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Canadian & Scottish Geology An Address delivered before the Edinburgh Geological Society at the Close of the Session 1883-4.

by

Sir William Dawson.

Canadian and Scottish Geology. An Address delivered before the Edinburgh Geological Society at the close of the Session of 1883-4. By Principal Sir Wm. Dawson, C.M.G., LL.D., F.R.S., &c., Principal and Vice-Chancellor of M'Gill College, Montreal, *Honorary Fellow of the Society.*

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Scientific work in all parts of the world is at present linked together by the intercommunication of those engaged in it; and in my present visit to Great Britain, and intercourse with my fellow geologists, such points as those to which I desire this evening to direct your attention are inevitably suggested. I do not propose, however, to attempt the impossible task of entering into a detailed comparison of Scottish and Canadian geology, but merely to glance at such of the more salient points as have come more immediately under my notice, and which will naturally be those more especially which are connected with investigations in which I have myself been engaged.

Before entering into these subjects, I may be allowed to remark that much of what has been done in Canadian geology has been the work of Scotsmen and their descendants. In this connection, I may mention the leading pioneer in the geology of Canada, Sir William E. Logan, a Scotsman by parentage and early education; and since archæology is now united with geology, Dr. Daniel Wilson of Toronto, who in that department has so few equals and no superior. You may truly say, however, that this applies not to Canada only, but to the other dependencies of the Empire, and to England itself, since Scotland can claim the great formative minds of English geology—Lyell and Murchison, as well as the now venerable Ramsay, and the present Director-General of the Geological Survey. This may depend in part on the natural peculiarities of Scotsmen, but very much also, I think, on the early prominence given to scientific studies in your universities. My own experience enables me to appreciate this. Though by birth a Nova Scotian, my parents belonged to old Scotland; and when, more than forty years ago, after completing my academical education, I looked around for a school of natural science, where I could attain the practical training necessary for a field geologist, I was attracted to this city by the reputation of the eminent men then filling the scientific chairs in your university; and to the two sessions which I spent here in scientific study, I owe much of what I have been able to do in original work, and in the promotion of scientific education in Canada.

But to turn from personal matters to geology itself, we are struck, in the first place, with the space occupied alike in the map of Canada and that of Scotland with those oldest of all formations, which Murchison called Azoic, and which we have now, I think, a right to term Eozoic. In both countries they attracted attention about the same time ; and Murchison, bending to the influence of the larger and more complete development of the Canadian series, and recognising the admirable work done by the Canadian Geological Survey, adopted, for Britain as well as for Canada, Logan's name, Laurentian, now universally employed to designate those oldest members of the great Eozoic group.

In both countries the great age of these ancient crystalline rocks is rendered indisputable by their coming out unconformably from beneath Cambrian and pre-Cambrian sediments. When, in connection with this, we find a precise similarity of mineral character in the oldest rocks of both continents, from Labrador to Brazil, and from Norway to Tropical Africa, and this mineral character indicating the deposit in the sea-bottom of silicates undecomposed by atmospheric action—destitute, therefore, of evidences of the existence of dry land, and apparently of aqueo-igneous rather than of aqueous origin—we may infer that in the oldest Laurentian we have the actual foundation rock of the geological series, and that your early Scottish geologists were not mistaken in calling it the fundamental granite, or fundamental gneiss.

Allow me to say here that I think you have, in your Western Islands and Western Coasts, two very distinct members of this ancient system, which may in future call for a more marked separation in our classifications than that at present accorded to them. You have, first, that ancient gneissic deposit, destitute of limestones, quartzite, or proper schists, which constitutes the lowest or basal Laurentian, the "Trembling Mountain Series" of Sir William Logan, and which, more recently, Canadian geologists have termed the "Ottawa Gneiss." Resting on this, you have the second member of the Laurentian, which Hunt has named the "Grenville Series," and in which limestones, quartzites, and schists abound, with deposits of apatite, as well as the earliest indications of life in beds of carbon in the form of graphite, and in the forms now known as *Eozoon Canadense*.

I shall not enter here on the discussion of the nature of the evidence of life in the Laurentian, but may remark that the organic nature of *Eozoon* is now pretty generally accepted by those who are best qualified to judge,—I mean by the naturalists and geologists who, with some knowledge of the structures of the tests of marine Protozoa, unite an acquaintance with the modes of preservation of the more ancient fossils and with the

chemical conditions under which hydrous silicates are formed in the sea bottom. My friend Dr. Carpenter, of London, has now in preparation a monograph on the subject, which, I hope, will set at rest the question as to the substantial resemblance of the structures of *Eozoon* to those of the modern Foraminifera. I have not yet seen any distinctly marked *Eozoon* from Scottish rocks. Certain forms recently discovered by Professor Heddle certainly show some resemblance to it; but the examination of slices in the possession of Dr. Carpenter has led me to doubt its affinity with the Canadian fossil. I have, however, recently obtained specimens from Professor Heddle and Dr. Nicholson, which I shall hope more fully to examine and compare when I return to Canada.

When we enter on the formations next above the Laurentian in Scotland, we also enter a battlefield, in which the strife of hammers and of tongues has long raged, and into which I scarcely feel that it would be safe to enter as a combatant, or proper to enter as an umpire, when so many eminent men have taken ground on opposite sides.[1] I prefer the humbler and safer task of making a few comparisons of fact. I may say, first, that those red and purple sandstones and conglomerates of your West Coast which rest upon the Laurentian, have a marked resemblance to a formation occupying a similar position in Newfoundland and Lake Superior, and which has been called Upper Huronian by Murray, and Kewenian by Hunt, but which I think is generally regarded among us as a probable equivalent of the lowest Cambrian. It is further evident that in the Lower Silurian limestones and hard sandstones which rest on these Cambrian beds, you have both lithologically and in fossils, equivalents of our Potsdam and Calciferous,[2] which represent with us the top of the Cambrian and base of the Silurian. But when some of your geologists inform us that these beds are again overlain by gneiss, mica schist, and chlorite schist, while others affirm that these are older beds obtruded from below, we find ourselves placed in a difficulty, which is not mitigated by the fact that in Eastern Canada and New England, where the Silurian rocks are folded and altered in a way not very unlike that of the Highlands, we have ourselves a similar uncertainty. With us the fact is, that while there are clay slates, mica schists, and hydro-mica schists which contain fossils of Silurian age, there are associated with them other crystalline

[1] Since this address was delivered, the main questions at issue respecting the older rocks of the Highlands have been virtually decided by the recent change of view announced (Nov. 1884) by the Director-General of the Geological Survey.—J. W. D.

[2] It seems unfortunate that the term Calciferous has been adopted in Scotland as a name for a member of the Lower Carboniferous.

rocks which contain no fossils, and which are so involved in flexures, overturns, and faults, that it has been difficult on stratigraphical grounds to arrive at any agreement respecting their precise age. In these circumstances resort has been had to mineral character, and on this ground large portions of these rocks have been relegated to the pre-Cambrian.

On this subject I may remark—(1.) That nothing is more likely than that older crystalline rocks may have been protruded through the Silurian beds, and now lie beside or over them. (2.) That by no probable process of metamorphism can true crystalline silicated rocks, having a base of felspar, be produced from ordinary sedimentary deposits. (3.) That, on the other hand, there is good evidence that ordinary mica schists and even imperfectly gneissose beds may result from the alteration of Cambrian and Silurian sediments. (4.) That American analogies would indicate that a great thickness of gneissose and schistose beds of different mineral compositions, as well as of quartzites, conglomerates, and limestones, may be expected to occur above the Laurentian and below the Cambrian. (5.) The best solution of the difficulty is to be found in the discovery of fossils in the disputed beds. Where these are discovered, it may appear that some rocks which may easily be mistaken for pre-Cambrian beds are really Silurian, and that, on the other hand, there are more ancient crystalline rocks implicated in the folds of the Silurian. (6.) In some parts of the American Silurian the deposits are complicated by contemporaneous volcanic action, and wherever this has occurred, a very distinct lithological character has been given to the formations, which might cause them when altered to be mistaken for much older beds. (7.) The undisputed Lower Silurian rocks of Scotland (the Ordovician of Lapworth), both in the northern and southern areas, resemble those of the Quebec group and those of Nova Scotia, rather than those of the great internal plains of North America. They are, in short, a part of the Atlantic margin of Silurian Europe, rather than a portion of the submerged continental plateau.

These considerations may appear to go but a very little way toward the settlement of the questions involved, but they are such as occur when these are contemplated from the Canadian point of view.

If we turn now to the Devonian, which the work of Hugh Miller has rendered classic and national, under its aspect of Old Red Sandstone, and in which so much has recently been done by Geikie and others, you have here again a formation corresponding to a marginal area, rather than to a continental. You have nothing to represent our great oceanic coral limestones, or even the rich marine limestones of the Eifel and the south coast of

England, but only sandstones, flags, and shales of shallow water origin, and probably formed in limited basins. We have similar phenomena in Gaspé and New Brunswick, where the marine limestones are absent, and the formation is represented by sandstones and shales holding land plants and fishes. Still, homogeneous though this development of the Devonian may be, it presents with us three distinct formations, Lower, Middle, and Upper, characterised by somewhat distinct animal and vegetable remains. The Lower you have well developed in Scotland, and it has afforded to the elder Peach, Thomas Brown, and others, those remarkable plants of the genera *Psilophyton* and *Arthrostigma*, which are equally characteristic of the same formation in Canada, where we have also fishes of the genera *Cephalaspis* and *Coccosteus*. The upper member, containing with us ferns of the genus *Archæopteris*, with fishes of the genera *Pterichthys*, *Diplacanthus*, *Phaneropleuron*, *Eusthenopteron*, *Glyptolepis*, &c., seems not so well represented in regard to its plants, though Mr. Kidston has, I believe, recently discovered some of these. We have, however, a Middle Devonian series, very rich in fossil plants, and more especially in ferns, including large tree ferns, which does not seem to have been recognised here. It should be looked for with care, as it may have been only locally developed, and, unless where the stratigraphy is clear, might be mistaken for a peculiar development of the Lower Carboniferous.

One of the most remarkable discoveries made in recent times in the Devonian, is that of the myriapods found by Peach in the Lower Devonian of Forfarshire. This discovery, I need hardly say, carries back this form of life much further than ever before, and justifies our Canadian discovery, made some time ago, of winged insects in the plant-beds of the Middle Devonian.

I would here, on Canadian grounds, enter a protest against the tendency to break up the Devonian, and to place its lower part in the Upper Silurian, and its upper part in the Carboniferous. This tendency is likely to exist in a country like Great Britain, where the local development of the system is incomplete. But in America, where it is one of the grandest of all our systems of formations in its development, both in thickness and in area, and where its animal and vegetable fossils are alike abundant and peculiar, we cannot agree to any such view.

It was because of the doubts existing some time ago as to the fate of your Devonian, as well as on account of the priority of the name "Erie Division" applied to it in the earliest classification of the Paleozoic rocks of America, that I ventured to propose and use the term Erian instead of Devonian. I trust, however, that in Scotland the Old Red Sandstone, at least, will ever retain its distinct and honourable position.

The maritime provinces of Canada resemble Scotland in the great development of the rocks of the Carboniferous system, so valuable in both countries in a practical point of view. In both countries there is a peculiar and interesting basal formation, having a somewhat distinct flora and fauna, the Calciferous series of Maclaren, the Tweedian of Tate, and in which in both countries numerous fossil fishes of peculiar types have been recognised, and also species of Lepidodendra and ferns distinct from those of the Coal Measures. Traquair, Peach, and Kidston are, I find, busy in developing the riches of this formation. It is remarkable, among other things, for affording the first traces of Batrachian life. This evidence in Canada and the United States has hitherto been limited to footprints, and of these the earliest were found in Nova Scotia. But Scotland has recently gone further, and I had the pleasure of seeing to-day for the first time, in the possession of Dr. Traquair, the skull of a large Labyrinthodont from this formation, and yet undescribed. The discovery by Mr. Peach of scorpions, millepedes, and decapod crustaceans in these basal beds is also of a most interesting character, and shows us that the land life of the Paleozoic was already at its culminating point, in some forms at least, immediately after the close of the Devonian age. In tracing scorpions and millepedes so far back, Scotland has taken the lead of America, which still, however, enjoys a monopoly of the land snails, though I imagine that the time cannot be far distant when these will be found here also. That a form of arthropod life so high and so specialised as that of the scorpions should have been represented by many and large species at the beginning of the Carboniferous age, and that millepedes, which seem to have culminated in that age, existed as far back as the Lower Devonian, are facts which raise many questions as to the possible occurrence of other forms of land life in these early periods, which still await their solution.[1] The connection now being worked out by Peach between the scorpions and animals hitherto regarded as crustaceans is also an important and novel contribution of Scotland to paleontology, though Packard in America had already on independent grounds indicated these affinities.

The coal formation of Scotland differing from that of England in the intercalation of marine beds, and in the mixture, so to speak, of the Carboniferous Limestone with the Coal Measures, and probably also in the earlier development of the characteristic coal flora, and of great beds of coal, resembles in this the coal areas of Newfoundland and of Cape Breton, rather than those

[1] The opening of the year 1885 has been signalised by the announcement of the discovery of scorpions in the Silurian of Gotland, in Sweden, and of Lanarkshire, in Scotland, by Professor Lindström and Dr. J. R. S. Hunter.—J. W. D.

of the middle regions of North America, and corroborates the principle which I have deduced from American facts, that the successive Paleozoic floras appeared first in the north, and made their way southward—a law which comes into relation with so many of the more recent facts in physical geography.

The plants of the coal formation were in this country, as elsewhere, early studied and roughly classified, but the more scientific working out of their affinities, and of the difficult problems which they present in this respect, has been a slower process, and is only now gradually being perfected. The remarkable Scottish deposits showing plants with structure, found by Grieve at Burntisland, and by Wunsch in Arran, have afforded to Williamson and Carruthers much new light on affinities; and the relations of the species to the different horizons of the strata, hitherto too much neglected, and in which we are in advance of you in Canada, have of late, I am glad to find, been attracting the attention of Mr. Kidston, one of your younger botanists. In all of these departments much remains to be done, and in the present condition of our knowledge, and with the constant accumulation of facts imperfectly understood, we are probably on the eve of new and perhaps unexpected revelations as to the relations of this old flora to that of the modern world. The condition of these questions may be not inaptly represented by our knowledge of those magnificent trunks of coniferous trees found in your quarries of Craigleith and Granton, and with which I made acquaintance when a student here in 1841, when I made slices of them, and compared them with our similar trunks. Long ago described by Witham, originally named *Pinites*, then *Dadoxylon* and *Araucarites*, and more recently *Araucarioxylon*, neither of which names probably expresses their true affinities, they remain known to us by internal structure, but we are in ignorance of their foliage and fruit, except conjecturally, though it is quite likely that these are separately known to us by other names. The discovery which shall unite their *disjecta membra*, and by enabling us to restore them in imagination in their primitive completeness, render fruitful all that has been done in fifty years, remains to be made, and may be made any day.

Scotland seems in its small areas of Permian and Trias to have little means of throwing light on the questions which are agitated respecting these formations, and Eastern America is, proportionally to its extent, scarcely more rich. Still we have enough to show the gradual passage upward and fading away of the carboniferous life in those sandstones which we call Permo-carboniferous, before the advent of the new life of the Mesozoic. If the footprints found in the Dumfries sandstones, and in which

I remember my old friend Sir William Jardine to have been much interested, are really Permian, and belong to sandy bays of that age enclosed in the Silurian hills, they hold out the promise of greater discoveries, and should excite renewed attention. Nor should Scottish geologists forget that, however slender the representation of the Permian in stratified deposits, it marks a period of the earth's history, and one in which perhaps the greatest change that ever occurred in animal and vegetable life took place, a period which, throughout the Northern Hemisphere, must have been marked by great physical revolutions, implying much disturbance and denudation of the older formations.

Scotland has not much to show of the Mesozoic and Tertiary, though, for that very reason, perhaps, some of its outliers and detached patches deserve more attention than they have received. Canada, since its boundaries were extended to the Pacific, has ceased to be an exclusively Paleozoic territory, and now possesses so great breadths of Cretaceous and Tertiary, that Scotland would require to extend its boundaries across Europe and beyond the Ural range, before it could rival Canada in the expanse of its great plains and of the mountain ranges of the West. In regard to these, I may remark that they show formations of these ages in conditions of undisturbed and unchanged horizontality on the great plains, and of the most extensive disturbance, metamorphosis, and mixture with igneous products in the Western Cordillera; and that they evidence the most gradual transition perhaps to be seen anywhere between the Cretaceous and the Tertiary. The Duke of Argyll has shown that, in the leaf-beds of Mull, you have American plants; and Mr. Starkie Gardner has recently endeavoured to prove that these belong rather to the Eocene than to the Miocene; a conclusion which, if established, would bring them more nearly into harmony with the age of our lignite-bearing beds of the Western Prairies.

In the development of these great western territories, I may remark, in passing, that from the time of Earl Selkirk to that of the present Canada Pacific syndicate, Scotsmen have borne a prominent share, and I hope that many of the sons and daughters of this country will find homes in those western plains, and thus practically annex them to Scotland. We are very willing to make up in this way for the small extension of the Cretaceous and Eocene in Scotland.

I have left little time to speak of one of the most vexed questions of geology, that of the glacial age and its boulder drift. Scotland, as might have been expected, has produced some of the most noted theorists on this subject, as well as some of the most eminent collectors of facts. I need only mention, as

older workers in this field, the late James Smith of Jordanhill, and the honoured President of this Society, and may associate with them Professor Geikie, Croll, Jameson, and Richardson. Of the later writings on the subject, I may here refer to two addresses recently delivered before this Society, in which views are stated, which, on the whole, commend themselves greatly to my judgment. I refer to the addresses of His Grace the Duke of Argyll and of your Vice-President, Mr Ralph Richardson. It seems clear from these papers that Scottish facts require for their interpretation the full admission of aqueous as well as of glacial agencies, and of somewhat abrupt changes, in contradistinction from a mere bald and featureless uniformity.

Canada, like Scotland, has large and widely spread monuments of the glacial age; and you can appreciate this, when I say that Dr. G. M. Dawson has described in the Missouri Coteau a series of ridges of boulder-drift 30 miles wide and 150 feet high, and extending for hundreds of miles along the plains. Over the prairie region, between the Laurentian watershed on the east, and the Rocky Mountains on the west, boulders have been carried seven or eight hundred miles from their original sites, and have been lodged on the foothills of the Rocky Mountains, at elevations of 4000 feet above the sea, while drift from the Rocky Mountains has been carried in the opposite direction, though not so abundantly or so far.

We are perhaps less astonished by the results of glacial action than you are, since we have the transport of boulders still actively in progress on the Lower St. Lawrence, and have still living in our waters, chilled by the Arctic current, the same molluscs that we find in the glacial clays and sands. We therefore are apt to lean to the school of moderate glacialists, and, while we admit the very plain evidences of land glaciation seen in our mountain valleys, are disposed to account for the wider dispersion of boulders over the plains by the agency of floating fields of ice in periods of submergence. It is true that in the United States the influence of Agassiz and of Dana has favoured extreme views as to glaciation, but Canada is likely to produce more sober theories.

I confess that on this question I attach great importance to the labours of the boulder committees which have so assiduously collected facts relating to the distribution of those travelled masses, each of which has some tale to tell with reference to its source and the circumstances of its transportation. In connection with this, it is of supreme importance to bear in mind the fact of the great submergence of the land of the Northern Hemisphere, which intervened between the continental period of the Pliocene and the second continental period, as it was called by

Lyell, of the post-glacial. The shells on Moel Tryfaen, in Wales, at the height of 1392 feet above the sea, constitute a tide-mark of a submergence which was general over the Northern Hemisphere, which extended on the west not only to the Apalachian and Laurentide Hills, but to the Rocky Mountains and the coast ranges of British Columbia, and which reached southward to the countries bordering the Mediterranean, and northward to Scandinavia; and even that high tide-mark was not its utmost limit. This vast and long-continued submergence, evidenced not only by accumulations of shells but by great earthy and boulder deposits, and by deeply cut cliffs and terraces, was the grand feature of the Pleistocene age, and must have constituted a potent factor in the whole matter of transport of material. This must have gone on during the whole period of submergence as well as of re-emergence, and must have been aided by fields of ice, of which our modern experience affords very faint conceptions. When this great and dominant fact is kept before our minds, questions as to supposed interglacial periods become of minor importance, and we have a clue to the explanation of multitudes of phenomena otherwise inexplicable, or requiring the most violent hypotheses to account for them. It is true that in Scotland you do not appear to have found marine shells of Pleistocene age at greater elevations than about 500 feet; but there are other indications of submergence extending to 2500 feet, and there is little doubt that you will yet find in the high gravel beaches of your mountains, evidences that the waves of the Pleistocene sea washed their heights, and that marine animals flourished on their sides.

This subject connects itself still farther with the appearance of man in Scotland. The Museum of your Society of Antiquaries and the Museum of Science and Art contain many curious relics of the arts and modes of life of the stone age in Scotland, and show an amount of ingenuity in turning to account the few resources in stone, shell, and bone within reach of the primitive people, not unworthy of the ancestors of the Scotsmen of the present time. But most if not all of these remains belong to the races still extant in the country, and, as one of your antiquaries has lately shown in a most instructive volume,[1] some of these industries have flourished locally up to recent times. But in England, on the continent of Europe, and in Asia, we have remains of men who belonged to an earlier period, who after the great glacial submergence had passed away, and when the land of Europe was higher and wider than it is now, spread themselves even into these islands, then probably connected with the mainland, and hunted here the mammoth and tichorhine rhinoceros

[1] "The Past in the Present," by Arthur Mitchell, M.D., &c.

and other large mammals, which seem to have perished with them in that shorter submergence of the post-glacial age which closed the second continental period, and separated it from the present races and their history. Some evidences have, I believe, been found of the existence of these "paleolithic," or, as they should rather be called, paleocosmic, men in Scotland; but if I may judge from the work of Mr. Milne Home on "Water-Lines," the subject is still in some uncertainty, and merits farther investigation. Geologists should co-operate with archæologists in these investigations, in order that more definite results as to the relations of the deposits containing such remains may be reached, and that due correction may be given to those exaggerated notions of time which have been imported into this subject, and which, however required by certain prevalent hypotheses, are not in accordance with the geological facts bearing on the date of the close of the glacial period, or of the great Pleistocene submergence. Canada can aid this work only in so far as it can furnish modern illustrations of the arts and implements which here may be altogether pre-historic, though recent there.

I have now carried my comparisons of Scottish and Canadian geology from the Laurentian to the modern period, and trust that I have shown, however imperfectly, that there is much of kinship and correspondence between work and workers on the two sides of the Atlantic. In closing, allow me to thank you for your kind invitation to deliver this address, and to welcome in return such Fellows of this Society as may honour us with their presence on occasion of the approaching meeting of the British Association in Montreal. Permit me also to express the hope that this Society may continue to grow and flourish, and to gather around itself all the workers in Scottish geology in friendly union and co-operation, and in intimate relations with their fellow-workers abroad; and that the second half-century of activity on which it is now entering, may be marked with achievements even greater than those of its first, and worthy of the successors of those great men who laid the foundations of Scottish geology.