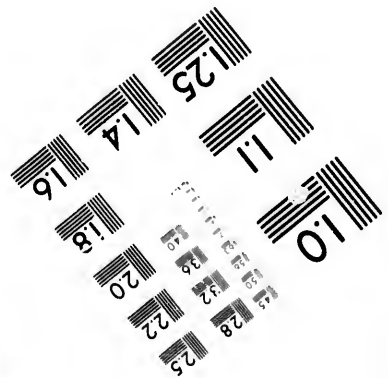
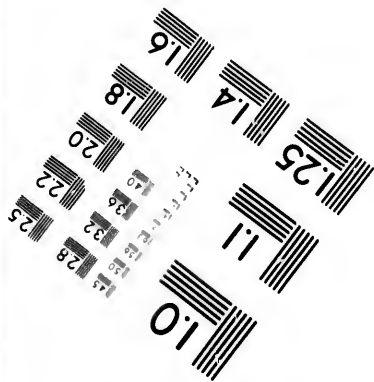
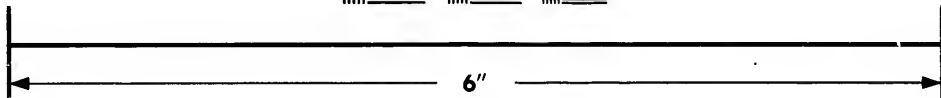
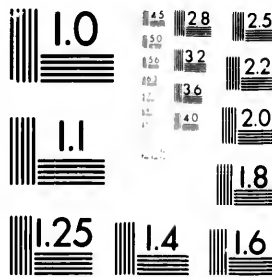


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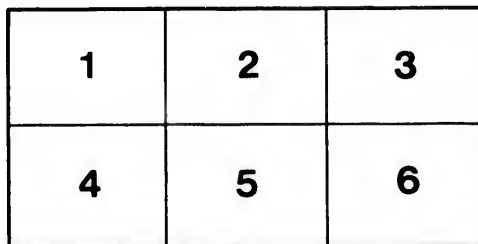
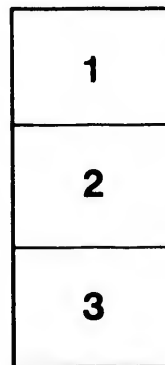
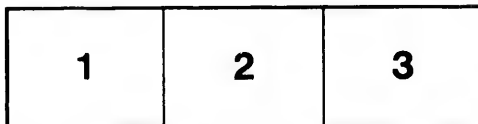
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THE QUEBEC GROUP OF SIR WILLIAM LOGAN.

By J. W. DAWSON, LL.D., F.R.S.

Being the Annual Address of the President of the Natural
History Society of Montreal, for 1879.

The scientific business of the Society in the past winter has included the reading at our monthly meetings of ten papers, comprising a considerable range of subjects. In Geology we have had papers by Dr. Harrington and myself on the mineralogy and mode of occurrence of Apatite; by Dr. Hunt on the various new points which engaged his attention in Europe in the summer of 1878; by Mr. Selwyn and Mr. Macfarlane on the disputed Stratigraphy of Eastern Canada; by Mr. Donald on the remains of a Fossil Elephant; by myself on the Extinct Floras of America. In other departments were Notes on Canadian Ferns by Mr. Goode; on an Esquimaux Bow and Arrow by Mr. Taylor; on the results of an Excursion to St. Jerome by Mr. Marler and Mr. Caulfield; on the Water supply of Montreal by Dr. Baker Edwards.

Of all these subjects that which has perhaps excited the greatest amount of attention, and which best deserves notice here, is the much disputed Geology of the Quebec Group and the associated rocks in the Province of Quebec. This is a subject which has long been in controversy, and which is mixed up with some of the most difficult questions in general geology and in the local structure of the eastern slope of the American continent, both in Canada and the United States. It is a subject on which I have up to the present time avoided any public expression of opinion:—not that I have been indifferent to it—no geologist could be so—nor that I have had no opinions of my own. Having travelled over and examined large portions of the territory occupied by these rocks, it was impossible to avoid arriving at some interpretation of them. But the subject was too intricate to be lightly treated, and others were working at it in detail, and with advantages of public aid which I did not possess. Now, however, it comes up before this Society, introduced in the elaborate and able paper of Mr. Selwyn, followed by the criticisms of Mr. Macfarlane; and these supplemented by Dr. Sterry Hunt's ex-

position of his own well-known views, in the discussion of Mr. Macfarlane's paper. Farther, in connection with all these various and somewhat discordant opinions, the conclusions arrived at by our late lamented colleague, Sir W. E. Logan, have been canvassed and to some extent set aside.

In these circumstances duty requires that some extended notice of this subject should be taken in this address; and that if no absolutely certain conclusions on all the points in dispute can be affirmed, the state of the controversy should be clearly explained to the bystanders, and the ground cleared for further wrestling on the part of the combatants, should this prove to be necessary. In attempting to perform this somewhat difficult task, it will be proper that I should refrain from entering into details, and that I should confine myself to the question as it relates to Canada, without discussing those features of it which belong to the regions farther south.

I would first say a few words as to the position of the late Sir William E. Logan in relation to the older rocks of Eastern Canada. When Sir William commenced the Geological Survey of Canada in 1842, these rocks, in so far as his field was concerned, were almost a terra incognita, and very scanty means existed for unravelling their complexities. The "Silurian System" of Murchison had been completed in 1838, and in the same year Sedgwick had published his classification of the Cambrian rocks. The earlier final reports of the New York Survey were being issued about the time when Logan commenced his work. The great works of Hall on the Palæontology of New York had not appeared, and scarcely anything was known as to the comparative palæontology and geology of Europe and America. Those who can look back on the crude and chaotic condition of our knowledge at that time, can alone appreciate the magnitude and difficulty of the task that lay before Sir William Logan. To make the matter worse, the most discordant views as to the relative ages of some of the formations in New York and New England which are continuous with those of Eastern Canada, had been maintained by the officers of the New York Survey.

Sir William made early acquaintance with some of these difficult formations. His first summer was spent on the coast of Gaspé and the Baie de Chaleur, where he saw four great formations, the Quebec group, the Upper Silurian, the Devonian, and the Lower Carboniferous, succeeding each other, obviously in

ascending order, and each characterized by some fossils, most of which, however, were at that time of very uncertain age. I remember his showing me in the autumn of that year the note-books in which he had carefully sketched the stratigraphical arrangements he had observed, and also the forms of characteristic fossils. But both wanted an interpreter. The plants of the Gaspé Devonian were undescribed; many of them of forms till then unheard of. The shells and corals and graptolites of the older formations could be only roughly correlated with some of those in the New York reports. The rock formations were very unlike those of the New York series. Still this work of 1842 and '43 was plain and easy compared with that which arose in the tracing of these formations to the south-west. I may add here that I have since studied some of these Gaspé sections with Sir William's manuscript note-books in my hand, and have been amazed by the extraordinary care and exactitude with which every feature of the rocks had been observed and noted down. Much of the detail in these early note-books of Sir William, still remains unpublished. Those who would detract from the work of Sir William Logan, if there are any such, should remember these early beginnings, and compare them with the massive foundations which have been laid for us to build upon.

And now, after the labour of more than thirty years on the part of Sir William and those he had gathered around him, how do these subjects stand? (1) We have all the comparatively flat and undisturbed formations of the great plains of Upper and Lower Canada, our share of the interior continental plateau of America, worked out and mapped, and their fossils characterized so that a child may read them. (2) The complex hilly districts with their contorted, disturbed and altered beds, which extend from New England to Gaspé, have been traversed in every direction,* the limits of their different formations marked, and a theory as to their age and structure put forth, which, whether we accept it or not, has in it important features of the truth, and rests on facts on which every disputant must take his stand. (3) We have the still older formations of the Laurentide hills traced in their

* The extent of measured and paced sections in these districts by Sir William and Mr. Richardson is almost incredible; and these have been made the basis not only of the geology but of the excellent topographical maps prepared by Mr. Barlow.

sinuous windings, and arranged in an order of succession which must stand whether the names given by Sir William, and now accepted throughout the world, be objected to or not. After the work of Sir William Logan, no cavilling as to names can ever deprive Canada of the glory of being the home of the scientific exploration of the Laurentian; and much examination of the ground which he explored enables me to affirm that no one will ever be able permanently to upset the general leading subdivisions which he established in the Laurentian and Huronian systems.

Let us turn now to the particular points brought before us in the papers to which reference has been made. It may be well however first to notice some general geological facts which must be present to our minds if we would enter intelligently into these discussions. The formations with which we have to deal in the more ancient geological periods all belong to the bed of the sea. Now in the sea bottom there have been in process of deposition, side by side and contemporaneously, four different kinds of material, differing extremely in their mineral character and in the changes of which they are susceptible. The first of these consists of earthy and fragmental matter washed by water from the surface or sea margins of the land and deposited in belts along coast-lines, or on broader areas where ocean currents have been drifting the detritus ground from the land by ice or washed down by great rivers. The second consists of organic remains of shells, corals and foraminifera, accumulated in coral reefs and the debris washed from them, in shell beds and in the chalky ooze of the deep ocean. Some beds of this kind are very widely distributed. The third is composed of material ejected by igneous action from the interior of the earth and either spread in the manner of lava-flows or of beds of fragments and fine volcanic ash. Such rocks naturally occur in the vicinity of volcanic orifices, which are often disposed in long lines along coasts or crossing ocean basins, but fragmental volcanic matter is often very widely spread by ocean currents and is interstratified with other kinds of aqueous deposit. The fourth and last description of bedded matter is that which is deposited in a crystalline form from solution in water. In later geological times at least, such deposits take place in exceptional circumstances, not of frequent occurrence. Such beds are dolomite, greensand, gypsum, and rock salt.

Now it may be affirmed that at each and every period of the earth's geological history, all or most of these kinds of deposit were in progress locally. But it may also be affirmed that in certain geological periods there was a predominance of one or more over very great areas; and that in any particular area, even of considerable size, there may be definite alternations of these different kinds of material characteristic of particular periods.

Again, along certain lines of the earth's crust, the beds deposited by water have been folded and crushed together, probably by the contraction of the earth's shell in cooling, and along these lines they have been changed, in the way of hardening and becoming crystalline or in being chemically recomposed—alterations which are usually known as metamorphic. But still further, some kinds of deposit are much more liable to such metamorphic changes than others. More especially the beds of igneous origin, from their containing abundance of basic matter, as well as of silica, very readily change under the influence either of heat or water, becoming it may be highly crystalline, or having new mineral substances formed in them by new combinations, or on the other hand, when acted on by water, combining with it and forming hydrous silicates.

One other curious coincidence it is necessary to mention.—It is where the greatest deposits of sediments are going on along coasts or in the course of currents, that crumpling and bending of the crust are most likely to occur, and igneous ejections to be thrown out; and conversely, where igneous ejections are piled up, coasts may be forming or currents deflected, so as to cause at these points the greatest deposit of sediment.

These considerations are sufficient to shew the true value of mineral character, first as a means of distinguishing rocks of different nature and origin, and secondly of separating rocks of different ages within limited localities; with its entire worthlessness when applied to distinguish the ages of beds in widely separated localities. There are in America rocks as widely apart in time as the Huronian of the East and the Carboniferous of the West, which are scarcely distinguishable in mineral character; there are rocks of identical age, as for instance the Lower Silurian of New York and Western Canada and that of Nova Scotia and of Cumberland, which are as unlike in mineral character as it is possible for rocks of the most diverse ages to be.

But can we trust implicitly to stratigraphy? Certainly, when

we find one rock directly superimposed on another we know that it is the newer of the two. But when we find old rocks slid over new ones by reversed faults, when we find sharp folds overturning great masses of beds, and when we find portions of beds hardened, altered, and become more resisting, standing up as hills in the midst of the softer materials, perhaps of the same age, which have been swept away from around them, then we have the real difficulties of stratigraphy.

We may have difficulties in fossils as well. Nothing is more common than to find in the modern ocean areas traversed by cold currents which have very different animals living in them from those in the same latitude where the water is warmer. The same thing occurs in older formations. The abundant corals and large shell-fishes in our Montreal limestone of the Trenton age, show a condition of things in which the great area of Central North America was covered with warm waters from the south, teeming with life, and was sheltered from the northern currents of cold and muddy water. But in the Utica shale which succeeds, we have the effect of these cold currents flowing over the same area, loading it with mud, over which lived Graptolites and old-fashioned northern Trilobites like *Triarthrus Beckii*, instead of the rich life of the Trenton. This is a mere change to a cold or glacial age.

Now when I inform you that all these causes of error embarrass the study of the Quebec group of Sir William Logan, you will be able to appreciate the difficulties of the case. Crossing the narrow line, a mere crack of the earth's crust, the great reversed fault of Eastern Canada and Lake Champlain, we pass at once from the flat uniform deposits of the great continental plateau of America to entirely different beds, formed at the same time along its Atlantic margin. These beds were affected by volcanic ejections mixing them with ash rocks and causing huge earthquake waves, which tore up the rocks of the sea-bottoms and coasts, and formed great irregular beds of conglomerate, sometimes with boulders many feet in length. In the intervals of these eruptions the area was overflowed by cold Arctic currents carrying sand and mud, sometimes altogether barren of fossils, or again loaded with cold-water creatures like the Graptolites, which occur in vast quantities in some of the beds. Alternating with all this were a few rare lucid intervals, when fossiliferous limestones, just sufficiently like those of the

great interior plateau to enable us to guess their similar age, were being produced here and there. Farther, this heap of most irregular and peculiar deposits was that along which subsequent flexures and igneous eruptions and alterations of beds both by heat and heated waters were most rife, all the way down to the Devonian period.

At first the real conditions of this problem were hidden from Sir William Logan, by the error of supposing, with most of the geologists of the United States, that the great reversed fault was a true stratigraphical superposition, and consequently that these strange deposits were newer than those to the west of them. But so soon as the actual nature of the case was made manifest, and this was first due to a right apprehension of the fossils, for which Mr. Billings deserves much of the credit, Sir William at once and for ever apprehended the real conditions of the problem, and set himself to work it out on the true line of investigation.

In evidence of this, and as presenting as clear a view of the whole matter as any we can give, up to the present time, I quote from a note by Sir William appended to Mr. Murray's report on Newfoundland for 1865, and which is less known than his utterances on this subject published in the Canadian reports:

“The sediments which in the first part of the Silurian period were deposited in the ocean surrounding the Laurentian and Huronian nucleus of the present American continent, appear to have differed considerably in different areas. Oscillations in this ancient land permitted to be spread over its surface, when at times submerged, that series of apparently conformable deposits which constitute the New York system, ranging from the Potsdam to the Hudson River formation. But between the Potsdam and Chazy periods, a sudden continental elevation, and subsequent gradual subsidence, allowed the accumulation of a great series of intermediate deposits, which are displayed in the Green Mountains, on one side of the ancient nucleus, and in the metalliferous rocks of Lake Superior, on the other, but which are necessarily absent in the intermediate region of New York and central Canada.

“At an early date in the Silurian period, a great dislocation commenced along the south-eastern line of the ancient gneissic continent, which gave rise to the division that now forms the western and eastern basins. The western basin includes those strata which extended over the surface of the submerged conti-

neut, together with the Pre-chazy rocks of Lake Superior, while the Lower Silurian rocks of the eastern basin present only the Pre-chazy formations, unconformably overlaid, in parts, by Upper Silurian and Devonian rocks. The group between the Potsdam and Chazy, in the eastern basin, has been separated into three divisions, but these subdivisions have not yet been defined in the western basin. In the western basin the measures are comparatively flat and undisturbed; while in the eastern they are thrown into innumerable undulations, a vast majority of which present anticlinal forms overturned on the north-western side. The general sinuous north-east and south-west axis of these undulations is parallel with the great dislocation of the St. Lawrence, and the undulations themselves are a part of those belonging to the Appalachian chain of mountains. It is in the western basin that we must look for the more regular succession of the Silurian rocks, from the time of the Chazy, and in the eastern, including Newfoundland, for that of those anterior to it."

In studying these rocks, as Sir William well knew that the great line of disturbance and igneous action lay to the east, as he further knew that in this belt of country rocks all the way up even to the Carboniferous had been profoundly altered, he was not surprised to find that in tracing the Quebec rocks to the south and east, the clay slates, still holding the same fossils, became micaceous or naereous slates, the bituminous shales graphitic slates, the limestones crystalline marble; and that even serpentine, chloritic slate and hard felspathic rocks appeared to take the place of ordinary aqueous sediments. Consequently he arrived at the large generalizations on the subject embodied in his map of Canada, and to which I believe he adhered to the last.

Was he right in these generalizations? In part, at least, it is certain that he was. I have myself, following in his track, seen distinct Lower Silurian fossils in the naereous slates and graphitic slates of the Townships, and I have seen these slates alternating with hard quartzites, and felspathic and brecciated rocks, and so far as could be made out by stratigraphy, with chloritic rocks, crystalline dolomite, soapstones and serpentine, these rocks seemingly representing the shales of Point Levis if not still newer members of the series. Dana has recently shown that rocks in Connecticut, usually referred to the Quebec group, or even to the Lower Taconic series of Emmons, and often in a highly

crystalline state, actually contain fossils newer than those of the Quebec group, or of Hudson River age.* Murray in Newfoundland has found the most unequivocal superposition of serpentine and chloritic slate on fossiliferous rocks of the Quebec group, and intervening in age between them and the Hudson River group, a point to which we must refer subsequently; and there is nothing incredible or even very unlikely in this. On the other hand, knowing the complexities of all the parts of this troubled sea of eastern palaeozoic rocks which I have studied, I cannot deny that there may exist crests of beds older than the Quebec group projecting locally and perhaps largely through these rocks. I am the more inclined to believe this, since there is the best reason to hold that the unaltered members of the Quebec group, as mapped by the Survey on the south shore of the St. Lawrence, include beds ranging all the way from the Lower Cambrian up to the Chazy. Similar, perhaps older, beds, no doubt exist largely, mixed with igneous outflows and breccias, in the hills of the interior.

But if any man thinks proper to put down a hard and fast line on the map of Eastern Canada, and to maintain that all the crystalline rocks which apparently project through and rise above the Quebec group, are of greater age, I must decline to go with him in this assertion, since I feel certain that such an extreme view cannot be in accordance with facts. No one, however, I feel persuaded, will now go so far as this; but I believe the pendulum has already swung farther than it should in this direction, and must go back again nearer to Sir William Logan's position. Facts in support of this conclusion rise before my mind as I write, and may be brought forward on some future occasion, but they would involve a series of papers for their full elucidation.

We have had presented to us ably and well by Mr. Selwyn, Mr. Macfarlane, and Dr. Hunt, conclusions differing more or less widely from those of Sir William, and from each other. There are no doubt important elements of truth in them all, but when these are fully and fairly sifted, the unprejudiced geologist will conclude that while they may modify the results of Sir William's work, they by no means overthrow them; and that we are still a long way from the solution in all their details of the problems

* American Journal of Science, May, 1879. One of the fossils recognized by Dana seems to be the *Stromatopora compacta* of Billings, really a *Stenopora*, known in Canada both below and above the Levis,

which occupied Sir William to the last, and which he left only partially solved.

We may now sum this matter up, in so far as Sir William Logan's work is concerned, and that of Richardson as his assistant, and of Hall and Billings in the department of Palæontology. Their researches have established :—(1) The general diversity of mineral character in the Palæozoic sediments on the Atlantic slope as compared with the internal plateau of Canada. In those results Bailey, Matthew, and Hartt in New Brunswick, and the writer in Nova Scotia, have also borne some part. (2) The establishment of the Quebec group of rocks as a series equivalent in age to the Calciferous of America, and to the Arenig and Skiddaw of England, and the elucidation of its peculiar fauna. (3) The tracing out and definition of the peculiar faulted junction of the coastal series with that of the interior plateau, extending from Quebec to Lake Champlain. (4) The definition in connection with the rocks of the Quebec group, by fossils and stratigraphy, of formations extending in age from the Potsdam sandstone to the Upper Silurian, as in contact with this group, in various relations, along its range from the American frontier to Gaspé; but the complexities in connection with these various points of contact and the doubts attending the ages of the several formations have never yet been fully solved in their details. (5) The identification of the members of the Quebec group and associated formations with their geological equivalents in districts where these had assumed different mineral condition, either from the association of contemporaneous igneous beds and masses, or from subsequent alteration or both. It is with reference to the results under this head, the most difficult of all, that the greater part of the objections to Sir William's views have arisen.

Let us now shortly examine Mr. Selwyn's new results, with reference to these conclusions, especially to the last.

The first point deserving of notice here is the inability of Mr. Selwyn to recognize in the extension of the Quebec group eastward and westward of Quebec, those subdivisions which have been named the Levis, Lauzon, and Sillery. Originally Sir William recognized two divisions only, the Levis and Sillery. Subsequently he introduced, on the ground merely of convenience, the intermediate Lauzon; though apparently not regarding the three-fold division as at all important, but merely as provisional*

* Report of 1866, p. 4.

Of those subdivisions the most important is the Levis, which forms the fossiliferous and most readily recognized horizon of the Quebec group. About the precise base of this division, held to be the lowest of the group, there is some uncertainty, Sir William has referred to it as resting on Potsdam rocks in the vicinity of Lake Champlain, and farther east on older shales and limestones; and Mr. Richardson has endeavoured to separate from it certain sandstones and associated beds on the Lower St. Lawrence. More especially I may refer to the sandstones and shales near Metis, holding *Astropolithon*, *Scolithus*, and *Arenicolites spiralis*, and to beds near Matane holding species of *Conocopholites* of very primitive type. In Newfoundland also, where the sequence of these beds is better seen than elsewhere, there are, according to Richardson and Billings, 2000 feet of beds under the typical Levis and over the Lower Calciferous, holding fossils unquestionably of the second fauna of Barrande, or Lower Silurian, and below them there is a great thickness of Calciferous and Potsdam. All these beds must exist in the Quebec group districts of Canada, folded up along with the Levis, and as yet very imperfectly separated from it, nor is it at all unlikely that in some localities they may have been confounded with the Lauzon and Sillery.

With regard to the distinction of these last-named formations as upper members of the Quebec group, we must agree with Mr. Selwyn that in the present state of our knowledge they cannot be clearly separated from the Levis or from one another. Nevertheless it is true that on the typical Levis there rest sandstones and shales of considerable thickness, not holding its characteristic fossils, and forming an upper member of the Quebec group, as yet not well defined, but representing in nature the Lauzon and Sillery of Logan.

In the next place, Mr. Selwyn is disposed to separate from the Quebec group the greater part of those altered and crystalline rocks associated with it, and which appeared to Sir William Logan to be metamorphosed equivalents of this group, and largely of its upper or Sillery division. Of these rocks he forms two series, which however he regards as closely associated, and probably not unconformable with each other.

The first and nearest in age to the Quebec group is defined as including "felspathic, chloritic, epidotic and quartzose sandstones, red, gray and greenish siliceous slates and argillites," with

“breccias and agglomerates, diorites, dolerites, and amygdaloids,” as well as serpentine, dolomite, and calcite. In short this formation is one of mixed igneous and aqueous origin, non-fossiliferous, except in the case of a few microscopic fragments, and mostly crystalline. As regarded by Sir W. E. Logan, these rocks, in consequence of their apparent conformity with the Levis series, and their apparent superposition in some sections, were held to be an upper member of the Quebec group, and were mapped as Sillery. They were thus placed in the same position with the serpentine and chloritic formation of Newfoundland, as described by Murray, with the Cobequid series as I have described it in Nova Scotia,* and with the Borrowdale igneous rocks resting on the English equivalents of the Levis beds as defined by Ward in Cumberland.

Mr. Selwyn, on the other hand, thinks that the main mass of these peculiar rocks either comes out unconformably from beneath the Levis series or is separated from it by a fault, and is in all probability older, though the obscure traces of fossils found in some of the beds would indicate that they are not older in any case than Lower Silurian or Upper Cambrian.

It is obvious that with reference to a formation so greatly disturbed, either of these theoretical views may be correct, or that there may be two crystalline series, one below and another above the Levis beds. Where I have had opportunity to observe the formation, at Melbourne, and in a few other places, I have seen no reason to dissent from Sir W. E. Logan's view; but at that time Mr. Selwyn's explanation was not before my mind, nor have I examined the sections on which he chiefly relies.

Had Sir W. E. Logan lived, it was his intention to have, at his own cost, bored through the crystalline rocks at some selected site, in order to obtain positive proof of the subterposition of the Levis beds. This expense is not now likely to be incurred, but the whole question will in course of time be settled by the careful re-examination and mapping, which now that these new views have been suggested by the head of the Geological Survey, the district is likely to receive.

Mr. Selwyn's third division, supposed to be still older, possibly Lower Cambrian, in some respects resembles the second, but is predominantly slaty and quartzose, though still with dolomites

* Acadian Geology, third edition.

and other magnesian rocks. These would naturally fall into the place assigned to them, if the age attributed to the second series be admitted, otherwise they come into the period of the Silery, or some newer formation, in an altered condition. I do not know that fossils have been found in these rocks, within the limits of Canada at least, but if they are really of Cambrian age, the richness of this fauna elsewhere in N. E. America would warrant the hope that the age assigned to them may be indicated by fossils, while, if like some similar beds to the southward, they hold Silurian species, these also must in some places be recognizable; so that if they finally fail to afford fossil remains or yield Lower Cambrian species, this, with their mineral character and apparent distribution, would sustain Mr. Selwyn's view; while, on the other hand, the discovery of a few distinctive Silurian forms might suffice to overturn it.

It would appear that the third and second series of Mr. Selwyn, above mentioned, are the same with the rocks which in Hitchcock's map of New Hampshire are named Montalban and Huronian. The former term has however been applied by Dr. Hunt to a series newer than the Huronian, and possibly of Lower Cambrian age, so that if it is correctly used by Hitchcock, his so-called Huronian may be in reality Upper Cambrian or Lower Silurian. It is to be deprecated as not conducive to correct conclusions, that terms of this kind should be used to represent merely mineral resemblances, irrespective of those evidences of geological age derived from stratigraphy and fossils. It is due here to Dr. Hunt to explain that he has for many years on independent grounds regarded the beds of Mr. Selwyn's second and third groups as, for the most part at least, Huronian in age, and a similar conclusion was also arrived at from comparison with the older formations of Scandinavia, by Mr. Macfarlane. Thus in one way or another all these gentlemen dissent from Sir William's conclusions, while also differing from each other, a sufficient evidence of the complicated character of the problem with which he had to deal, and whose ultimate solution may embrace elements of all the generalizations which have been put forth.

Some suggestions may at least be offered toward the solution of these questions which deserve the attention of those who have been occupied with them. The first is that we should accustom ourselves to the anticipation that contemporaneous palaeozoic

rocks in the regions of the western lakes, of the plains of Ontario and Quebec, and of the eastern slope, are not likely to be identical in mineral character. Farther, that even in the central of these three regions we may expect differences in approaching certain parts of the older rocks. At Murray Bay, for example, on the border of the Laurentian, we find the Black River limestones in great part represented by coarse sandstones, and we find similar changes in the Chazy near Grenville. A third suggestion is, that in order to understand the eastern members of the Lower Silurian, it is necessary to be acquainted with the contemporaneous igneous ejections mixed with these rocks, and if possible to distinguish them from those of similar character so largely present in the Huronian. This I have attempted, though with only partial success, to effect for the Acadian Provinces. Another, to which Dr. Hunt has directed attention in his recent report in connection with the Survey of Pennsylvania, is the importance of inquiry as to which of the many successive movements and plications of the earth's crust occurring in palæozoic time, have most seriously affected the now so greatly plicated and disturbed rocks of the Quebec group. Still another, and one of the most important, is the study of the various kinds of alteration which these rocks have undergone. We have in eastern Canada rocks as young as the Devonian which have been sensibly affected in this way, and there can be no doubt that large areas of the Quebec group have suffered similar changes, and that on the one hand it is possible that these metamorphosed portions have been confounded with older series, or that on the other these older series have been inadvertently mixed with them.

The value to be attached to fossils is another point of much importance. Long experience has convinced me that in the Cambrian and Silurian ages this kind of evidence is the most conclusive of all; but then it must be rightly understood. As already observed, we must discriminate the animals characteristic of the cold Atlantic waters loaded with Arctic sediment, from those of the sheltered continental plateau. We must also bear in mind that oceanic and probably floating forms of low grade, like the Graptolites, have an enormous range in time, as compared, for example, with the Trilobites, and the same remark applies to some mollusks proper to sandy or muddy bottoms, like the Lingulæ and their allies, as compared with other nausca.

All these precautions must be taken in the study of these

rocks, and it involves no depreciation of the geologists above-mentioned, to say that the different conclusions at which they have arrived, depend very much on the different degrees of importance which they have attached to the various kinds of evidence accessible.

One word, before closing, respecting names. These are of little importance in themselves, but it is of consequence that they should not be needlessly changed, and that they should not be misapplied.

The name "Quebec Group," introduced by Sir William Logan, should be retained for that peculiar development of the rocks of the second fauna, eminently exposed and accessible in the vicinity of Quebec, to whatever extent its extensions east and west may be circumscribed; and whatever value may be attached to the local subdivisions into Levis, Lauzon and Sillery. On the one hand, the use of one of these terms, Levis, for the whole, leads to misconception; and the absurdity of the term "Canadian" (applied in one widely-known text book to the rocks of this age) becomes apparent when we see it made correlative with a purely local name like "Trenton," and when we consider that Canada is a region greater than the United States of America, and with equally varied geological structure.

The more recent developments in the geology of North America require, as Dr. Hunt and Mr. Selwyn have urged, that the Cambrian system should be recognized as a group altogether distinct from the Silurian; and whatever views as to the use of these names may ultimately prevail in England, for us the dividing line between the Cambrian and the Siluro-Cambrian or Lower Silurian, unquestionably comes about the horizon of the Potsdam. As to the formations older than the Cambrian, I am disposed to regard the Montalban and Taconian of Dr. Hunt as representing definite groups of rocks, which may however eventually prove to belong to the base of the Cambrian, with which equivalent strata in the Maritime Provinces of Canada seem to be associated. The Huronian series of Logan represents another great fact in the geology of North America, namely a period of immense igneous ejection and disturbance intervening between the Laurentian and the Cambrian. In the typical Huronian area of Lake Huron it unquestionably rests unconformably on the Laurentian, and is itself overlaid by rocks of Cambrian or still greater age. It has precisely the same mineral characters

and position as far east as New Brunswick and Newfoundland, and as far west as the Pacific slope,* and is thus one of the most widely diffused of American formations, though I believe it has locally been confounded with rocks of similar mineral character but of newer date. The upper Laurentian of Logan, the Norian of Hunt, is entirely different in mineral character from the Huronian, and stratigraphically is related to the Middle Laurentian rather than to the Huronian, notwithstanding local unconformity. The Lower Laurentian of Logan may now, since the explorations of Vennor, † be safely divided into a lower and middle group, the former being however nothing more than the great gneissic formation recognized by Logan as the Trembling Mountain gneiss, which forms the base of his well-known Laurentian section, and the Bojian gneiss of European observers. The idea that the Middle Laurentian, the horizon of Eozoon Canadense and of the great Phosphate and Graphite deposits, is identical with the Hastings group, or with the Huronian, has, I am fully convinced, after some study of the Lake Huron, Madoc and St. John exposures of these formations, no foundation in fact. There seems, however, good reason to believe that the gap between the Lower Laurentian of Lake Huron and the Huronian, is to be filled not merely by the Middle Laurentian and the Norian, but by such rocks as those described by Dr. Bigsby, Prof. Bell and Dr. G. M. Dawson on the Lake of the Woods and other regions west and north of Lake Superior, and at present included in the Huronian, to the base of which many of them no doubt belong. ‡

I should not have occupied your time so long with these matters, but for their great importance geologically, and the able papers in which they have been brought under our notice, and for the circumstance that I have been renewing my studies of these rocks, in the hope of contributing some notes on Sir William Logan's share in their investigation, to a biographical sketch of that eminent geologist now in progress under the care of our associate, Dr. Harrington, to whom it has been committed by Sir William's executors.

* Clarence King's Report of the 40th Parallel. The rugged features and precipitous sides of the Laurentian and Huronian exposures in this region correspond with Logan's view of the steep slope of the Laurentian and at the time of the deposition of the Quebec Group rocks.

† Report Geological Survey of Canada.

‡ G. M. Dawson's Report on 49th Parallel; Bell, Reports Geological Survey of Canada.

