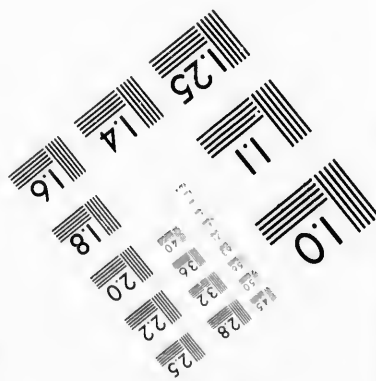
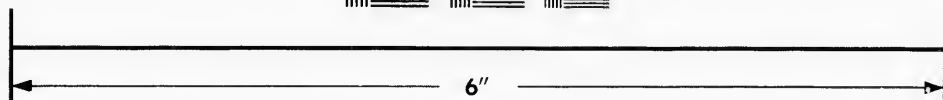
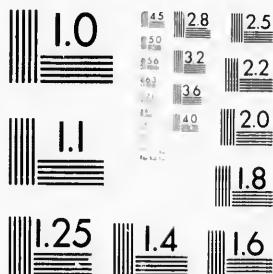


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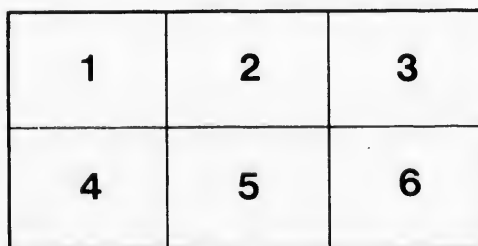
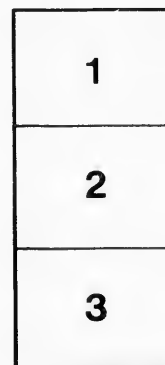
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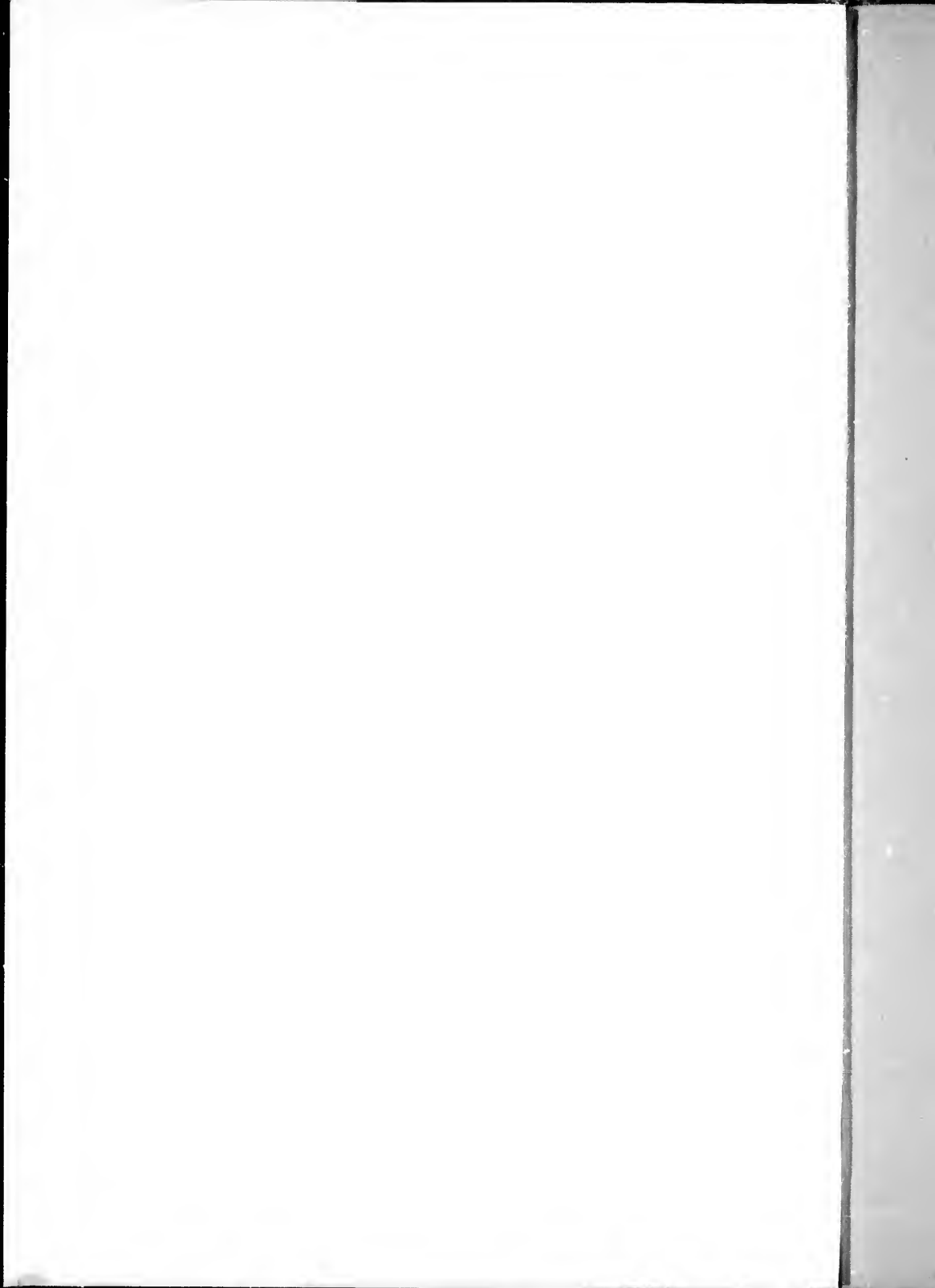
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*Rev. Prosper Lafontaine
Quebec*

[From the *American Geologist*, April 1890.]

per Dr. Bell

THE GEOLOGICAL HISTORY OF THE
QUEBEC GROUP.

By T. STERRY HUNT, LL.D.



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THE GEOLOGICAL HISTORY OF THE QUEBEC GROUP.

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The history of the Quebec group fills a considerable place in American geology, and I have been at some pains to write and to publish elsewhere the principal facts regarding it. As the questions involved therein are still imperfectly understood it has seemed proper to me as the only survivor of those who were present at the naming of this group, and as the one who wrought its downfall, to rehearse briefly its history.

In the American Journal of Science for February, 1890, is a review by Mr. Charles D. Walcott of a second report by Dr. R. W. Ells, of the Canada geological survey, on the geology of parts of the province of Quebec, wherein he treats of the uncrystalline fossiliferous strata named by Logan the Quebec group, and also of the crystalline schists adjacent to them in the hills on the east and south, described by Logan as being of contemporary age, and the result of a so-called metamorphosis over a large area of the lower portions of the same Quebec group, and hence mapped and designated by him as the Altered Quebec group. The reviewer refers to this region of eastern Canada as "the battle ground where Logan and his adherents have been finally driven from position to position until there is now little left to defend of what seemed in 1863, a well-supported position." Ells moreover, after his studies of the fossiliferous rocks of the group, concludes, according to Walcott, that the farther use of the name of Quebec group for the uncrystalline strata in question "appears not only undesirable but to a certain extent objectionable," although the terms Levis and Sillery may be retained for the subdivisions.

We are next invited by the reviewer "to consider the breaking down of this elaborately constructed geological group, built up by the labors of Sir W. E. Logan and his associates, Mr. E. Billings, Dr. T. Sterry Hunt and Mr. James Richardson." Selwyn, we are told, "began the work of disintegration when he showed in his report for 1877-78 that the rocks of the Canadian extension of the Green Mountain (or Sutton Mountain) range and its northeasterly extension were arranged in an anticlinal instead of a synclinal form as supposed by Logan. This removed the keystone on which the stratigraphic structure of the altered portion of the Quebec group was based." The crystalline schists were now referred to a "pre-Cambrian group, probably Huronian;" and what Selwyn had previously called a Volcanic group (unrecognized however by Logan and his assistants) was imagined to be pre-Cambrian.

Besides the false conception with regard to the stratigraphical structure, according to Ells, "another source of error, and probably the most considerable, was the assumption that the metamorphic rocks of that area must of necessity be the equivalent of the unaltered sediments of the St. Lawrence region, a theory which once suggested seems to have been unhesitatingly maintained, although for its support unnecessary inversions of strata and profound chemical changes were requisite." Still farther Ells has shown, according to Walcott, with regard to the uncrystalline Quebec group, that "the order of succession was inverted by Logan, and that the Levis series is conformably superjacent to the Upper Sillery (Lauzon of Logan) while the Lower Sillery forms the base of the section in the vicinity of Quebec."

There are thus embodied in the preceding paragraphs four important propositions:

1. The crystalline schists of the Green Mountain range and of its prolongation northeastwards in the province of Quebec—the so-called Altered Quebec group—do not form a synclinal, and are not metamorphosed paleozoic rocks, but on the contrary constitute an anticlinal axis of ancient strata, "pre-Cambrian and probably Huronian" in age.

2. The uncrystalline fossiliferous strata along the western and northern flanks of this range are newer rocks of Cambrian and Ordovician age.

3. The order of these newer strata was mistaken by Logan

who placed the Sillery at the summit and the Levis at the base, whereas the true succession shows the Sillery at the base, followed conformably by the Lauzon, the Levis being at the summit.

4. The name of the Quebec group should be rejected in geology.

To all of these propositions I assent most heartily, the more so that I have maintained them nearly twenty years, for the most part single-handed, and on every favorable occasion.

A slight acquaintance with the history of geological opinion as to the crystalline rocks of the Green Mountain range and their relations to the adjacent uncrystalline sediments would have shown our authors that the views advanced concerning these two classes of rocks were not simply those of "Logan and his adherents," but of the majority of American geologists for the past fifty years. Amos Eaton and Ebenezer Emmons had, it is true, taught that the region of crystalline rocks in question constitutes an ancient anticlinal axis, and that the uncrystalline sediments along its northern and western base were deposited unconformably upon these old rocks and were in part made up of their ruins. The doctrine of regional metamorphism, then and since carried to great lengths both in Europe and in America, was, however, adopted by Mather; whose large quarto volume on the geology of the Southeastern District of New York, published in 1843, was at once generally accepted as authority, so far as New York and western New England were concerned. The continued eastward dips observed in the paleozoic strata east of the Hudson and the supposed gradual transition of the uncrystalline sediments into crystalline schists led Mather to assert that these latter were nothing else than the upper portion of the Champlain division of the New York paleozoic series, or the so-called Hudson slates in an altered condition. This view was cited with approbation in 1844 by H. D. Rogers, who, in company with his brother, W. B. Rogers, attempted to show in 1846 that the gneisses and mica-schists of the White Mountain belt, lying to the east of the Green mountains, were still newer rocks, and represented probably the horizon of the Oneida, Medina and Clinton of the New York series. Chas. T. Jackson moreover in his volume on the geology of New Hampshire, in 1846, while he declared that the White mountains constitute an axis of the

primary rocks, regarded the crystalline schists of the Green mountains as altered paleozoic strata, the metamorphosis of which he declared to have been effected by intrusive serpentines and intrusive quartzites.

As regards the geological horizon of the paleozoic sediments in question, we may note that Amos Eaton maintained the existence in the region in debate of two distinct series each consisting principally of argillites and sandstones, which he called the First and Second Graywackes, much resembling each other; the first of these being below the horizon of the Trenton limestone, and the second above it, or between this same and the Niagara limestone. The absence of such a Graywacke series in parts of New York below the Trenton led Mather to deny its existence, and to confound in one group the First and Second Graywackes along the Hudson valley, under the common name of the Hudson slates (called collectively by Vanuxem, the Hudson-River group); which were assumed to be the equivalent of the Loraine shales, with the addition of the Utica shale below and the Gray or Oneida sandstone above. Mather's view of the post-Trenton age of the whole of the Hudson River Graywacke and of its extension north and east through Vermont to the city of Quebec, was accepted by James Hall, by C. B. Adams, by W. B. Rogers, and for a time by Emmons himself; who, in his final report in 1842 on the geology of the Northern District of New York, describes the rocks at Quebec as Loraine shales with their overlying sandstones, which he speaks of as extending from the valley of the Hudson through eastern Vermont to the city of Quebec. In another chapter of the same volume, however, Emmons reverts to the teaching of Eaton, and in his subsequent writings includes these rocks in the First Graywacke—his Upper Taconic series. This view, however, was not accepted by other geologists. James Hall continued to maintain Mather's doctrine of the post-Trenton age of the Graywacke series in question. C. B. Adams, charged with a geological survey of Vermont, held in 1846 that the Red Sandrock of that state, "now included by Emmons in the First Graywacke or Upper Taconic, is of "the period of the Medina sandstone and the Clinton groups," while W. B. Rogers, in 1851, considered that limestones, which near Burlington, Vermont, are associated with this Red Sandrock are probably "of the Medina group."

When, then, in 1847, Logan began the examination of the belts of crystalline and uncrystalline rocks from the frontier of Vermont to the vicinity of the city of Quebec, he framed no new hypothesis, but adopted without question, the views of Mather, Hall, Adams and Rogers as to the post-Trenton age of the uncrystalline sediments. In like manner he accepted unhesitatingly Mather's hypothesis of their stratigraphical equivalence with these of the crystalline schists of the Green Mountain range, sustained as it was by the approval of the Messrs. Rogers and of C. T. Jackson. Logan, constitutionally diffident, and venturing in a new field, was disposed to defer to those whom he, like myself, his young assistant in the campaigns of 1847-49, had been taught to regard as authorities not to be questioned. Hence it was that the limestones and argillites of Pointe Levis were described as Hudson-River group, supposed to be younger than the Trenton limestone of Beaufort, while the great mass of 2000 feet of Sillery sandstone, apparently overlying these, was regarded as the equivalent of the Oneida or Shawangunk sandstone and conglomerate of New York; as may be seen in the little colored map in the *Equisse Géologique du Canada* published in Paris in 1855. The crystalline rocks adjacent to the south and east were in like manner designated as Altered Hudson-River group. The doctrine of regional metamorphism being then taken for granted, and at the time scarcely questioned, I sought for proof of it alike in the field and in the laboratory, and found in the composition of certain detrital beds near the crystalline schists, then regarded as beds of passage, evidence apparently confirming the metamorphic hypothesis.

In the views of his masters, then implicitly accepted, Logan made in his life-time only a single change, one forced upon him by the results of the paleontological studies of Billings, which showed that the so-called Hudson-River group at Pointe Levis was really, as Eaton and, in his later view, Emmons had maintained, not post-Trenton in age, but pre-Trenton, and belonged to the First Graywacke of Eaton. It is unnecessary to remind the reader that subsequent researches have shown the same to be true of the greater part of the sedimentary rocks in question from the valley of the St. Lawrence to that of the Hudson.

Logan's first acknowledgement of this conclusion was in a

letter to Barrande, dated in 1860 but published March 1861, to the effect that certain fossiliferous strata included in the Hudson-River group at Quebec had long been maintained by Emmons to be older than the Trenton, adding "The fossils which have been obtained this year [1860] at Quebec pretty clearly demonstrate that he is right." Instead, however, of calling these Upper Taconic with Emmons, or First Graywacke with Eaton, Logan proposed in his letter to Barrande the name of Quebec group, of which the apparently overlying Sillery sandstones constituted the summit, the great underlying mass of shales and limestone being called the Levis, and an intermediate division being subsequently proposed with the name of Lauzon. With the exception of this change in horizon of the group rendered inevitable by the progress of paleontological study, and the corresponding change in name, no alteration was made in the views of Logan, which were still those of Mather. The Hudson-River group of the latter was found to be pre-Trenton and was named Quebec group, and their crystalline schists were henceforth called Altered Quebec group instead of Altered Hudson-River group.

But the way was slowly preparing for the overturning of the whole hypothesis of Mather, and the establishment of the older view of Eaton and Emmons with regard to those crystalline schists, as well as to the uncrystalline sediments. My studies of the crystalline rocks of the Ottawa and the great lakes had shown close resemblances between certain of these rocks and the crystalline schists of the Green Mountain range as seen alike in New England and in Quebec, and I was led to consider carefully the teaching of Eaton and of Emmons, that this range is itself a primitive or pre-Cambrian axis more ancient than the uncrystalline sediments along its western and northern base. I had found and described in 1857 in conglomerates interstratified with the fossiliferous beds of the Hudson-River group at Pointe Levis fragments of purplish and greenish lustrous schists, apparently chloritic, and had moreover described in 1861 the presence of pebbles of green and bluish slates in conglomerates of the Potsdam age near the outlet of lake Champlain; in both cases evidently derived from rocks of greater antiquity, apparently the primitive schists of Eaton.¹

¹See History of Cambrian and Silurian in *Chemical and Geological Essays*, page 400.

In 1862 Thomas Macfarlane, who was familiar with the crystalline schists of Norway, which there underlie the Cambrian, compared them with those of the Green Mountain range and of the great lakes already noticed, and concluded that they are all essentially similar, lithologically. Bigsby, the earliest scientific observer of these rocks in the Northwest, moreover announced independently, in 1863, their apparent identity with the crystalline schists of Scandinavia. In the *Geology of Canada* 1863, I called attention (p. 705) to these resemblances, mentioning that the crystalline schists of the north shore of lake Superior "recall the strata of the [altered] Quebec group."

The whole question of their probable identity, and of the great antiquity of these crystalline schists of the Green Mountain range as evinced by the pebbles and fragments found at different localities in the uncrystalline lower paleozoic sediments was at that time repeatedly discussed with Logan, but, as I have elsewhere said, "official reasons then and for some years afterward prevented the writer from expressing any dissent from the views of the director of the geological survey of Canada." It was not until after having spent some months in 1869 and 1870, in geological studies along the southern coast of New Brunswick, and made examinations at various points on the coasts of Maine, Massachusetts and Rhode Island, that I ventured to declare in October 1870, in a communication to the Boston Society of Natural History, (Proceedings XIV, 45, 46,) entitled "Notes on the Geology of the vicinity of Boston," that the crystalline schists (previously described as altered Devonian), which near St. John, New Brunswick, underlie unconformably the Cambrian sediments, belong to the same series as those underlying such sediments near Boston; classing them moreover with similar crystalline rocks at Newport, Rhode Island, and on the coast of Maine. It was then said "to the same series I refer the great range of gneissic and dioritic rocks with serpentines, chloritic, talcose and epidotic schists which stretches through western New England," that is to say, the Green Mountain range. In a farther notice of this series of rocks in February, 1871, it was added, "they apparently belong * * * to the great Huronian system," (Amer. Journ. Science III., 1, 84). See also *Azoic Rocks*, being Report E., second geological survey of Pennsylvania, page 114. Having reached this point, the attention of Logan was once again invited, and

I proposed to serve as his guide to the more important localities, a proposition which he abruptly refused. Advancing years and failing health made him unfit to bear any questioning as to the correctness of the views which he had so long maintained as to the Green Mountain range, and the consequence as is known to many, was a severance of the intimate and friendly relations of half a life-time and my withdrawal in June, 1872, from the geological survey of Canada, after more than twenty-five years of service.

The above conclusions as to the Green Mountain rocks were reiterated and enforced at length in my address in August 1871, as retiring president of the American Association for the Advancement of Science, which the reader may consult in the published Transactions, and also in my volume of *Chemical and Geological Essays* under the title of "The Geology of the Appalachians." It is there said, "Although I have in common with most other American geologists maintained that the crystalline rocks of the Green mountains and the White Mountain series are altered palaeozoic sediments, I find on a careful examination of the evidence, no satisfactory proof of such an origin, but an array of facts which appear to me incompatible with the hitherto received view, and lead me to conclude that the whole of our crystalline schists in eastern North America are not only pre-Silurian but pre-Cambrian in age."

These conclusions were arrived at and published while I was yet an officer of the geological survey of Canada. They were, moreover, explained at length on many occasions to Selwyn, already in 1870 director of the survey, who was furnished with my various publications on the question in 1870, 1871, 1872, 1876 and 1878, and soon began to investigate the arguments urged by me against the metamorphic hypothesis maintained by Mather and by Logan, as to the crystalline rocks of the Green Mountain range. The result was that in 1878 I was able to write "The investigations of the geological survey of Canada during the years 1876 and 1877, have, according to the director of the survey, demonstrated the correctness of the view so long maintained by the writer, that the crystalline rocks of the Green Mountain series belong to a more ancient system, which underlies unconformably the uncrystalline Cambrian sediments of the Quebec group."²

²Azoic Rocks Rep. E., Second Geol. Survey of Penn., p. 198.

Moreover as appears from the official report of the First International Geological Congress, held at Paris in September 1878, after a communication by myself on the crystalline rocks of North America, Selwyn, who was present, made some remarks which were thus resumed. "As to the crystalline rocks, which form the Green Mountains in the province of Quebec, they are according to Sir. W. E. Logan, altered paleozoic strata, making part of the Quebec group. Mr. Selwyn however feels it his duty to say that the recent researches of the geological survey of Canada have confirmed the correctness of the view maintained for some years by Mr. Sterry Hunt. These crystalline rocks appear to belong to a more ancient terrane than the fossiliferous strata of the Quebec group and probably form the equivalent of the Huronian."³

C. H. Hitchcock who had for some years maintained a similar view, published in 1877 his final report on the geology of New Hampshire wherein he calls the Altered Quebec group of Logan Huronian and in the second volume moreover gives a map of New England and eastern Canada in which the areas of the Green Mountain series in Vermont and New Hampshire are described and represented as Huronian. To say as Mr. Walcott has done that "Selwyn in his report of 1877-78, [dated and published in 1879] began the work of disintegration" in the Quebec group, by showing the anticlinal structure and the unconformable infraposition of these crystalline rocks is so obviously contrary to all the facts of the case as to require no comment. Selwyn's recognition of these facts and his frank avowal before the International Geological Congress in 1878 was neither more nor less than a final surrender on the part of Logan's successor to the persistent attacks upon the famous hypothesis of Mather and Logan, begun by me in 1857 and 1861, and supported by Macfarlane on lithological grounds in 1862. The view finally formu-

³"Quant aux roches cristallines qui forment les Montagnes Vertes dans la province de Quebec elles seraient d'après Sir William Logan des couches paleozoïques altérées faisant partie de la groupe de Quebec. M. Selwyn croit devoir dire cependant que les recherches récentes de la Commission Géologique du Canada ont confirmé la justice de la vue soutenue depuis quelques années par M. Sterry Hunt. Ces roches cristallines semblent donc appartenir à un terrain plus ancien que les couches fossilifères du groupe de Québec et probablement forment l'équivalent du terrain huronien," Mr. Selwyn, having spoken in English the thanks of the president were given to Mr. Ch. Barrois who thus resumed them in French. (loc. cit. pp 233—234.)

lated by me in 1870 and 1871 was but a return, fortified by a great accumulation of stratigraphical and lithological evidence, to the old conclusion that the Green Mountain range represents an anticlinal axis of primitive schists, as shown by Amos Eaton in his engraved sections published in 1824, and again in 1832, and constantly maintained and taught by him and by Ebenezer Emmons.

Having thus disposed of the question of the age and structure of the Green Mountain range we come to the more particular history of the uncrystalline sediments, of the vicinity of Quebec, as seen in the sections of Sillery, the island of Orleans and Pointe Levis. Whether referred to the Second or later to the First Graywacke, whether called Hudson-River group or Quebec group, the apparent succession, as described by Logan in this typical region, was assumed to be the true one. The massive and apparently overlying sandstone of Sillery was declared to be the newest and the Levis division the oldest of this great series of strata. From many years of careful study of this vicinity, and of other out-crops of the same rocks elsewhere, I was however led to an opposite conclusion, which so far as I am aware was first set forth in 1872, when it was said: "If, as I am disposed to believe, the southeastward-dipping series of the older strata near Quebec exhibits the northwest side of an overturned and eroded anticlinal, in which the normal order of the strata is inverted, then the Lauzon and Sillery divisions which there appear to overlie the Levis limestones and shales are older rocks, occupying the position of the Potsdam, or of still lower members of the Cambrian." Billings in a private communication to me in 1876, a little while before his death, expressed his approval of my view, which was in accordance with his paleontological studies.

The same view was again set forth in a note on The Quebec group in Geology, read before the Boston Society of Natural History, October, 1876. (Proc. xix pp. 2-4.) Therein it was explained that the series of rocks to which Logan had given that name near the city of Quebec have a measured thickness of over 5000 feet and dip at a high angle to the southeast. "The whole was described by Logan as having originally occupied a position *conformably* beneath the Trenton limestone of the vicinity, and as having been brought to the surface by a great break and uplift of the strata. The speaker however showed

in 1871-1872, that this fault was imaginary, and that the Quebec group really occupies a position *unconformably* beneath the Trenton; moreover that the series near Quebec is inverted, being probably the northwest side of an overturned anticlinal, so that the Sillery is in fact the oldest member of the series and was followed by the Lauzon and the fossiliferous Levis limestone, to which succeeded the graptolitic shales, the newest portion of the Quebec group." He then referred again to the testimony of Billings as to the greater antiquity of the few organic forms (*Obolella* and *Lingula*) found in the Sillery. After discussing at some length, by the help of numerous sections and by comparisons, the relations of the Cambrian rocks of Great Britain and of Scandinavia to the so-called Quebec group, "it was urged that the name given by Logan to this group should be rejected as misleading, although that of Levis, as designating a horizon of fossiliferous strata of Tremadoc age, might be advantageously retained in American geology, care being taken to distinguish it from the Quebec graptolitic zone."

The faunal relations of this group of strata I have discussed more at length in Report E of the second geological survey of Pennsylvania, where it is said: (p. 112.) "The great continental belt of rocks originally designated Hudson River group, and subsequently called Upper Taconic and Quebec group, has already afforded us at least three distinct faunas: 1. That of the Red Sandrock or so-called Lower Potsdam; 2. that of the Levis limestone, and 3: that of the *Phyllograptus* shale of Quebec." Still another fauna is found in certain black slates at Farnham, Quebec, at first referred by Logan, from their apparent infraposition, to the Potsdam, being "at one time conceived to underlie the whole Levis or Orleans section, and were still placed near its base. From their fossils however, these slates belong to a horizon above that assigned to the Quebec group, and correspond to the Trenton or the still higher members of the Champlain division." [*loc. cit.*, pp., 116, 119.] Further south, in the Hudson valley, within the apparent limits of the so-called Hudson-River group, are other areas of similar strata of Ordovician age, carrying the fauna of the Loraine shales and thus affording a certain justification for the frequent use in times past of the name of Hudson River group as synonymous with Loraine shales. The area of Silurian rocks at Be-

craft's mountain, near the town of Hudson, and other related cases, must not be forgotten.

When geologists abandoning the hypothesis of Mather recognize the fact that in the area mapped by him and his disciples as belonging to the Hudson-River group, there exists a great development of more or less fossiliferous strata alike of Cambrian, of Ordovician and, more rarely, of Silurian age,—that the Cambrian strata are greatly disturbed so that their real succession has been frequently misunderstood—and moreover that they are overlaid, unconformably by Ordovician strata, which were affected by later movements, and in the local absence of the massive Trenton limestones are often confounded with the subjacent Cambrian, some of the confusion which now perplexes workers in that region will be removed.

The weighty testimony of James Hall in this connection in 1862 should not be lost sight of. Referring to the evidence of organic remains then recently found in the Hudson-River slates in Vermont and Canada he remarks that they “prove conclusively that these slates are to a great extent of older date than the Trenton limestone” adding that “the occurrence of well known forms of the second fauna—*Leptana sericea*, *Orthis testudinaria*, *Asaphus (Isotelus) Trinucleus*, etc.—in intimate relation with and apparently constituting a part of the series along the Hudson river, requires some explanation. Looking critically at the localities in the Hudson valley which yield these fossils we find them of limited and almost insignificant extent. Some of them are at the summits of elevations which are synclinal axes * * * * where the remains of newer formations would naturally occur. Others are apparently unconformable to the rocks below, or are entangled in folds of the strata, * * * * while the enormous thickness of beds exposed is almost destitute of fossils.” The graptolites of the Hudson valley “which have hitherto been referred to the age of the other fossils found in the small outliers, or to the second fauna, in reality hold a lower position and belong to the great mass of slates below.” Inasmuch then as the Hudson-River strata in their typical localities are, as a body, older than the Trenton limestone, which is itself older than the Loraine shales and the shales and sandstones of Pulaski “the term Hudson-River group can not be properly extended to these rocks, which on the *west side* of the Hudson are separated from the Hudson-River

group proper by a fault not yet fully ascertained."⁴ In subsequent examinations of the region by Logan and Hall conjointly a narrow belt of Loraine shales was traced along the *east side* of the Hudson to a point a little above Hyde Park where the boundary between the two formations crosses to the west bank, and the rocks of the older series thence occupy both sides of the Hudson down to the Highlands. (Azoic Rocks, pp. 120-121.)

In concluding the note of 1876, cited above, it was said "the author many years since pointed out that the fossiliferous Levis strata near Quebec hold in their conglomerates pebbles from the crystalline Huronian rocks which were described by Logan as altered Levis and Lauzon rocks. These crystalline schists were by Logan maintained to belong to this horizon because they are in some places overlaid by Sillery sandstone, but inasmuch as it now appears that the Sillery is really the lowest member of the Quebec group, it is clear that these crystalline schists must belong to a more ancient series."

It is to be noted that while the Second, or what we may call the Ordovician Graywacke, has for its lower member the Utica slate overlaid by the Loraine shale and terminated by the massive Oneida sandstone and conglomerate this order is reversed, in the First or Cambrian Graywacke, the Upper Taconic as defined by Emmons, a massive sandstone there forming the base of the series. For the rest, the general lithological resemblances between the two Graywacke series are such that as we have seen, Emmons from the apparent stratigraphy of the Quebec section was at first led to refer it to the Second Graywacke, a determination accepted without hesitation by Logan, who shared in the general mistrust and disfavor shown to the later conclusions of Emmons until convinced at the end of 1860 that the contention of the latter with regard to the Upper Taconic was true. Meanwhile, accepting the metamorphic hypothesis of Mather, which maintained the transformation of the Levis and Lauzon sedimentary strata into crystalline schists, the small amounts of oxyds of titanium, chrome and nickel, of magnesian silicate (and even the distinct portions of serpentine) found in certain beds of the Sillery divis-

⁴See *Geology of Wisconsin*, 1862, p. 443, cited in the author's report on *Azoic Rocks, E.*, Second Geological Survey of Pennsylvania, page 118.

ion were explained as due to the penetration of a mysterious process of metamorphism into the superior member of the sedimentary series, rather than to the accumulation of detrital matters from the older crystalline schists in the basal member of a new and unconformable group of uncrystalline sediments.⁵

Park Avenue Hotel, New York, March 1, 1890.

