf and Brögger : —

TABULAR VIEW OF THE LOWER PALÆOZOIC ROCKS OF NORWAY.\*

Etage 3. 142 feet.	3 c. { 3 c γ. Der Orthocerenkalk. 3 c β. Der Expansusschiefer. 3 c α. Der Megalaspiskalk.	Second fauna.	Supra-Primordial fauna.	Cambrian System.
	3 b. Der Phyllograptusschiefer.	Swanton slates.		
3 a. { 3 a γ. Der Ceratopygenkalk. 3 a β. Der Ceratopygenschiefer. 3 a α. Schiefer und Kalk mit <i>Symphysurus incipiens</i> .	Phillipsburgh or Point Lévis Group.			
Etage 2. 150 feet.	2 e. Dycyonemaschiefer. 2 d. Kalk mit <i>Peltura</i> . 2 c. Schichten mit <i>Eurycare</i> . 2 b. Schichten mit <i>Parabolina</i> . 2 a. <i>Olenus-Niveau</i> .	Olenus Zone.	Primordial fauna.	Taconic System.
Etage 1. 80 feet.	1 d. <i>Paradoxides Forchhammeri</i> , <i>Ellipsocephalus</i> , <i>Obolella</i> . 1 c. <i>Paradoxides Tessini</i> , <i>Par. regulosus</i> , <i>Conocephalites</i> . 1 b. <i>Paradoxides Kjerulfi</i> , <i>A-crotreta</i> , <i>Hyalithes</i> .	Paradoxides Zone. or Acadian or St. John Group. Braintree and St. Mary's Bay (Newfoundland).		
Gneiss, Granite, Syenite, Porphyry, Gabbro, Labradorite, Diabase, and Diorite.				

The first division, or Etage 1, represents the zone of *Paradoxides*, and is equivalent to the zone of *Paradoxides* in Newfoundland, Massachusetts, and New Brunswick. It is called "*Paradoxides* slates of Krekling" near Vestfosen. After its deposit there was a dislocation strongly marked at Sandswær near Christiania, which seems to be contemporary with the dislocation at Newfoundland, St. Mary's, Trinity, and Conception Bays, and St. John, New Brunswick. For more than twenty years Prof. Kjerulf has recognized this resemblance, and has placed this first division in the Taconic System. The fossils are: *Paradoxides Kjerulfi*, *P. Tessini*, *P. regulosus*, and *P. Forchhammeri*; *Arionellus primevus* and *A. difformis*; *Conocephalites ornatus*, and *C. Sulzesi*; *Ellipsocephalus circulus*; *Liostracrus Linnarsoni* and *L. microphthalmus*; *Dolichometopus Suecicus*; twenty species at least

\* See *Udsigt over det Sydlige Norges Geology*, by Theodor Kjerulf, 4to, with Atlas, folio (Christiania, 1879); and *Die Silurischen Etagen 2 und 3 im Kristiania gebirt und auf Eker*, by W. C. Brögger, 4to (Kristiania, 1882).

of *Agnostus*; *Hyalolithes socialis*, *H. tenuistriatus*, and *H. plicatus*; *Lingula*, *Orthis*, *Obolella*, *Acrothele*, and *Acrotreta*.

This fauna indicates the lower part of the true Primordial. But the American Infra-Primordial has not yet been recognized in Norway.

The second division (Etage 2), or "Die *Olenus* schiefer," with an average thickness of 150 feet, is subdivided by Mr. W. C. Brögger into five parts, called 2 *a*, 2 *b*, 2 *c*, 2 *d*, 2 *e*. The first is especially the level of the *Olenus*; then come the beds with *Parabolina*, closely allied to the genus *Olenus*, with which it has often been confounded; then the *Eurycare*, the *Peltura*, and a schist with *Dyctyonema* (*Graptolites*), forming the base of the Supra-Primordial fauna. Beside the trilobites belonging to the genera already cited, and two or three others, forming a total of twenty-one species, only one *Orthis*, one *Lingula*, and one *Obolus* have been found.

It is clearly the same fauna as that of the Georgia slates, or zone of *Olenellus*, of America.

In the lithology the assimilation is the same; for in Norway the slates enclose small limestone lentils, in the middle of which the fossils are found by preference, just as in Vermont.

The third division (Etage 3), or "Die *Asaphus* Etage" of Brögger, follows that with *Olenus* in concordant stratification, as is shown in a fine section of the railroad to Vestfosen near Christiania.\*

In this remarkable memoir, the first, or 3 *a* group, which is subdivided into *a*, *β*, and *γ*, has a mixture of primordial trilobites, with forms belonging to the second fauna, resembling the deposits at Hof, at Point Lévis, and at Phillipsburgh. The *Ceratopyge* are so near the *Olenus*, that Prof. Sars has put them in the same genus. The genus *Dikelocephalus*, so remarkable in America, is found in Norway in the subdivision *γ* of the group 3 *a*. Further, there are also *Agnostus*, *Cyclognathus*, a genus allied to the *Peltura* and the *Olenus*, and one *Parabolina*. On the other hand, the following genera of trilobites make their first appearance: *Amphion*, *Cheirusurus*, *Holometopus*, *Harpides*, *Triarthrus*, *Megalaspis*, *Niobe*, *Symphysurus*, and *Ampyx*; all belonging to genera that made their first apparition in America at the same epoch.

In this division 3, subdivision 3 *a*, mollusks are more rare than in America; there are only one *Orthoceras*, one *Bellerophon*? one *Orthis*, two *Lingula*, one *Lingulella*, two *Obolus*, one *Obolella*, one *Discina*,

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\* Die Silurischen Etage 2 und 3 in Kristianiagebirt und auf Eker, by W. C. Brögger, p. 29 (Kristiania, 1882).

and two *Acrotreta*; all having a decidedly primordial aspect. *Graptolites* are also found.

On the whole, the parallelism of the lower part of division 3 (Etage 3), and of the "Dyctonemaschiefer," with the Phillipsburgh and Point Lévis Group, can hardly admit of doubt.

Above come the schists with compound Graptolites, called "Phyllograptus schiefer," or 3 *b*, in which are found the *Graptolites* of Point Lévis. Then comes group 3 *c*, the two first subdivisions of which, 3 *c a* and 3 *c β*, form, with the 3 *b*, a mass of sixty feet average thickness of schists with *Graptolites* at the base, and then with limestone lentils filled with fossils, four fifths of which belong to the second fauna, the primordial fauna only being represented by one *Agnostus*, and some Brachiopods (*Orthis*, *Lingula*, *Lingulella*, *Discina?*), and one *Acrotreta*.

The schist with *Graptolites*, or 3 *b*, may be considered as equivalent to those of Point Lévis, Quebec, and Swanton, of the "Swanton Group." But farther up there is an important hiatus in the series of Norwegian fossils; those of the subdivisions 3 *c a* and 3 *c β* appearing to belong to the fauna of the subdivision 3 *c γ*, or "Orthocerenkalk," which in Norway certainly represents the Chazy and Black River of the second fauna in America.

A slight tie, however, unites the Norwegian fauna of 3 *c a* and 3 *c β* to the Supra-Primordial fauna; and considering the great distance of Norway from the typical Taconic region of America, it seems probable that the two faunæ were contemporary, and we have there the last term of the Taconic System.

It is certain that the conditions in America for the development of organic life in the Taconic seas were far more favorable than those of Scandinavia, and it is not strange if we find important differences in the evolution of life in two regions so far distant from each other.

The small division of the "Potsdam sandstone" has no representative in Scandinavia, nor in Bohemia; not that the sediments were arrested in this part of Europe during the time that this formation was deposited, but because we have not yet the means of finding the parallelism. It is possible that the "*Porambonites* schicht" (schists with *Spirifer porambonites*), of only three feet thickness, which form the base of the "Orthocerenkalk" at the section of Vestfosen near Lunde, Norway, may be the representative of the Potsdam; and in Dalecarlia (Sweden) the "Oboluskalk," containing *Obolella*, only six to ten feet thick, which has been found between the "Ceratomyge lime-

stone" and the "Phyllograptus schiefer" at the base of the "Orthoceras limestone" by S. L. Tornquist, and referred by him to the "Tremadoc Group" of England. The section of Vikarbyn, in which the "*Obolus-Konglomerat*" and "*Obolus-Gruskalk*" lie on the granite, may offer the equivalent of the Potsdam. (See "In Öfversigt öfver Bergbyggnaden in om Siljåusomr (Edet," Dalarne, 4to, Stockholm, 1883.)

If the Potsdam really exists in Europe, it is in the Iberian peninsula and in Brittany, where the sandstone of Cabo-Busto with *Scolithus* in the Asturias (Spain), the quartzites with *Bilobites* of Bussaco (Portugal), and the sandstones with *Scolithes* of Brittany (France) are in the same stratigraphic position, especially in the province of Caceres in Spain, and in Portugal, where the sandstones with *Scolithes* are deposited on the Taconic schists, denuded and eroded, exactly like the "Red Sandrock" of Vermont resting on the denuded and eroded Taconic schists of America.

The great dislocation of the Green Mountains drove from the American regions all the types of the second fauna that had made their appearance in the upper parts of the Taconic schists. Then during the special deposit, limited in time and space, of conglomerates, sands, and limestones that have been called "Potsdam sandstone," certain characteristic primordial forms shed a last light before disappearing forever.

I speak especially of the trilobites, the evolution of which is easier to follow than that of organisms placed lower in the scale of the animal kingdom.

The dislocation that ended the Potsdam deposits ended also the existence of the primordial fauna in America; and we pass suddenly into the second fauna with the "Calciferous and Chazy divisions." The sediments were changed, and all was prepared in the American sea in which the deposit was made of the series of the "Champlain System," or "Cambrian" proper, for the exclusive development of the second fauna.

Nevertheless, it is well to notice that as yet several animal forms of the second fauna which made their first appearance in the "Phillipsburgh and Swanton Groups" have never reappeared in America, while they have had their complete evolution in Europe. For instance, I will cite the genus *Amphyx*.

And further, according to the careful palæontological researches of Prof. A. Hyatt, no true *Endoceras* with cone in cone structure has yet been found below the true "Chazy limestone" and "Calciferous sand-

rock." All *Orthoceratites* found in the Taconic belong to the genera *Saunionites*, *Piloceras*, and true *Orthoceras*. Finally, the *Lituities* of Phillipsburgh are very rare in America, and disappear almost totally with the "Taconic System."

#### VL. TACONIC *versus* CAMBRIAN AND SILURIAN.

The time has now come to make clear the prior right and the real advantage to be found in the use of the term "Taconic System," instead of the so generally employed expressions "Cambrian" and "Silurian," to designate the strata enclosing the primordial fauna. First, it is a question of justice; and it is hardly possible that the third International Geologic Congress, which is to meet at Berlin, should fail to consider the names to be chosen for the great divisions of formations on the geological map of Europe.

Facts and dates will prove that America has the right to name one of the great systems, or series of strata, and that the observations made and work done on this side of the Atlantic have first made known the true base of the stratigraphic scale.

Murchison, not wishing to use the German name of "Grauwacke," nor the French term "Terrain de transition," explains as follows the origin of the terms Silurian and Cambrian.\*

"At this time [1835] I proposed the term *Silurian*, and it came about in this way. My friend, the eminent French geologist, Élie de Beaumont, seeing what a clear classification I had made out by order of superposition and characteristic fossils in each descending formation, earnestly urged me to adopt a name for the whole of the natural groups. Seeing that the region in which the best types of it occurred was really the country of the Silures of the old British king Caractacus, I adopted that name [Silurian]. I had seen that all geological names founded on mineral or fossiliferous characters had failed to satisfy, and that fanciful Greek names were still worse. Hence it seemed to me that a well-sounding geographical term, taken from the very

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\* *Cambria*, from the Latin *Cimbri* (robbers), and from the Celtic *Cymry*, the *Britannia secunda* of the Romans, comprehended the whole of Wales from the river Severn to the river Dee. Three tribes inhabited it: on the south, the Silures (*Siluria*); on the west, the Dimetes (*Dimetia*); and on the north, the Ordovices (*Ordovicia*). All these names have been used by English geologists, who have also proposed other Welsh names, such as Menevian, Pebidian, Arvonian, Longmynd, Llamberris, Harleck, Festiniog, Tremadoc, Arenig, Caradoc, etc. The little principality of Wales has furnished more geographical names to geology than any other country.



region wherein the classification had been elaborated, and where every one might go and see the truthfulness of it, was the best."\*

"The word *Cambrian* was first used in print in the year 1836. . . . It originated in the following manner. . . . On sending a copy of my new classification to M. Élie de Beaumont, that eminent geologist, wishing to mark strata separated by lines of dislocation by separate names, suggested the propriety of further distinguishing those last-mentioned unconformable and inferior rocks by the term *Hercynian*, as taken from the Hartz mountain in Germany, where, as he then believed, the oldest slaty group would prove to be of higher antiquity than the strata to which I had applied the word *Silurian*. Unwilling that the name for these infra-Silurian rocks should be taken from a foreign country, in which no precise palæozoic horizon had then been fixed, I at once urged Professor Sedgwick to apply to his slaty rocks, which were confidently believed to be inferior to my own, some term on the same geographical principle by which I had been governed in proposing *Silurian*.

"I even ventured to suggest the word *Snowdonian*, because I knew that my friend then considered the northwestern portion of the Welsh chain to be made up of the oldest fossiliferous masses; but preferring a more comprehensive geographical name, he took that of *Cambrian*. With this arrangement we both felt certain that no anomaly could be introduced into the lower palæozoic classification, as the relations and fossil contents of mineral masses, which were contiguous, must be eventually cleared up without fear of error or the introduction of theoretical views." †

According to these quotations, Élie de Beaumont was the inspirer of the geographic names in *ian* to designate stratigraphic groups. This is only a partial truth. De Beaumont only proposed two geographic names, the *Grès Vosgien* in 1841, and the *Cumbrien* (from Cumberland) in 1847. The last was an endeavor to make Murchison and Sedgwick harmonize, and to designate the strata containing the second fauna. Neither of the adversaries accepted this transaction. But de Beaumont had been struck with the success of the names *Portlandien*, *Kimmeridien*, *Corallien*, and *Oxfordien*, proposed and

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\* Life of Sir Roderick I. Murchison, vol. i. p. 227 (London, 1875).

† "On the Meaning originally attached to the term 'Cambrian System,' and on the Evidence since obtained of its being geologically synonymous with the previously established term 'Lower Silurian.'" By Sir Roderick I. Murchison. In the *Quarterly Journal of the Geological Society of London*, vol. iii. pp. 166, 167 (1847).

employed since 1832 by Jules Thurmann, in his "Essai sur les Soulèvements jurassiques du Porrentruy." Thurmann, a geologist of new and original ideas, was the first to recognize the utility of geographic terms uniformly ending in *ien*, and who first used them in 1832 for his very remarkable orographic classification of the Jura Mountains. In 1834, pursuing the same idea, he found and employed the name *Néocomien*, to designate the lower part of the cretaceous formation, called at that time the *Crétacé du Jura*, or *Jura-Crétacé*. This name was proposed and employed in a reunion of the Geological Society of the Monts-Jura, at Besançon, on the 1st and 2d of October, 1835, according to a letter that Thurmann wrote to Élie de Beaumont, which the latter published in the seventh volume of the Bulletin de la Société Géologique de France, 1<sup>er</sup> Série, page 209, where we read, "Je (Thurmann) propose de donner le nom de terrain Néocomien (*Neocomensis*), c'est à dire de Neuchâtel comme on dit Portlandien, Oxfordien, etc."

The coincidence of Élie de Beaumont's suggestion, in 1835, of the use of the word *Hercynian*, with the creation of the term *Neocomian*, which Thurmann had communicated to him, shows that the initiative of these terms ending in *ien* or *ian* comes truly from Thurmann, as the dates of the published documents prove.

Sedgwick and Murchison had made a friendly association with each other to study the ancient stratified rocks of England; Murchison exploring the grauwackes of Hereford, Radnor, and Pembroke counties, while Sedgwick studied especially the slaty or schistose region of the North of Wales. The latter quickly recognized the succession of the principal groups of schist, as well as the dislocations that have affected them. He saw very well that his "Group of Bala" rested in discordance of stratification on the schists of Festiniog and of Longmynd; and as no fossils had been found in the strata below the Group of Bala, their thickness and their structure were not at first studied. It sufficed to know that their thickness must be very great and their structure very complicated, especially in the counties of Pembroke, Cardigan, and Caernarvon. The attention of Sedgwick was concentrated on the Group of Bala. He recognized there a series of strata, which he subdivided into two portions, containing an entire special fauna. Sedgwick did not occupy himself with the study of it in Shropshire and Montgomeryshire, where Murchison found it, and took it to form his "Lower Silurian." Murchison gave as his excuse, that he thought the fossils collected by Sedgwick were different from those he had placed in his "Lower Silurian," and that he was much sur-

prised to learn that Sedgwick had only found Silurian fossils in his Cambrian. Consequently, he says, "the Cambrian is not inferior in its position than the lowest stratified rocks of my Silurian of the region of Shropshire and the adjacent part of Montgomeryshire, as we had supposed, but is merely extension of the same strata."\*

In order to fix the date, Murchison hastened to publish his "Silurian System," in 1839, taking great care to have all the fossils he had procured described by such specialists as Agassiz, Sowerby, and especially Lonsdale. He had also the skill to submit some portions of his manuscript, principally the Introduction, to his friend Sedgwick, to whom he dedicated it, and he included in his volume, as his own, a quantity of observations of very great value by other geologists, who had with great liberality communicated them to him. We will mention the Rev. T. T. Lewis, vicar of Aymestry, who had cleared up and classed all the strata of his neighborhood before Murchison went there, and whose talents as an observer, according to Prof. Phillips, a good judge, were at least equal to those of Murchison.†

Sedgwick, with his integrity and fairness of character, and simplicity of manners, thinking only of the progress of stratigraphy and geology, of which he was certainly the most learned representative and the most capable since the death of "Strata Smith," failed to see at first the great benefit of this publication, which in some sort cut the grass from under his feet, and stole a march upon him. He continued his studies, collecting his materials patiently, with the greatest care, above all observing with great knowledge and ability all the superpositions, dislocations, and associations of strata, and slowly made ready the publication of his fossils in 1855, under the title, "A Synopsis of the Classification of the British Palæozoic Rocks, by Adam Sedgwick, with a Systematic Description of the British Palæozoic Fossils in the Geological Museum of the University of Cambridge, by Frederick McCoy" (Royal 4to, Cambridge.)

It is true, that meanwhile a very active controversy, especially on the part of Murchison, arose between the associates. They became irreconcilable enemies; and a complete rupture, much to be regretted in the interests of science, took place between them.

It is now admitted that Sedgwick was right to insist upon the independence of the second fauna, and its separation from the third fauna, which alone has the right to be called "Silurian." That from the

\* Siluria, 1st ed., 8vo, p. 8 (London, 1854).

† Life of Murchison, vol. i. p. 242.

first observations he recognized a different system from that of the groups of Wenlock and Ludlow, and that in calling it "Cambrian" he followed the rules recognized in stratigraphy for establishing the great formations or systems.

But we must go back, to show the progress accomplished, first outside of England, and then in England itself.

The publication of "The Silurian System," in 1839, was truly an event, and marks an important point in the progress of geology. Nevertheless, it is well to say that this book had at first hardly any influence in America, and only after the visit of de Verneuil, in 1846, did it attain a certain limited influence.

Since 1836, Vannuxem, Emmons, and Conrad had studied with the greatest success the "Transition formations" of the State of New York. The beds being in part horizontal, or nearly so, and succeeding each other in a receding series, the American geologists easily established a good classification without having to make the difficult connection and joining which arrested Murchison and Sedgwick in England.

In Europe the publication of the "Silurian System" had at once a very great influence, owing to very different causes. In the first place, the author went over Europe in all directions, trying everywhere to recognize and establish his Silurian classification.

There was a sufficient resistance by the German, Scandinavian, and Russian geologists; but he succeeded in surmounting it, thanks to the French geologists, always much disposed to Anglomaniæ. Barrande it was, above all others, who made the fortune of the "Silurian System." Exiled at Prague with the royal family of France, Barrande had already for some years been studying the basin of Bohemia, systematically collecting both fossils and geological sections. The want of points of comparison, and the resistance of the Bohemian geologists and palæontologists, who declared that the geology of that country was unique, and unconnected with anything similar in the earth's history, caused Barrande to receive the first copy of the "Silurian System," at Vienna, in 1840, with the same joy that a sailor by night in a fog perceives a lighthouse. And in gratitude for the great service this book rendered him, he not only employed the term "Silurian," but extended it to strata far below the level of those described by Murchison, adding at once an average of ten thousand two hundred feet of beds containing the primordial fauna, his division C, — entirely unknown to Murchison and Sedgwick, — and also his azoic beds A and B.

Barrande, although having heard of the different views of Sedgwick and Murchison, and the controversy which broke out in 1846 and 1847 between them, could only form an opinion of the worth of Sedgwick's claims by studying the question in Wales and Shropshire, which was materially impossible for him at that time in his life, — the little time at his disposal being given to his studies on the geology of Bohemia.

Sedgwick published his "Synopsis," with fossils by McCoy, in 1855, so that Barrande was without it in his classification of 1850, and he makes no mention in his publications in the Bulletin de la Société géologique de France, 1851, nor in his first volume of the "Système Silurien du Centre de la Bohême," 1852, of the "Cambrian system," of which he had no cognizance, palæontologically at least. Otherwise, with his great loyalty and love of justice, Barrande would doubtless have recognized the real rights of Sedgwick and his "Cambrian System," as he did later those of the "Taconic System," of which he was equally ignorant, though published in 1846. His classification once published and his great work begun, Barrande could not vary from the term adopted, or change his title.

These are Barrande's divisions of the "Silurian System" in Bohemia.

TABULAR VIEW OF THE "SYSTÈME SILURIEN DU CENTRE DE LA BOHÈME."

Upper Silurian. 900 feet.	H. Hluboceper group. G. Braniker group. F. Koniepruser group. E. Kuchelbader group.	Third fauna.	Silurian System.
Lower Silurian. 16,200 feet.	6,000 D. feet. { d <sup>5</sup> . Kœnigshofer group. d <sup>4</sup> . Zahorzaner group. d <sup>3</sup> . Vinicer group. d <sup>2</sup> . Mont Drabow group. d <sup>1</sup> . Voseker group.	Colonies of the third fauna exist in both groups.	Second fauna.  Cambrian System.
	Porphyry. 1,200 C. Ginecer schists, or Protozoic slates of Ginetz and Skrey. 9,000 feet. { B. Prizbramer grauwacke. A. Prizbramer schiefer.	Supra-Primordial fauna wanting. — Primordial fauna, only the Paradoxides Zone. — Infra-Primordial fauna wanting, except a few Arenicolites.	Taconic System.
Granite and Gneiss.			

Barrande insists on the great difference between the primordial fauna of Bohemia and the second fauna. He says, "Nos étages C et D peuvent être cités, comme présentant la différence la plus absolue que l'on connaisse entre les faunes de deux étages consécutifs." The cause of this is the total absence of the Supra-Primordial fauna in Bohemia.

Murchison hastened to profit by the excellent work of Barrande, and, before Sedgwick had finally decided to publish his "Synopsis," — long since announced and only appearing in 1855, although dated 1851 and 1852 in the Introduction, — Murchison, always on the *qui vive*, brought out a new and more popular edition, in octavo form, of his "Silurian System." Without consideration, he not only boldly placed in his "Lower Silurian" the formations of Caradoc and Llandeilo, or Bala Group of Sedgwick, but he went further, and placed there also the "Lingula flags" and the "Longmynd or Bottom rocks," and entirely suppressed the "Cambrian."

He did even more; the success of the term "Silurian" caused him to forget all prudence, and he included in his new edition of the "Silurian System" all the palæozoic series under the unique title of "Siluria"; placing under this rubric of "Siluria" the primordial, second, and third faunæ, the Devonian, Carboniferous, and even all the New Red Sandstone of Russia (*Dyas* and *Trias*), which he called by the Russian name "Permian." In the second and third editions of "Siluria," in 1859 and 1867, the description of strata given always increased in number, citing already the Jurassic and Cretaceous, and if another edition had appeared, the whole stratigraphic series would have passed under the title "Siluria," stopping only at the glacial Quaternary.

This excess of Siluria and Silurian brought on a reaction, and Barrande himself gave the signal for it.

Let us remember that forty years ago, or even thirty, communication was not so easy as it is now, and that publications in one country and in one hemisphere reached their destination in another with much difficulty, or not at all.

So we must not be astonished if, notwithstanding the active and persistent researches of Barrande to find all that had appeared upon the primordial fauna and the rocks that enclose it, all the memoirs and reports of Emmons had entirely escaped him. With a truly prophetic intuition Barrande had successively announced the extension of the primordial fauna he had established in Bohemia in 1846 to Sweden, Norway, England, Spain, the Upper Mississippi, Braintree near Boston, Georgia, Texas, and Missouri.

This was not done without opposition, the centre of which was in England, where no one accepted it, — Sedgwick no more than Murchison and the Geological Survey. Barrande, in his fine and courteous way, called the “Primordial fauna” *Mademoiselle de Trop* (Miss of Too-much). In truth, it was too much for Murchison, who thought he had included the whole in his “Silurian System,” and it was also very *mal à propos* for Sedgwick, who had caused McCoy to describe all the fossils found in his “Cambrian,” and who was right in regarding them as the most ancient forms, the base of organic types.

Lastly, the Geological Survey, with its numerous staff of assistants and collectors of fossils, and the extreme care with which it studied Wales and the Malvern Hills, did not like to admit that a stranger, in a short stay in London, and during a rapid visit to other points of the country in the winter of 1850–51, had been able to find an entirely new fauna which had completely escaped them.

No one has shown greater elevation of mind, or carried to a higher point the moral distinctions in his geological and palæontological discoveries and researches, than Barrande. He had consecrated the greater part of his time and resources for fifteen years to “the creation of the primordial fauna,” to follow the expression of D’Omalius d’Halloy, and when in 1860 he received from Dr. Emmons and Billings the documents published on the “Taconic System,” he did not hesitate a moment in recognizing and proclaiming the right of priority for Emmons and the “Taconic System.” He says:—

“At its origin, that is to say from 1838 to 1844, this Taconic System was presented as founded on petrographic and stratigraphic observations, and constituted simply the *sedimentary base*, according to the American expression. It was still without any characteristic fauna. But in 1844, Dr. Emmons having discovered in this formation fossils before unknown, his Taconic System for him represented the *palæozoic base*.

“This expression, used on the other side of the Atlantic, is evidently equivalent to that of ‘Primordial fauna,’ which I have applied to the trilobitic group, the oldest of Bohemia, defined for the first time in my *Notice préliminaire*, in 1846. It is known that the *Lingulæ* which characterize the corresponding horizon of Lingula flags in Wales, that is, in the Cambrian region of England, were only discovered by Mr. Davis in 1845. (*Siluria*, 2d ed., p. 43, 1859.)

“In comparing these dates it is clear that Dr. Emmons had first announced the existence of a fauna anterior to that which had been established in the ‘Silurian system’ as characterizing the ‘Lower

Silurian' division, and which I have named *Second fauna*. It is then just to recognize this priority, and I think it all the more fitting to state it at this time, that it has not been claimed to this day."\*

A more complete demonstration and justification of the priority of the "Taconic System," of its position at the base of all the systems of strata, and of the large place it holds in the stratigraphic scale, could not be desired.

It is evident that, if Barrande had seen the memoirs of Emmons when they appeared, he would have used the name "Taconic" to designate all that lower part of the most ancient strata of Bohemia which, having nothing better, he called divisions A, B, and C of the "Lower Silurian."

There is no doubt, also, that if Sedgwick and McCoy had published fifteen years sooner the "Synopsis of the British Palæozoic Rocks and Fossils," Barrande would have recognized the "Cambrian" in his division D of the quartzites with the second fauna. But Barrande published his "Système Silurien de la Bohême" in 1852, while Sedgwick first published his great work in 1855, and the Taconic documents of Emmons did not reach Barrande until 1860.

These dates explain and answer all objections. There can no longer be any question as to including in one system the primordial, second, and third faunæ; to do this would be in the actual state of our knowledge as great an anachronism as to make one system of the strata containing the triassic, jurassic, and cretaceous faunæ. Thus, Linnarson, notwithstanding the slight thickness of the strata of the lower Palæozoic in Sweden, has not hesitated to recognize three great formations, which he calls *Cambrian*, *Ordovician*, and *Silurian*. This *savant* was not concerned with the question of priority, nor to know precisely the signification of the term "Cambrian." As to the term "Ordovician," † put forward lately by some English geologists (Prof. Charles Lapworth and others) to designate the rocks containing the second fauna, there is no more reason to accept it than the name "Cambro-Silurian" proposed formerly by Sir Charles Lyell. The term "Taconic," brought forward so strikingly by Barrande, is well known to-day; it has been used in Germany, Norway, Spain, Italy, and France. I have used it in the two editions of my essay of a "Geological Map of the World."

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\* "Documents anciens et nouveaux sur la Faune Primordiale et le Système Taconique en Amérique," in Bull. Soc. géol. de France, 2 sér., tom. xviii. p. 225, 1861.

† Dr. Emmons gave the name "Champlain," in 1842, to the same group of rocks containing the second fauna.



The name "Cambrian" can be justly applied only to the series of rocks enclosing the second fauna. To wish to extend it to the strata of the primordial and second fauna, as the school of Cambridge in England has tried to do for several years, is to fall into the same fault that Murchison is reproached with, who, in his "Silurian System," extended the name "Silurian" to the second and third faunæ. Sedgwick and McCoy were completely ignorant of the existence of the primordial fauna, and in their "Synopsis," etc., of 1855, there is not a single primordial fossil. With such a hiatus and an absolute ignorance of the order of appearance of the organic types, and of the first term of the palæontologic evolution, how can one try to apply the name "Cambrian" to the base of the stratigraphic scale? It would be contrary to all the rules that have hitherto directed the classification and denomination of the great formations.

As Barrande has said,—for we must always return to him and quote him when we touch anything relating to the first three great faunæ preserved in the strata of the earth,—the "moral aspect which accelerates or delays the solution of scientific questions should be considered in a spirit of equity and justice." The time for controversy and animosity has passed away. There are very few survivors; and by the close of the century, not one will remain of all those who have taken part in the discussion.

It is for the young generation of geologists now to render to each of the masters who created the classifications, and who were the first in the difficult work of deciphering and explaining the manuscript of the earth, that which is their due; taking into consideration the equilibrium of the general classification, the logic of registered facts, and, above all, the *priority!* On all these accounts I do not hesitate to propose to them, as a solution, the three groups or systems which follow:—

- III. Silurian System, containing the third fauna.
- II. Cambrian System, containing the second fauna.
- I. Taconic System, containing the primordial faunæ.

Systems corresponding in time and space, and in the evolution of life, to three other great consecutive systems, such as, for example, the triassic, jurassic, and cretaceous formations.

The question of the relations and passage of one great fauna to another is a fact admitted to-day as incontestable, and which all the explanations by means of invisible faults and foldings of the uniformist school of absolute and mathematical rules can neither arrest nor suppress.

Barrande first discovered and showed in Bohemia the "Colonies" of the third fauna in the second fauna. Then I called attention to the "Colonies" of the second fauna in the primordial fauna of the borders of Lake Champlain. Dr. E. Kayser has recognized, in the Hartz and in Nassau, "Colonies" placed also in limestone lentils of the third or Silurian fauna, in the fourth or Devonian fauna. Prof. H. S. Williams has lately found in the State of New York, at Ithaca and Lake Canandaigua, a "Colony" of the fifth or Carboniferous fauna in the fourth or Devonian fauna.

Lastly, in India, New Zealand, California, in the Tithonic, the Rhetic, the Lower Dyas, the Laramie Group, etc., everywhere, at all degrees of the stratigraphic scale and in all latitudes, these passages exist; organic beings are mixed in sufficient proportions to connect all the links of the chain, and form a continual series of general evolution.

The great lines of the stratigraphic series are now distinctly drawn, at least for the northern hemisphere.

The European geologists have had the honor to recognize and create this magnificent classification in the chronological order of time which has passed since the earth has been inhabited. Upon one point they have been anticipated by their colleagues of America. The first degree of the scale, the most ancient of all the systems, was first recognized in the New World. It is only just that this discovery should be registered in the general classification.

To the European geologists I would say, America occupies a place in the history of geology which is but little below that occupied by Europe. Every day discoveries of great importance are made in America; and, as Prof. K. A. Zittel of Munich has lately said, after a rapid excursion across North America, "The time of great discoveries has begun in America; it is over in Europe. . . . It is beyond question that the future development of geology and palæontology will be essentially influenced by America." By accepting the "Taconic System" and placing it in the scale of the formations, you will act with graceful courtesy.

To the American geologists I would say, you have a patriotic duty to fulfil. On your own soil, and by one of you, — an American in the full sense of the term, for Dr. Ebenezer Emmons never even went to Europe, — was found, and described and named for the first time, the primordial fauna and the beds that contain it. By employing the term "Taconic," you defend a right that since Barrande no geologist has disputed.

Finally, to all my geological fellow-workers, as well American

as European, to those of India, Australia, New Zealand, Java, and Africa, I ask you, in the name of justice, right of priority, and of equity, to make use of the "Taconic System."

## VII. CONCLUSION.

The "Taconic System" comprehends all the strata in which the primordial faunæ are found. These faunæ are three in number.

The *Infra-Primordial*, which has as yet furnished only about ten fossils well characterized, all belonging to the inferior order of beings, and of a very simple organization. No trilobite has yet been found there with certainty. This number of from ten to twelve species will be doubled, and even quadrupled; but it is doubtful if it ever reaches fifty species.

The *Primordial* fauna properly so called — that of Bohemia and Scandinavia, including the great zones with *Paradoxides* and *Olenus* — is especially remarkable for the large trilobites, which hitherto have made their appearance suddenly, without prophetic prototypes to announce them. The species belong to the *Crustacea* (trilobites), *Pteropoda*, and *Brachiopoda*, with one or perhaps two *Cephalopoda*. The number of the different species is very limited, although there are from ten to thirty and forty to be counted together; and one can hardly number for the whole earth two hundred and fifty species. In future discoveries and researches we may reach twice and three times that number, but it is unlikely ever to reach one thousand.

The *Supra-Primordial* fauna, containing colonies of the second fauna in America and Scandinavia, is much richer in fossils. Hundreds of species are met with at once; all of the orders of *Crustacea*, *Mollusca*, *Radiata*, and *Bryozoa*. Many new and previously unknown forms make their appearance here. Already the number of fossils of this fauna of the upper part of the "Taconic System" reaches more than fifteen hundred species, and we may confidently look forward to great discoveries that will carry this number to three or even four thousand.

A peculiarity common to all the primordial faunæ, which was pointed out by Dr. Emmons when he made his discovery, is that the fossils are found in a sporadic way, — here and there, or entirely isolated, — contrary to the geographic distribution of the other faunæ, which are spread over and sometimes fill up the strata without interruption for hundreds of miles. We have here true centres of the appearance of species, or "centres of creation," as Prof. Edward Forbes has well expressed it. In consequence of their sporadic arrangement and tendency,

the Primordial fauna are composed of species having a very limited geographic distribution ; and it is very rare — although the forms are similar — that one species extends from one country to another, being common to two Taconic deposits, even when they are very near each other. This fact is worthy of notice by all who study the evolution of living beings, that at the Taconic epoch the marine zoölogical provinces were more numerous, and much more limited in their geographical extension, and in the number of species and individuals, than in any other geologic epoch, including even that of the present day.

Lithologically, the greater part of the "Taconic System" is formed of slates, with quartzites here and there, and especially limestone lentils enclosed in the schists. The size of these lentils varies from that of a kidney or a man's head to dimensions of twenty, fifty, one hundred, and one thousand feet, and even more ; they are scattered throughout the system, though more persistent and of larger size in the upper part.

With very few exceptions, nearly all the Taconic limestones are magnesian. Sometimes they are true dolomites, and contain no fossils. But if a very little magnesia is present, fossils are found ; and they are more abundant when the magnesia is in very small quantity. Lastly, if the limestones do not contain any magnesia, and are clayey, then the fossils become directly more numerous, and it is in these lentils of pure lime that the Colonies of the second fauna are found.

Almost all observers who have studied and sought out the primordial fossils *in situ* have been struck by the total absence, or at least the very great rarity, of fossils in the slates enclosing the limestone fossiliferous lentils. We have the right to conclude that lime was a most important element in the existence of these marine creatures of the first period of life on the earth.

The "Taconic System" is of great thickness, with the exception of Scandinavia, where all the palæozoic strata are also of slight depth. In America it may be estimated at an average of ten thousand feet.