# IX.—*Synopsis of the Geology of Canada. (Being a Summary of the principal terms employed in Canadian Geological Nomenclature.)*

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## INTRODUCTION.

In describing the various geological formations which compose the earth's crust in the Dominion of Canada it is the purpose of the writer to add such notes on the geological structure of other portions of British North America (which portions we hope will sooner or later form part of our great Dominion) as will show the relation which exists between them and its present divisions.

For the sake of convenience, and to a great extent depending upon its physiographical as well as geological characters, British North America will be divided into five sections or regions, and the descriptions given of the various geological formations will proceed, as nearly as possible, from the east in a westerly direction as follows :—

I.—*The Acadian Region*, comprising the Maritime provinces of Nova Scotia, New Brunswick and Prince Edward Island, also Newfoundland and Gaspé peninsula, together with that portion of the province of Quebec south-east of the great Champlain-Appalachian fault or dislocation which runs in the Gulf and River as well as along the south shore of the St. Lawrence through Quebec city, and west, to St. Nicholas, then to the north-east corner of Lake Champlain, and proceeding in a southerly direction through the New England States, as far south as Alabama.

II.—*The Lawrencian Lowlands*, which extend from Anticosti west to the City of Quebec and to Lake Huron including the Huron-Erie Peninsula of Ontario, South Eastern Ontario, the Ottawa Palæozoic Basin, and the flat-lying Palæozoic sediments of the province of Quebec.

III.—*The Laurentian Highlands*, which include the great peninsula of Labrador to the east of Hudson Bay and the Archæan country to the west and north-west of the same bay.

IV.—*The Interior Continental Plain*, which runs north from the 49th parallel towards the Arctic ocean and embraces Manitoba, Assiniboia, Alberta, Saskatchewan, and portions of the districts of Athabasca, MacKenzie, and Franklin.

V.—*The Cordilleran or British Columbia Region*, which extends across the Rocky mountain region of Canada, from the foot-hills to the Pacific ocean, and includes the great Cordilleran belt from the 49th parallel to Alaska.

The following table gives the list of geological systems recognized in Canada:

Quaternary.
Tertiary.
Cretaceous.
Jurassic.
Triassic.
Permian.
Carboniferous.
Devonian.
Silurian.
Ordovician.
Cambrian.
Huronian.
Laurentian.

In dealing with the classification of the various formations of Canada included in the above systems and occurring in the five regions afore-mentioned the writer has been compelled to affix provisional formational names to various series of sedimentary rocks which have not as yet received any designation. He deems it, however, a case of dire necessity in this case, inasmuch as it is impossible to classify geological horizons or sub-divisions in the strata of the earth's crust, as developed in Canada, according to the latest and most approved methods and in keeping with the classification of other geological formations in the same systems in other parts of the world, without formational names. There are horizons and formations in Canada which are known only in terms descriptive of their lithological or palæontological characters, combined in some cases with their economic relations, and these are not as a rule acceptable as geological terms of value in nomenclature.

## The Laurentian System.

Of the three million six hundred and sixteen thousand nine hundred and eighty square miles of territory in British North America, nearly two-thirds of this area belongs to the Archæan, which term is used to embrace both the rocks of the Laurentian and those of the Huronian systems. The Laurentian constitutes the fundamental or older series in the Archæan.

*The Acadian Region.*—The Laurentian system is well developed in many portions of Cape Breton, New Brunswick, and Newfoundland where it consists of granitoid and foliated gneisses and syenites.

In New Brunswick crystalline schists of the *Portland* group, the felspathic and chloritic gneisses of the St. John region are assigned to this horizon by Dr. Matthew and Dr. Ells. The Boisdale and East Bay hills of Cape Breton are also referred to the Laurentian by Mr. Hugh Fletcher. From Cape Ray to Canada Bay and from Hermitage Bay to Cape Freels, two parallel belts of Laurentian rocks occur in Newfoundland.

*The Laurentian Highlands.*—Rocks of the Laurentian system constitute nearly nine-tenths of the area of the great peninsula of Labrador, and according to Mr. A. P. Low, consist for the most part of foliated hornblende and granite-gneiss, such as occur in the fundamental or *Ottawa gneiss*, overlaid by mica gneisses and mica schists belonging to the *Grenville Series.*

In the province of Quebec, north of the island of Montreal, Dr. Adams informs us that the fundamental gneiss consists largely of igneous rocks, banded and foliated, owing to the movements and arrangement amongst the constituents caused by pressure. These gneisses are penetrated everywhere by other igneous masses, including the anorthosite rocks, belonging to the gabbro family, with plagioclase predominant. These latter constitute the *Norian* or Upper Laurentian of Hunt and older geologists, but are known to cut the *Grenville* series also referred to the Upper Laurentian and are therefore post-Grenvillian eruptives.

In Central Ontario, Dr. Adams together with Dr. A. E. Barlow agree in the statement that the Laurentian gneisses occur in that province, and occupy a large portion of the area coloured as Archæan, where they consist of granitoid gneisses, diorites, and gabbros, all more or less clearly foliated. Associated with these gneisses, in the two areas last mentioned, there occur the *Grenville* and *Hastings* series respectively. These two are held to be probable equivalents and newer than the fundamental gneiss of the Laurentian.

Dr. Barlow aptly describes the fundamental gneiss of the Laurentian as follows :—

"It may possibly represent, in great part, the first-formed crust of the earth, which, necessarily thin and fragile, and so liable to frequent upswellings of the molten mass beneath, has undergone successive fusions and recementations before reaching its present condition. As at present mapped, it is regarded as a complex of irruptive plutonic rocks, representing repeated and intricate intrusions of basic and acidic material.

Although in many instances, and in limited areas, the succession of such irruptions can be ascertained with tolerable accuracy, any attempt to correlate this succession in detail over extended areas has invariably ended in more or less complete failure."

The *Grenville Series* includes a small quantity of altered sediments, chiefly limestones. The *Hastings Series* consists of thinly bedded limestones and dolomites "cut through by great intrusions of gabbro, diorite and granite."

In the Nipissing and Temiscaming regions more recently studied both in their field as well as petrographical or microscopical characters, the Laurentian rocks are divided by Dr. Barlow into two groups, as follows :—

"I. *An acidic group*: consisting of those foliated rocks similar in composition to granites, etc., to which they correspond, their differentiation being determined solely by their foliated texture, which, usually pronounced, is sometimes obscure and occasionally altogether absent.

"II. *A basic group:* These rocks occur interbanded with the more acidic gneisses and represent either basic segregated portions of the granite magma, or foliated basic irruptives allied to diorites, diabases, etc., caught up in it."

In a careful petrographical study of the rocks of the Laurentian in this area, Dr. Barlow, in conjunction with Mr. W. F. Ferrier, have recognized seven groups of acidic gneisses, besides two varieties of basic or hornblende gneisses.

Except in limited and isolated basins, throughout the length and breadth of Ungava and Quebec as well as Labrador—forming the Labrador Peninsula and the right limb of the great V-shaped Protaxis upon which the Post-Archæan sediments were laid—Mr. A. P. Low has recognized Laurentian and Huronian rocks, in his numerous traverses.

To the west of Hudson bay, there is, according to Mr. J. B. Tyrrell, an extensive and undifferentiated mass of granites which represents in the main the fundamental gneisses of the southern part of the great Canadian Protaxis. They consist of granites and gneisses and other crystalline rocks which are similar in structure and chemical composition to the fundamental gneisses (typical Laurentian) and newer crystalline limestones (probably equivalent to the Grenville series) in the same portion of Canada. Northward, in the Athabasca lake and Churchill river basins, Tyrrell has also recognized Laurentian rocks which he describes as granitoid gneisses, hornblende and mica-granites, gabbros

and norites, all of which have been subjected to crushing and foliating agencies.

*The Cordilleran Region.*—In the Cordilleran region of British Columbia the Selkirk range of mountains belongs in part to the Laurentian system, and forms the axis upon which were deposited, both east and west, the succeeding and newer sedimentary geological formations. Granite gneisses carrying both muscovite and biotite, also hornblende gneisses and graphitic gneisses have been described by Dr. G. M. Dawson from the Yale district of British Columbia, whilst in the remote northerly portion of the Yukon territory, biotite-granite-gneiss, assigned to the Laurentian system have been recorded by Mr. R. G. McConnell.

In the extreme north of British North America a considerable portion of the islands in the Arctic Archipelago belongs to the Laurentian system. Granitoid gneisses, limestones and other crystalline rocks occur which resemble those met with in southern Canada.

## The Huronian System.

*The Acadian Region.*—To this system have been referred the diorites, diabases, felsites and ashrock of the "*Coldbrook Group*" of New Brunswick, besides epidotic and chloritic and mica-schists and slates from King's, Albert, St. John, and Charlotte counties of the same province. The "*Kingston series*" as exemplified by the gneissoid rocks of Northumberland county, the felsite, talco-chloritic and other schists of Bostwick brook in King's county have also been referred by Dr. R. W. Ells and Prof. L. W. Bailey to the Huronian system. No rocks of this horizon have as yet been recorded from Nova Scotia. It is not improbable, however, that some of the crystalline limestones, dolomites, felsites, and more or less altered rocks classed as Pre-Cambrian may belong to the Huronian system. The "*Momable* slates" of Newfoundland by some called Huronian may belong to the Cambrian system.

*The Laurentian Highlands.*—In the peninsula of Labrador, Mr. Low has recognized two large areas of Huronian rocks; the first along the East Main river for a distance of 160 miles; the second, an area south-west of Lake Mistassini. Along the East Main river the Huronian consists of mica-schist, conglomerate, felspathic and quartzose schists, chloritic schist, hydro-mica slate, agglomerates and felspathic sandstones. On Belle Isle, Dr. Selwyn records the occurrence of felspathic sandstones, shales, tufaceous sandstones, and diorite schists; whilst on the west side of Cape Wolstenholm, and Skynner's cove, Nachvak, Labrador, Dr. Bell obtained in 1885 green chloritic schists and a compact steatite or pipestone ascribed to this system.

In Pontiac county in the province of Quebec, Mr. A. S. Cochrane obtained specimens of a gray shaly sandstone, chloritic, and hydro-mica schists along with dark green schistose diorite which have since been classified in the Huronian. In the districts of Nipissing and Algoma, we have classic ground for the student of Huronian geology. It was on the north shore of Lake Huron that the original Huronian rocks, as described by Sir Wm. Logan, Alexander Murray, Dr. Bell and other Canadian geologists were first studied. The Huronian is very extensively developed, and forms numerous, wide, more or less interrupted bands between Lake Huron and James's bay. It is in this region that the Huronian system attains its greatest development. The Huronian is well described by Dr. G. M. Dawson in his summary on the Archæan of Canada, read before the British Association for the Advancement of Science, Toronto Meeting, 1897, in which he writes:

"The Huronian comprises felspathic sandstone or greywacke, more or less tufaceous in origin, quartzites, and arkoses passing into quartzose conglomerates and breccia conglomerates, often with large fragments of many different varieties of granite, syenite, etc., diorite, diabase, limestones, and shales or slates changing to phyllites in contact with the numerous associated igneous masses. Over wide areas altered greenstones and their associated tuffs preponderate, often with micaceous, chloritic, sericitic and other schists, many of which are of pyroclastic origin, although some may represent ordinary aqueous deposits, and all have been affected by subsequent dynamic metamorphism."

It will thus be seen that the Huronian system is partly sedimentary, and partly igneous.

In the Nipissing and Lake Temiscaming regions just recently described by Dr. Barlow, the Huronian rocks were found to be widely developed, especially in the north-western part of the region. They consist of the basal series made up of "breccia-conglomerate, containing pebbles and fragments often angular though usually subangular or rounded in outline, of granitite, diabase, diorite, etc., embedded in a matrix composed of the same materials in a finer state of division, while the more minute interstices are filled up with scales and flakes of chlorite and sericite."

This fragmental rock passes up and into a greywacke which in turn merges above into an exceedingly compact and fine grained rock of similar composition which gradually assumes a banded and slaty character. The latter forms the slate or shale division of the series. Superimposed upon these directly, a quartzite grit made up chiefly of granitic quartz and felspar, resembling arkose, are found.

The relation which exists between the Huronian of the typical area and the *Hastings* series of Ontario, the *Keewatin* series, *Coutchiching* series of the Lake of the Woods and Algoma generally, and the *Grenville* series of the Ottawa district, is a subject full of intricate problems in petrography and field geology combined, of the highest interest

No separate geological names of formations have been assigned to the three sub-divisions of the Huronian, as developed in the Lake Temiscaming region, but there is no doubt that forthcoming researches on the part of students in Archæan geology in Canada will result in the probable definition and correlation of the different members of both the Laurentian and Huronian systems in a manner which will enable us to classify the various phases of these two systems and their taxonomic equivalents in different regions, as regular formations not very dissimilar from the methods or principles used in the scale adopted in the nomenclature of subsequent systems. The most conspicuous periods of volcanic activity together with periods of quiescence as indicated by the strata would form important factors in the determination and separation of the different formations.

In the Rainy river district, in Algoma and Lake of the Woods regions, as elsewhere, Huronian rocks are extensively developed and prove to be an important metalliferous series, carrying gold, silver, nickel, copper, iron, and other useful minerals.

Along the west coast of Hudson bay and in the interior, as well as on Marble Island, rocks of *Huronian* age, consisting of chloritic, and micaceous schists, also of fine-grained quartzite associated with diabase and gabbro, are classified as Huronian. Mr. J. B. Tyrrell describes a large belt of Huronian rocks, 120 miles in length, along the west coast of Hudson bay from near Baker's foreland to a point 45 miles north of Cape Esquimaux. From the shore of Hudson bay inland, these rocks were traced for seventy miles up Ferguson river. On the Telzoa and Kazan rivers two additional areas of *Huronian* rocks are described, besides others in the basins of Doobaunt, Wharton, Kasba and Ennadai lakes.

In the district of Keewatin, and Lake Winnipeg region, Dr. Bell and Messrs. Tyrrell and Dowling have recognized many areas of Huronian quartzites, chloritic, steatitic, felspathic, and diorite schists, besides conglomerates and breccias.

Along Athabasca lake, and Churchill rivers Tyrrell recognized Huronian rocks, consisting of white quartzites besides fine red calcareous sandstones and schists.

*The Cordilleran Region.*—In British Columbia and Yukon territory, the Huronian system has been recognized as consisting, for the most part,

of diabases and diorites, with chloritic schists, mica schists, quartzites, and slates, which have proved to be highly productive of minerals of economic value to man; gold, silver, lead and copper being conspicuous.

*General Note.* In no other country on the face of the earth is there such a development of old crystalline rocks referable to the Laurentian and Huronian as is to be found in Canada. The rocks which constitute them are highly metalliferous, and the varieties or species of minerals of economic value, which must lie hidden in their formations, are so numerous that the latent resources of Canada can be affirmed to be a store of untold wealth. These will, no doubt, soon be more extensively developed and utilized as the country is opened up and our population increases from year to year.

The *Algonkian* of Van Hise and other North American geologists is a newly-coined term which embraces practically the same rock-formations as the Huronian. Prof. Van Hise's Map of the Algonkian compared with Sir Wm. Logan and Murray's Map of the Huronian system suffices to show that the two systems are synonymous—the earlier term Huronian having priority.

No definite organisms have as yet been recorded from the Laurentian or Huronian of Canada. The terms Laurentian and Huronian introduced into geological nomenclature by Sir Wm. Logan in the early days of the Canadian Geological Survey are now very generally adopted throughout the world.

## The Cambrian System.

The Cambrian system forms the base of the Palæozoic column, and is the term now generally adopted to include those sedimentary formations which hold entombed in their strata the earliest truly recognizable forms of animal life in a fossillized condition.

*The Acadian Region.*—In Newfoundland, Nova Scotia and New Brunswick, the three divisions into which the Cambrian formations are naturally and generally divided, namely: Lower, Middle and Upper, are all well represented. In certain portions of Newfoundland, at Smith's Sound and Signal Hill, and St. John, N.B., also on the Kennebecasis river, series of fossiliferous sediments have been assigned by Dr. G. F. Matthew to the *Etcheminian* system and by him separated from the Cambrian proper. The *Etcheminian* appears to be a phase or formation in the series of fossiliferous Lower Cambrian sediments, and its position is evidently in the Lower or Eo-Cambrian.

The gold-bearing series of Nova Scotia, consisting of an upper slate formation and a lower quartzite formation, both destitute of fossils,

have been referred to the lower division of the Cambrian and has been designated as the "*Atlantic Coast* series" or *Acadian* 'group' or 'division' of this system.

This series constitutes the productive gold belt of the Acadian region. Staurolite-schist, mica-schist, andalusite-schist, quartzites, and slates, occur in this series in Guysborough, Queens, Halifax, Lunenburg, Shelburne, and Yarmouth counties of Nova Scotia. The gold-bearing quartz veins and accompanying strata of Nova Scotia have been thrown into a series of plications or folds, consisting of anticlines and synclines, by a number of important intrusive masses.

Surrounding these masses of intrusive rocks, the slates and quartzites which still maintain their relative position as lower and upper members of the "Lower Cambrian" appear as two metamorphosed or altered series of sediments, and constitute a "metamorphic series" according to Messrs. H. Fletcher and E. R. Faribault. To the "quartzite group" of the gold-bearing series of Nova Scotia the designation *Guysborough* formation appears to be appropriate, whilst the term *Halifax* formation is proposed for the "slate group" of the gold-bearing series. A remarkable feature in the mode of occurrence of the gold is that it appears usually in the axis of the anticlines, and inasmuch as mining in Nova Scotia has revealed the presence of many anticlines superimposed one upon the other, at different depths and intervals, it is calculated that the gold-bearing veins or saddles will be found to hold out and continue to a great depth. Deep mining in the gold-bearing rocks of Lower Cambrian age in Nova Scotia will thus likely prove of great value and importance. The productive gold-bearing deposits of Victoria and New South Wales in Australia may be of similar age, and appear to be of similar structure to those of Nova Scotia.

Overlying and newer than the gold-bearing rocks of Nova Scotia, we find shales and limestones holding abundance of fossil organic remains. Below McAdam's brook, Escasonie river, near McFee's point, Bras d'Or river, and along Mira river in Cape Breton, and at Barachois (constituting the *Mira* series or formation), beds referred to the Upper and Neo-Cambrian have proved highly fossiliferous. These are now undergoing revision and the systematic classification of the various formations and zones of fossiliferous Cambrian will no doubt soon be made known.

In New Brunswick, through the researches of Dr. G. F. Matthew, the characteristic fossils of the various strata constituting the Cambrian system, which was also called the "*St. John group*" have been carefully described, and include for present purposes the *Etcheminian* series also. At Loch Lomond, in St. John county, on Caton's island, King's county,

where the latter series is well developed, whilst the lower division of the St. John group holding *Protolenus* and *Paradoxides* occurs at Hastings cove, along the Kennebecasis valley, and in St. John city itself. The middle division of the St. John group holding *Lingulella* is well developed in St. John city, and constitutes a formation consisting of dark and light gray slates and flags, with sandstones seven hundred and fifty feet in thickness. In the upper division of the St. John group, such as it is developed on Navy island and in St. John city, *Dictyonema flabelliforme*, and *Peltura scarabæoides* are the characteristic fossils of the gray sandstones and fine black shales of this upper series. The rocks of Hanford brook are highly fossiliferous and constitute the *Hanford* formation of Prof. C. D. Walcott. These are of same age, as the slates of Ratcliff's Mill stream, Caton's Island, Porter's Brook, etc.

The limestones, etc., of Chapel Arm, Trinity bay, and at Manuel's brook, in Newfoundland, correspond to the lower division of the St. John group as developed in New Brunswick. In Gloucester county, on the Tête à Gauche river, on the Nipisiguit river, near Landing Falls, on the Serpentine river, on the Miramichi river, in Northumberland Co., at Porter's brook in St. John county in N.B., the Cambrian has been recognized by Dr. Ells, Dr. Matthew, and Prof. Bailey, and described by them.

The *Avalon*, *Random*, *Sound* and *Signal Hill* series of Newfoundland have been defined by Murray and Howley as well as by Prof. C. D. Walcott from that island and constitute part of the Cambrian system.

South-east of the St. Lawrence-Appalachian dislocation in the province of Quebec, the Cambrian system has been recognized by Logan, Richardson, Ells, and other geologists, and includes the gold-bearing slates of the Chaudière valley and Beauce district, as well as the *Sillery* slates or "pillar" sandstones, which are held by some to be the equivalent of the Potsdam formation of New York state. *Sillery* slates, sandstones, and conglomerates occupy a wide belt in the province of Quebec south of the St. Lawrence.

In the counties of Bonaventure, Gaspé, Rimouski, and Temiscouata, as well as in Bellechasse and Lévis, the *Sillery* shales and quartzites, limestones and argillites, limestone-conglomerate and quartz-conglomerate, slates and felspathic sandstones also occur, and many of them prove to be fossiliferous, as at Matane, Métis, &c., Cape Rosier, Little Fox river, Magdalen river, Ste. Anne des Monts, Cap Chatte, Whale cape, Sandy bay, Little Métis, Island of Orleans, Point Lévis, Sillery, Cap Rouge, and Chaudière falls and river for the most part referable to the Upper Cambrian.

In the Eastern townships, on the east side of the Sutton mountain anticline, Cambrian rocks also occur, and likewise east of the Missisquoi valley in Potton, in Lisgar, at Waterloo, Richmond, Sweetsburg, Frelighsburg, Granby, where slates and quartzites referable to this system have been recognized and so classified by Dr. Ells. From the adjoining State of Vermont the "*Georgian*" or "*Georgia*" formation has been recognized, and it may be the equivalent of the "*L'Anse au Loup*" limestones, and other early Cambrian strata of the St. Lawrence valley.

*The Laurentian Highlands.*—Overlying the more or less irregular floor of Archæan rocks, and filling the hollows throughout several areas or isolated basins, Cambrian limestones, and quartzites, and dolomites associated with certain dioritic traps are found, viz.:—along the Labrador coast at L'Anse au Loup (*L'Anse au Loup* limestones or formation), at Lake Mistassini (*Mistassini* formation), along Richmond gulf, and Nastapoka group of islands on the east coast of Hudson bay. At L'Anse au Loup, white sub-crystalline limestones, carrying abundance of fossil remains, described by Billings, form part of the Lower Cambrian strata. Dr. Bell recognizes the *Manitounuck* group and the *Nastapoka* group or formations along the eastern coast of Hudson bay. These two Dr. Bell held to be equivalent of the *Nipigon* formation which, in turn, he held, to represent the *Keweenawan* of Lake Superior. Mr. Low, who has examined these more recently, would place these two groups below the Keweenawan, and reckons them as equivalents of the older *Animikie*.

On the Larch river, on the Wiachouchan, on the Koksoak, on the Hamilton and Kaniapiskau rivers, Mr. Low records areas of Cambrian, which lie almost horizontally, and consist largely of shale resting on light yellow compact cherty dolomite, overlaid by bands of brownish and greenish argillaceous limestones interbedded with rusty shales associated with a large exposure of bedded iron ore consisting of a mixture of magnetite and hæmatite.

On the west of Hudson bay Mr. Tyrrell describes the occurrence of sandstones and conglomerates (*Athabasca* formation) which represent the basal portion of the Cambrian of Doobaunt lake and other localities, including the valley of the Thelew river. These sandstones may extend into the regions south and east of Lake Athabasca, where they appear as red and mottled sandstones and sandy shales, referred by some to the *Keweenawan* of Lake Superior. In the vicinity of Churchill Mr. Tyrrell has recorded a small outlier of Cambrian, forming a narrow strip of land between Cape Churchill and the fort of the same name.

North of Lake Superior and Lake Huron, the *Animikie* and *Keweenawan* or *Nipigon* formations are classed as the basal series in the

Cambrian. As has been already pointed out by Dr. Selwyn, Dr. G. M. Dawson, and more recently by Dr. A. E. Barlow, these two formations which appear to overlie the Archæan unconformably, form the base of the palæozoic column. In the vicinity of Sudbury certain shales and felspathic sandstones, at times concretionary, have been ascribed to the Cambrian by Dr. Bell, and are so coloured in his geological map of that region. The rocks which constitute the *Nipigon* and *Keweenawan* formations consist for the most part of conglomerates, sandstones, ash-rock, slates, argillites, quartzites, cherts, amygdaloidal and porphyritic traps and diorites, and are extensively developed in the Thunder bay district of Lake Superior.

*The Cordilleran Region.*—In the Kamloops district of British Columbia, and in the West Kootenay, Dr. Dawson recognizes a Cambrian horizon in the dark argillites of the *Nisconlith series* (15,000 ft. in thickness), which are superimposed by 25,000 feet of volcanic rocks, described as the *Adams Lake series*. In the Rocky mountains proper, Mr. McConnell and Dr. Dawson have described lower, middle and upper Cambrian sedimentaries. In the *Castle Mountain* group in the *Bow River* series, along the valley of the Kicking Horse river, and near Donald, limestones and slates and sandstones have afforded fossil remains, which enable the geologist to recognize (1) a lower Cambrian or *Olenellus* zone; (2) a middle Cambrian or *Ptychoparia* zone; and (3) an upper Cambrian or *Ogygopsis* zone : In the Yale district of British Columbia, and in the Selkirk range, schists, sandstones, argillites, and limestones, constitute the Cambrian of the southern interior of the province. The Cambrian strata of Mt. Stephen, near Field, along the line of the Canadian Pacific Railway, are highly fossiliferous, and that locality proves to be one of the best in the world for collecting Neo-Cambrian trilobites which occur at about 11,000 ft. altitude. The designation *Stephen* formation is suggested for the trilobitic beds of shale and limestone with *Ogygopsis Klotzi*, *Zachanthoides spinosus*, *Ptychoparia Cordillerae* and associated fauna.

It is not unlikely that the quartzites and slates so prevalent in the gold-bearing district of the Yukon district are also of Cambrian age. This precise position of Palæozoic sediments in the column has not been definitely ascertained, but Mr. McConnell has recently defined the various series under the following designations in descending order:—

*Moose Hide* group (in part) ; *Klondike* series ; *Hunker Creek* series; *Indian River* series.

Messrs. S. F. Emmons and J. E. Spurr have described the "*Rampart*" series, "*Birch Creek*" and *Forty-mile* series from the Klondike and adjacent Alaskan districts of North Western America.

## The Ordovician System.

*The Acadian Region.*—The first discovery of truly Ordovician rocks in the Maritime provinces, was that along the valley of the Beccaguimic river in north-western New Brunswick in 1880, by Prof. L. W. Bailey. The fossils then obtained, referable to the *Beccaguimic* formation, were determined by the writer, and a preliminary note upon them embodied in the Report of Progress of the Geological Survey of Canada for 1885. They occupy a position very near the base of this system. In the vicinity of St. John, N.B., certain black graptolitic shales probably synchronous with the *Levis formation* of Quebec were discovered by Dr. Matthew in what he called the upper or Bretonian division of the "St. John Group." These shales hold a fauna akin to the Arenig and Skiddaw horizon of Great Britain in the lower or Eo-Ordovician.

In Newfoundland, the fossiliferous rocks of Great Bell and Kelly's island, in Conception Bay have recently been described by Dr. Matthew as Ordovician, but they may possibly be referable to an upper Cambrian horizon. The term *Waban* formation is suggested as an appropriate designation for the iron-bearing strata of great Bell Island.

The rocks of McFee's point, in Cape Breton, have been referred to the Ordovician by Dr. Matthew. There are numerous and extensive areas in several counties of Nova Scotia and New Brunswick which have been placed in the Ordovician solely on stratigraphical grounds, by various geologists. Until definite palæontological evidence is at hand, that horizon must remain uncertain.

*The Quebec Group of Logan and Billings.*—In the disturbed region south-east of the great Champlain-Appalachian fault in the province of Quebec, the Lower Palæozoic, characterized by a series of fossiliferous sediments deposited under special conditions is divisible into three distinct horizons or formations: the *Sillery* formation at the base (constituting a presumably Upper Cambrian horizon), followed by the *Levis formation*, which consists of black graptolitic slates and fossiliferous limestones associated with conglomerate bands, which latter often hold pebbles of Cambrian limestone. Both the *Sillery* and *Levis* formations are followed upwards by a third, the *Quebec formation*, consisting for the most of black or dark brown bituminous graptolitic shales, impure limestones, limestone-conglomerate and conglomerates, which hold a higher fauna. The Quebec group, with these three horizons, is easily recognized along the south shore of the St. Lawrence and in the eastern townships of Quebec. The precise place and relations of the *Lauzon* formation of early writers in the succession of palæozoic sediments in Quebec, has not been definitely ascertained as yet.

The precise limits or geological horizon of the *Quebec* formation is not yet definitely ascertained, but evidence obtained points to an horizon in the Ordovician some parts of which are not far from the lower Trenton. Some of its strata are older, some newer.

There is a remarkable similarity between the Ordovician of the provinces of Quebec and New Brunswick and the Ordovician of western Europe as developed in Great Britain: The Skiddaw and Arenig, the Hartfell and Llandeilo formations, being easily recognized in Canada and appear to have the same taxonomic relations as in Europe.

In the south-western portion of the Eastern Townships of Quebec, near the head of Lake Champlain, the Quebec group assumes a rather different character from its equivalent in the vicinity of Quebec city, so that what is probably the equivalent of the Levis graptolitic slates and cream-coloured limestone of the latter area, consist of dove-gray limestones or marbles, at times highly fossiliferous. At Philipsburgh, and Bedford, &c., these limestones are superimposed by the black slates and limestones of Farnham, at times graptolitic. Similar strata are developed in the Lake Memphremagog basin. These constitute a succession of stratified rocks in tnis portion of Canada which may be termed the *Philipsburgh, Bedford, Farnham* and *Magog* formations. The former two are akin to the Fort Cassin beds of Vermont, and the last to the Norman's kiln shales of New York State.

*The Laurentian Highlands.*—Within the area included under this term, which comprises the great Labrador and Keewatin arms or sides of the Hudson Bay basin, are included several Ordovician outliers of greater or less extent. In Ungava Bay, at Akpatok island and at the head of Frobisher Bay in Baffin Land rocks of Upper Ordovician age were found by Capt. C. F. Hall, Mr. A. P. Low and Dr. Bell. Dr. Whiteaves and Dr. Schuchert have recently described the fauna of this remote district and refer it to the Trenton formation.

In the Arctic islands, north of Coronation gulf and the gulf of Boothia, rocks of Trenton age, in the Upper Ordovician have also been recognized. West of Hudson Bay in the Nicholson Lake and Churchill outliers, also forming a belt north, south and west, and also from the limestone rapids of the Nelson river, fossiliferous and dolomitic limestones are extensively developed and characteristic Trenton fossils were found by Mr. J. B. Tyrrell.

In the Lake Temiscaming and Lake Nipissing basins, fossiliferous limestones belonging to the Black River division of the Trenton group are also known to occur both in loose masses and *in situ* respectively. These outliers and their fossils have been recently described by Dr. A. E. Barlow and the writer.

*The Lawrencian Lowlands.*—In this region we have the following descending series of fossiliferous Ordovician formations :

7.—The Lorraine (sometimes called Hudson River).
6.—The Utica.
5.—The Trenton.
4.—The Bird's Eye and Black River.
3.—The Chazy.
2.—The Calciferous.
1.—The Potsdam.

These seven distinct formations follow one another in regular order, covering the irregular surfaces of the Archæan north-west of the great fault of the province of Quebec, and in Ontario. The *Potsdam* consists for the most part of a yellowish white or dark brown or red sandstone, with occasional beds of conglomerate, from which the *Protichnites* or tracks and trails of marine animals were obtained. No truly Cambrian species have as yet been recorded from the *Potsdam* sandstones of Canada, on the contrary, the fauna is eminently Ordovician and one of the "Second fauna" of Barrande. The *Calciferous* is a magnesian limestone, often arenaceous, whilst the *Chazy* is characterized by arenaceous limestones, shales and limestones. The *Black River* formation consists for the most part of limestones of a decided lithographic character in its lower half, and usually heavily bedded in its upper portion. This and the succeeding *Trenton* limestones, along with the upper *Chazy*, have afforded excellent building stone for some of the finest buildings erected in Ontario and Quebec. The *Utica* consists for the most part of black brittle shale, bituminous in character, with bands of impure, magnesian and bituminous limestones interstratified at the base, whilst the *Lorraine* formation consists of deep gray, brown, fine-grained mudstones, and magnesian limestones. These formations are extensively developed in the neighbourhoods of Montreal, Ottawa and Quebec, and the uppermost four occur throughout eastern Ontario.

*The Interior Continental Plain.*—In Manitoba the Ordovician rocks are extensively developed, forming the main mass of rock occurring in the Winnipeg and Lake Manitoba regions.

The greatest thickness of Ordovician strata in the province of Ontario is doubtless to be found in the vicinity of Toronto city. At Clarkson's, eighteen miles west of Toronto, there occur some 1,457 feet of shales, limestones and arkose bands, the *Lorraine*, measuring 650 feet; the *Utica*, 150 feet; the *Trenton*, 500 feet; the *Black River*, 157 feet.

*Interior Continental Plain.*—Both the Trenton and Lorraine formations (which by some geologists are classed as Galena-Trenton and Hud-

son River respectively), consist of cream-coloured limestones and dolomites, with red calcareous marls and shales abounding in fossil remains. In eastern Manitoba Mr. Dowling describes the following succession in descending order :—

V. Hudson River shales.
IV. Upper Mottled limestones.
III. Cat Head limestones.
II. Lower Mottled limestones.
I. Winnipeg sandstones.

There is no doubt that a belt of Ordovician rocks underlies the Silurian, Devonian and Cretaceous system along the eastern prairie plateau, both northward, westward and southward. Dr. J. F. Whiteaves has described a very interesting series of Galena-*Trenton* and Black River fossils from Lake Winnipeg and its vicinity.

*The Cordilleran Region.*—In British Columbia rocks of Ordovician age appear in the Rocky mountains proper, at Devil's Head lake, near Banff. Along the Kicking Horse river at Glen Ogle, graptolitic slates and limestones with shales carrying an Ordovician fauna have been described by Mr. McConnell. The graptolitic fauna recognized by Prof. C. Lapworth, of Birmingham, is here classed as constituting the *Wapta* formation, and belonging to the upper half of the Ordovician system.

In the Selkirk range, no outcrop of rocks definitely referable to this age have as yet been detected, but some of the black graphitic and bituminous slates and limestones may possibly belong to this system. In the Yale district, west of Lansdowne, at Adam's lake, Dr. Dawson and Mr. McEvoy have recorded, and refer, certain crystalline limestones to this horizon, and on the Dease river, in the Yukon territory, graptolitic slates similar to those of the *Wapta* formation at the Glen Ogle quarries on the Kicking Horse river have been described by Mr. McConnell, and the graptolites which those slates carry were studied by Prof. Chas. Lapworth, of Mason Science College, Birmingham, and reported upon to the Canadian Geological Survey.

## The Silurian System.

*The Acadian Region.*—The Silurian system as understood in Canada, and restricted to the upper division of Sir Roderick Murchison's Silurian is extensively developed both in Nova Scotia and New Brunswick. At Arisaig, in Antigonish Co., Nova Scotia, several thousand feet of more or less disturbed and inclined strata, including an almost regular succession of different members of this system, made up of sandstones, slates, iron ores, and black graptolitic slates and limestones, with mud-

stones, are well exposed, and present a compact fauna, which in *facies* closely resembles rocks in Herefordshire, in Cumberland, Westmoreland, in the Kendal and Ludlow regions of England. The "*Knoydart*" formation consisting of red shales and sandstones and calcareous bands holding pteraspidian and ostracoderm fishes and crustaceans referable to the Cornstone or lower Old Red sandstone of Great Britain, almost immediately overlies the Silurian strata, though no actual contact has been observed. The Silurian series at Arisaig consists of at least four distinct geological formations. Beginning above we have first the "*Stonehouse*" formation, consisting for the most part of dark red, fine-grained shales and mudstones, holding a conspicuous lamellibranchiate fauna, of which *Grammysia Acadica*, Billings, is a well known species, together with a number of interstratified more or less thin calcareous bands holding brachiopods, gasteropods, trilobites and ostracods in abundance. Below this we find the "*Moydart*" formation, which consists of more or less heavy-bedded, light greenish gray and rusty-weathering calcareous strata (in which the "Red Stratum" of authors occurs) and holds brachiopods, gasteropods, cephalopods and crinoids. Beneath this again we have the "*McAdam*" formation, consisting for the most part of impure black carbonaceous shales, which are splintery at times, holding a lamellibranchiate fauna and graptolites. At the base occurs the "*Arisaig*" formation, which comprises buff-weathering, fine-grained compact sandstones and shales, containing corals (chiefly *Streptelasma*), brachiopods, gasteropods and trilobites. The thorough investigation of this series of strata, which indeed, may require further subdivision, is expected to furnish data bearing on the settlement of the mooted question as to where the Silurian stops and the Devonian of America.[1]

In the county of Annapolis, Nova Scotia, and in the vicinity of Nictaux, Silurian strata occur including the *Nictaux* iron ore beds and the *Torbrook* sandstone formation, whilst near Kentville, the *Kentville* formation is seen as well as on Angus Brook in the Gaspereau Valley, also at New Canaan, with *Dictyonema Websteri*, Dawson, and at Wolfville in King's county where coralline limestones, red and green graptolitic slates, and other strata at times highly cleaved, squeezed and metamorphosed form conspicuous ridges, and constitute the oldest sedimentaries in the vicinity of the Bay of Fundy and the Blomidon region in the "Land of Evangeline."

In Cumberland county, along the northern slope of the Cobequids, isolated areas of Silurian strata have been mapped out and described by

[1] Remarks on subdivisions of *Arisaig* Silurian are inserted after going to press.—H. M. A.

Mr. Scott Barlow and Mr. H. Fletcher, the Wentworth and Farmington areas being among the most important and best known. These appear to belong to the lower half of the Silurian.

At White Bay and the Bay of Exploits Silurian strata occur in Newfoundland.

In New Brunswick, on the Beccaguimic river, in Charlotte county, near Canterbury in York Co., typical areas of Silurian rocks have been described by Prof. Bailey, Dr. Ells and Mr. Chalmers and other writers. In the northern part of this province, in the vicinity of Dalhousie, on Elm-Tree river, and other localities, rocks belonging to the Upper or Neo-Silurian consisting for the most part of limestones and slates have been recorded. The *Dalhousie* limestones bear a striking resemblance to the limestones of Lower Helderberg age in New York State.

In the peninsula of Gaspé, besides the *Chaleur group* or formation of Billings, which occupies a position about the horizon of the Guelph formation of Ontario, and the *Chatte* river limestones, several important areas of limestones have been recorded by Sir William Logan, and Dr. Ells. At Port Daniel, Percé, the *Percé* formation is met with, exhibiting cream-coloured fossiliferous limestones about the age of the Wenlock of England and Niagara of Ontario and New York ; and, along the Restigouche, Grand river, and Scaumenac river, as well as on the Cascapedia river, formations probably equivalent to the Niagara, Guelph, and Lower Helderberg and Water Lime group of the west, have also been recorded. In the Eastern Townships of Quebec, south-east of the great fault, in Stanstead, and Compton counties, limestones and shales holding Silurian fossils constitute several more or less isolated, but at one time connected Silurian strata, overlying unconformably the upturned edges of the older formations which have been eroded. In the more disturbed regions of these townships the upturned edges of the older formations have been recorded. In the more disturbed regions of these townships the Silurian strata often assume the character of mica schists, and when they are fossiliferous, resemble closely rocks of the same age in the Scandinavian peninsula, the organic remains suffering deformation and obliteration in direct ratio to the degree of alteration of the matrix.

*The Laurentian Highlands.*—In the region comprised under this term, the most important outcrop of Silurian occurs in the Hudson Bay basin. On the Nelson river about sixty miles above its mouth, on the Attawapishkat river, and on Mansfield and Southampton island strata which can be referred to this system have been described by Dr. Bell, and the fossil remains identified by Mr. J. F. Whiteaves and the writer. In the islands above named in connection with the Ordovician, Silurian strata overlie the former in regular succession. Fossil remains derived

from the Arctic regions have been described by Dr. Etheridge, Mr. Salter, and other writers, and indicate a Niagara or Wenlock age.

In the Lake Temiscaming basin Silurian fossils abound and are well preserved, some *eighty* species having been recently collected by Dr. Bell and Dr. Barlow, and these have since been studied and determined by Mr. Lambe and the writer. The horizon of this outlier was determined by Mr. Billings from fossils obtained by Mr. James Richardson, one of the staff under Sir William Logan in the early years of the Geological Survey of Canada.

*The Lawrencian Lowlands.*—Thin bedded limestones and shales in Anticosti form an important area of Silurian rocks. To this peculiar development Mr. Billings gave the name of Middle Silurian, inasmuch as the limestones of the Lorraine or uppermost Ordovician formation of this island passed upward without any break in lithological character or origin of sedimentation into several divisions or life zones which find their equivalent in other parts of Canada, in the Medina, Clinton, and Niagara formations. Local designations for the various members of the Silurian strata of Anticosti, based upon the faunistic relations which exist between the divisions as separated by Billings, will, it is hoped, shortly be discussed by the writer.

Isolated areas in the province of Quebec, referable to the lowest division of the system, namely, the Medina, occur on the south shore of the St. Lawrence, along the Yamaska river south of Lake St. Peter and notably near St. Grégoire, Que., where a strong brine has recently been struck. The *Medina* formation at this point is probably not less than 600 feet in thickness. On St. Helen's island, opposite Montreal, and on Belœil mountain (Montagne de Belœil), the *Lower Helderberg* formation which has been held for such a long time to represent the summit of the Silurian system in North America, may be seen in somewhat limited patches of compact and considerably altered light-gray limestone which abound in fossils. There is little doubt that at one time the Silurian system extended widely throughout the St. Lawrence valley, but Post Devonian erosion has carried off nearly every trace of its existence.

In Ontario, the Silurian system is well developed, and its different members which include in descending order :—

6.—The Water Lime formation
5.—The Onondaga formation
4.—The Guelph formation
3.—The Niagara formation
2.—The Clinton formation
1.—The Medina formation

As in New York state, these follow each other in regular succession. There is no evidence of a *Lower Helderberg* fauna or formation in the province of Ontario. *The Medina formation* consists for the most part of conglomerates and sandstones, with marls, red in colour, holding but few fossils, whilst the *Clinton* shales, calcareous and arenaceous, with a few dolomitic bands, and red or iron ore bands, such as may be readily seen in the Niagara gorge and escarpments near Hamilton, are followed by limestones and dolomites, compact and cherty, abounding in fossil remains belonging to the *Niagara* formation.

The *Guelph* formation with its light cream-coloured dolomites forms a not unimportant formation which is highly fossiliferous, and its fauna has been carefully and elaborately described by Hall, Billings and Whiteaves. In many localities in Canada the Medina, Clinton, Niagara and Guelph formations yield natural gas. The *Salina*, *Onondaga* and *Water-Lime* formations from which the salt, gypsum and cement stones of Ontario are derived, consist for the most part of light yellowish-gray compact dolomite which assumes a lithographic aspect in Welland county.

*Interior Continental Plain.*—At Cross lake rapids, and near the foot of the Grand rapids, on the lower Saskatchewan, as well as on the east side of Lake Winnipegosis, in portions of the province of Manitoba, as well as in the district of Saskatchewan, light yellowish-gray limestones, and cream-coloured dolomites sometimes porous, underlie the rocks of Devonian age. Their geological as well as palæontological characters have recently been made known by Messrs. Tyrrell, Dowling and Dr. Whiteaves and are referable in part to the Niagara formation. *Pentamerus decussatus* is a characteristic species from this horizon.

*The Cordilleran Region.*—In the Rocky mountain belt, in British Columbia, Mr. McConnell and Prof. A. P. Coleman, have examined a number of limited areas, probably referable to this system; notably along the Kicking Horse river, near the Glen Ogle slate quarries, and near the head-waters of the Columbia and Saskatchewan rivers. These localities have afforded fine examples of the genus *Halysites* (probably *H. catenulatus*) usually characteristic of the Silurian.

## The Devonian System.

*The Acadian Region.*—In Nova Scotia and New Brunswick, where the sedimentary formations of the palæozoic were being deposited along a more or less sinuous and broken coast line similar to that of the present day, many varieties of sediments occur. The only marine Devonian known in Nova Scotia to date is found in Annapolis county in the vicin-

ity of Bear River and Nictaux where it consists for the most part of dark gray and green and brown shales or reddish sandstone or arenaceous limestones, considerably squeezed and altered, constituting the *Bear river* formation. *Pleurodictyum problematicum* is one of the characteristic species of this horizon which is evidently lower or Eo-Devonian. The Devonian period in this province must have been one of extreme volcanic activity. It is most probable that the large areas of intrusive granites of the South mountain and other elevations along the main axis of Nova Scotia were thrown up during this period. Along McArras's brook, in Antigonish county, an extensive series of red shales and marls associated with tufaceous bands and grits appear to be shallow water and terrigenous in origin, and carry a fauna which in *facies* resembles that of Hereford, Eng., and the island of Spitzbergen. The presence of Ostracoderm and Cephalaspidian fishes indicate a horizon either at the base of the Devonian or the very summit of the (Upper) Silurian. This series of strata is designated as the *Knoydart formation*, and is a North American outcrop of the Lower or "Old Red sandstone" and Cornstone of Europe.

Devonian strata appear on the north side of White Bay, Newfoundland, which resemble in general character the Gaspé sandstones.

In Nova Scotia, lying unconformably underneath the limestones and gypsums of the province are found several thousand feet of stratified sandstones and shales, which carry a fauna and flora, whose affinities would place them within the Carboniferous system. This underlying series which constitutes the *Union* and *Riversdale* formations, has been classified as Devonian by a number of geologists. These strata correspond, in their taxonomic relations, to the *Mispec* and *Lancaster* formations of New Brunswick, consisting of red slates, conglomerates, and black shales, etc. From the internal palæontological evidence obtained during the last five years in rocks of this age, both in Nova Scotia and New Brunswick, the writer is constrained to place these series both from Nova Scotia and New Brunswick in the Carboniferous system. The *Riversdale formation* of Nova Scotia was placed in the Meso-carboniferous (Millstone Grit) by Sir William Dawson. Dr. D. White and Mr. R. Kidston recently place the *Lancaster* and Riversdale floras in the middle and Upper Carboniferous of America and Europe, respectively.

In Rocky Brook, Nashwaak, as well as on the Little Pokiok creek, along the Beccaguimic valley, N.B., strata, which appear to belong to the early or Eo-Devonian have been traced by Prof. Bailey, and Mr. C. Robb, whilst at Campbellton, along the Baie de Chaleurs coast, certain volcanic ash-beds carrying fish remains described by Dr. Whiteaves and Prof. Traquair are classed here as the *Campbellton* formation in the Eo-

Devonian. Across the bay in the peninsula of Gaspé numerous Devonian sediments both of marine and estuarine origin are well developed. At Indian Cove, Gaspé, Tar point, along the Dartmouth river, near Cape Haldimand, at Long cove, Red Head, also at Grande Grève, limestones and sandstones belonging to the base of this System have been described by Sir Wm. Logan, and their entombed fauna and flora studied by the late Mr. Billings and Sir Wm. Dawson.

There are other beds which may be called "passage beds" between the Silurian and the Devonian. At Scauminac bay, an interesting series of greenish-gray sandstone (*Scauminac* formation) occurs holding remains of Bothriolepis and Archæopteris which are placed at the summit of the Devonian, a probable equivalent to part of the Catskill of New York, as pointed out by Sir William Dawson, and other geologists.[1]

*The Laurentian Highlands.*—Within the Hudson Bay basin, Dr. Bell has recognized bituminous limestones and shales belonging to the Devonian along the Abitibi river. In some places the limestone contains free petroleum. On Moose river, on the Missinaibi, Devonian rocks, probably equivalent to the Corniferous of Ontario are found. On Rainy island and Lowasky island between the cliff and innumerable islands along the Attawapishkat river, also on the Albany river and Kenogami river, Devonian limestones, some of which appear to be the equivalent to the Hamilton formation of Ontario, have been recorded by Dr. Bell, and the fossils described by Dr. Whiteaves. Mr. Low also records Devonian limestones from a branch of the Severn river.

*The Lawrencian Lowlands.*—In the province of Quebec only a few isolated patches or outliers of Devonian occur. On the Famine river, coralline limestones occur of Eo-Devonian age, also on the Etchemin river, and in the Lake Memphremagog basin, where a *Cauda-Calli* horizon recently noticed by the writer, 1894, occurs, associated with coralline and shaly limestones referred by Sir Wm. Logan to the Devonian system. The presence of occasional pieces of Devonian limestone in the volcanic conglomerates of St. Helen's island, opposite Montreal, serves to indicate the former existence of Devonian limestone in that region, and points to a post-Devonian time in which Mount Royal was formed. In Ontario, the Silurian system characterized in its uppermost strata by beds of compact dolomite, are followed upward by the various members of the Devonian system which have an intimate relation with those of the states of New York, Pennsylvania, and Ohio.

[1] The term *Grande Grève* formation, suggested by the writer some time ago, has been recently accepted by Prof. J. M. Clarke and Mr. Schuchert, whilst they suggest the terms *St. Alban* and *Cape Bon Ami* to include the beds numbered 1 and 2, and 3, 4, 5, 6, respectively, in Billings's Gaspé section. (Inserted on going to press).

The following succession of Devonian formations obtains in Ontario, in descending order :

5.—The Chemung.
4.—The Portage and Genesee.
3.—The Hamilton.
2.—The Corniferous.
1.—The Oriskany sandstone.

The *Oriskany* consists of some thirty feet of light yellowish, at times calcareous sandstones, holding fossil remains in abundance, some *eighty* species have been recorded by Billings, Schuchert, and others. The *Oriskany* is overlaid by coralline limestones and dolomites teeming with corals, shells, and other fossil remains including fishes, constituting the *Corniferous formation,* followed upwards by the shales, limestones, and clays of the *Hamilton formation.* These shales also abound in corals and various groups of invertebrates with a few large fishes. The Hamilton formation is overlaid by a series of dark brown or black bituminous plant-bearing shales, with an occasional series of limestone bands, and brownish sandstones interstratified, which constitute the upper or Neo-Devonian of Ontario. These strata correspond to the *Chemung, Huron* and *Erie* shales of Ohio and Michigan. The petroleum-bearing strata of the Huron-Erie peninsula belong to this system.

*The Interior Continental Plain.*—Limestones of Devonian age have long been recognized in the Lake Winnipegosis and L. Manitoba regions of northern Manitoba, and the North West Territories. The rocks consist of cream-coloured dolomites and limestones teeming with organic remains. Mr. Tyrrell divides the Devonian of this region into three series; the Upper Devonian or *Manitoban* formation, the Middle Devonian or *Winnipegosan* formation, the third or Lower Devonian, not being yet clearly defined. It is from these limestones that Dr. Whiteaves recognized the "*Stringocephalus zone,*" or horizon overlaid by the beds which probably represent the "*Cuboides zone*!" These Devonian strata are also met with in the district of Saskatchewan. In the MacKenzie river basin, limestones, shales, and dolomites usually dark gray in colour are recorded by Mr. McConnell; also on the Liard river, a branch of the MacKenzie, and from the MacKenzie itself, they form an important trough of palæozoic rocks from Lake Athabasca to Great Slave and Great Bear lakes, northward covering the uneven surface of the Archæan floor. It was from these limestones that the fossils described by F. B. Meek were obtained.

*The Cordilleran Region.*—In the Rocky mountains, in the Cascade belt and the Fairholme mountains, dark gray cherty dolomitic limestones

and other limestones have been recognized; also in the neighborhood of Banff Springs hotel, (*Banff* shales), dark-gray shaly limestones, probably referable to the Neo-Devonian, whilst Dr. Dawson, Mr. Tyrrell and the writer have examined and recognized limestones of this age in the Crow's Nest and Kootenay passes. In his explorations along the north Saskatchewan Mr. McConnell has recognized a group of limestones referable to the Devonian, and which he calls the "*Intermediate* limestone." They consist of about 1500 feet of dolomitic limestones. In the Pipestone Pass, Sir Jas. Hector obtained *Atrypa reticularis* from strata supposed to be of Devonian age.

## The Carboniferous System.

*The Acadian Region.*—The *Carboniferous* System is one of the most important and extensively developed in Nova Scotia. The important coal-fields of Sydney, C.B., Pictou and Cumberland, contain vast quantities of fossil fuel for generations to come. The classification of the various members of this system in Nova Scotia requires further investigation before a complete tabular view can be given, although the general stratigraphical succession, or order in which the different formations or larger groups and series of strata, were laid down, has been fairly well established through the writings of Sir William Logan, Sir Chas. Lyell, Sir J. Wm. Dawson, Dr. Gesner, Dr. Ells, Mr. H. Fletcher, the Messrs. Poole, and other geologists.

In the Lower or Eo-Carboniferous, I provisionally place the terrigenous, or estuarine deposits, known as the *Union* and *Riversdale* formations which consist of red shales and marls with sandstones and conglomerates overlying gray and black siliceous and carbonaceous shales, &c., with impure coaly seams, which latter are of no special economic value. These strata, from their nature and composition, were evidently deposited upon a rapidly sinking floor and hold a fauna and flora which bind them to the Carboniferous rather than to the Devonian system to which they have been ascribed for many years. In the *Eo-Carboniferous* I would also place the *Horton* formation which throughout the Bay of Fundy trough, consists of black and gray carbonaceous and calcareous shales, &c., overlying granitic sandstones and marls, &c., which latter series constitute a separate formation in the Wolfville and Horton district. The name *Gaspereau* formation is suggested for these granitic sandstones of the Avon River valley and from Angus brook in the Gaspereau valley in King's county, N.S. Fossil plants found in strata of the Union or Riversdale formations, between Riversdale and Union stations (I.C.R.) in Colchester county also appear to have been found in the *Horton formation.*

The Union and Riversdale formations appear to lie unconformably below the limestones, gypsum and marls of the Windsor formation.

Overlying these Eo-Carboniferous rocks in Nova Scotia, there occur marine limestones and gypsum associated with limestone conglomerate and shales, and sandstones, and sandstone-conglomerates, commonly described as a *"Lower Carboniferous Series."* The most fossiliferous limestones, as at Windsor and Brookfield, have been referred to the *Windsor formation*, but a number of limestone bands of this series have been described by C. F. Hartt and Sir Wm. Dawson, from various localities in the same province under various designations and from researches carried on by the writer during the past five years in Nova Scotia, there is no doubt that several distinct horizons in the Carboniferous are marked by the different calcareous or limestone bands.

The *Windsor* formation is followed upward or accompanied by an extensive series of sandstone conglomerates and grits, or freestone, to which the term "Millstone Grit" formation has been applied. In the Pictou Coal Field the writer has recognised and described the *Westville formation*, equivalent to the so-called "Millstone Grit" of that district, which former name is suggested, inasmuch as the true and original "Millstone Grit" of England is doubtfully equivalent to the series of strata referred to the same name in Canada. The freestones and conglomerates of the *Westville formation* as developed along the Joggins shore, below the productive Coal Measures of Cumberland county are extensively used in the manufacture of grindstones and polishing materials. The *Stellarton formation* is the name applied to the shales, sandstones and associated coal-bearing strata of the "Coal Measures" of Pictou county as developed at Stellarton, on East River, along McLellan's brook and at the Acadia and other mines in Westville. The sedimentation in the Joggins region was remarkably different from that which we find in the Pictou basin, although not so far apart, and it may be advisable for the sake of accuracy and more exact definition to give different geological names to these two sets or series of strata occurring in these two districts at a later date.

Above the productive Coal Measures in the Joggins section (which section is probably the most complete and uninterrupted in Eastern America belonging to this system, being upward of 14,000 feet in thickness) we find more sandstones and shales, with conglomerates which are well developed along the east side of the Cumberland basin.

In Pictou county, unconformably above the *Westville formation* the *New Glasgow conglomerates* (*New Glasgow formation*) form a conspicuous feature in the Carboniferous sequence, as the basal series of a continuous section of strata extending from New Glasgow to Northumberland straits,

and continuing northward into equivalent and newer strata on Prince Edward Island.

The *New Glasgow* formation is overlaid by some 25 feet of impure fossiliferous limestone, which in turn is capped by sandstones, shales and coaly or carbonaceous bands (*Smelt Brook* formation.) Then follow an extensive series of yellowish gray and green freestones or grits, such as are seen in the vicinity of Pictou town, (*Pictou formation*); these are followed upward by coarser grits and conglomerates with an occasional band of cherty limestone overlaid by red shales and sandstones of Cape John and vicinity, constituting the *Cape John formation.* The Cape John rocks, sometimes called Permo-Carboniferous, are well developed in Prince Edward Island, especially along the south shore and probably represent the equivalent of the Windsor and Westville formations of Nova Scotia.

In New Brunswick, the *"Albert shales,"—Albert formation*—of Albert and Westmoreland counties, containing some forty per cent of hydrocarbons, belong to the Eo-Carboniferous. These are overlaid by conglomerates and marls, usually referred to the Millstone Grit.

The "Millstone grit formation" (so-called) appears to occupy almost the entire area of Carboniferous rocks in north and eastern, as well as central New Brunswick. The coal-bearing strata of Grand lake belong to this formation. In several isolated areas, outliers of Carboniferous limestones are seen to occur, and occupy a position, according to some, unconformably below the "millstone grit." The strata which by many geologists have been classed as Devonian in New Brunswick, in the vicinity of St. John, and which comprise the *Bloomsbury conglomerate*, the *Dadoxylon sandstone*, the *Cordaite shales* (constituting what the writer terms the Bloomsbury and Lancaster formations), with the *Mispec* series, are referred by me to the Carboniferous, as equivalents of the Union and Riversdale formations.

In the St. George Bay basin of Newfoundland, rocks of Carboniferous age also are recognised and probably represent the equivalents of the Windsor and Westville formations of Nova Scotia.

The only Carboniferous rocks so far recognized in the province of Quebec occur in Gaspé, and consist of conglomerates, called the "Carboniferous conglomerate," "Bonaventure conglomerate" or more simply and properly: *Bonaventure formation.*

*The Laurentian Highlands.*—North of the great Archeæn nucleus or protaxis, and on the most northerly of the Arctic islands, Carboniferous strata were discovered by the various explorers who visited the polar regions. Gypsiferous rocks and limestones occur on the east side of Prince Regent Inlet. Lower Carboniferous series overlaid by Car-

boniferous limestone have also been mapped by Dr. G. M. Dawson. Coal is recorded from several localities, viz.: Bank's Land, Cape Nares, Melville Island, and Bathurst Island.

*The Lawrencian Lowlands and the Interior Continental Plain.*—There are no Carboniferous rocks as yet detected in Ontario, nor in the interior continental plateau of the great North-West. It may not be at all improbable that in the south-western portion of Manitoba, and along the international boundary line, borings may reveal Carboniferous strata intervening between the Devonian and the Cretaceous.

*The Cordilleran Region.*—In the Cascade mountain ranges, along the Bow river pass, in the vicinity of Banff, in the Crow's Nest and Kootenay passes, Carboniferous limestones, holding characteristic marine fossils have been traced by Mr. McConnell and other geologists. In the Kamloops district Dr. Dawson records the occurrence of the *Cache Creek* formation, consisting of an upper series of limestone and a lower one of argillites. Some of the limestones from British Columbia contain *Fusulina* and *Loftusia*, and other Carboniferous fossil remains. In the Atlin and Yukon country limestones referable to this series also occur.

## The Permian System.

Under the term "Permian," Mr. Hugh Fletcher has included an important series of sandstones, shales and conglomerates of Nova Scotia in Pictou and Cumberland counties, but no characteristic fossil evidence has as yet been obtained to enable us to clearly separate these rocks from the Upper or Neo-Carboniferous. It is very possible however that the *Cape John* formation and associated formations may be equivalent to 'Permian' strata in other portions of North America or Europe.

## The Triassic System.

*The Acadian Region.*—Along the east coast of the Bay of Fundy, and associated with the traps of Annapolis and King's counties, an extensive series of bright red sandstones occur, which are usually referred to the Triassic system. Northeastward along the border of the Basin of Minas, as far as Truro, and again covering almost entirely the Chignecto isthmus and adjoining districts of Prince Edward Island, everywhere maintaining their peculiar soft red lithological character, extensive series of strata have been referred to this system. These sandstones are probably the northern extension of the "*Newark series*" of New Jersey, and of the Southbury area in Connecticut. In New Brunswick rocks of this age also appear along the west shores of the Bay of Fundy,

at Quaco, and other localities. The amygdaloidal traps and associated eruptives of Blomidon and the North mountain are probably contemporaneous with the red sandstones and hence of Triassic age also. The term *Grand Pré* formation is suggested for those soft Triassic sandstones as they are well developed at the Evangeline Beach on Long Island, Grand Pré near Wolfville, King's County, Nova Scotia.

*The Cordilleran Region.*—In the southern interior of British Columbia, the "*Nicola* series," or *Nicola formation*, is described by Dr. G. M. Dawson as consisting of volcanic rocks associated with limestones and argillites belonging to this system. In the Kamloops district as well as in the Similkameen river valley, the same writer also records Triassic rocks. In the northern part of Vancouver island, as well as in the vicinity of the Straits of Georgia, and in the Queen Charlotte islands, several areas of dark-gray fossiliferous limestones and shales with *Monotis subcircularis*, Gabb, indicate the occurrence of Triassic measures, including Forward inlet. Quatsino sound, Cape Commerell, and Hernando. In the Queen Charlotte islands, and underlying the Cretaceous system unconformably, rocks of this age are extensively developed on Moresby island, Burnaby island, and Ramsay island, along the shores of the Houston-Stewart channel, also on Richardson inlet. They consist of flaggy calcareous argillites, thin and massive limestones, underlaid by volcanic accumulations, at times including limestone beds of doubtful Carboniferous age. Near Glenora on the Stikeen river, and below the Devil's portage on the Liard river, in lat. 69° 16′ and longit. 125° 35′, Triassic rocks are also recorded.

On the Upper Pine river, and on the Peace river, in the vicinity of longit. 122°, lat. 56°, both Dr. Selwyn and Mr. J. Hunter obtained fossiliferous shales and limestones of Triassic age. The fauna which they hold serves to correlate the horizon of this region with the Triassic of the Queen Charlotte Islands and of California, *Monotis subcircularis*, Gabb, being the most characteristic species in common.

## The Jurassic System.

Save in the Arctic archipelago, there are but few occurences of rocks which may be definitely ascribed to the Jurassic system. On Grinnell island, Prince Patrick island, and Bathurst island, outcrops of Liassic rocks have been described by Prof. Haughton. Considerable discussion arose as to the age of the fossil remains obtained in these distant islands which eventually ended in the view that the fauna has a rather middle Jurassic *facies* than one of Liassic (Lower Jurassic) affinities. Of the interesting animal remains discovered, were those

from Exmouth island, obtained by Sir E. Belcher ascribed by Sir Richard Owen to *Ichthyosaurus*.

In the interior Continental plateau overlying the Trias of the Peace and Pine river country, certain shales and sandstones may possibly be referred to the Jurassic system. The continent of America and that portion with which this chapter deals was probably elevated to a great extent above the sea level, and erosion rather than deposition was going on in those days.

## The Cretaceous System.

*The Acadian Region.*—Overlying the eruptive traps of the North mountain in Annapolis county, near Ira Woodworth's bay, below Scot's bay, and on the east side of the bay of Fundy, there occur a series of light yellowish gray and green impure limestones and shales, which Dr. Ells has recently discussed in an interesting paper in which he argues the possible existence of strata referable to the Cretaceous system. No trace of organic remains has as yet been detected in these limestones. Obscure concretions are said to occur in them, but no definite fauna has yet been examined. These strata lie unconformably over the latest eruptives of the region and constitute a well-defined horizon in which subsequent researches may afford palæontological data to enable us to correlate the strata in question.

In the *Laurentian Highlands*, and throughout the *Lawrencian Lowlands* no rocks of Cretaceous age have as yet been detected either *in situ* or in Pleistocene drift. These portions of Canada must have been above the level of the sea during Mesozoic and Tertiary times.

*The Interior Continental Plain.*—In Manitoba and vicinity along the Red Deer river, north of Pine river, along the Vermillion and Assiniboine, and at Shoal lake, as well as at Deloraine, the Cretaceous system is represented by the following series of formations in ascending order: 1, *The Dakota formation*, consisting of light and dark brown, at times friable compact or shaly sandstones, especially on the Red Deer and Rolling rivers, in Saskatchewan. 2, *The Benton formation*, consisting for the most part of dark-bluish, gray or black shales, sometimes carbonaceous, at others holding glauconite in the form of foraminiferal casts, as seen in the drillings from the Deloraine well, from a depth of 1820 feet. 3, *The Niobrara formation*, which consists of dark gray or brown and bluish more or less fissile and phosphatic fossiliferous shales, characterized by the presence of *Inoceramus problematicus*, Schlotheim, interstratified with more or less dolomitic limestones. This formation is well developed on the Vermillion river. 4, *The Pierre formation*,

which Mr. Tyrrell divides into two series, the *Millwood series* (or formation), and "*Odanah series*," or formation. The former includes light and dark gray or brown, soft, friable or brittle shales and limestones which hold numerous Radiolaria. On the Duck and Poreupine mountains of Manitoba, the *Millwood* series is well developed. The *Odanah* series, with its light gray, finely laminated shales and clays, as seen on Shoal lake and Deloraine, and along the Assiniboine, in Manitoba, constitutes the uppermost member of the Cretaceous system in the eastern portion of the Great plains. In the western portion of the Great prairie plateau, including Alberta, Assiniboia, and Saskatchewan, and the districts to the north, the following succession obtains: 1, the *Dakota*; 2, the *Niobrara-Benton* or *Colorado formation*; 3, the *Belly River* series; 4, the *Fort Pierre*, (*Fort Pierre* and *Fox Hills*) or *Montana formation*; 5, the *Laramie formation*, which Dr. G. M. Dawson divides into (*a*) *Porcupine Hill* series; (*b*) *Willow Creek* series, (c) *St. Mary* (River) series; while Mr. Tyrrell divides the Laramie of Northern Alberta into two formations, viz.: (*a*) the *Edmonton series*, or formation (*b*) the *Paskapoo series* or formation. This latter is of decided Eocene or Tertiary age from the character of its entombed fossil remains.

The *Dakota* or lowest formation in the series of upper Cretaceous sediments of this region, appears to overlie unconformably and overlap rocks of Devonian age in its eastern extension. It is essentially a sandstone formation, and in the United States carries a luxuriant fossil flora.

The *Niobara-Benton* formation, consisting for the most part of shales and sandstones which are oftimes fossiliferous as in the Peace river section, is represented by the *Fort St. John shales*; the *Peace R. sandstones*, and the *Loon River shales*, whilst in the Athabasca section, these find their equivalent in the *La Biche* shales (lower part), the *Pelican* sandstones, and *Pelican shales*, and the *Grand Rapid* sandstones, and *Clearwater shales*. In the Peace R. section the *Dunvegan sandstones* appear overlying the *Fort St. John shales*, and are overlaid by the *Montana formation*, including the *Smoky R.* shales, and also the *Fox Hills sandstones*. In the Athabasca R. section the *Dunvegan* formation is absent, and the *Montana formation* is represented by (*a*) the *La Biche shales* (upper part), (*b*) *Fox Hills* sandstones. In both of these districts Laramie sandstones and shales constitute the newest sediments in the Cretaceous system. One of the most interesting features of the Cretaceous of the plains is the interpellation of the *Belly River* series of estuarine and fresh water sediments, between the Fox Hills and Ft. Pierre formations and the Niobrara-Benton constituting a series of beds in which the organic remains found resemble those of post-Pierre (or Laramie) age—equivalent to the St. Mary River series of Dr. Dawson.

Many types of animal life characterizing the *Belly River* series or formation, occur in abundance in the *Laramie,* which overlies the Fox Hills and Fort Pierre formation. In some respects the *Dunvegan* group of the Peace river country also resembles the Canadian Laramie and Belly R. formation. It is described as a plant-bearing series from which Sir Wm. Dawson has described an interesting flora, and may be termed the *Dunvegan formation.*

*The Cordilleran Region.*—In British Columbia, and in the Yukon district, rocks of Cretaceous age have been recognized by Dr. Dawson and Mr. McConnell, and their fossils recognised by Dr. Whiteaves and Sir Wm. Dawson. Along the foothills of the Rockies and on the summits and passes of the same mountains the various members of the Cretaceous of the prairie region are met with, but in a disturbed and broken condition. The Niobrara-Benton and Devil's Head lake deposits have afforded palæontological evidence to prove the existence of Cretaceous rocks, to the east, whilst in the southern interior of British Columbia, in the Kamloops district, beds of earlier Cretaceous age, consisting of argillites, limestones and sandstones which constitute a cycle of sedimentation which appears to be equivalent to similar rocks in the Queen Charlotte islands. On the west coast of British Columbia, the *Nanaimo formation* constitutes an important series of coal-bearing sediments, which is referable to the Upper or Neo-Cretaceous, besides the important outliers in the Queen Charlotte islands, also coal-bearing, constituting the *Queen Charlotte Island series.* These may be divided into several distinct horizons or formations in which most of the invertebrate fauna of the rocks of Skidegate Inlet constitute an important formation (the *Skidegate* formation) holding such forms as *Desmoceras Beudanti, Lytoceras Sacya, Melina Skidegatensis, Thetis affinis,* etc., etc., as described by Dr. J. F. Whiteaves. Hitherto, only a Lower or Earlier Cretaceous and an Upper or Later Cretaceous division in this system have been adopted. These Cretaceous coal-bearing rocks consist of shales, sandstones, conglomerates and iron ore, overlaid by coarse conglomerates (lower), which, in turn, are capped by an upper series of shales and sandstones which are ascribed to the Earlier Cretaceous, whilst the coal-bearing rocks of Nanaimo and the Vancouver Island region, which consist of marine limestones and shales, belong to the Upper Cretaceous.

There are but few species in common between the faunas and floras of the Upper Cretaceous of the Pacific coast and those of the same age in the Prairie region of Canada.

In dealing with the extinct floras of the Cretaceous system in Canada, Sir Wm. Dawson has recognized the following:—1, *The Lower Cretaceous,* including the *"Kootanie series,"* or *Kootenay* formation, of

the Rocky Mountains, with cycads, pines, and ferns, followed upward by the "*Intermediate series*" of the Rocky Mts., the "Queen Charlotte series," and Suskwa R., with their cycads, pines, and a few dicotyledons. 2, *The Middle Cretaceous*, comprising the "*Mill Creek series*" or *Mill Creek* formation of the Rocky Mts., and the "*Dunvegan series*" (Dunvegan formation), of the Peace river, with dicotyledons and coniferæ, which find their equivalents in the *Dakota group* of the United States. 3, *Upper Cretaceous*, including the coal-measures of Nanaimo (*Nanaimo* formation), with many dicotyledons, palms, etc., the "*Belly R. series*" with its lignites, conifers and dicotyledons. The Lower Laramie, or "*St. Mary R. series*," including the *Lemna* and *Pistia* beds of the bad lands of the Red Deer R., including lignites, also the Middle Laramie, or "*Willow Creek series*," which are overlaid by the "*Porcupine Hill series*," or Upper Laramie. From the Cretaceous rocks of Canada, Sir Wm. Dawson has recognized 179 species of fossil plants, and Mr. Whiteaves 394 species of fossil animal remains, if we include the whole of the Laramie as a part of the Cretaceous system. Along the Rink rapids of the Lewes R. marine Cretaceous fossils have been recorded, from the Yukon district. The Yukon district coal is probably of Cretaceous age. The coal beds at Anthracite, and the Crow's Nest coal strata are both of *Kootenay* age.

## The Tertiary System.

Neither in the Acadian region nor in the Laurentian Highlands, nor again throughout the Lawrencian Lowlands, are there found any recognizable traces of rocks properly referable to the Eocene, Miocene, or Pliocene, unless some of the pre-glacial gravels along the north shore of Lake Ontario, underlying the glacial deposits of the Toronto region may prove to be Tertiary in age.

*The Interior Continental Plain.*—The "*Paskapoo series*," or Paskapoo formation, or upper division of the Laramie, consisting of gray and brownish-weathering lamellar, or massive sandstones, and olive sandy shales of fresh-water origin, has, no doubt, been correctly referred to the Eocene Tertiary, and separated from the Cretaceous by Mr. Tyrrell. The fauna which these rocks hold, as well as their flora, affording satisfactory evidence in support of this view. This series overlies the *Edmonton* formation, and together with it, correspond to the *Porcupine Hill* and *Willow Creek series*, and part of the *St. Mary River series*, of Dr. Dawson in the South. The thickness of this formation is between 5000 and 6000 feet. It has been traced along with the Edmonton series, as the Laramie or Lignite Tertiary formation, by Richardson, Selwyn, Dawson,

and McConnell, southward from Alberta to the U. S. boundary line; eastward to Turtle mountain, in Manitoba; and northward to the Arctic circle in the MacKenzie river valley. The *Fort Union* beds or formation have also been recognized in the Souris River district.

It is believed that about the beginning of the Tertiary or the close of the Cretaceous, the Rocky Mts. began to be uplifted, whilst the plains sank beneath the surface of the sea. Then were deposited on the gradually sinking floor, the sandstones and shales of this series, in which occur the remains of deinosaurs, fresh-water shells, land plants, with occasional beds of coal.

*Miocene.*—In the Hand hills of the Prairie region, Mr. Tyrrell finds light-gray argillaceous marls interbedded with fine-grained sands, which pass upward into a bed of quartzite pebbles more or less held together in some places by a hard calcareous cement, forming a compact conglomerate. These strata resemble the argillites of the Cypress hills, first examined by Dr. Hector, in 1859, and are, no doubt, equivalent to the Miocene of the Cypress hills in the Assiniboia region, described by Mr. McConnell, known as Miocene conglomerates, etc. It was from the Cypress hills region that Mr. McConnell and Mr. Weston obtained the interesting series of fossil mammalian remains, described by the late Prof. E. D. Cope and referred to the *White River* division of the Tertiary, according to United States geologists or Lower Miocene. The *Saskatchewan* gravels are doubtfully referred to the Pliocene by some geologists.

It was possibly during this or a somewhat later period that many of the Æolian deposits of the west were laid down.

*The Cordilleran Region.*—In the Kamloops district of British Columbia, Dr. Dawson refers certain conglomerates and sandstones to the *Oligocene*, under the terms "*Coldwater Group*" and "*Similkameen*" beds. In the "*Tranquille Beds*" he describes and includes volcanic basalts and bedded tuffs ascribed to the *Earlier* and *Later* Miocene respectively. In the same region, unconformably over the *Tranquille* beds or formation, conglomerates of Early Pliocene age are also recorded. In the vicinity of the city of Vancouver, Mr. James Richardson, Dr. Dawson, and Mr. Amos Bowman, have examined the plant-bearing beds of this district, which form part of the "*Puget group.*" The strata in question form part of the lowland about the mouth of the Fraser river, extending northward to Burrard inlet. These strata are at least 3000 feet in thickness, holding carbonaceous matter, and more or less lignite coal at different horizons. Dr. Dawson further notes the possible

equivalency of certain unfossiliferous beds overlying the *Nanaimo* (coal bearing) formation at Comox and elsewhere in Vancouver island, as possibly in part equivalent to the *Tejon group* of California. In the southern interior of British Columbia volcanic rocks, sandstones, and shales, with fossil insects and plants, constituting the *Similkameen* formation, have been referred to the Miocene Tertiary. In the Queen Charlotte islands, rocks of Tertiary age occur on Graham island. They form the greater part of the island, extending from Skidegate to Pillar bay, and at the head of Masset inlet Tertiary volcanics prevail. On the north side of Skidegate inlet the Tertiary rocks consist of hard, thin-bedded, arenaceous clays, oftimes gray and micaceous associated with gravels and conglomerates, argillaceous lignite, holding trunks and branches of trees. At Ya-Kan point, and on the bank of the Hi-Ellon River at Toe Hill, calcareous sandstones and brown weathering granular dolerite occur, whilst at Skon-Un Point fossiliferous sandstones of Miocene or possibly Pliocene age (*Skonun* formation), have yielded an interesting fauna described by Mr. Whiteaves. On Ain river, Manin river and other localities, banded trachyte, lignites, volcanic agglomerates and obsidian have been detected and recorded. At Carmanagh Point, the *Astoria* Miocene occurs.

In the Arctic islands, Oswald Heer has described and recorded the existence of Miocene Tertiary plants and deposits on Prince Patrick island and Banks Land, from collections and observations made by McClintock, McClure, and Armstrong. Ballast beach, on Banks Land, has afforded large quantities of fossil wood, and plants.

On the Lewes and Yukon rivers, Dr. Dawson has recorded the occurrence of hard compact flinty and grayish-white argillite, holding plant remains, which may probably be referable to the Upper Laramie or Eocene Tertiary. The *Horsefly* Gravels and *Klondike* drift are also described by him as Pliocene.

## The Quaternary System.

The Quaternary deposits of Eastern British North America may be divided into three periods, viz.: 1, the *Glacial*, or boulder clays; 2, the *Champlain*, or marine clays deposited during period of submergence; 3, the Recent or terrace period of elevation.

*The Acadian Region.*—In summing the results of observation thus far made in south-eastern Canada, Mr. Chalmers says: "1. The glaciation of south-eastern Quebec, and northern New Brunswick was effected largely by local glaciers which moved northward and southward from the highest land or watershed adjacent to Notre Dame mountains, this watershed forming a gathering ground for the snow and neve which sent

local glaciers down the valley and along the lines of drainage into the St. Lawrence valley on the one hand, and the Baie de Chaleur, gulf of St. Lawrence, and St. John valley, on the other. The glacial deposits of the Acadian region of early pleistocene or glacial period proper, consist of typical boulder-clay or till, moraines, boulders, erratics, drumlins, &c., derived from pre-glacial rotted rock *in situ* angular boulders, gravel, sand, etc., which are known to have existed in sporadic masses and detached sheets in many portions of this region." It thus appears that local glaciers covered the greater portion of this region where to-day glacial striæ, boulders and other phenomena of the glaciation are everywhere evident. The nature and character of the boulder-clays depend upon the rocks characterizing the formations to be found in the valleys in which the glaciers travelled, so that at Pleasant ridge, in Northumberland county, N.B., for instance, in a limited area, Mr. Chalmers records the following number and variety of boulders: Granite, 88; diorite, 80; slate, 40; gneiss, 16; felsite, 12; quartz, 4. Among the glaciers described by Chalmers there are the Baie de Chaleur glacier, the Northumberland glacier, the Chignecto glacier, and the St. John valley glacier; which latter was the largest of the sheets occupying Canadian territory south of the St. Lawrence valley. Its source or nevé-ground was in the highlands of northern Maine, of the eastern townships of Quebec, and north-western N. B. At the close of the glacial period the St. Lawrence valley was probably an open channel as far west as the Thousand islands, where ice flowed in from the north and south, whilst land glaciers existed south of the estuary and gulf of St. Lawrence, in the elevated regions. Similar phenomena of glacial erosion and deposition followed by marine submergence and fossiliferous clay deposits occur on the island of Newfoundland. It is interesting to note that there are no evidences of Pleistocene ice action on the Magdalen islands, no boulder-clay having as yet been recorded or observed in that group.

Post-glacial earth movements are recorded by Dr. Matthew from near St. John, N.B.

*The Laurentian Highlands.*—The Labrador peninsula, during the glacial period, must have been covered with a great thickness of land ice which scattered the subjacent materials for drift into the valleys and fiords over a wide area of these Laurentian Highlands, extending in a south-westerly direction, over the Lawrencian Lowlands of Quebec and Ontario. Mr. A. P. Low observes that the striæ and other glacial phenomena between Hudson Bay and Ungava Bay show that the region was completely covered with ice during the glacial period, and that the ice

moved outward and downward from a narrow nevé near the present watershed.

The ice sheet which covered this peninsula has been termed the "*Labradorean glacier.*" The lower portions of the country traversed by Mr. Low are everywhere more or less covered with a mantle of boulder-clay or till, the hill-tops are for the most part bare, a tail of drift being deposited on the lee side. Lenticular hills or drumlins are not infrequent, and more or less parallel to the direction of the striæ. Erratics, eskars, or ridges of modified drift, occur between Hudson Bay and the watershed. On the west side of Hudson Bay, Tyrrell has described the *Keewatin glacier*, a name applied to the ice sheet which covered the central continental Archæan area. This glacier flowed outward from a gathering ground which lay north or north-west of Doobaunt lake during early glacial times, but subsequently changed its gathering ground and moved south-eastward to the country between Doobaunt and Yathkyed lakes. From these centres the ice seems to have flowed westward and south-westward to within a short distance of the base of the Rocky mountains, southward for more than 1600 miles to Iowa and Illinois; eastward into the basin of Hudson Bay; and northward into the Arctic ocean.

To the drift from the great Labrador peninsula and glacier the term *Labrador formation* is ascribed and for the sheet of till spread over the central portion of North America by the Keewatin glacier the term *Rupert* formation is suggested in order to designate its transported materials as we find them unmodified at the present time.[1]

*The Lawrencian Lowlands.*—As mentioned above, the boulder-clay or till, occupies the bottom of the valley of the St. Lawrence river constituting the *Labrador* formation, and underlies the newer marine clays and sands almost everywhere throughout its hydrographic basin. In Ontario, boulder-clays also occur in which the pebbles belong to all the formations present from the Archæan to the Devonian, and are superimposed by the *Erie* clay, which in turn is overlaid by the *Saugeen* clay and sands, also the *Artemisia* gravel and *Algoma* sand, besides the recent alluvial deposits overlying all. In the vicinity of Toronto, Prof. Coleman has recorded two boulder-clays interstratified with fossiliferous clays and sands to which the name *Toronto* formation has been applied. An interesting Pleistocene flora has recently been described by Prof. Penhallow from the Scarborough and Toronto beds, as well as from the Ottawa valley. Sir Wm. Dawson's work in Canadian Pleistocene geology is of great value and indispensable to the student.

[1] The term *Keewatin* has been applied by Lawson to rocks of Archæan age.

*Interior Continental Plain.*—Overlying the greater portion of the pre-glacial surface of this region are found a sheet of superficial sands, clays, and gravels, filling in and levelling up many of the irregularities in the surface of the Ordovician, Silurian, Devonian, Cretaceous and Laramie rocks, whilst in the case of many of the rolling hills, they serve to add to the surface irregularities. The following section of Quaternary rocks in the prairie region is given from the reports by Dr. Dawson and Mr. Tyrrell :—

Stratified sands, gravels, and silts.
Upper boulder clay.
Interglacial deposit with peat.
Lower boulder clay.
Quartzite, shingle, and associated beds.

The boulder clay consists of sand and clay held firmly together, holding pebbles composed of quartzite and gneiss in the eastern portion, whilst the percentage of quartzite pebbles becomes reduced out on the plains and sandstone pebbles more numerous, with fragments of lignite usually present. Ancient drainage systems, anterior to the present one, have been detected in many portions of the North-west territories. In the Athabasca lake and Churchill river districts, according to Mr. Tyrrell, the quaternary deposits include:—(4) Recent lake beaches and flood plains of the present streams; (3) Sand plains; (2) Ancient shore lines; (1) Till, drumlins, moraines, kames, eskars, and ispatinows. It is not at all unlikely that marine sediments constitute part of the prairie region of Canada. Glacial Lake Agassiz has been described by Warren Upham from Manitoba and adjoining districts.

The *Albertan* drift formation "belongs doubtless to the stage of general accumulation of the Ice Sheet followed by some recession, and then by the maximum glaciation known as the *Kansan* stage."

*The Cordilleran Region.*—The Cordilleran glacier is defined by Dr. Dawson as the ice cap, during the early portion of the glacial period, in British Columbia, which attained a maximum development of nearly 1200 miles in length from north to south. The main gathering ground of this ice sheet was between the 55th and 59th parallels of north latitude, extending in opposite directions, traversing to the Coast ranges, then filled the wide valley between Vancouver island and the mainland. The ice there divided and flowed in opposite directions, as subsidiary glaciers of Queen Charlotte Sound, and the Straits of Georgia. During the maximum of the *Cordilleran* glacier this region stood at a level considerably higher than it now does, and the great plains were probably depressed so as to admit waters from the sea. The retreat of the *Cor-*

*dilleran* glacier was contemporaneous with, if not caused by, a subsidence of the mountain region. Numerous observations of glaciation at levels reaching to 6880 feet, and ranging between 3150 feet and that figure, are recorded on the plateau between North Thompson R. and Dead Man R., on Mount Murray, in the Lytton mountains, and on the plateau between the Thompson and Nicola valleys, and the valley which connects Nicola lake and Kamloops. The *Cordilleran* formation, or drift, appears to be applicable to materials deposited by the Cordilleran glaciers, both east and west of the main axis of dispersion. On Barnes creek the following section occurs :—

(*c*) Silty deposits.
(*b*) Boulder-clay obscurely stratified, and
(*a*) Stratified gravels, silts and sands.

Terraces and shore lines are frequently met with, and white silts, also drumlin-like ridges, moraines, and other drift ridges.

Auriferous placer deposits occur in different periods of the drift of British Columbia. In the Yukon district Dr. Dawson, Mr. Tyrrell, and Mr. McConnell have recorded interesting glacial phenomena, and stratified gravels and sands, many of which have proved to be auriferous. Terraces, indicating higher levels or former reaches of rivers, and glacial lake deposits have also been described.

*The Champlain Period.*—This was a period of subsidence in which the Acadian region as well as a portion of the Laurentian Highlands along their margin, and the Lawrencian Lowlands for the most part were depressed beneath the level of the Atlantic waters. Stratified gravels, sands and clays and kames associated therewith overlaid by river and lake terraces and accompanying kames inland, and *Leda* clays and kames, together with *Saxicava* sands, the latter formed by marine agency, characterize this period throughout Nova Scotia, Prince Edward island, and New Brunswick, whilst the most recent deposits or formations of Quaternary age consist of the river flats and intervales (alluvium) estuarine flats, mussel or oyster beds, natural dykes, etc., with dune or blown sand overlying both. In both the St. Lawrence and Ottawa River valleys terraces of marine clays occur to a height of over 600 feet, and are overlaid by sands and gravels, constituting the *Leda* clay formation and *Saxicava* sand, which nearly everywhere prove to be highly fossiliferous. At River du Loup, Beauport, St. Liboire, and Montreal island, at the Mile End quarries, and the Tanneries, in the province of Quebec, and at Green's creek, and Besserers, near Ottawa, and other localities in the Ottawa valley, an interesting fauna and flora, indicating cold and marine conditions abound. The *Montreal Saxicava* (sand) formation, the *Beauport* sands and gravels, the Leda clay, the *Macoma* sands, the

*St. Maurice* and *Sorel* sands, etc., are as many geological horizons and formations which enter into the nomenclature of the Pleistocene of eastern Canada.

*The Interior Continental Plain.*—In Manitoba, lake beaches and delta deposits characterize the recent pleistocene period. The Champlain period is represented in this province by the beaches and deltas of Lake Agassiz, associated with terraces and valleys. During the glacial period in Manitoba, till, moraine, drumlins and kames in the valleys occur throughout, whilst on the Rolling river may be seen clays and sands possibly referable to inter-glacial or pre-glacial times.

## The Recent Period.

It was not until after the close of the Champlain period in Canada, that man made his appearance. A period of elevation followed the period of submergence. On the north shores of Lake Erie, remains of the mastodon and the mammoth, which were the elephants of the New World, indicate their presence immediately after the close of the glacial period. The remains of deserted villages of the aborigines of British North America, characterizing the various strides of the American race, their graves, or burial places, have been found, together with their stone or copper implements, in all our provinces and only in the most recent of our superficial deposits, whilst with these implements, are found associated remains of beaver, deer, bear and other animals of the chase identical with those of to-day.