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'97

THE

PHYSICAL GEOGRAPHY AND GEOLOGY

OF

CANADA,

BY

GEORGE M. DAWSON, C.M.G., F.R.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

A most excellent treatise.

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Reprinted from the Handbook of Canada, issued by the Publication Committee of the Local Executive of the British Association.

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THE Dominion of Canada embraces the northern half of the continent of North America, with its adjacent islands, including those of the Arctic Ocean between the 141st meridian and Greenland, but exclusive of Alaska, in the extreme north-west, the island of Newfoundland, which still remains a separate British colony, and the small islands of St. Pierre and Miquelon, retained by France. In order, therefore, to include the sister colony of Newfoundland, the general name, British North America must still be employed. The total area of Canada is estimated at about 3,574,980 square miles, of which the Arctic islands to the north of the continental land make about 309,000 square miles. Thus, with Newfoundland (42,000 square miles), the aggregate area of British North America is 3,616,980 square miles. This area is somewhat larger than the United States (including Alaska), and not much less than all Europe.

The form of the North American continent may be described as that of an isosceles triangle, of which the narrower part, pointing to the south, constitutes Mexico, a wide central belt, the United States, while the broader base is the Dominion of Canada. The northern base-line of the continental land lies approximately on the seventieth parallel of north latitude,

but is broken into by the geographically important sea named Hudson Bay, 800 miles from north to south, and some 600 miles in width. Historically, this great indentation of the northern land has been notable in connection with the exploration and trade of British North America, and it promises in the future, when modern means of communication have been adapted to the circumstances, again to become important. But the ruling physical features upon which the existence of Canada as a country depends, and about which its history has grown up, are, the proximity of the north-eastern part of the continent to Europe, and the existence of a great waterway, the River St. Lawrence, running to the very centre of the continent, and expanding there into the group of inland seas generally spoken of as the Great Lakes. The first of these made the landfall of Cabot in 1497 possible, the second led Cartier (in 1535) to the sites now occupied by the cities of Quebec and Montreal, and opened a route of exploration and commerce to subsequent explorers and traders of France, by which they overran much of the central and western country of North America before the colonists of New England, further to the south, achieved a way across the Appalachian highlands which there barred their progress.

The course of the St. Lawrence and the position of the Great Lakes may be regarded as being determined by the southern outline of the Laurentian plateau, composed of ancient crystalline rocks, which in U-shaped form surrounds the central depression of Hudson Bay. Spreading widely in the Labrador peninsula, this tract of relatively high and generally rocky land, runs with narrower dimensions round the southern extremity of the bay, and thence is continued north-westward to the Arctic Ocean. With one important exception, that of the Ontario peninsula, which juts far to the south, the great river and its reservoirs lie

along the southern edge of these highlands, while the Winnipeg system of lakes, Athabasca, Great Slave and Great Bear Lakes, occupy a very similar position on the outer rim of the north-western extension of the plateau.

Suess has named this plateau, composed of Archæan rocks, the "Canadian shield." In respect to form, it is the most important geological feature of the continent, for, under whatever name, it must be considered its nuclear tract or "protaxis." About it the later sediments, from Cambrian times to the present day, have been spread, their material being largely supplied by its waste, and against it or parallel to its main outlines, successive movements of the earth's crust have forced up the newer and now higher ranges of the Appalachian and the Cordilleran systems, while, so far as we are able now to determine, the ancient shield itself has remained comparatively unaltered and fixed. Following the trends of the south-east and south-west sides of the Laurentian highlands respectively, the Appalachian mountains and those comprised in the western Cordillera converge to the south, embracing between them, to the south of the Great Lakes, the central plain of the continent, based upon comparatively undisturbed and nearly horizontal strata, which it may reasonably be conjectured repose, at no very great depth below the surface, upon a now concealed southern extension of the original platform. But there is an important want of symmetry in these main orographic features, for, between the western edge of the Laurentian highlands and the Cordilleran ranges, a wide tract of the central plain runs northward to the Arctic Ocean, constituting in its southern part, the great arable inland country of western Canada.

From a physiographical and geological standpoint, the Canadian part of the continent may very naturally be regarded as composed of two great divisions—an

eastern and a western; the line between these beginning at the south near Winnipeg, on the central longitude, and running thence along the outer edge of the Laurentian plateau north-westward to the Arctic Ocean. To the east of this line, while the surface is generally broken and irregular, the relief is nearly everywhere comparatively low. The rocks are almost altogether referable to the Palæozoic systems or to systems older than these, and there is little evidence of important change during the later geological periods, beyond such as is incident to the gradual wearing away and denudation of very ancient highlands and mountain systems.

To the west, the Mesozoic and Tertiary systems become important. The entire spread of the great plains is floored by such rocks, and they occupy also a large part of the western Cordilleran belt, although there mingled with important areas of much older rocks. At a late date, geologically, the Pacific Ocean has spread over nearly all this part of the continent. The vast orogenic changes which have resulted in excluding the sea from the region are comparatively recent; many of the mountain ranges of the Cordillera are rugged, new and lofty, and the processes of denudation are still going on very rapidly, with rivers and streams flowing at high grades, and very far from that passive condition found where the drainage system has approximately reached the base-level of erosion.

A two-fold division of the northern part of the continent, of the kind above indicated, although based upon fundamental facts in its geological history, is, however, much too general for the purposes of description of its several regions as they present themselves to us to-day. The characteristically mountainous region of the Cordillera, and that of the great central plain, must be separately treated; while the great eastern division is not only larger than that of the

west, but, being in its southern portion the home of the greater part of the population, requires closer consideration. The boundaries of the several provinces, resulting from circumstances of a more or less political kind, do not always correspond with the natural features, and cannot therefore be adopted as the best for purposes of geographical and geological description. Relying chiefly upon the physical and geological facts, we may therefore further subdivide the continental part of Canada as follows :—

(1.) *The Acadian Region*, including the Maritime Provinces of the Atlantic, with the similarly characterized south-eastern part of the Province of Quebec, bounded by a line running from the Strait of Belle Isle to the City of Quebec, and thence to Lake Champlain.

(2.) *The Lowlands of the St. Lawrence Valley*, extending, with an irregular width, from the City of Quebec to Lake Huron, and including the Ontario peninsula.

(3.) *The Laurentian Plateau*, which, notwithstanding its vast area, may, from a physiographical point of view, be regarded as a unit.

(4.) *The Interior Continental Plain*, running with narrowing dimensions from the 49th parallel to the Arctic Ocean, and embracing part of Manitoba and the North-West Territory.

(5.) *The Cordillera*, or great mountain belt of the west, including the greater part of British Columbia and the whole of the Yukon district.

Before entering upon the description of the several regions thus defined, something may be said of the drainage system of the northern part of the continent as a whole. Only the most general notice can be given to the rivers and lakes of Canada in a review so short as this must necessarily be, but no feature of the country is more important, whether historically

or geographically, than the great length and volume of its principal watercourses, and the manner in which these interlock and penetrate almost every part of its area. Besides the St. Lawrence, with its drainage basin of 530,000 square miles, to which allusion has already been made, there are three more rivers of the first class, of which the watersheds are wholly or in great part included by Canada. These are the Nelson, the Mackenzie and the Yukon. The first-named reaches Hudson Bay, bringing with it the waters of the Saskatchewan and other large and long rivers which drain a vast region in the centre of the continent. Its basin is estimated at 367,000 square miles. The Mackenzie, flowing into the Arctic Ocean, drains not only most of the northern part of the interior plain of the continent, but also considerable portions both of the Rocky Mountain region and the Laurentian plateau, with a basin of about 677,000 square miles. Next to the St. Lawrence, it is the longest river of Canada, being not less than 1,800 miles from its source to its mouth. The Yukon, discharging into the northern part of Behring Sea, unwaters a great tract of the northern part of the Cordilleran region comprised in Canada, besides flowing across the whole width of Alaska.

It is only by contrast with these greatest rivers that many more are relegated to a second or third rank, as an examination of the map will show. It will also be apparent that much the larger part of the country lies on the northern slope of the continent, regarded as a whole, and that the remainder is divided between the Atlantic and Pacific sides, but an inconsiderable region being tributary to the southward-flowing system of the Missouri and its branches.

It may be useful, in this connection, to state the heights of a few of the larger lakes, as ruling features in physical geography. The Great Lakes, although

they stand at four levels, in reality occupy only two distinct stages, separated by the Niagara Falls. Below this cataract is Lake Ontario, 247 feet, above it Lake Erie, 573 feet, Lakes Huron and Michigan, 581 feet, and Lake Superior, 602 feet.

Further to the west and north-west are, Lake of the Woods, 1,062 feet, Lake Winnipeg, 710 feet, Lakes Manitoba and Winnipegosis, 810 and 830 feet, respectively, Athabasca Lake, 690 feet, Great Slave Lake, about 520 feet, and Great Bear Lake, about 340 feet. Each of these lakes marks the lowest level of large tracts of adjacent land.

The Acadian Region, regarded as a whole, forms the north-eastward continuation of the Appalachian mountain system. This mountain system, beginning not far from the Gulf of Mexico, gives form to the eastern coast of the United States, from which it is never far distant. In Vermont and New Hampshire, it is represented by the Green and White Mountains, and its main line runs on, though with much decreased elevation, through the south-eastern part of the Province of Quebec, under the name of the Notre-Dame Mountains. Not far below the City of Quebec it approaches the St. Lawrence, and thence continues parallel with that river and its great estuary, all the way to Gaspé, on the open gulf. In the Gaspé peninsula it is known as the Shickshock Mountains. Considerable parts of these mountains rise well above 3,000 feet, but the Notre-Dame range seldom exceeds 1,000 or 1,500 feet, and its elevations resemble rolling and broken hills and ridges, rather than mountains properly so called. The whole length of this main continuation of the Appalachian system in Canada is about 500 miles.

Subordinate and less continuous elevations, nearly parallel to the main range thus outlined, occur in New Brunswick, chiefly along two lines, one of which strikes the Baie des Chaleurs below its head, the other, some-

what divergent in direction to the eastward, bordering the southern shore of the province along the Bay of Fundy. The rocks of all these ranges are in the main older than those of the Carboniferous system, and between the two last-mentioned ridges, in New Brunswick, lies a broad triangular area of nearly horizontal beds referable to the Carboniferous formation. Besides this large level area, there are many others of lesser size and numerous large valleys, comprised in what has been designated the Acadian region, in Quebec and New Brunswick. These often afford excellent arable land, or support valuable forests. The character of the soil varies greatly, chiefly in conformity with that of the subjacent rocks; but it has also been considerably affected, as in almost all parts of Canada, by the nature and amount of the deposits due to the glacial period.

Though lying at some distance to the south-eastward of the main line, the peninsula of Nova Scotia may best be regarded as a member of the Appalachian system of uplifts, with which it is parallel. Its elevation nowhere exceeds 1,200 feet, and is in general very much less. A broad range of broken hills and uplands extends along the Atlantic coast of the province and into the island of Cape Breton. The Cobequid Hills are next in importance to this, running to the north of that arm of the Bay of Fundy known as Minas Basin, and joining the last at an angle, near the middle of the province. The Atlantic coast range is chiefly composed of old Cambrian rocks and granites, with little land of agricultural value, but rich in gold-bearing veins, which occur in all parts of its length. With the disturbed area of the Cobequids, rocks as new as the Devonian are largely involved. The best arable lands of Nova Scotia are situated towards the Bay of Fundy, and along the northern side of the peninsula generally. Here also, and in Cape Breton, the important coal-fields occur.

In the general and inclusive sense in which the

term "Acadian region" has been employed, this has thus a width of about 350 miles, between the outer coasts of Nova Scotia and the St. Lawrence estuary. Followed to the south-eastward, this belt of country embraces the New England States and part of New York, all with very similar physical characters. In the opposite direction it is interrupted by the Gulf of St. Lawrence, but reappears in the great island of Newfoundland, still preserving most of its characteristic features, although somewhat modified in appearances by differing climatic conditions. Throughout this region, including Newfoundland, the geological structure is alike, the formations represented are nearly the same, and, both in composition and from a palæontological standpoint, they often resemble those of the opposite side of the Atlantic more closely than they do those of other parts of North America.

Before speaking of the geological features of the Acadian region in Canada, two exceptional areas within its limits may be referred to. In the semi-circular bay formed by the coasts of New Brunswick and Nova Scotia, separated from the mainland by Northumberland Strait, is Prince Edward Island, a province by itself, although not much more than 2,000 square miles in area. This lies opposite the Carboniferous and Permo-Carboniferous lowlands of eastern New Brunswick and northern Nova Scotia, and consists entirely of undisturbed and unaltered Permo-Carboniferous and Triassic red sandstones and shales. Characteristic fossils of both formations have been found, but the circumstances render it difficult to draw a line between them. The surface of the island is for the most part fertile and highly cultivated, nowhere exceeding 500 feet above the level of the sea.

The second area of an exceptional character, is that of the island of Anticosti, lying in the wide estuary of the St. Lawrence, and 140 miles in length. This again consists of nearly flat-lying rocks, chiefly of the

Silurian with some of Cambro-Silurian or Ordovician age (Hudson River) along its northern side. The island evidently represents part of a submerged and undisturbed Cambro-Silurian and Silurian tract of the northern part of the Gulf of St. Lawrence, the rocks of which differ in some respects from their representatives further to the west. The island is generally wooded, and is at present very scantily inhabited.

The geological scale is well represented in Nova Scotia and New Brunswick, from the Archæan to the Triassic, but thereafter ensues a long gap, during which no deposits appear to have been formed, probably because the area in question then existed as land, exposed to denuding agencies alone. Closing this unrepresented lapse of time we find only the clays and sands referable to the glacial period, with still more recent deposits, such as those of the fertile marsh lands of the Bay of Fundy.

With the exception of the flat-lying tracts between the several axes of elevation the wide Carboniferous area in New Brunswick and marginal developments of rocks of the same age along the northern coast of Nova Scotia and in Cape Breton, the region must be considered as one of exceptional geological disturbance and complexity, which, notwithstanding the large amount of investigation it has received, is still but imperfectly understood. One cause of difficulty lies in the existence, at several horizons, of thick masses of strata composed of ancient volcanic materials, generally without organic remains. This is a character common to the rock-formations of most parts of the Appalachian region of North America, which has been at many times the theatre of great volcanic activity. The occurrence of similar rocks in the south-eastern part of the Province of Quebec has been the cause of much of the uncertainty attaching to the understanding of the "Quebec group" there.

The region is not a typical one for the Archæan

rocks, but areas of crystalline schists referable to this time occur. Most of these have so far been mapped simply as pre-Cambrian, for no separation into groups has yet been effected. A large tract of the kind occupies the northern part of Cape Breton. In the southern highlands of New Brunswick, particularly in the vicinity of the city of St. John, the Archæan is better characterized and bears a resemblance, almost amounting to identity, with the typical developments of these rocks in Quebec and Ontario. A Lower Laurentian series comparable with the "Fundamental gneiss" is found, with an upper series composed of crystalline limestones, quartzites, etc., like the Grenville series. Newer than these is a mass of strata composed chiefly of volcanic materials, breccias or agglomerates, greenstones and felsites, which is referred to the Huronian system. Further areas of the same kind occur in central New Brunswick.

Forming the backbone of the peninsula of Nova Scotia and bordering its whole Atlantic coast, is a belt characterized by granitic masses and old stratified rocks assigned to the Lower Cambrian. This belt is widest in the south-west part of the province and narrows gradually in the opposite direction. The granites date from about the Devonian period, and it was probably in connection with their intrusion that the bedded rocks were thrown into the great series of parallel, sharp flexures, in which they now lie and which bear so intimate a relation to the systems of gold-bearing veins. The disturbances incident to this period are, in fact, those which have chiefly given form to the Maritime Provinces. All the older rocks are involved in them, while those of the Carboniferous remain comparatively unaffected.

These Cambrian rocks consist of a lower quartzite series and an upper clay-slate or argillite series, the latter generally dark in colour. It must be added that no really characteristic fossils have yet been obtained

from these gold-bearing rocks. Distinctive Cambrian faunas have been found only in a few places in Cape Breton.

In the vicinity of St. John, New Brunswick, a remarkably interesting and complete section of Cambrian rocks, well characterized by fossils, occurs. This may now be regarded as typical for the eastern part of Canada and Mr. G. F. Matthew, to whom its elaboration is chiefly due, remarks particularly the resemblance of the fauna to that found in rocks of the same age around the Baltic sea, rather than to that of the interior of North America. In time, the series runs from the Etcheminian (older than the *Olenellus* zone) to the highest Cambrian.

Rocks of Cambro-Silurian (Ordovician) age have also been determined in the locality just referred to, and sparingly in other parts of New Brunswick. In Nova Scotia, the only fossils of the kind come from a single place in Cape Breton, but considerable areas supposed to be of this age, chiefly composed of volcanic materials, occur in other parts of the province.

Silurian (Upper Silurian) rocks, are widely spread in northern New Brunswick, and in adjacent portions of Quebec, occupying the greater part of the area which drains to the Baie des Chaleurs. They recur in the southern part of New Brunswick and in the northern part of Nova Scotia, and although comprising limestones, sandstones and shales, are often greatly intermixed with contemporaneous volcanic materials, indicating, it will be observed, a third important volcanic interlude in the history of this part of the continent. In Nova Scotia, important bedded iron ores (hæmatite) appear in this series. The geological horizons represented, as compared with those of the New York scale, range from the Clinton to the Lower Helderberg.

In the rocks of Devonian age, occurring in that portion of the Appalachian region covered by Nova Scotia, New Brunswick, the Gaspé peninsula of Quebec, and

a part of the adjacent State of Maine, a remarkably full representation of the flora of that ancient period is found, from which more than 125 species of land plants have been catalogued by Sir J. Wm. Dawson; while at Scaumenac, on the Baie des Chaleurs, rocks of this age have yielded many interesting fish remains, investigated by Mr. J. F. Whiteaves, which compare closely with those of the Old Red Sandstone. Further west, in beds of the same period in Ontario and New York, the fossils are chiefly marine molluscs, with comparatively little evidence of the existence of adjacent land. The lower part of the Devonian of the Maritime Provinces holds a similar fauna, and contains in Nova Scotia bedded fossiliferous iron ores. The geographical extent of the Devonian rocks in Nova Scotia and New Brunswick is comparatively limited, but in the Gaspé peninsula of Quebec it becomes somewhat important.

The Carboniferous system, both from its extent and because of its economic value, must be considered as one of the most important features of Nova Scotia and New Brunswick, although there is reason to believe that much larger tracts of this formation still lie beneath the waters of the Gulf of St. Lawrence and the Atlantic. Its total thickness is, in some parts of Nova Scotia, estimated at 16,000 feet, but it is very irregular in this respect and over the greater part of New Brunswick is comparatively thin. At the Joggins, on the north arm of the Bay of Fundy, is a remarkable continuous section showing 14,570 feet of strata, including more than seventy seams of coal, which has been made the subject of investigation by Logan, Lyell, and Sir J. Wm. Dawson. From beds in this section numerous specimens of a land-inhabiting reptilian fauna have been described. The flora of the period is well represented in many places, particularly in Nova Scotia, and includes that of several distinct stages, beginning with the Horton group at the base

(comparable with the "calciferous sandstone" of Scotland and the lower part of the sub-Carboniferous of Ohio, Tennessee and West Virginia,) and at the top containing so many forms referable to the Permian, that the name Permo-Carboniferous has been applied to this part of the section.

Several local unconformities have been determined in different parts of this great succession of beds. With the marine limestones, important deposits of gypsum are found. The workable coal-seams occur in what is called the Middle Carboniferous, and some of these, in the Pictou district, are of unusual thickness. Coal mining is actively in progress in Cumberland and Pictou counties and in Cape Breton, the total annual output being between two and three million tons. In New Brunswick, the productive area for coal appears to be small, and the seams so far found are of inconsiderable thickness.

To complete this very brief review of the geology of what has been called, broadly, the Acadian region of eastern Canada, it now only remains to add a few words concerning that main line of uplift and disturbance, the course of which was first traced through the Province of Quebec, from the vicinity of Lake Champlain to Gaspé. This structurally complicated belt of country has been the subject of much controversy, and possesses now a literature of its own. It is bounded to the north-westward by an important dislocation or break, known as the St. Lawrence and Champlain fault, which may be traced from Lake Champlain to Quebec City, and thence follows the estuary of the St. Lawrence, probably running to the south of Anticosti. To the west of this line are the flat-lying Cambro-Silurian strata of the St. Lawrence plain, chiefly limestones, and doubtless resting upon a strong shelf of the Laurentian nucleus at no great depth. Against this stable edge, the eastern strata have been folded, faulted and ridged up by the forces

which produced the Appalachian range. Were this all, a careful study of the beds on the two sides of the line would readily show their identity; but, it appears, that previous to the great epoch of disturbance the original physical conditions themselves differed. To the west, a sheltered sea came into existence about the close of the Cambrian period, in which Cambro-Silurian strata, in large part limestones, were laid down. To the east, sedimentation began much earlier, and the circumstances of deposition were different and more varied. Even the animal life present in the two districts was largely dissimilar at the same period, probably as a result of different temperatures in the sea water. Thus it was not until much study and thought had been given to the problem that Logan was enabled to affirm the equivalency of a great part of the strata on the two sides of the St. Lawrence and Champlain fault. To those on the east, differing in composition and fauna from the rocks of the typical New York section, he applied the name "Quebec group." Regarded as a local name attached to the Atlantic type of the lower members of the Ordovician, and distinguishing these from rocks of the same date deposited upon the Continental plateau, this term may still be employed with advantage, expressing as it does a most important fact. Subsequent investigations have shown, however, that in the ridging up of this part of the Appalachian region, not only are some very old Cambrian rocks brought to the surface, but considerable areas of crystalline schists which are evidently pre-Cambrian, and very possibly referable to the Huronian. These were originally included in the "Quebec Group," under mistaken ideas of metamorphism, but their elimination from it, now rendered possible, does not detract from the merit of the original discovery, nor does it impair the value of the term "Quebec group," as a descriptive one, if properly limited.

In this folded and disturbed region of south-eastern Quebec, copper ores, asbestos and chromic iron are among the more important minerals of value. Silurian rocks and some of Devonian age rest in places unconformably upon the older corrugations.

Some facts respecting the glacial deposits of the Appalachian region are given on a later page, with general statements relating to this period in eastern Canada.

Lowlands of the St. Lawrence Valley. The tract of country which it is found convenient to include under this name, comprises but a small part of the hydrographic basin of the great river, which in all is about 530,000 square miles in extent. Nor is it altogether uninterrupted, although clearly enough defined in a general way by the edge of the Laurentian plateau on the north, the Appalachian highlands to the south-east, and on the south, further west, by the line of the St. Lawrence River and the lower members of the system of the Great Lakes. It may be described as extending from a short distance below the city of Quebec to Lake Huron, with a length of over 600 miles and an area of more than 35,000 square miles, all of which may be regarded as fertile arable land—the greatest connected spread of such land in eastern Canada.

These lowlands are based upon nearly horizontal strata, ranging in age from the latest Cambrian (Potsdam sandstone) to the Devonian. On a geological map its limits are readily observable; but in order to understand its character, it is necessary to consider it somewhat more clearly, and under such scrutiny it is found to break up naturally into three parts. The first of these is divided between the Provinces of Quebec and Ontario, running west along the St. Lawrence and its great tributary the Ottawa somewhat beyond the 76th meridian, or to a north-and-south line drawn about twenty-five miles west of the city of Ottawa. It is here interrupted by a projecting, but not bold,

spur of the Laurentian plateau, which crosses the St. Lawrence at the lower end of Lake Ontario, forming there the Thousand Islands, and runs southward to join the large Archæan tract of the Adirondacks in the State of New York. This Eastern division, with an area of 11,400 square miles, constitutes what may be called the St. Lawrence plain proper, parts of which were among the first of those occupied by the early French settlers. Much of its surface is almost absolutely level, and it nowhere exceeds a few hundred feet in elevation above the sea, although a few bold trappean hills stand out in an irregular line, with heights of 500 to 1,800 feet. Mount Royal, at Montreal, is one of these, and from it all the others are in sight, while the Laurentian highlands may also be seen thirty miles to the north, and to the southward the Green Mountains and Adirondacks, forming the boundary of the plain in that direction, are apparent on a clear day.

Beyond the projecting spur of ancient crystalline rocks above referred to, from the lower end of Lake Ontario, near Kingston, to Georgian Bay of Lake Huron, the southern edge of the Laurentian plateau runs nearly due west, with a slightly sinuous line, for 200 miles. Between this edge and Lake Ontario on the south, lies a second great tract of plain, the lowest parts of which may be considered as level with Lake Ontario (247 feet) but of which no part exceeds 1,000 feet above the sea. This plain is naturally bounded to the south and west by the rather bold escarpment of the Niagara limestone, which, after giving rise to the Falls of Niagara between Lakes Ontario and Erie, runs across this part of the Province of Ontario to Lake Huron, forming there a long projecting point and continuing still further west, in the chain of the Manitoulin Islands. The city of Hamilton lies close under a part of this escarpment. The area of this second tract of plain is about 9,700 square miles. It is scarcely

more varied in its surface than that to the eastward, and most of its extent is a fertile farming country.

The third and last subdivision of the lowlands of the St. Lawrence valley, is an area of triangular form included between the Niagara escarpment and Lakes Erie and Huron. This constitutes what is generally known as the Ontario peninsula, and its south-western extremity touches the 42nd parallel, the latitude of Rome. The area of the Ontario peninsula is 14,200 square miles, and both in soil and climate it is singularly favored. Grapes, peaches and Indian corn, or maize, are staple crops in many districts. To the north, some parts of this tract are high and bold, but most of its surface varies from 500 to 1,000 feet above the sea.

The geological features of the lowlands of the St. Lawrence valley are comparatively simple. The rocks flooring the region lie either horizontally or at very low angles of inclination upon the spreading base of the Archæan mass to the northward, the crystalline rocks of which have frequently been met with in deep borings. The formations represented correspond closely with those of the New York section, which had been rendered typical by the researches of James Hall and his colleagues, before any definite examination of the geology of Canada was begun. Hall's nomenclature has been adopted for the series, which, beginning with the Potsdam sandstones, continues upward without any marked break, to the Chemung or Later Devonian.

In the first or eastern subdivision of this region, the Potsdam sandstone, although strictly speaking referable to the Upper Cambrian, physically considered is really the basal arenaceous and conglomeritic member of the Cambro-Silurian (Ordovician) series which follows. The several members of the Cambro-Silurian occupy almost the entire surface, diversified merely by a few light structural undulations, which to the south

and east of Lake St. Peter result in the introduction of some higher beds that are referred, although with some doubt, to the Silurian. Fossils referable to this period are also found associated with a small patch of volcanic breccia on St. Helen's Island, opposite Montreal. This is probably connected with the adjacent igneous mass of Mount Royal, and by it the age of this mass, as well as that of the other similar prominent points of the same character in the vicinity, is pretty definitely fixed as latest Silurian or Lower Devonian. It would in fact appear that these igneous masses represent the necks of ancient volcanic eruptions, which have since been subjected to prolonged denudation. In their vicinity the sedimentary rocks are shattered and disturbed and traversed in all directions by trap dykes. Basic rocks (theralite, etc.,) together with nepheline-syenites are characteristic.

Passing to the second, or central subdivision, to the west of Kingston, the Cambro-Silurian formations just referred to are found to be repeated, in ascending order, along the north shore of Lake Ontario, with very similar characters and equally undisturbed. The Trenton limestone occupies the greatest area, extending in a wide belt to Georgian Bay of Lake Huron. Above this lie the Utica shales, and over these the Hudson River formation, upon which Toronto is situated. This is the highest member of the Cambro-Silurian, but the plain also overlaps the lower members of the succeeding Silurian system irregularly, finding its natural boundary, from a physical point of view, only at the massive outcrop of the Niagara limestone.

The course of the escarpment produced by this outcrop has already been traced; above it and to the south-west, lies the higher plain generally known as the Ontario peninsula, constituting the third subdivision of the St. Lawrence lowlands. More than half of the area of this peninsula is occupied by Devonian rocks, which succeed the Silurian regularly in

ascending order, the highest beds being met with in the extreme south-west of Ontario, beyond which, they are soon followed by the Carboniferous basin of the Michigan peninsula. The Silurian and Devonian strata are affected only by slight and low undulations, but these are important in connection with the exploitation of the oil and gas of the region.

In the two eastern subdivisions of the lowlands of the St. Lawrence valley, with the exception of structural materials, such as stone, lime and clay, minerals of economic value are scarcely found; but in the third or westernmost subdivision, in addition to these, gypsum, salt, petroleum and natural gas have become important products. The gypsum and salt are derived from the Onondaga formation of the Silurian. The salt is obtained in the form of brine, from deep wells, but beds of rock-salt are known to occur at considerable depths. At Goderich, two beds of very pure salt have been proved by boring to exist at a depth slightly exceeding 1,000 feet, with an aggregate thickness of over 60 feet. Petroleum is chiefly derived from the Corniferous limestone of the Devonian, and natural gas is obtained from several horizons both in the Devonian and Silurian.

The Laurentian Plateau. The great region thus named, composed of very ancient crystalline rocks, has an area of over 2,000,000 square miles, or more than one-half that of the entire Dominion of Canada. In a horse-shoe-like form, open to the north, it surrounds three sides of the comparatively shallow sea known as Hudson Bay. Its southern part is divided between the Provinces of Quebec and Ontario, its eastern side expanding into the Labrador peninsula, while the western runs, with narrower dimensions, to the Arctic Sea, west of the great bay.

In geographical extent it is thus very important, although somewhat monotonous in its physical and geological features. It contributes little to the fertile

areas of the country in proportion to its size, but in the aggregate, comprises a considerable amount of land which is either cultivated or susceptible of cultivation. Elsewhere, in its southern parts, it carries forests of great value, and its mineral resources are already known in some places to be very important. It constitutes, moreover, a gathering ground for many large and almost innumerable small rivers and streams, which, in the sources of power they offer in their descent to the lower adjacent levels, are likely to prove, in the near future, of greater and more permanent value to the industries of the country than an extensive coal field. Particularly notable from this point of view is the long series of available water powers which runs from the Strait of Belle Isle nearly to the head of Lake Superior, coincident with the southern border of the plateau.

Although it is appropriate to describe this region as a plateau or table-land, such terms, it must be understood, are applicable only in a very general way. Its average elevation of about 1,500 feet is notably greater than that of the adjacent lands, and is maintained with considerable regularity, but its surface is nearly everywhere hummocky or undulating. Away from its borders, the streams draining it are, as a rule, extremely irregular and tortuous, flowing from lake to lake in almost every direction; but assuming more direct and rapid courses in deeply cut valleys as they eventually leave it. Many of the surface features are of very great antiquity, Mr. Low's observations in Labrador going to show that the larger valleys there existed much in their present form before the Cambrian period.

The average height of the central parts of the Labrador peninsula is about 1,700 feet, and the most of its drainage is divided between Hudson Bay, Ungava Bay and the Atlantic coast, the main watershed lying not very far to the north of the St. Lawrence estuary and gulf. Along the Atlantic coast, to the north of

Hamilton Inlet, the region assumes a really mountainous character, numerous elevations attaining 3,000 feet, and some as much as 5,000 or 6,000 feet. These are the highest known points connected with any part of the Laurentian region, and are quite exceptional in character. The same high range is continued to the north of Hudson Strait in the western part of Baffin Land.

To the south of Hudson Bay, the watershed is, at least in one part, as low as 1,000 feet. East of Lake Winnipeg, the Nelson and Churchill Rivers cross the Laurentian plateau, in a wide depression, to reach Hudson Bay. Still further north, this part of the plateau has a height of about 1,100 feet above the sea.

Generally speaking, the surface of the plateau is barren and rocky, though often with wide swampy tracts towards the height-of-land. To the south-west of Hudson Bay it is overlapped by an important spread of Silurian and Devonian rocks, over which, and the adjacent parts of the crystalline rocks, is rather uniformly spread a mantle of alluvial deposits, affording a good soil, which in some places may eventually be of value, although the climate is doubtfully favourable to the growth of ordinary crops.

The striking features of the Laurentian plateau are immeasurable lakes, large and small, with intervening rounded rocky elevations, wooded, in their natural conditions to the south, rising above the tree line to the northward; while in the far north, on both sides of Hudson Bay, hills and valleys become eventually characterized by grasses, mosses and lichens alone, constituting the great "barren lands" of North America. The rivers and lakes are everywhere well stocked with fish, while deer and moose in the southern parts, and to the north the caribou, abound wherever the Indian hunters have not followed them too closely. Thus, where the region can be entered without undue diffi-

culty, it has already become a much favoured resort of the sportsman.

The name by which it is found convenient to refer to this region, although derived from that of the Laurentian system of geologists, must not be supposed to imply that the rocks attributed to this system occupy the whole area. There are, besides, several wide and many narrower bands of Huronian rocks, as well as outlying areas referred to the Lower Cambrian, and more such exceptional areas of both kinds doubtless remain to be discovered. It must be understood, too, that in employing the name Laurentian for the most widely represented member of this great Archæan plateau, this is done in a very general and inclusive manner; the term "basement complex" is adopted by some geologists in nearly the same sense. The results of late investigations, particularly those of Dr. F. D. Adams, seem to prove that in the Laurentian, as thus understood, there is a distinctly stratified series of limestones and other sedimentary rocks, all now highly altered and crystalline, as well as another series of more massive gneissic rocks, of which the apparent bedding is really a foliation due to pressure, and which frequently pass into granites by imperceptible gradations. The first of these is known as the Grenville series, and the second as the Fundamental Gneiss; but even where most closely studied it has been found impossible completely to separate the two series, except quite locally, and thus, for the purposes of a general geological map, both must of necessity be indicated by a single colour. The complication alluded to is further increased by the frequent occurrence of true eruptive masses of granite or syenite of much later date, as well as by that of numerous great areas of anorthosite, a rock of the gabbro family, composed principally of plagioclase felspar.

The Huronian rocks are as a rule darker in colour and more basic in composition than those of the

Laurentian. They are often still distinctly bedded, although very frequently in the form of schists in which no true bedding is now distinguishable, and some of which have evidently resulted from the crushing of eruptive rocks. Over great areas the original material of the Huronian has clearly been in large part the result of volcanic eruptions of the time, but elsewhere, as on the north shore of Lake Huron, and in the Sudbury and Lake Temiscaming districts, it comprises thick masses of argillite, quartzite and quartz or jasper conglomerate. The rocks composing the Fundamental Gneiss often assume the physical relations of eruptives, of later date to the Huronian, along the lines of contact; but in how far this may really be the fact, and in how far this appearance may be attributed to a certain amount of re-fusion of previously existing basal rocks, has not been determined.

The Cambrian outliers date from a time subsequent to the main era of folding and crushing of the subjacent rocks, in comparison with which they are little disturbed. In the Labrador perinsula, they characterize considerable areas, and they form a border, tilted against the edge of the Laurentian plateau on the east side of Hudson Bay. These areas appear to represent the Animikie series of the Lake Superior section; well seen in similar relations in the vicinity of Port Arthur. These rocks are evidently separated by a vast period of unrepresented time from the Archæan below, and it is assumed that they may be attached with greatest probability to the base of the Cambrian, although no distinct fossils have been obtained from them. To the west of Hudson Bay and far to the north, are other outliers, largely composed of sandstones, conglomerates and traps, which resemble the Keweenawan or Nipigon of Lake Superior, somewhat later in age than the last. These also are provisionally classed as Lower Cambrian. The Nipigon rocks are well shown along the line of the Canadian Pacific railway to the east of Port Arthur.

Minerals of economic value in the Laurentian are almost entirely confined to the Grenville series, which yields, in various parts of its extent, mica, apatite (phosphate), graphite, iron and marble. The Huronian rocks are those in connection with which numerous important gold-bearing veins and deposits are now being found and opened up in western Ontario, as well as the nickel and copper deposits of Sudbury, iron and other metallic ores. In the Cambrian rocks near Port Arthur are silver-bearing veins, some of which have been extensively worked, and iron ores, while in the Labrador peninsula vast quantities of iron ores have been discovered in the same series.

Glaciation of Eastern Canada. Something may be added here on the events of the glacial period as affecting the eastern part of Canada as a whole, although many points connected with this particular period, still remain uncertain and the subject of debate. Like the Scandinavian peninsula, the Laurentian plateau at one stage in the glacial period apparently became the seat of a great confluent ice-sheet, which, when at its maximum, flowed down from it in all directions in general conformity with its main slopes. Climatic conditions and relatively local physical features may have conspired to render the discharge of glacier-ice more important in some directions than in others, and it is even possible that at no single time was the whole extent of the plateau equally ice-clad; but on the hypothesis above stated, it has been proposed by the writer to designate the ice-sheet of the Laurentian highlands, the Laurentide glacier. If several distinct centres of dispersion existed throughout, these may be named collectively the Laurentide glaciers. It is certain, at least, that such local centres must have grown up at the beginning of the period of cold, and that towards its close similar centres must have again remained as the last seats of ice action. Two of these have been defined by the existing marks

of rock striation and transport, one to the west of the northern part of Hudson Bay, named by Mr. Tyrrell the Keewatin glacier, the other, resulting from the observations of Mr. Low, to the east of the bay, the Labradorian glacier.

During the whole of this period the Laurentian plateau was in the main an area of denudation. From it the surface material was carried away in all directions, even to the northward, for there is absolutely no evidence that any "polar ice-sheet" ever trenched upon the continent of North America. The generally bare ice-scored rocky surface of these highlands is evidence of this denudation, while the existence of broken, angular masses of unmoved local débris in the central part of Labrador and in the central area of the Keewatin glacier, shows that across these neutral gathering-grounds, no ice ever passed.

As to the distance to which the solid glacier-ice came southward from the Laurentian plateau, the evidence is yet inconclusive, for it is at best a matter of difficulty at the present day to definitely separate true moraines from beaches upon which floating ice impinged. Neither is it certain at how many times or to what extent the glacial period was interrupted by relatively warm epochs, but it may be stated that the flora of at least one of these interglacial epochs, as represented in the vicinity of Toronto, is such as to indicate a climate fully as warm as that at present existing, during which it seems improbable that much, if any, glacier-ice could have persisted on the Laurentian highlands.

These problems cannot be discussed here, but it is certain that at or about the decline of the glacial period, the eastern part of Canada as a whole stood at a relatively low level. Without quoting in detail the heights to which the sea is known to have reached at this time in various places, it may be stated that it invaded the St. Lawrence valley as far at least as Lake

Ontario. Water-formed terraces are found at elevations of 230 feet in the Gaspé peninsula, to a maximum of 895 feet in the vicinity of Richmond, midway between Quebec and Montreal. Near Ottawa, the highest recognized shore-line is at 705 feet. The plains lying below these are floored by deposits holding marine shells of sub-arctic type, and these have been found at Montreal to a height of 560 feet. It is uncertain whether or not at the time of greatest subsidence the water covering the area of the Great Lakes stood at the same level as, and was in direct connection with the sea, but it is not improbable that what has been described as the "Iroquois beach," around these lakes, may actually form the continuation of a high marine shore-line. The question is complicated by the unequal amount of the subsidence and re-elevation to which the land has been subjected, a question requiring much further investigation.

As a result of the circumstances noted, the St. Lawrence plain, as far west as Ottawa and Kingston at least, is deeply covered by deposits due to the glacial period, including boulder-clay, Leda clay and an overlying Saxicava sand, the two last, often full of fossil shells of the period. In the coastal regions of the Maritime Provinces similar deposits occur, to which the same names have been extended, but to the west, around the Great Lakes, no marine forms have been found. The stony boulder-clay is there overlain by a fine clay named the Erie clay and by various newer sandy and clayey beds. All these deposits of the glacial period possess great importance in respect to the soil and agricultural character of the country over which they prevail, and in large part its exceptional fertility is to be attributed to them.

Before leaving this subject, it may be noted that the Laurentide glacier in the east, below the city of Quebec, never crossed the estuary of the St. Lawrence. A separate but smaller gathering-ground of ice existed

in New Brunswick and adjacent parts of the State of Maine, which has been called the Appalachian glacier. This has been very clearly shown by the work of Mr. Chalmers. The Magdalen Islands, in the centre of the Gulf of St. Lawrence, have never been glaciated, and it is at least a matter of doubt whether any ice, except that originating on the peninsula itself, ever passed over Nova Scotia. Newfoundland similarly shows evidence of having produced a local ice-sheet which flowed away toward the sea in all directions along the natural slopes. It is also found by Mr. Chalmers, that when the Laurentide glacier invaded the lowlands to the west of Quebec, the Appalachian glacier had either greatly decreased or had vanished. There are in this district two distinct boulder-clays, one referable to each of these glaciers, and it is probable that interglacial beds will yet be found there.

The Interior Continental Plain. This is bounded on the west by the Rocky Mountains, running about north-northwest, and on the east by the edge of the Laurentian plateau, which, taking a more westerly direction than the mountains, causes the gradual narrowing of the intervening plain to the north. Thus on the 49th parallel, here constituting the southern boundary of Canada, the plain has a width of about 800 miles; but it is reduced to less than 400 miles on the 56th parallel. To the north of the 62nd parallel, it is very greatly narrowed, and is broken by echelon-like flanking ranges of the Rocky Mountains, but still further northward it again expands, and appears to have a width of nearly 300 miles, where it terminates on the Arctic Ocean.

The southern part of this great plain is not only the most important from an economic point of view, but is also that about which most is known. It includes the wide prairie country of the Canadian west, with a spread of about 193,000 square miles of open grass-land, an area more than twice that of Great Britain. Beyond the

North Saskatchewan River, the plain becomes essentially a region of forest, with only occasional prairie tracts, such as those of the Peace River valley. By chance rather than by intention, the boundary line on the 49th parallel, to the west of the Red River, nearly coincides with the low watershed which separates the arid drainage-basin of the Missouri from that of the Saskatchewan and its tributaries, cutting off only 20,000 square miles from the Missouri slope. Another line, nearly coinciding with a second low transverse watershed, may be drawn on the 54th parallel. The watershed crosses this line several times, but in the main it may be taken as dividing the Saskatchewan system of rivers from those of the Mackenzie and the Churchill. The belt of country comprised between these latitude lines is 350 miles wide, with a total area of about 295,000 square miles.

The whole interior plain slopes eastward or northeastward, from the Rocky Mountains towards the foot of the Laurentian highlands, so that a line drawn from the base of the mountains near the 49th parallel to Lake Winnipeg, shows an average descent of over five feet to the mile, fully accounting for the generally rapid courses of the rivers of the region. There are, however, in the area to the south of the 54th parallel, two lines of escarpment or more abrupt slope, which serve to divide this part of the plain into three portions, and although such division is by no means definite, it may usefully be alluded to for purposes of description.

The first or lowest prairie-level is that of the Red River valley, of which the northern part is occupied by the Winnipeg group of lakes, its average elevation being about 800 feet above the sea, although gradually rising to the southward, along the axis of the valley, till it reaches a height of 960 feet about 200 miles to the south of the International boundary. Its area in Canada is about 55,000 square miles, including the lakes, and to the south of Lake Winnipeg it comprises

some 7,000 square miles of prairie land, which to the eye is absolutely flat, although rising uniformly to the east and west of the river. This is the former bed of the glacial "Lake Agassiz," the sediments of which constitute the richest wheat lands of Manitoba.

The escarpment bounding this plain on the west, begins at the south in what is known as "Pembina Mountain," and is continued northward in the Riding, Duck, Porcupine and Pasqua hills, which overlook Manitoba and Winnipegosis Lakes, constituting the main eastern outcrop of the Cretaceous rocks of the plains. From this escarpment, the second prairie-level extends westward to a second and nearly parallel marked rise, which, in general, is known as the Missouri Côteau. The area of this plain is about 105,000 square miles, of which more than half is open prairie. Its average elevation is about 1,600 feet, and its surface is more diversified by undulations and low hills and ridges than that of the last, while the river-valleys are often deeply cut as well as wide. The greater part of the surface is well adapted for agriculture, although in places the scarcity of trees constitutes a disadvantage. The character of the soil is also more varied than that of the lower plain.

The third and highest plain, lying between the last and the base of the Rocky Mountains, may be stated to have an average height of 3,000 feet, with an area, between the parallels of latitude first referred to, of about 134,000 square miles, of which by far the greater part is almost absolutely devoid of forest, its wooded area being confined to its northern and north-western edges, near the North Saskatchewan River or its tributaries. The surface of this plain is still more irregular than that of the last, and it is evident that both before and after the glacial period the denuding forces of rain and rivers have acted upon it longer and more energetically. Table-lands like those of the Cypress Hills and Wood Mountain, must be regarded as outlying rem-

nants of an older plain of the Tertiary period, and the slopes and flanks of such outliers show that similar processes of waste are still in operation, adding to the length and depth of the ravines and "coulées," by which the soft Cretaceous and Tertiary rocks are trenched. The deposits of the glacial period, with which even this high plain is thickly covered, have tended to modify the minor asperities resulting from previous denudation. The soil is generally good, and often excellent, but large tracts to the south and west are sub-arid in character, and suited rather for pasturage than for agriculture.

Along the base of the Rocky Mountains is a belt of "foot-hills," forming a peculiar and picturesque region, of which the parallel ridges are due to the differing hardness of the Cretaceous rocks, here thrown into wave-like folds, as though crushed against the resistant mass of the older strata of the mountains.

Taken as a whole, the central plain of the continent in Canada may be regarded as a great shallow trough, of which, owing doubtless to post-Tertiary differential uplift, the western part of the floor is now higher in actual elevation than its eastern Laurentian rim. But although thus remarkably simple and definite in its grand plan, there are many irregularities in detail. The second prairie-level has, for instance, some elevations on its surface as high as the edge of the third plain, both to the west and east of the valley of the Assiniboine River, which, again, is abnormally depressed. It is not possible here to do more than characterize its features in a general way.

Ever since an early Palæozoic time, the area now occupied by the interior plain appears to have remained undisturbed, and to have been affected only by wide movements of subsidence or elevation, which, although doubtless unequal as between its different parts, have not materially affected the regularity of the strata laid down. Upon this portion of the continental platform, in

its eastern part, on Lake Winnipeg and its associated lakes, Cambro-Silurian, Silurian and Devonian rocks are found outcropping along the stable base of the Laurentian plateau. Following this line of outcrop northward, the Devonian rocks gradually overlap those of older date and rest directly upon the Archæan. They continue to the Arctic Ocean and there occupy a great part of the Northern Archipelago. To the south of Athabasca Lake they rest, without any apparent angular unconformity, upon sandstones referred to the Lower Cambrian, to which allusion has already been made, giving evidence, in the stratigraphical hiatus, of prolonged periods during Palæozoic time in which land as well as water existed in some parts of the area. On the western side of the Great Plains the Palæozoic strata reappear crumpled and broken in the Rocky Mountains, where the vast crustal movements of the Cordilleran belt found their inland limit.

These rocks consist, for the most part, of pale-grey or buff, often magnesian limestones, along the eastern outcrop, and from them Mr. Whiteaves has described an extensive and somewhat peculiar fauna. Some, at least, of the Palæozoic formations represented, probably extend beneath the entire area of the Great Plains, but they are wholly concealed there by later strata of Cretaceous age, consisting chiefly of clay-shales and sandstones, generally but little indurated and flat-lying, or nearly so. The uniformity in the surface features of this country is principally due to that of these deposits, which, although since greatly denuded, have worn down very equally, and have apparently never been very long subjected to waste at a great height above the base-level of erosion. The whole area has in fact been one rather of deposition than of denudation up to a time geologically recent, and has very lately been levelled up still further by the superficial deposits due to the glacial period.

The Cretaceous rocks are for the most part distinctly marine, although beginning with the Dakota sandstones, indicative at least of shallow seas, and from which, in the Western States, a considerable flora of land plants has been recovered. These are followed, in the eastern part of the plains, by the Benton shales, the Niobrara, largely calcareous and foraminiferal in some places, the Pierre shales, and lastly by the Fox Hill sandstones. Further west, in Alberta, a part of the Pierre (with probably also the upper portion of the Niobrara), is represented by the Belly River formation, with a brackish water fauna, and containing beds of coal or lignite. The Dunvegan series of the Peace River, to the north, similarly characterized, is perhaps somewhat older. The Cretaceous strata in fact change very materially in composition and character toward the Rocky Mountains, and when followed to the north, giving rise to the necessity for local names, and rendering a precise correlation difficult in the absence of connecting sections over great tracts of level country.

All the Cretaceous strata so far referred to belong to the later stages of that system, but in the foot-hills the earlier Cretaceous is represented by the Kootanie formation, holding coal, and reappearing as infolds in the eastern ranges of the Rocky Mountains. One of these is followed by the valley of the Bow River between Banff and Canmore, and affords both anthracite and bituminous coal.

Overlying the Cretaceous rocks proper, in considerable parts of their extent, particularly in Alberta, are those of the Laramie, which although perfectly conformable with the marine strata beneath, contain brackish water, and in their upper part entirely fresh water forms of molluscs, together with an extensive flora and numerous beds of lignite-coal or coal. As a whole, this formation may be regarded as a transition from the Cretaceous to the Tertiary, with a blending of

organic forms elsewhere considered as characteristic of one or the other. The lower parts are undoubtedly most nearly related to the Cretaceous and particularly to the Belly River beds, which were laid down under similar physical conditions at an earlier stage. The remains of Dinosaurian reptiles are still abundant in these. The upper beds, constituting what was originally named the Fort Union group, with its local representatives under different names, is on the contrary more nearly allied to the Eocene.

A still later stage in the Tertiary is represented by beds of Oligocene, or early Miocene age, found particularly as an outlier capping the Cypress Hills. These have afforded numerous mammalian bones, described by Professor Cope and referred by him to the stage of the White River beds of the Western States.

The aggregate thickness of the Cretaceous strata of the plains, so far as known, may in the eastern part be stated as about 2,000 feet; in the west, in northern Alberta, it is about the same, but exceeds 2,500 feet in south-western Alberta, without including the Kootanie series of some 7,000 feet or more. The thickness of the Laramie is also great toward the Rocky Mountains, reaching probably 3,700 feet.

The Pliocene (with perhaps the latter part of the Miocene) appears to have been a time of erosion only in the area of the Canadian plains; wide, flat-bottomed valleys were cut out in the foot-hills, and to the east of these great tracts of country between the now outstanding plateaux must have been reduced to the extent of 1,000 feet or more in height.

Mineral fuels, in the form of coals and lignite-coals, constitute economically the most important products of the Cretaceous and Laramie rocks of the plains. To the south of the 56th parallel in Canada, an area of not less than 60,000 square miles is underlain by beds of such fuel. These consist entirely of lignite to the eastward, but on entering the foot-hills bituminous

coals are found, and similar coals recur in infolded areas in the Rocky Mountains, together with anthracite.

Natural gas has been found in considerable quantities in borings in several places, but is not yet utilized. Great outcrops of Cretaceous sandstones saturated with tar or maltha occur along the Athabasca River, probably evidencing the existence of important petroleum deposits in the subjacent Devonian rocks. Salt springs appear on the borders of Manitoba Lake, and much further north in the Athabasca basin, but have been utilized to a very limited extent only. Gypsum also occurs in the Silurian and Devonian rocks along their eastern outcrop. Gold is washed from the sands of several of the larger rivers, but this, it is supposed, is for the most part derived by natural concentration from the drift deposits.

The Cordillera. Of this great mountainous region of the Pacific coast, a length of nearly 1,300 miles is included by the western part of Canada. Most of this is embraced in the Province of British Columbia, where it has a width of about 400 miles between the Great Plains and the Pacific Ocean. To the north, it is continued in the Yukon district of the North-West Territory, till it reaches, in a less elevated and more widely spreading form, the shores of the Arctic Ocean on one side, and on the other passes across the 141st meridian of west longitude into Alaska. Its strongly marked features result from enormous crustal movements parallel to the edge of the Pacific, by which its strata have at several periods and along different lines, been crumpled, crushed and faulted. These movements having continued at intervals to times geologically recent, and the mountains produced by them still stand high and rugged, with streams flowing rapidly and with great erosive power down steep gradients to the sea.

Although preserving in the main, a general north-

north-westerly trend, the orographic features of this region are very complicated in detail. No existing map yet properly represents even the principal physical outlines, and the impression gained by the traveller or explorer may well be one of confusion. Disregarding, however, all minor irregularities, two dominant mountain systems are discovered—the Rocky Mountains proper, on the east, and the Coast Range of British Columbia, on the west.

The first of these, it has been proposed to name, from an orographic point of view, the "Laramide Range," as it is essentially due to earth movements, occurring about the close of the Laramie period, and rocks of that age are included in its flexures. Although not quite continuous (for there are several echelon-like breaks, in which one mountain-ridge assumes the dominance previously possessed by another), this range, beginning two or three degrees of latitude to the south of the 49th parallel, forms the eastern member of the Cordillera all the way to the Arctic Ocean, which it reaches not far to the west of the Mackenzie delta. It is chiefly composed of Palæozoic rocks, largely limestones, and where it has been closely studied is found to be affected by series of overthrust faults, parallel to its direction, of which the easternmost separates it from the area of the Cretaceous foot-hills. Here the older rocks have been thrust eastward for several miles over the much newer strata. The structure has as yet been worked out in detail only along the line of the Bow River pass, by Mr. R. G. McConnell. In width, this range seldom exceeds sixty miles. The heights formerly attributed to some peaks appear to have been exaggerated, but many points in its southern part exceed 11,000 or 12,000 feet.

The Coast Range of British Columbia constitutes the main western border of the Cordillera. Beginning near the estuary of the Fraser River, it runs uninterruptedly northward, with an average width of about

100 miles, for at least 900 miles, when it passes inland beyond the head of Lynn Canal. This range is largely composed of granite, with infolded masses of altered Palæozoic strata. It is not, as a rule, so rugged in outline as the last, but its western side, rising from the sea, shows the full value of its elevation there, while its main summits often exceed 8,000 or 9,000 feet. Several rivers rising in the plateau country to the eastward, flow completely across this range to the Pacific, where the lower parts of their valleys, as well as those of many streams originating in the mountains themselves, in a submerged state constitute the remarkable system of fiords of British Columbia. Even in the arrangement of the islands adjacent to the coast, the further extension of these valleys and of others running with the range, may be traced, the evidence being of great subærial erosion when the land previously stood at a higher stage. The cutting out of these deep valleys probably began in Eocene times, but was renewed and greatly increased in the later Pliocene.

Outside the Coast Range and in a partly submerged condition, lies another range, of which Vancouver Island and the Queen Charlotte Islands are projecting ridges. This stands on the edge of the Continental plateau with the great depths of the Pacific beyond it. The rocks resemble those of the Coast Range but include also masses of Triassic and Cretaceous strata which have participated in its folding, while horizontal Miocene and Pliocene beds skirt some parts of the shores.

In the inland portion of British Columbia, between the Coast and Rocky Mountain systems above particularly alluded to, are numerous less important mountain ranges, which, while preserving a general parallelism in trend, are much less continuous. Thus, in travelling westward by the line of the Canadian Pacific Railway, after descending from the Rocky Mountain summit and crossing the Upper Columbia valley, the

north-westerly trend, the orographic features of this region are very complicated in detail. No existing map yet properly represents even the principal physical outlines, and the impression gained by the traveller or explorer may well be one of confusion. Disregarding, however, all minor irregularities, two dominant mountain systems are discovered—the Rocky Mountains proper, on the east, and the Coast Range of British Columbia, on the west.

The first of these, it has been proposed to name, from an orographic point of view, the "Laramide Range," as it is essentially due to earth movements, occurring about the close of the Laramie period, and rocks of that age are included in its flexures. Although not quite continuous (for there are several echelon-like breaks, in which one mountain-ridge assumes the dominance previously possessed by another), this range, beginning two or three degrees of latitude to the south of the 49th parallel, forms the eastern member of the Cordillera all the way to the Arctic Ocean, which it reaches not far to the west of the Mackenzie delta. It is chiefly composed of Palæozoic rocks, largely limestones, and where it has been closely studied is found to be affected by series of overthrust faults, parallel to its direction, of which the easternmost separates it from the area of the Cretaceous foot-hills. Here the older rocks have been thrust eastward for several miles over the much newer strata. The structure has as yet been worked out in detail only along the line of the Bow River pass, by Mr. R. G. McConnell. In width, this range seldom exceeds sixty miles. The heights formerly attributed to some peaks appear to have been exaggerated, but many points in its southern part exceed 11,000 or 12,000 feet.

The Coast Range of British Columbia constitutes the main western border of the Cordillera. Beginning near the estuary of the Fraser River, it runs uninterruptedly northward, with an average width of about

100 miles, for at least 900 miles, when it passes inland beyond the head of Lynn Canal. This range is largely composed of granite, with infolded masses of altered Palæozoic strata. It is not, as a rule, so rugged in outline as the last, but its western side, rising from the sea, shows the full value of its elevation there, while its main summits often exceed 8,000 or 9,000 feet. Several rivers rising in the plateau country to the eastward, flow completely across this range to the Pacific, where the lower parts of their valleys, as well as those of many streams originating in the mountains themselves, in a submerged state constitute the remarkable system of fiords of British Columbia. Even in the arrangement of the islands adjacent to the coast, the further extension of these valleys and of others running with the range, may be traced, the evidence being of great subærial erosion when the land previously stood at a higher stage. The cutting out of these deep valleys probably began in Eocene times, but was renewed and greatly increased in the later Pliocene.

Outside the Coast Range and in a partly submerged condition, lies another range, of which Vancouver Island and the Queen Charlotte Islands are projecting ridges. This stands on the edge of the Continental plateau with the great depths of the Pacific beyond it. The rocks resemble those of the Coast Range but include also masses of Triassic and Cretaceous strata which have participated in its folding, while horizontal Miocene and Pliocene beds skirt some parts of the shores.

In the inland portion of British Columbia, between the Coast and Rocky Mountain systems above particularly alluded to, are numerous less important mountain ranges, which, while preserving a general parallelism in trend, are much less continuous. Thus, in travelling westward by the line of the Canadian Pacific Railway, after descending from the Rocky Mountain summit and crossing the Upper Columbia valley, the

Selkirk Range has to be surmounted. Beyond this, the Columbia on its southward return is again crossed, and the Gold Range is traversed by the Eagle Pass before entering the Interior Plateau of British Columbia, which occupies the space remaining between this and the Coast Range. The system of ranges lying immediately to the west of the Rocky Mountains proper, notwithstanding its breaks and irregularities, is capable of approximate definition and its components have been designated collectively the Gold Ranges. Further north, it is represented by the Cariboo Mountains, in the mining district of the same name. The highest known summit of this system is Mount Sir Donald, 10,645 feet, one of the Selkirk Mountains.

This mountain system is believed to be the oldest in British Columbia. It comprises Archæan rocks with granites and a great thickness of older Palæozoic beds, much disturbed and altered.

The Interior Plateau constitutes an important physical feature. Near the International boundary it is terminated southward by a coalescence of rather irregular mountains, and again, to the northward, it ends about latitude 55° 30′ in another plexus of mountains without wide intervals. Its breadth between the margins of the Gold Ranges and the Coast Range is about 100 miles, and its length is about 500 miles. It is convenient to speak of the country thus defined as a plateau, because of its difference, in the large, from the more lofty bordering mountains. It comprises the area of an early Tertiary denudation-plain (or peneplain) which has subsequently been greatly modified by volcanic accumulations of the Miocene, and by river-erosion while it stood at a considerable altitude, in the Pliocene; but its true character as a table-land is not obvious until some height has been gained above the lower valleys, where the eye can range along its level horizon-lines. It is highest to the southward, but most of the great valleys traversing it are less in elevation

than 3,000 feet above the sea. To the north, and particularly in the vicinity of the group of large lakes occurring there, its main area is less elevated than 3,000 feet, making its average height about 3,500 feet.

Beyond this plateau to the north, the whole width of the Cordillera, very imperfectly explored as yet, appears to be mountainous as far as the 59th parallel of latitude, when the ranges diverge or decline, and in the upper basin of the Yukon, rolling or nearly flat land, at moderate elevations, again begins to occupy wide intervening tracts.

As a whole, the area of the Cordillera in Canada may be described as forest-clad, but the growth of trees is more luxuriant on the western slopes of each of the dominant mountain ranges, in correspondence with the greater precipitation occurring on these slopes. This is particularly the case in the coast region and on the seaward side of the Coast Range, where magnificent and dense forests of coniferous trees occupy almost the whole available surface. The Interior Plateau, however, constitutes the southern part of a notably dry belt, and includes wide stretches of open grass-covered hills and valleys, forming excellent cattle ranges. Further north, along the same belt, similar open country appears intermittently, but the forest invades the greater part of the region. It is only toward the Arctic coast, in relatively very high latitudes, that the barren Arctic tundra country begins, which, sweeping in wider development to the westward, occupies most of the interior of Alaska.

With certain exceptions, the farming land of British Columbia is confined to the valleys and tracts below 3,000 feet, by reason of the summer frosts occurring at greater heights. There is, however, a considerable area of such land in the aggregate, with a soil generally of great fertility. In the southern valleys of the interior, irrigation is necessary for the growth of crops.

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The geological structure of the Cordillera is extremely complicated, and it has as yet been studied in detail over limited tracts only. There have been no appropriate terms of comparison for the formations met with, and these it has consequently been necessary to investigate independently by the light of first principle. The difficulty is increased by the abundance of rocks of volcanic origin referable to several distinct periods, resembling those of the Appalachian mountain region, though on a vastly greater scale, and like them, almost entirely devoid of organic remains. The recognition, early in their investigation, of the originally volcanic nature of a large part of the rocks, has rendered it possible, however, to understand the main geological features, which at first appeared to present an almost insoluble problem.

Rocks referable to the Archæan obtain a considerable development in British Columbia, but it has not so far been found possible to recognize definitely the Laurentian and Huronian systems. Where they have been noted and examined, chiefly in the Gold Ranges and Interior Plateau, they have been distinguished as the Shuswap series. They include rocks resembling the Fundamental Gneiss of the east in character and composition, together with crystalline limestones, quartzites and gneissic rocks like those of the Grenville series and evidently representing metamorphosed sediments. At this distance from the typical developments of the Laurentian and Huronian, it is not to be expected that any precise parallelism in mineral composition and degree of alteration can be established, but that these rocks really are Archæan, has been determined by their unconformable infraposition to the lowest Palæozoic strata.

Above the Shuswap series, in the Rocky Mountains, Gold Ranges and elsewhere, is a great thickness of Cambrian strata, or of Palæozoic rocks at present collectively classed under this system. Fossils referable

to the *Olenellus* zone, have been found about half-way down in these strata in the Rocky Mountains, but from the lower conformable mass of beds, no recognizable organic forms have yet been obtained. A great thickness of contemporaneous volcanic material is generally included in the Cambrian. The Cambro-Silurian and Silurian, on the evidence in each case of a few characteristic fossils, are known to exist in the western part of the Rocky Mountains proper, and far to the north, on the Dease River (near lat. 60°), an interesting Graptolitic fauna of Trenton age has been found. The Devonian has not been distinctly recognized.

In the Rocky Mountains, the Carboniferous is largely represented, chiefly by massive limestones, and the fossils found in these pass down to a stage which has been characterized as Devono-Carboniferous. No single trace of the flora of the Carboniferous period has yet been discovered in the western regions of Canada. In the Interior Plateau and along the coast, the Carboniferous consists below of volcanic accumulations and quartzites and above of limestones, some of which are largely foraminiferal and composed of *Fusulina* and *Loftusia*.

The Triassic, in the southern part of the Rocky Mountains proper, is represented by red sandstones, the deposits of an interior Mediterranean of the period. To the west and north, it becomes a marine formation, with peculiar fossils of the "Alpine Trias" type, but over large areas it consists almost entirely of contemporaneous volcanic accumulations.

In a few places in the southern part of British Columbia, this formation appears (following the views of Prof. A. Hyatt on its fossils) to pass up into the Jurassic; but the next important series of beds, succeeding a very great stratigraphical break, is the Cretaceous. Rocks of the Earlier Cretaceous (Kootanie and Queen Charlotte Island formations) occur in places in the Rocky Mountains and throughout

British Columbia as far as the coast, also northward to the Porcupine River, between latitudes 67° and 68°, in the Yukon District. Newer Cretaceous rocks are developed particularly in Vancouver Island, where they constitute the productive coal measures. In the Crow's Nest Pass region and elsewhere in the Rocky Mountains, as well as in the Queen Charlotte Islands, the Earlier Cretaceous rocks contain abundance of good coal. All the strata of the Cretaceous period are more or less tilted and folded, and are evidently prior in date to the last great orogenic movements of the Cordillera. Evidences of contemporaneous volcanic action are again abundant in some parts of the extent of the Cretaceous.

Rocks referable to the Laramie or transition period between the Cretaceous and Tertiary, are found in the Yukon district and in the vicinity of the Fraser delta, holding lignite-coals and numerous remains of plants. Beds assigned to the Oligocene and Miocene are also well developed in the southern part of the Interior Plateau of British Columbia, where the latter period has been an epoch of notable volcanic eruptions, producing both effusive and fragmental rocks, but toward the close flooding large tracts with basaltic flows. Traces of similar volcanic activity, of the same date, are found in the Queen Charlotte Islands and in Vancouver Island. The Pliocene was chiefly a time of erosion, but deposits referred to this period are not entirely wanting.

Until the completion of the Canadian Pacific transcontinental railway, the west coast of Canada was a remote region, accessible with difficulty; but long before this, coal had been successfully mined in Vancouver Island, and in 1858 and succeeding years, the discovery and working of placer gold deposits brought the then isolated colony of British Columbia into considerable prominence. From the time of the quarrel with Spain on the Nootka question, in 1790, little had

been heard of the region, which remained unprized and suffered naturally in consequence when the "Oregon" boundary was settled with the United States.

The yield of alluvial gold reached its maximum in 1863, and thereafter, as in all mining regions of this kind, began steadily to decline. But of late years, and consequent on the introduction of means of communication, a remarkable development has begun. The conditions in this disturbed region of the continent are so varied, that it is difficult to name many metallic minerals which do not occur in it; but silver, gold, lead and copper have already begun to be produced in important quantity where certain districts in its southern part have been prospected, while the placer mining of gold had extended very far to the north in the Yukon valley and to the border of Alaska. Coal mining has continued uninterruptedly since its first beginning, and the product is now exported to many countries on the Pacific seaboard, but more particularly to California.

The Cordilleran region of Canada is undoubtedly destined to become one of the most important mining countries of the world, and probably before many years the value of its output will more than equal that of all other parts of the Dominion combined.

Glaciation of Western Canada. Like the eastern part of Canada, the western has been largely affected by the events of the glacial period. Most of the superficial deposits can be explained only by reference to this period, and to it also the diversion of many rivers and streams and other important changes are due. It is not yet possible to give a connected account of these events which will meet with general agreement, but, as in the east, the main facts have already been made sufficiently plain.

At an early time in the glacial period, the Cordillera, standing probably at a relatively high elevation, became covered by a confluent ice-sheet, extending

approximately from latitude 48° to latitude 63°, with a total length, at its maximum, of some 1,200 miles. The form of the surface prevented the ice from discharging in all directions like that of Greenland, and forced the bulk of the outflow to move south-eastward and north-westward, in conformity with the direction of the ruling mountain ranges, from a central neutral gathering-ground or nevé, situated approximately between the 55th and 59th parallels. The southward-moving portion of the great glacier filled the Interior Plateau of British Columbia, while its opposite extremity in the main flowed into the Yukon basin. Smaller streams from the main mass undoubtedly crossed the Coast Range by transverse valleys, to reinforce secondary, but large glaciers, which reached the sea to the south and north of Vancouver Island, while others extended through the Bow River valley and similar depressions in the Rocky Mountains to the western margin of the Great Plains.

This Cordilleran glacier, as shown by late observations in the western part of the Great Plains, was the first to affect that region, and may perhaps prove to be the first notable ice-cap developed during the glacial period in North America. At a later time it became gradually very much reduced, but subsequently, at least once, again extended to dimensions in some places approaching those first held by it. Rock striation and the transport of erratics, show that the southern part of the Cordilleran glacier, when at its maximum, passed uninterruptedly over projecting points between 6,000 and 7,000 feet in height above the sea.

In the opinion of the writer, there is evidence such as to render it probable that the first retreat of the Cordilleran glacier was contemporaneous with a depression of the Cordillera to the amount of 4,000 feet or more, enabling water at the level of the sea to reach such elevations on both sides of the Rocky Mountains.

Subsequently, during the second spread of the glacier-ice, the land is supposed to have risen; and at a still later date, there is fairly conclusive evidence to the effect that it stood about 2,500 feet lower relatively to the sea than it now does.

The above hypotheses are stated under all reserve and subject to further enquiry, but the main facts and the evidences of glaciation of a very pronounced type, rock-scoring, boulder-clay, moraines, terraces, kames and eskers are abundantly evident throughout the greater part of British Columbia and the Yukon district.

In the area of the Great Plains, as above noted, the first recognized evidences of glacial conditions are those connected with the eastward spread of comparatively limited tongues of glacier-ice from the Rocky Mountains, and the deposit, on the western plains, of boulder-clay and rolled gravels attributed to what it has been proposed to name the Albertan stage. Subsequently, at least two more distinct boulder-clays, separated by important interglacial deposits, have been laid down over the whole western part of the Great Plains, ending above in silty, sandy and gravelly beds, with large scattered superficial erratics. In connection, doubtless, with one of these boulder-clays, is the remarkable monument of the Glacial period known as the Missouri Côteau (crossed by the Canadian Pacific railway west of Parkbeg station), which may be regarded either as part of a continental moraine or as the marginal accumulation of an ice-laden sea. These later boulder-clays differ from those of the Albertan stage in being largely composed of debris of the Laurentian and Huronian rocks and Palæozoic limestones found in places on the eastern side of the interior continental plain. The direction of transport of these erratics has been from the north-east or north-northeast. The manner of their carriage and that of the deposition of the beds in which they occur, is still a subject of discussion; but

there can be no doubt that great relative and absolute changes in elevation have occurred in the region, while terraces occurring at heights of 5,300 feet in the Porcupine Hills, near the base of the Rocky Mountains, show that that part of the plains at least was flooded to a corresponding height, which is practically identical with that previously found in the mountain region of British Columbia. To the writer there appears to be strong presumptive evidence that this water was in more or less direct communication with that of the sea, but other hypotheses have been advanced, and it remains for future investigation to determine that which may eventually prevail. It is with hesitation that we are prepared to admit great succeeding changes in level of large areas of the continent, but the alternative explanations, attributing as they must the most extraordinary effects to glacier-ice, seem to present at least equal difficulty.

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THE PHYSICAL GEOGRAPHY AND GEOLOGY OF CANADA,

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Reprinted from the Handbook of Canada, issued by the Publication Committee of the Local Executive of the British Association.

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THE Dominion of Canada embraces the northern half of the continent of North America, with its adjacent islands, including those of the Arctic Ocean between the 141st meridian and Greenland, but exclusive of Alaska, in the extreme north-west, the island of Newfoundland, which still remains a separate British colony, and the small islands of St. Pierre and Miquelon, retained by France. In order, therefore, to include the sister colony of Newfoundland, the general name, British North America must still be employed. The total area of Canada is estimated at about 3,574,980 square miles, of which the Arctic islands to the north of the continental land make about 309,000 square miles. Thus, with Newfoundland (42,000 square miles), the aggregate area of British North America is 3,616,980 square miles. This area is somewhat larger than the United States (including Alaska), and not much less than all Europe.

The form of the North American continent may be described as that of an isosceles triangle, of which the narrower part, pointing to the south, constitutes Mexico, a wide central belt, the United States, while the broader base is the Dominion of Canada. The northern base-line of the continental land lies approximately on the seventieth parallel of north latitude,

but is broken into by the geographically important sea named Hudson Bay, 800 miles from north to south, and some 600 miles in width. Historically, this great indentation of the northern land has been notable in connection with the exploration and trade of British North America, and it promises in the future, when modern means of communication have been adapted to the circumstances, again to become important. But the ruling physical features upon which the existence of Canada as a country depends, and about which its history has grown up, are, the proximity of the north-eastern part of the continent to Europe, and the existence of a great waterway, the River St. Lawrence, running to the very centre of the continent, and expanding there into the group of inland seas generally spoken of as the Great Lakes. The first of these made the landfall of Cabot in 1497 possible, the second led Cartier (in 1535) to the sites now occupied by the cities of Quebec and Montreal, and opened a route of exploration and commerce to subsequent explorers and traders of France, by which they overran much of the central and western country of North America before the colonists of New England, further to the south, achieved a way across the Appalachian highlands which there barred their progress.

The course of the St. Lawrence and the position of the Great Lakes may be regarded as being determined by the southern outline of the Laurentian plateau, composed of ancient crystalline rocks, which in U-shaped form surrounds the central depression of Hudson Bay. Spreading widely in the Labrador peninsula, this tract of relatively high and generally rocky land, runs with narrower dimensions round the southern extremity of the bay, and thence is continued north-westward to the Arctic Ocean. With one important exception, that of the Ontario peninsula, which juts far to the south, the great river and its reservoirs lie

along the southern edge of these highlands, while the Winnipeg system of lakes, Athabasca, Great Slave and Great Bear Lakes, occupy a very similar position on the outer rim of the north-western extension of the plateau.

Suess has named this plateau, composed of Archæan rocks, the "Canadian shield." In respect to form, it is the most important geological feature of the continent, for, under whatever name, it must be considered its nuclear tract or "protaxis." About it the later sediments, from Cambrian times to the present day, have been spread, their material being largely supplied by its waste, and against it or parallel to its main outlines, successive movements of the earth's crust have forced up the newer and now higher ranges of the Appalachian and the Cordilleran systems, while, so far as we are able now to determine, the ancient shield itself has remained comparatively unaltered and fixed. Following the trends of the south-east and south-west sides of the Laurentian highlands respectively, the Appalachian mountains and those comprised in the western Cordillera converge to the south, embracing between them, to the south of the Great Lakes, the central plain of the continent, based upon comparatively undisturbed and nearly horizontal strata, which it may reasonably be conjectured repose, at no very great depth below the surface, upon a now concealed southern extension of the original platform. But there is an important want of symmetry in these main orographic features, for, between the western edge of the Laurentian highlands and the Cordilleran ranges, a wide tract of the central plain runs northward to the Arctic Ocean, constituting in its southern part, the great arable inland country of western Canada.

From a physiographical and geological standpoint, the Canadian part of the continent may very naturally be regarded as composed of two great divisions—an

eastern and a western; the line between these beginning at the south near Winnipeg, on the central longitude, and running thence along the outer edge of the Laurentian plateau north-westward to the Arctic Ocean. To the east of this line, while the surface is generally broken and irregular, the relief is nearly everywhere comparatively low. The rocks are almost altogether referable to the Palæozoic systems or to systems older than these, and there is little evidence of important change during the later geological periods, beyond such as is incident to the gradual wearing away and denudation of very ancient highlands and mountain systems.

To the west, the Mesozoic and Tertiary systems become important. The entire spread of the great plains is floored by such rocks, and they occupy also a large part of the western Cordilleran belt, although there mingled with important areas of much older rocks. At a late date, geologically, the Pacific Ocean has spread over nearly all this part of the continent. The vast orogenic changes which have resulted in excluding the sea from the region are comparatively recent; many of the mountain ranges of the Cordillera are rugged, new and lofty, and the processes of denudation are still going on very rapidly, with rivers and streams flowing at high grades, and very far from that passive condition found where the drainage system has approximately reached the base-level of erosion.

A two-fold division of the northern part of the continent, of the kind above indicated, although based upon fundamental facts in its geological history, is, however, much too general for the purposes of description of its several regions as they present themselves to us to-day. The characteristically mountainous region of the Cordillera, and that of the great central plain, must be separately treated; while the great eastern division is not only larger than that of the

west, but, being in its southern portion the home of the greater part of the population, requires closer consideration. The boundaries of the several provinces, resulting from circumstances of a more or less political kind, do not always correspond with the natural features, and cannot therefore be adopted as the best for purposes of geographical and geological description. Relying chiefly upon the physical and geological facts, we may therefore further subdivide the continental part of Canada as follows :—

(1.) *The Acadian Region*, including the Maritime Provinces of the Atlantic, with the similarly characterized south-eastern part of the Province of Quebec, bounded by a line running from the Strait of Belle Isle to the City of Quebec, and thence to Lake Champlain.

(2.) *The Lowlands of the St. Lawrence Valley*, extending, with an irregular width, from the City of Quebec to Lake Huron, and including the Ontario peninsula.

(3.) *The Laurentian Plateau*, which, notwithstanding its vast area, may, from a physiographical point of view, be regarded as a unit.

(4.) *The Interior Continental Plain*, running with narrowing dimensions from the 49th parallel to the Arctic Ocean, and embracing part of Manitoba and the North-West Territory.

(5.) *The Cordillera*, or great mountain belt of the west, including the greater part of British Columbia and the whole of the Yukon district.

Before entering upon the description of the several regions thus defined, something may be said of the drainage system of the northern part of the continent as a whole. Only the most general notice can be given to the rivers and lakes of Canada in a review so short as this must necessarily be, but no feature of the country is more important, whether historically

or geographically, than the great length and volume of its principal watercourses, and the manner in which these interlock and penetrate almost every part of its area. Besides the St. Lawrence, with its drainage basin of 530,000 square miles, to which allusion has already been made, there are three more rivers of the first class, of which the watersheds are wholly or in great part included by Canada. These are the Nelson, the Mackenzie and the Yukon. The first-named reaches Hudson Bay, bringing with it the waters of the Saskatchewan and other large and long rivers which drain a vast region in the centre of the continent. Its basin is estimated at 367,000 square miles. The Mackenzie, flowing into the Arctic Ocean, drains not only most of the northern part of the interior plain of the continent, but also considerable portions both of the Rocky Mountain region and the Laurentian plateau, with a basin of about 677,000 square miles. Next to the St. Lawrence, it is the longest river of Canada, being not less than 1,800 miles from its source to its mouth. The Yukon, discharging into the northern part of Behring Sea, unwaters a great tract of the northern part of the Cordilleran region comprised in Canada, besides flowing across the whole width of Alaska.

It is only by contrast with these greatest rivers that many more are relegated to a second or third rank, as an examination of the map will show. It will also be apparent that much the larger part of the country lies on the northern slope of the continent, regarded as a whole, and that the remainder is divided between the Atlantic and Pacific sides, but an inconsiderable region being tributary to the southward-flowing system of the Missouri and its branches.

It may be useful, in this connection, to state the heights of a few of the larger lakes, as ruling features in physical geography. The Great Lakes, although

they stand at four levels, in reality occupy only two distinct stages, separated by the Niagara Falls. Below this cataract is Lake Ontario, 247 feet, above it Lake Erie, 573 feet, Lakes Huron and Michigan, 581 feet, and Lake Superior, 602 feet.

Further to the west and north-west are, Lake of the Woods, 1,062 feet, Lake Winnipeg, 710 feet, Lakes Manitoba and Winnipegosis, 810 and 830 feet, respectively, Athabasca Lake, 690 feet, Great Slave Lake, about 520 feet, and Great Bear Lake, about 340 feet. Each of these lakes marks the lowest level of large tracts of adjacent land.

The Acadian Region, regarded as a whole, forms the north-eastward continuation of the Appalachian mountain system. This mountain system, beginning not far from the Gulf of Mexico, gives form to the eastern coast of the United States, from which it is never far distant. In Vermont and New Hampshire, it is represented by the Green and White Mountains, and its main line runs on, though with much decreased elevation, through the south-eastern part of the Province of Quebec, under the name of the Notre-Dame Mountains. Not far below the City of Quebec it approaches the St. Lawrence, and thence continues parallel with that river and its great estuary, all the way to Gaspé, on the open gulf. In the Gaspé peninsula it is known as the Shickshock Mountains. Considerable parts of these mountains rise well above 3,000 feet, but the Notre-Dame range seldom exceeds 1,000 or 1,500 feet, and its elevations resemble rolling and broken hills and ridges, rather than mountains properly so called. The whole length of this main continuation of the Appalachian system in Canada is about 500 miles.

Subordinate and less continuous elevations, nearly parallel to the main range thus outlined, occur in New Brunswick, chiefly along two lines, one of which strikes the Baie des Chaleurs below its head, the other, some-

what divergent in direction to the eastward, bordering the southern shore of the province along the Bay of Fundy. The rocks of all these ranges are in the main older than those of the Carboniferous system, and between the two last-mentioned ridges, in New Brunswick, lies a broad triangular area of nearly horizontal beds referable to the Carboniferous formation. Besides this large level area, there are many others of lesser size and numerous large valleys, comprised in what has been designated the Acadian region, in Quebec and New Brunswick. These often afford excellent arable land, or support valuable forests. The character of the soil varies greatly, chiefly in conformity with that of the subjacent rocks; but it has also been considerably affected, as in almost all parts of Canada, by the nature and amount of the deposits due to the glacial period.

Though lying at some distance to the south-eastward of the main line, the peninsula of Nova Scotia may best be regarded as a member of the Appalachian system of uplifts, with which it is parallel. Its elevation nowhere exceeds 1,200 feet, and is in general very much less. A broad range of broken hills and uplands extends along the Atlantic coast of the province and into the island of Cape Breton. The Cobequid Hills are next in importance to this, running to the north of that arm of the Bay of Fundy known as Minas Basin, and joining the last at an angle, near the middle of the province. The Atlantic coast range is chiefly composed of old Cambrian rocks and granites, with little land of agricultural value, but rich in gold-bearing veins, which occur in all parts of its length. With the disturbed area of the Cobequids, rocks as new as the Devonian are largely involved. The best arable lands of Nova Scotia are situated towards the Bay of Fundy, and along the northern side of the peninsula generally. Here also, and in Cape Breton, the important coal-fields occur.

In the general and inclusive sense in which the

term "Acadian region" has been employed, this has thus a width of about 350 miles, between the outer coasts of Nova Scotia and the St. Lawrence estuary. Followed to the south-eastward, this belt of country embraces the New England States and part of New York, all with very similar physical characters. In the opposite direction it is interrupted by the Gulf of St. Lawrence, but reappears in the great island of Newfoundland, still preserving most of its characteristic features, although somewhat modified in appearances by differing climatic conditions. Throughout this region, including Newfoundland, the geological structure is alike, the formations represented are nearly the same, and, both in composition and from a palæontological standpoint, they often resemble those of the opposite side of the Atlantic more closely than they do those of other parts of North America.

Before speaking of the geological features of the Acadian region in Canada, two exceptional areas within its limits may be referred to. In the semi-circular bay formed by the coasts of New Brunswick and Nova Scotia, separated from the mainland by Northumberland Strait, is Prince Edward Island, a province by itself, although not much more than 2,000 square miles in area. This lies opposite the Carboniferous and Permo-Carboniferous lowlands of eastern New Brunswick and northern Nova Scotia, and consists entirely of undisturbed and unaltered Permo-Carboniferous and Triassic red sandstones and shales. Characteristic fossils of both formations have been found, but the circumstances render it difficult to draw a line between them. The surface of the island is for the most part fertile and highly cultivated, nowhere exceeding 500 feet above the level of the sea.

The second area of an exceptional character, is that of the island of Anticosti, lying in the wide estuary of the St. Lawrence, and 140 miles in length. This again consists of nearly flat-lying rocks, chiefly of the

Silurian with some of Cambro-Silurian or Ordovician age (Hudson River) along its northern side. The island evidently represents part of a submerged and undisturbed Cambro-Silurian and Silurian tract of the northern part of the Gulf of St. Lawrence, the rocks of which differ in some respects from their representatives further to the west. The island is generally wooded, and is at present very scantily inhabited.

The geological scale is well represented in Nova Scotia and New Brunswick, from the Archæan to the Triassic, but thereafter ensues a long gap, during which no deposits appear to have been formed, probably because the area in question then existed as land, exposed to denuding agencies alone. Closing this unrepresented lapse of time we find only the clays and sands referable to the glacial period, with still more recent deposits, such as those of the fertile marsh lands of the Bay of Fundy.

With the exception of the flat-lying tracts between the several axes of elevation the wide Carboniferous area in New Brunswick and marginal developments of rocks of the same age along the northern coast of Nova Scotia and in Cape Breton, the region must be considered as one of exceptional geological disturbance and complexity, which, notwithstanding the large amount of investigation it has received, is still but imperfectly understood. One cause of difficulty lies in the existence, at several horizons, of thick masses of strata composed of ancient volcanic materials, generally without organic remains. This is a character common to the rock-formations of most parts of the Appalachian region of North America, which has been at many times the theatre of great volcanic activity. The occurrence of similar rocks in the south-eastern part of the Province of Quebec has been the cause of much of the uncertainty attaching to the understanding of the "Quebec group" there.

The region is not a typical one for the Archæan

rocks, but areas of crystalline schists referable to this time occur. Most of these have so far been mapped simply as pre-Cambrian, for no separation into groups has yet been effected. A large tract of the kind occupies the northern part of Cape Breton. In the southern highlands of New Brunswick, particularly in the vicinity of the city of St. John, the Archæan is better characterized and bears a resemblance, almost amounting to identity, with the typical developments of these rocks in Quebec and Ontario. A Lower Laurentian series comparable with the "Fundamental gneiss" is found, with an upper series composed of crystalline limestones, quartzites, etc., like the Grenville series. Newer than these is a mass of strata composed chiefly of volcanic materials, breccias or agglomerates, greenstones and felsites, which is referred to the Huronian system. Further areas of the same kind occur in central New Brunswick.

Forming the backbone of the peninsula of Nova Scotia and bordering its whole Atlantic coast, is a belt characterized by granitic masses and old stratified rocks assigned to the Lower Cambrian. This belt is widest in the south-west part of the province and narrows gradually in the opposite direction. The granites date from about the Devonian period, and it was probably in connection with their intrusion that the bedded rocks were thrown into the great series of parallel, sharp flexures, in which they now lie and which bear so intimate a relation to the systems of gold-bearing veins. The disturbances incident to this period are, in fact, those which have chiefly given form to the Maritime Provinces. All the older rocks are involved in them, while those of the Carboniferous remain comparatively unaffected.

These Cambrian rocks consist of a lower quartzite series and an upper clay-slate or argillite series, the latter generally dark in colour. It must be added that no really characteristic fossils have yet been obtained

from these gold-bearing rocks. Distinctive Cambrian faunas have been found only in a few places in Cape Breton.

In the vicinity of St. John, New Brunswick, a remarkably interesting and complete section of Cambrian rocks, well characterized by fossils, occurs. This may now be regarded as typical for the eastern part of Canada and Mr. G. F. Matthew, to whom its elaboration is chiefly due, remarks particularly the resemblance of the fauna to that found in rocks of the same age around the Baltic sea, rather than to that of the interior of North America. In time, the series runs from the Etcheminian (older than the *Olenellus* zone) to the highest Cambrian.

Rocks of Cambro-Silurian (Ordovician) age have also been determined in the locality just referred to, and sparingly in other parts of New Brunswick. In Nova Scotia, the only fossils of the kind come from a single place in Cape Breton, but considerable areas supposed to be of this age, chiefly composed of volcanic materials, occur in other parts of the province.

Silurian (Upper Silurian) rocks, are widely spread in northern New Brunswick, and in adjacent portions of Quebec, occupying the greater part of the area which drains to the Baie des Chaleurs. They recur in the southern part of New Brunswick and in the northern part of Nova Scotia, and although comprising limestones, sandstones and shales, are often greatly intermixed with contemporaneous volcanic materials, indicating, it will be observed, a third important volcanic interlude in the history of this part of the continent. In Nova Scotia, important bedded iron ores (hæmatite) appear in this series. The geological horizons represented, as compared with those of the New York scale, range from the Clinton to the Lower Helderberg.

In the rocks of Devonian age, occurring in that portion of the Appalachian region covered by Nova Scotia, New Brunswick, the Gaspé peninsula of Quebec, and

a part of the adjacent State of Maine, a remarkably full representation of the flora of that ancient period is found, from which more than 125 species of land plants have been catalogued by Sir J. Wm. Dawson; while at Scaumenac, on the Baie des Chaleurs, rocks of this age have yielded many interesting fish remains, investigated by Mr. J. F. Whiteaves, which compare closely with those of the Old Red Sandstone. Further west, in beds of the same period in Ontario and New York, the fossils are chiefly marine molluscs, with comparatively little evidence of the existence of adjacent land. The lower part of the Devonian of the Maritime Provinces holds a similar fauna, and contains in Nova Scotia bedded fossiliferous iron ores. The geographical extent of the Devonian rocks in Nova Scotia and New Brunswick is comparatively limited, but in the Gaspé peninsula of Quebec it becomes somewhat important.

The Carboniferous system, both from its extent and because of its economic value, must be considered as one of the most important features of Nova Scotia and New Brunswick, although there is reason to believe that much larger tracts of this formation still lie beneath the waters of the Gulf of St. Lawrence and the Atlantic. Its total thickness is, in some parts of Nova Scotia, estimated at 16,000 feet, but it is very irregular in this respect and over the greater part of New Brunswick is comparatively thin. At the Joggins, on the north arm of the Bay of Fundy, is a remarkable continuous section showing 14,570 feet of strata, including more than seventy seams of coal, which has been made the subject of investigation by Logan, Lyell, and Sir J. Wm. Dawson. From beds in this section numerous specimens of a land-inhabiting reptilian fauna have been described. The flora of the period is well represented in many places, particularly in Nova Scotia, and includes that of several distinct stages, beginning with the Horton group at the base

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(comparable with the "calciferous sandstone" of Scotland and the lower part of the sub-Carboniferous of Ohio, Tennessee and West Virginia,) and at the top containing so many forms referable to the Permian, that the name Permo-Carboniferous has been applied to this part of the section.

Several local unconformities have been determined in different parts of this great succession of beds. With the marine limestones, important deposits of gypsum are found. The workable coal-seams occur in what is called the Middle Carboniferous, and some of these, in the Pictou district, are of unusual thickness. Coal mining is actively in progress in Cumberland and Pictou counties and in Cape Breton, the total annual output being between two and three million tons. In New Brunswick, the productive area for coal appears to be small, and the seams so far found are of inconsiderable thickness.

To complete this very brief review of the geology of what has been called, broadly, the Acadian region of eastern Canada, it now only remains to add a few words concerning that main line of uplift and disturbance, the course of which was first traced through the Province of Quebec, from the vicinity of Lake Champlain to Gaspé. This structurally complicated belt of country has been the subject of much controversy, and possesses now a literature of its own. It is bounded to the north-westward by an important dislocation or break, known as the St. Lawrence and Champlain fault, which may be traced from Lake Champlain to Quebec City, and thence follows the estuary of the St. Lawrence, probably running to the south of Anticosti. To the west of this line are the flat-lying Cambro-Silurian strata of the St. Lawrence plain, chiefly limestones, and doubtless resting upon a strong shelf of the Laurentian nucleus at no great depth. Against this stable edge, the eastern strata have been folded, faulted and ridged up by the forces

which produced the Appalachian range. Were this all, a careful study of the beds on the two sides of the line would readily show their identity; but, it appears, that previous to the great epoch of disturbance the original physical conditions themselves differed. To the west, a sheltered sea came into existence about the close of the Cambrian period, in which Cambro-Silurian strata, in large part limestones, were laid down. To the east, sedimentation began much earlier, and the circumstances of deposition were different and more varied. Even the animal life present in the two districts was largely dissimilar at the same period, probably as a result of different temperatures in the sea water. Thus it was not until much study and thought had been given to the problem that Logan was enabled to affirm the equivalency of a great part of the strata on the two sides of the St. Lawrence and Champlain fault. To those on the east, differing in composition and fauna from the rocks of the typical New York section, he applied the name "Quebec group." Regarded as a local name attached to the Atlantic type of the lower members of the Ordovician, and distinguishing these from rocks of the same date deposited upon the Continental plateau, this term may still be employed with advantage, expressing as it does a most important fact. Subsequent investigations have shown, however, that in the ridging up of this part of the Appalachian region, not only are some very old Cambrian rocks brought to the surface, but considerable areas of crystalline schists which are evidently pre-Cambrian, and very possibly referable to the Huronian. These were originally included in the "Quebec Group," under mistaken ideas of metamorphism, but their elimination from it, now rendered possible, does not detract from the merit of the original discovery, nor does it impair the value of the term "Quebec group," as a descriptive one, if properly limited.

In this folded and disturbed region of south-eastern Quebec, copper ores, asbestos and chromic iron are among the more important minerals of value. Silurian rocks and some of Devonian age rest in places unconformably upon the older corrugations.

Some facts respecting the glacial deposits of the Appalachian region are given on a later page, with general statements relating to this period in eastern Canada.

Lowlands of the St. Lawrence Valley. The tract of country which it is found convenient to include under this name, comprises but a small part of the hydrographic basin of the great river, which in all is about 530,000 square miles in extent. Nor is it altogether uninterrupted, although clearly enough defined in a general way by the edge of the Laurentian plateau on the north, the Appalachian highlands to the south-east, and on the south, further west, by the line of the St. Lawrence River and the lower members of the system of the Great Lakes. It may be described as extending from a short distance below the city of Quebec to Lake Huron, with a length of over 600 miles and an area of more than 35,000 square miles, all of which may be regarded as fertile arable land—the greatest connected spread of such land in eastern Canada.

These lowlands are based upon nearly horizontal strata, ranging in age from the latest Cambrian (Potsdam sandstone) to the Devonian. On a geological map its limits are readily observable; but in order to understand its character, it is necessary to consider it somewhat more clearly, and under such scrutiny it is found to break up naturally into three parts. The first of these is divided between the Provinces of Quebec and Ontario, running west along the St. Lawrence and its great tributary the Ottawa somewhat beyond the 76th meridian, or to a north-and-south line drawn about twenty-five miles west of the city of Ottawa. It is here interrupted by a projecting, but not bold,

spur of the Laurentian plateau, which crosses the St. Lawrence at the lower end of Lake Ontario, forming there the Thousand Islands, and runs southward to join the large Archæan tract of the Adirondacks in the State of New York. This Eastern division, with an area of 11,400 square miles, constitutes what may be called the St. Lawrence plain proper, parts of which were among the first of those occupied by the early French settlers. Much of its surface is almost absolutely level, and it nowhere exceeds a few hundred feet in elevation above the sea, although a few bold trappean hills stand out in an irregular line, with heights of 500 to 1,800 feet. Mount Royal, at Montreal, is one of these, and from it all the others are in sight, while the Laurentian highlands may also be seen thirty miles to the north, and to the southward the Green Mountains and Adirondacks, forming the boundary of the plain in that direction, are apparent on a clear day.

Beyond the projecting spur of ancient crystalline rocks above referred to, from the lower end of Lake Ontario, near Kingston, to Georgian Bay of Lake Huron, the southern edge of the Laurentian plateau runs nearly due west, with a slightly sinuous line, for 200 miles. Between this edge and Lake Ontario on the south, lies a second great tract of plain, the lowest parts of which may be considered as level with Lake Ontario (247 feet) but of which no part exceeds 1,000 feet above the sea. This plain is naturally bounded to the south and west by the rather bold escarpment of the Niagara limestone, which, after giving rise to the Falls of Niagara between Lakes Ontario and Erie, runs across this part of the Province of Ontario to Lake Huron, forming there a long projecting point and continuing still further west, in the chain of the Manitoulin Islands. The city of Hamilton lies close under a part of this escarpment. The area of this second tract of plain is about 9,700 square miles. It is scarcely

more varied in its surface than that to the eastward, and most of its extent is a fertile farming country.

The third and last subdivision of the lowlands of the St. Lawrence valley, is an area of triangular form included between the Niagara escarpment and Lakes Erie and Huron. This constitutes what is generally known as the Ontario peninsula, and its south-western extremity touches the 42nd parallel, the latitude of Rome. The area of the Ontario peninsula is 14,200 square miles, and both in soil and climate it is singularly favored. Grapes, peaches and Indian corn, or maize, are staple crops in many districts. To the north, some parts of this tract are high and bold, but most of its surface varies from 500 to 1,000 feet above the sea.

The geological features of the lowlands of the St. Lawrence valley are comparatively simple. The rocks flooring the region lie either horizontally or at very low angles of inclination upon the spreading base of the Archæan mass to the northward, the crystalline rocks of which have frequently been met with in deep borings. The formations represented correspond closely with those of the New York section, which had been rendered typical by the researches of James Hall and his colleagues, before any definite examination of the geology of Canada was begun. Hall's nomenclature has been adopted for the series, which, beginning with the Potsdam sandstones, continues upward without any marked break, to the Chemung or Later Devonian.

In the first or eastern subdivision of this region, the Potsdam sandstone, although strictly speaking referable to the Upper Cambrian, physically considered is really the basal arenaceous and conglomeritic member of the Cambro-Silurian (Ordovician) series which follows. The several members of the Cambro-Silurian occupy almost the entire surface, diversified merely by a few light structural undulations, which to the south

and east of Lake St. Peter result in the introduction of some higher beds that are referred, although with some doubt, to the Silurian. Fossils referable to this period are also found associated with a small patch of volcanic breccia on St. Helen's Island, opposite Montreal. This is probably connected with the adjacent igneous mass of Mount Royal, and by it the age of this mass, as well as that of the other similar prominent points of the same character in the vicinity, is pretty definitely fixed as latest Silurian or Lower Devonian. It would in fact appear that these igneous masses represent the necks of ancient volcanic eruptions, which have since been subjected to prolonged denudation. In their vicinity the sedimentary rocks are shattered and disturbed and traversed in all directions by trap dykes. Basic rocks (theralite, etc.,) together with nepheline-syenites are characteristic.

Passing to the second, or central subdivision, to the west of Kingston, the Cambro-Silurian formations just referred to are found to be repeated, in ascending order, along the north shore of Lake Ontario, with very similar characters and equally undisturbed. The Trenton limestone occupies the greatest area, extending in a wide belt to Georgian Bay of Lake Huron. Above this lie the Utica shales, and over these the Hudson River formation, upon which Toronto is situated. This is the highest member of the Cambro-Silurian, but the plain also overlaps the lower members of the succeeding Silurian system irregularly, finding its natural boundary, from a physical point of view, only at the massive outcrop of the Niagara limestone.

The course of the escarpment produced by this outcrop has already been traced; above it and to the south-west, lies the higher plain generally known as the Ontario peninsula, constituting the third subdivision of the St. Lawrence lowlands. More than half of the area of this peninsula is occupied by Devonian rocks, which succeed the Silurian regularly in

ascending order, the highest beds being met with in the extreme south-west of Ontario, beyond which, they are soon followed by the Carboniferous basin of the Michigan peninsula. The Silurian and Devonian strata are affected only by slight and low undulations, but these are important in connection with the exploitation of the oil and gas of the region.

In the two eastern subdivisions of the lowlands of the St. Lawrence valley, with the exception of structural materials, such as stone, lime and clay, minerals of economic value are scarcely found; but in the third or westernmost subdivision, in addition to these, gypsum, salt, petroleum and natural gas have become important products. The gypsum and salt are derived from the Onondaga formation of the Silurian. The salt is obtained in the form of brine, from deep wells, but beds of rock-salt are known to occur at considerable depths. At Goderich, two beds of very pure salt have been proved by boring to exist at a depth slightly exceeding 1,000 feet, with an aggregate thickness of over 60 feet. Petroleum is chiefly derived from the Corniferous limestone of the Devonian, and natural gas is obtained from several horizons both in the Devonian and Silurian.

The Laurentian Plateau. The great region thus named, composed of very ancient crystalline rocks, has an area of over 2,000,000 square miles, or more than one-half that of the entire Dominion of Canada. In a horse-shoe-like form, open to the north, it surrounds three sides of the comparatively shallow sea known as Hudson Bay. Its southern part is divided between the Provinces of Quebec and Ontario, its eastern side expanding into the Labrador peninsula, while the western runs, with narrower dimensions, to the Arctic Sea, west of the great bay.

In geographical extent it is thus very important, although somewhat monotonous in its physical and geological features. It contributes little to the fertile

areas of the country in proportion to its size, but in the aggregate, comprises a considerable amount of land which is either cultivated or susceptible of cultivation. Elsewhere, in its southern parts, it carries forests of great value, and its mineral resources are already known in some places to be very important. It constitutes, moreover, a gathering ground for many large and almost innumerable small rivers and streams, which, in the sources of power they offer in their descent to the lower adjacent levels, are likely to prove, in the near future, of greater and more permanent value to the industries of the country than an extensive coal field. Particularly notable from this point of view is the long series of available water powers which runs from the Strait of Belle Isle nearly to the head of Lake Superior, coincident with the southern border of the plateau.

Although it is appropriate to describe this region as a plateau or table-land, such terms, it must be understood, are applicable only in a very general way. Its average elevation of about 1,500 feet is notably greater than that of the adjacent lands, and is maintained with considerable regularity, but its surface is nearly everywhere hummocky or undulating. Away from its borders, the streams draining it are, as a rule, extremely irregular and tortuous, flowing from lake to lake in almost every direction; but assuming more direct and rapid courses in deeply cut valleys as they eventually leave it. Many of the surface features are of very great antiquity, Mr. Low's observations in Labrador going to show that the larger valleys there existed much in their present form before the Cambrian period.

The average height of the central parts of the Labrador peninsula is about 1,700 feet, and the most of its drainage is divided between Hudson Bay, Ungava Bay and the Atlantic coast, the main watershed lying not very far to the north of the St. Lawrence estuary and gulf. Along the Atlantic coast, to the north of

Hamilton Inlet, the region assumes a really mountainous character, numerous elevations attaining 3,000 feet, and some as much as 5,000 or 6,000 feet. These are the highest known points connected with any part of the Laurentian region, and are quite exceptional in character. The same high range is continued to the north of Hudson Strait in the western part of Baffin Land.

To the south of Hudson Bay, the watershed is, at least in one part, as low as 1,000 feet. East of Lake Winnipeg, the Nelson and Churchill Rivers cross the Laurentian plateau, in a wide depression, to reach Hudson Bay. Still further north, this part of the plateau has a height of about 1,100 feet above the sea.

Generally speaking, the surface of the plateau is barren and rocky, though often with wide swampy tracts towards the height-of-land. To the south-west of Hudson Bay it is overlapped by an important spread of Silurian and Devonian rocks, over which, and the adjacent parts of the crystalline rocks, is rather uniformly spread a mantle of alluvial deposits, affording a good soil, which in some places may eventually be of value, although the climate is doubtfully favourable to the growth of ordinary crops.

The striking features of the Laurentian plateau are immeasurable lakes, large and small, with intervening rounded rocky elevations, wooded, in their natural conditions to the south, rising above the tree line to the northward; while in the far north, on both sides of Hudson Bay, hills and valleys become eventually characterized by grasses, mosses and lichens alone, constituting the great "barren lands" of North America. The rivers and lakes are everywhere well stocked with fish, while deer and moose in the southern parts, and to the north the caribou, abound wherever the Indian hunters have not followed them too closely. Thus, where the region can be entered without undue diffi-

culty, it has already become a much favoured resort of the sportsman.

The name by which it is found convenient to refer to this region, although derived from that of the Laurentian system of geologists, must not be supposed to imply that the rocks attributed to this system occupy the whole area. There are, besides, several wide and many narrower bands of Huronian rocks, as well as outlying areas referred to the Lower Cambrian, and more such exceptional areas of both kinds doubtless remain to be discovered. It must be understood, too, that in employing the name Laurentian for the most widely represented member of this great Archæan plateau, this is done in a very general and inclusive manner; the term "basement complex" is adopted by some geologists in nearly the same sense. The results of late investigations, particularly those of Dr. F. D. Adams, seem to prove that in the Laurentian, as thus understood, there is a distinctly stratified series of limestones and other sedimentary rocks, all now highly altered and crystalline, as well as another series of more massive gneissic rocks, of which the apparent bedding is really a foliation due to pressure, and which frequently pass into granites by imperceptible gradations. The first of these is known as the Grenville series, and the second as the Fundamental Gneiss; but even where most closely studied it has been found impossible completely to separate the two series, except quite locally, and thus, for the purposes of a general geological map, both must of necessity be indicated by a single colour. The complication alluded to is further increased by the frequent occurrence of true eruptive masses of granite or syenite of much later date, as well as by that of numerous great areas of anorthosite, a rock of the gabbro family, composed principally of plagioclase felspar.

The Huronian rocks are as a rule darker in colour and more basic in composition than those of the

Laurentian. They are often still distinctly bedded, although very frequently in the form of schists in which no true bedding is now distinguishable, and some of which have evidently resulted from the crushing of eruptive rocks. Over great areas the original material of the Huronian has clearly been in large part the result of volcanic eruptions of the time, but elsewhere, as on the north shore of Lake Huron, and in the Sudbury and Lake Temiscaming districts, it comprises thick masses of argillite, quartzite and quartz or jasper conglomerate. The rocks composing the Fundamental Gneiss often assume the physical relations of eruptives, of later date to the Huronian, along the lines of contact; but in how far this may really be the fact, and in how far this appearance may be attributed to a certain amount of re-fusion of previously existing basal rocks, has not been determined.

The Cambrian outliers date from a time subsequent to the main era of folding and crushing of the subjacent rocks, in comparison with which they are little disturbed. In the Labrador peninsula, they characterize considerable areas, and they form a border, tilted against the edge of the Laurentian plateau on the east side of Hudson Bay. These areas appear to represent the Animikie series of the Lake Superior section; well seen in similar relations in the vicinity of Port Arthur. These rocks are evidently separated by a vast period of unrepresented time from the Archæan below, and it is assumed that they may be attached with greatest probability to the base of the Cambrian, although no distinct fossils have been obtained from them. To the west of Hudson Bay and far to the north, are other outliers, largely composed of sandstones, conglomerates and traps, which resemble the Keweenawan or Nipigon of Lake Superior, somewhat later in age than the last. These also are provisionally classed as Lower Cambrian. The Nipigon rocks are well shown along the line of the Canadian Pacific railway to the east of Port Arthur.

Minerals of economic value in the Laurentian are almost entirely confined to the Grenville series, which yields, in various parts of its extent, mica, apatite (phosphate), graphite, iron and marble. The Huronian rocks are those in connection with which numerous important gold-bearing veins and deposits are now being found and opened up in western Ontario, as well as the nickel and copper deposits of Sudbury, iron and other metallic ores. In the Cambrian rocks near Port Arthur are silver-bearing veins, some of which have been extensively worked, and iron ores, while in the Labrador peninsula vast quantities of iron ores have been discovered in the same series.

Glaciation of Eastern Canada. Something may be added here on the events of the glacial period as affecting the eastern part of Canada as a whole, although many points connected with this particular period, still remain uncertain and the subject of debate. Like the Scandinavian peninsula, the Laurentian plateau at one stage in the glacial period apparently became the seat of a great confluent ice-sheet, which, when at its maximum, flowed down from it in all directions in general conformity with its main slopes. Climatic conditions and relatively local physical features may have conspired to render the discharge of glacier-ice more important in some directions than in others, and it is even possible that at no single time was the whole extent of the plateau equally ice-clad; but on the hypothesis above stated, it has been proposed by the writer to designate the ice-sheet of the Laurentian highlands, the Laurentide glacier. If several distinct centres of dispersion existed throughout, these may be named collectively the Laurentide glaciers. It is certain, at least, that such local centres must have grown up at the beginning of the period of cold, and that towards its close similar centres must have again remained as the last seats of ice action. Two of these have been defined by the existing marks

of rock striation and transport, one to the west of the northern part of Hudson Bay, named by Mr. Tyrrell the Keewatin glacier, the other, resulting from the observations of Mr. Low, to the east of the bay, the Labradorian glacier.

During the whole of this period the Laurentian plateau was in the main an area of denudation. From it the surface material was carried away in all directions, even to the northward, for there is absolutely no evidence that any "polar ice-sheet" ever trenched upon the continent of North America. The generally bare ice-scored rocky surface of these highlands is evidence of this denudation, while the existence of broken, angular masses of unmoved local débris in the central part of Labrador and in the central area of the Keewatin glacier, shows that across these neutral gathering-grounds, no ice ever passed.

As to the distance to which the solid glacier-ice came southward from the Laurentian plateau, the evidence is yet inconclusive, for it is at best a matter of difficulty at the present day to definitely separate true moraines from beaches upon which floating ice impinged. Neither is it certain at how many times or to what extent the glacial period was interrupted by relatively warm epochs, but it may be stated that the flora of at least one of these interglacial epochs, as represented in the vicinity of Toronto, is such as to indicate a climate fully as warm as that at present existing, during which it seems improbable that much, if any, glacier-ice could have persisted on the Laurentian highlands.

These problems cannot be discussed here, but it is certain that at or about the decline of the glacial period, the eastern part of Canada as a whole stood at a relatively low level. Without quoting in detail the heights to which the sea is known to have reached at this time in various places, it may be stated that it invaded the St. Lawrence valley as far at least as Lake

Ontario. Water-formed terraces are found at elevations of 230 feet in the Gaspé peninsula, to a maximum of 895 feet in the vicinity of Richmond, midway between Quebec and Montreal. Near Ottawa, the highest recognized shore-line is at 705 feet. The plains lying below these are floored by deposits holding marine shells of sub-arctic type, and these have been found at Montreal to a height of 560 feet. It is uncertain whether or not at the time of greatest subsidence the water covering the area of the Great Lakes stood at the same level as, and was in direct connection with the sea, but it is not improbable that what has been described as the "Iroquois beach," around these lakes, may actually form the continuation of a high marine shore-line. The question is complicated by the unequal amount of the subsidence and re-elevation to which the land has been subjected, a question requiring much further investigation.

As a result of the circumstances noted, the St. Lawrence plain, as far west as Ottawa and Kingston at least, is deeply covered by deposits due to the glacial period, including boulder-clay, Leda clay and an overlying Saxicava sand, the two last, often full of fossil shells of the period. In the coastal regions of the Maritime Provinces similar deposits occur, to which the same names have been extended, but to the west, around the Great Lakes, no marine forms have been found. The stony boulder-clay is there overlain by a fine clay named the Erie clay and by various newer sandy and clayey beds. All these deposits of the glacial period possess great importance in respect to the soil and agricultural character of the country over which they prevail, and in large part its exceptional fertility is to be attributed to them.

Before leaving this subject, it may be noted that the Laurentide glacier in the east, below the city of Quebec, never crossed the estuary of the St. Lawrence. A separate but smaller gathering-ground of ice existed

in New Brunswick and adjacent parts of the State of Maine, which has been called the Appalachian glacier. This has been very clearly shown by the work of Mr. Chalmers. The Magdalen Islands, in the centre of the Gulf of St. Lawrence, have never been glaciated, and it is at least a matter of doubt whether any ice, except that originating on the peninsula itself, ever passed over Nova Scotia. Newfoundland similarly shows evidence of having produced a local ice-sheet which flowed away toward the sea in all directions along the natural slopes. It is also found by Mr. Chalmers, that when the Laurentide glacier invaded the lowlands to the west of Quebec, the Appalachian glacier had either greatly decreased or had vanished. There are in this district two distinct boulder-clays, one referable to each of these glaciers, and it is probable that interglacial beds will yet be found there.

The Interior Continental Plain. This is bounded on the west by the Rocky Mountains, running about north-northwest, and on the east by the edge of the Laurentian plateau, which, taking a more westerly direction than the mountains, causes the gradual narrowing of the intervening plain to the north. Thus on the 49th parallel, here constituting the southern boundary of Canada, the plain has a width of about 800 miles; but it is reduced to less than 400 miles on the 56th parallel. To the north of the 62nd parallel, it is very greatly narrowed, and is broken by echelon-like flanking ranges of the Rocky Mountains, but still further northward it again expands, and appears to have a width of nearly 300 miles, where it terminates on the Arctic Ocean.

The southern part of this great plain is not only the most important from an economic point of view, but is also that about which most is known. It includes the wide prairie country of the Canadian west, with a spread of about 193,000 square miles of open grass-land, an area more than twice that of Great Britain. Beyond the

North Saskatchewan River, the plain becomes essentially a region of forest, with only occasional prairie tracts, such as those of the Peace River valley. By chance rather than by intention, the boundary line on the 49th parallel, to the west of the Red River, nearly coincides with the low watershed which separates the arid drainage-basin of the Missouri from that of the Saskatchewan and its tributaries, cutting off only 20,000 square miles from the Missouri slope. Another line, nearly coinciding with a second low transverse watershed, may be drawn on the 54th parallel. The watershed crosses this line several times, but in the main it may be taken as dividing the Saskatchewan system of rivers from those of the Mackenzie and the Churchill. The belt of country comprised between these latitude lines is 350 miles wide, with a total area of about 295,000 square miles.

The whole interior plain slopes eastward or northeastward, from the Rocky Mountains towards the foot of the Laurentian highlands, so that a line drawn from the base of the mountains near the 49th parallel to Lake Winnipeg, shows an average descent of over five feet to the mile, fully accounting for the generally rapid courses of the rivers of the region. There are, however, in the area to the south of the 54th parallel, two lines of escarpment or more abrupt slope, which serve to divide this part of the plain into three portions, and although such division is by no means definite, it may usefully be alluded to for purposes of description.

The first or lowest prairie-level is that of the Red River valley, of which the northern part is occupied by the Winnipeg group of lakes, its average elevation being about 800 feet above the sea, although gradually rising to the southward, along the axis of the valley, till it reaches a height of 960 feet about 200 miles to the south of the International boundary. Its area in Canada is about 55,000 square miles, including the lakes, and to the south of Lake Winnipeg it comprises

some 7,000 square miles of prairie land, which to the eye is absolutely flat, although rising uniformly to the east and west of the river. This is the former bed of the glacial "Lake Agassiz," the sediments of which constitute the richest wheat lands of Manitoba.

The escarpment bounding this plain on the west, begins at the south in what is known as "Pembina Mountain," and is continued northward in the Riding, Duck, Porcupine and Pasqua hills, which overlook Manitoba and Winnipegosis Lakes, constituting the main eastern outcrop of the Cretaceous rocks of the plains. From this escarpment, the second prairie-level extends westward to a second and nearly parallel marked rise, which, in general, is known as the Missouri Côteau. The area of this plain is about 105,000 square miles, of which more than half is open prairie. Its average elevation is about 1,600 feet, and its surface is more diversified by undulations and low hills and ridges than that of the last, while the river-valleys are often deeply cut as well as wide. The greater part of the surface is well adapted for agriculture, although in places the scarcity of trees constitutes a disadvantage. The character of the soil is also more varied than that of the lower plain.

The third and highest plain, lying between the last and the base of the Rocky Mountains, may be stated to have an average height of 3,000 feet, with an area, between the parallels of latitude first referred to, of about 134,000 square miles, of which by far the greater part is almost absolutely devoid of forest, its wooded area being confined to its northern and north-western edges, near the North Saskatchewan River or its tributaries. The surface of this plain is still more irregular than that of the last, and it is evident that both before and after the glacial period the denuding forces of rain and rivers have acted upon it longer and more energetically. Table-lands like those of the Cypress Hills and Wood Mountain, must be regarded as outlying rem-

nants of an older plain of the Tertiary period, and the slopes and flanks of such outliers show that similar processes of waste are still in operation, adding to the length and depth of the ravines and "coulées," by which the soft Cretaceous and Tertiary rocks are trenched. The deposits of the glacial period, with which even this high plain is thickly covered, have tended to modify the minor asperities resulting from previous denudation. The soil is generally good, and often excellent, but large tracts to the south and west are sub-arid in character, and suited rather for pasturage than for agriculture.

Along the base of the Rocky Mountains is a belt of "foot-hills," forming a peculiar and picturesque region, of which the parallel ridges are due to the differing hardness of the Cretaceous rocks, here thrown into wave-like folds, as though crushed against the resistant mass of the older strata of the mountains.

Taken as a whole, the central plain of the continent in Canada may be regarded as a great shallow trough, of which, owing doubtless to post-Tertiary differential uplift, the western part of the floor is now higher in actual elevation than its eastern Laurentian rim. But although thus remarkably simple and definite in its grand plan, there are many irregularities in detail. The second prairie-level has, for instance, some elevations on its surface as high as the edge of the third plain, both to the west and east of the valley of the Assiniboine River, which, again, is abnormally depressed. It is not possible here to do more than characterize its features in a general way.

Ever since an early Palæozoic time, the area now occupied by the interior plain appears to have remained undisturbed, and to have been affected only by wide movements of subsidence or elevation, which, although doubtless unequal as between its different parts, have not materially affected the regularity of the strata laid down. Upon this portion of the continental platform, in

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its eastern part, on Lake Winnipeg and its associated lakes, Cambro-Silurian, Silurian and Devonian rocks are found outcropping along the stable base of the Laurentian plateau. Following this line of outcrop northward, the Devonian rocks gradually overlap those of older date and rest directly upon the Archæan. They continue to the Arctic Ocean and there occupy a great part of the Northern Archipelago. To the south of Athabasca Lake they rest, without any apparent angular unconformity, upon sandstones referred to the Lower Cambrian, to which allusion has already been made, giving evidence, in the stratigraphical hiatus, of prolonged periods during Palæozoic time in which land as well as water existed in some parts of the area. On the western side of the Great Plains the Palæozoic strata reappear crumpled and broken in the Rocky Mountains, where the vast crustal movements of the Cordilleran belt found their inland limit.

These rocks consist, for the most part, of pale-grey or buff, often magnesian limestones, along the eastern outcrop, and from them Mr. Whiteaves has described an extensive and somewhat peculiar fauna. Some, at least, of the Palæozoic formations represented, probably extend beneath the entire area of the Great Plains, but they are wholly concealed there by later strata of Cretaceous age, consisting chiefly of clay-shales and sandstones, generally but little indurated and flat-lying, or nearly so. The uniformity in the surface features of this country is principally due to that of these deposits, which, although since greatly denuded, have worn down very equally, and have apparently never been very long subjected to waste at a great height above the base-level of erosion. The whole area has in fact been one rather of deposition than of denudation up to a time geologically recent, and has very lately been levelled up still further by the superficial deposits due to the glacial period.

The Cretaceous rocks are for the most part distinctly marine, although beginning with the Dakota sandstones, indicative at least of shallow seas, and from which, in the Western States, a considerable flora of land plants has been recovered. These are followed, in the eastern part of the plains, by the Benton shales, the Niobrara, largely calcareous and foraminiferal in some places, the Pierre shales, and lastly by the Fox Hill sandstones. Further west, in Alberta, a part of the Pierre (with probably also the upper portion of the Niobrara), is represented by the Belly River formation, with a brackish water fauna, and containing beds of coal or lignite. The Dunvegan series of the Peace River, to the north, similarly characterized, is perhaps somewhat older. The Cretaceous strata in fact change very materially in composition and character toward the Rocky Mountains, and when followed to the north, giving rise to the necessity for local names, and rendering a precise correlation difficult in the absence of connecting sections over great tracts of level country.

All the Cretaceous strata so far referred to belong to the later stages of that system, but in the foot-hills the earlier Cretaceous is represented by the Kootanie formation, holding coal, and reappearing as infolds in the eastern ranges of the Rocky Mountains. One of these is followed by the valley of the Bow River between Banff and Canmore, and affords both anthracite and bituminous coal.

Overlying the Cretaceous rocks proper, in considerable parts of their extent, particularly in Alberta, are those of the Laramie, which although perfectly conformable with the marine strata beneath, contain brackish water, and in their upper part entirely fresh water forms of molluscs, together with an extensive flora and numerous beds of lignite-coal or coal. As a whole, this formation may be regarded as a transition from the Cretaceous to the Tertiary, with a blending of

organic forms elsewhere considered as characteristic of one or the other. The lower parts are undoubtedly most nearly related to the Cretaceous and particularly to the Belly River beds, which were laid down under similar physical conditions at an earlier stage. The remains of Dinosaurian reptiles are still abundant in these. The upper beds, constituting what was originally named the Fort Union group, with its local representatives under different names, is on the contrary more nearly allied to the Eocene.

A still later stage in the Tertiary is represented by beds of Oligocene, or early Miocene age, found particularly as an outlier capping the Cypress Hills. These have afforded numerous mammalian bones, described by Professor Cope and referred by him to the stage of the White River beds of the Western States.

The aggregate thickness of the Cretaceous strata of the plains, so far as known, may in the eastern part be stated as about 2,000 feet; in the west, in northern Alberta, it is about the same, but exceeds 2,500 feet in south-western Alberta, without including the Kootanie series of some 7,000 feet or more. The thickness of the Laramie is also great toward the Rocky Mountains, reaching probably 3,700 feet.

The Pliocene (with perhaps the latter part of the Miocene) appears to have been a time of erosion only in the area of the Canadian plains; wide, flat-bottomed valleys were cut out in the foot-hills, and to the east of these great tracts of country between the now outstanding plateaux must have been reduced to the extent of 1,000 feet or more in height.

Mineral fuels, in the form of coals and lignite-coals, constitute economically the most important products of the Cretaceous and Laramie rocks of the plains. To the south of the 56th parallel in Canada, an area of not less than 60,000 square miles is underlain by beds of such fuel. These consist entirely of lignite to the eastward, but on entering the foot-hills bituminous

coals are found, and similar coals recur in infolded areas in the Rocky Mountains, together with anthracite.

Natural gas has been found in considerable quantities in borings in several places, but is not yet utilized. Great outcrops of Cretaceous sandstones saturated with tar or maltha occur along the Athabasca River, probably evidencing the existence of important petroleum deposits in the subjacent Devonian rocks. Salt springs appear on the borders of Manitoba Lake, and much further north in the Athabasca basin, but have been utilized to a very limited extent only. Gypsum also occurs in the Silurian and Devonian rocks along their eastern outcrop. Gold is washed from the sands of several of the larger rivers, but this, it is supposed, is for the most part derived by natural concentration from the drift deposits.

The Cordillera. Of this great mountainous region of the Pacific coast, a length of nearly 1,300 miles is included by the western part of Canada. Most of this is embraced in the Province of British Columbia, where it has a width of about 400 miles between the Great Plains and the Pacific Ocean. To the north, it is continued in the Yukon district of the North-West Territory, till it reaches, in a less elevated and more widely spreading form, the shores of the Arctic Ocean on one side, and on the other passes across the 141st meridian of west longitude into Alaska. Its strongly marked features result from enormous crustal movements parallel to the edge of the Pacific, by which its strata have at several periods and along different lines, been crumpled, crushed and faulted. These movements having continued at intervals to times geologically recent, and the mountains produced by them still stand high and rugged, with streams flowing rapidly and with great erosive power down steep gradients to the sea.

Although preserving in the main, a general north-

north-westerly trend, the orographic features of this region are very complicated in detail. No existing map yet properly represents even the principal physical outlines, and the impression gained by the traveller or explorer may well be one of confusion. Disregarding, however, all minor irregularities, two dominant mountain systems are discovered—the Rocky Mountains proper, on the east, and the Coast Range of British Columbia, on the west.

The first of these, it has been proposed to name, from an orographic point of view, the "Laramide Range," as it is essentially due to earth movements, occurring about the close of the Laramie period, and rocks of that age are included in its flexures. Although not quite continuous (for there are several echelon-like breaks, in which one mountain-ridge assumes the dominance previously possessed by another), this range, beginning two or three degrees of latitude to the south of the 49th parallel, forms the eastern member of the Cordillera all the way to the Arctic Ocean, which it reaches not far to the west of the Mackenzie delta. It is chiefly composed of Palæozoic rocks, largely limestones, and where it has been closely studied is found to be affected by series of overthrust faults, parallel to its direction, of which the easternmost separates it from the area of the Cretaceous foot-hills. Here the older rocks have been thrust eastward for several miles over the much newer strata. The structure has as yet been worked out in detail only along the line of the Bow River pass, by Mr. R. G. McConnell. In width, this range seldom exceeds sixty miles. The heights formerly attributed to some peaks appear to have been exaggerated, but many points in its southern part exceed 11,000 or 12,000 feet.

The Coast Range of British Columbia constitutes the main western border of the Cordillera. Beginning near the estuary of the Fraser River, it runs uninterruptedly northward, with an average width of about

100 miles, for at least 900 miles, when it passes inland beyond the head of Lynn Canal. This range is largely composed of granite, with infolded masses of altered Palæozoic strata. It is not, as a rule, so rugged in outline as the last, but its western side, rising from the sea, shows the full value of its elevation there, while its main summits often exceed 8,000 or 9,000 feet. Several rivers rising in the plateau country to the eastward, flow completely across this range to the Pacific, where the lower parts of their valleys, as well as those of many streams originating in the mountains themselves, in a submerged state constitute the remarkable system of fiords of British Columbia. Even in the arrangement of the islands adjacent to the coast, the further extension of these valleys and of others running with the range, may be traced, the evidence being of great subærial erosion when the land previously stood at a higher stage. The cutting out of these deep valleys probably began in Eocene times, but was renewed and greatly increased in the later Pliocene.

Outside the Coast Range and in a partly submerged condition, lies another range, of which Vancouver Island and the Queen Charlotte Islands are projecting ridges. This stands on the edge of the Continental plateau with the great depths of the Pacific beyond it. The rocks resemble those of the Coast Range but include also masses of Triassic and Cretaceous strata which have participated in its folding, while horizontal Miocene and Pliocene beds skirt some parts of the shores.

In the inland portion of British Columbia, between the Coast and Rocky Mountain systems above particularly alluded to, are numerous less important mountain ranges, which, while preserving a general parallelism in trend, are much less continuous. Thus, in travelling westward by the line of the Canadian Pacific Railway, after descending from the Rocky Mountain summit and crossing the Upper Columbia valley, the

Selkirk Range has to be surmounted. Beyond this, the Columbia on its southward return is again crossed, and the Gold Range is traversed by the Eagle Pass before entering the Interior Plateau of British Columbia, which occupies the space remaining between this and the Coast Range. The system of ranges lying immediately to the west of the Rocky Mountains proper, notwithstanding its breaks and irregularities, is capable of approximate definition and its components have been designated collectively the Gold Ranges. Further north, it is represented by the Cariboo Mountains, in the mining district of the same name. The highest known summit of this system is Mount Sir Donald, 10,645 feet, one of the Selkirk Mountains.

This mountain system is believed to be the oldest in British Columbia. It comprises Archæan rocks with granites and a great thickness of older Palæozoic beds, much disturbed and altered.

The Interior Plateau constitutes an important physical feature. Near the International boundary it is terminated southward by a coalescence of rather irregular mountains, and again, to the northward, it ends about latitude 55° 30′ in another plexus of mountains without wide intervals. Its breadth between the margins of the Gold Ranges and the Coast Range is about 100 miles, and its length is about 500 miles. It is convenient to speak of the country thus defined as a plateau, because of its difference, in the large, from the more lofty bordering mountains. It comprises the area of an early Tertiary denudation-plain (or peneplain) which has subsequently been greatly modified by volcanic accumulations of the Miocene, and by river-erosion while it stood at a considerable altitude, in the Pliocene; but its true character as a table-land is not obvious until some height has been gained above the lower valleys, where the eye can range along its level horizon-lines. It is highest to the southward, but most of the great valleys traversing it are less in elevation

than 3,000 feet above the sea. To the north, and particularly in the vicinity of the group of large lakes occurring there, its main area is less elevated than 3,000 feet, making its average height about 3,500 feet.

Beyond this plateau to the north, the whole width of the Cordillera, very imperfectly explored as yet, appears to be mountainous as far as the 59th parallel of latitude, when the ranges diverge or decline, and in the upper basin of the Yukon, rolling or nearly flat land, at moderate elevations, again begins to occupy wide intervening tracts.

As a whole, the area of the Cordillera in Canada may be described as forest-clad, but the growth of trees is more luxuriant on the western slopes of each of the dominant mountain ranges, in correspondence with the greater precipitation occurring on these slopes. This is particularly the case in the coast region and on the seaward side of the Coast Range, where magnificent and dense forests of coniferous trees occupy almost the whole available surface. The Interior Plateau, however, constitutes the southern part of a notably dry belt, and includes wide stretches of open grass-covered hills and valleys, forming excellent cattle ranges. Further north, along the same belt, similar open country appears intermittently, but the forest invades the greater part of the region. It is only toward the Arctic coast, in relatively very high latitudes, that the barren Arctic tundra country begins, which, sweeping in wider development to the westward, occupies most of the interior of Alaska.

With certain exceptions, the farming land of British Columbia is confined to the valleys and tracts below 3,000 feet, by reason of the summer frosts occurring at greater heights. There is, however, a considerable area of such land in the aggregate, with a soil generally of great fertility. In the southern valleys of the interior, irrigation is necessary for the growth of crops.

The geological structure of the Cordillera is extremely complicated, and it has as yet been studied in detail over limited tracts only. There have been no appropriate terms of comparison for the formations met with, and these it has consequently been necessary to investigate independently by the light of first principle. The difficulty is increased by the abundance of rocks of volcanic origin referable to several distinct periods, resembling those of the Appalachian mountain region, though on a vastly greater scale, and like them, almost entirely devoid of organic remains. The recognition, early in their investigation, of the originally volcanic nature of a large part of the rocks, has rendered it possible, however, to understand the main geological features, which at first appeared to present an almost insoluble problem.

Rocks referable to the Archæan obtain a considerable development in British Columbia, but it has not so far been found possible to recognize definitely the Laurentian and Huronian systems. Where they have been noted and examined, chiefly in the Gold Ranges and Interior Plateau, they have been distinguished as the Shuswap series. They include rocks resembling the Fundamental Gneiss of the east in character and composition, together with crystalline limestones, quartzites and gneissic rocks like those of the Grenville series and evidently representing metamorphosed sediments. At this distance from the typical developments of the Laurentian and Huronian, it is not to be expected that any precise parallelism in mineral composition and degree of alteration can be established, but that these rocks really are Archæan, has been determined by their unconformable infraposition to the lowest Palæozoic strata.

Above the Shuswap series, in the Rocky Mountains, Gold Ranges and elsewhere, is a great thickness of Cambrian strata, or of Palæozoic rocks at present collectively classed under this system. Fossils referable

to the *Olenellus* zone, have been found about half-way down in these strata in the Rocky Mountains, but from the lower conformable mass of beds, no recognizable organic forms have yet been obtained. A great thickness of contemporaneous volcanic material is generally included in the Cambrian. The Cambro-Silurian and Silurian, on the evidence in each case of a few characteristic fossils, are known to exist in the western part of the Rocky Mountains proper, and far to the north, on the Dease River (near lat. 60°), an interesting Graptolitic fauna of Trenton age has been found. The Devonian has not been distinctly recognized.

In the Rocky Mountains, the Carboniferous is largely represented, chiefly by massive limestones, and the fossils found in these pass down to a stage which has been characterized as Devono-Carboniferous. No single trace of the flora of the Carboniferous period has yet been discovered in the western regions of Canada. In the Interior Plateau and along the coast, the Carboniferous consists below of volcanic accumulations and quartzites and above of limestones, some of which are largely foraminiferal and composed of *Fusulina* and *Loftusia*.

The Triassic, in the southern part of the Rocky Mountains proper, is represented by red sandstones, the deposits of an interior Mediterranean of the period. To the west and north, it becomes a marine formation, with peculiar fossils of the "Alpine Trias" type, but over large areas it consists almost entirely of contemporaneous volcanic accumulations.

In a few places in the southern part of British Columbia, this formation appears (following the views of Prof. A. Hyatt on its fossils) to pass up into the Jurassic; but the next important series of beds, succeeding a very great stratigraphical break, is the Cretaceous. Rocks of the Earlier Cretaceous (Kootanie and Queen Charlotte Island formations) occur in places in the Rocky Mountains and throughout

British Columbia as far as the coast, also northward to the Porcupine River, between latitudes 67° and 68°, in the Yukon District. Newer Cretaceous rocks are developed particularly in Vancouver Island, where they constitute the productive coal measures. In the Crow's Nest Pass region and elsewhere in the Rocky Mountains, as well as in the Queen Charlotte Islands, the Earlier Cretaceous rocks contain abundance of good coal. All the strata of the Cretaceous period are more or less tilted and folded, and are evidently prior in date to the last great orogenic movements of the Cordillera. Evidences of contemporaneous volcanic action are again abundant in some parts of the extent of the Cretaceous.

Rocks referable to the Laramie or transition period between the Cretaceous and Tertiary, are found in the Yukon district and in the vicinity of the Fraser delta, holding lignite-coals and numerous remains of plants. Beds assigned to the Oligocene and Miocene are also well developed in the southern part of the Interior Plateau of British Columbia, where the latter period has been an epoch of notable volcanic eruptions, producing both effusive and fragmental rocks, but toward the close flooding large tracts with basaltic flows. Traces of similar volcanic activity, of the same date, are found in the Queen Charlotte Islands and in Vancouver Island. The Pliocene was chiefly a time of erosion, but deposits referred to this period are not entirely wanting.

Until the completion of the Canadian Pacific transcontinental railway, the west coast of Canada was a remote region, accessible with difficulty; but long before this, coal had been successfully mined in Vancouver Island, and in 1858 and succeeding years, the discovery and working of placer gold deposits brought the then isolated colony of British Columbia into considerable prominence. From the time of the quarrel with Spain on the Nootka question, in 1790, little had

been heard of the region, which remained unprized and suffered naturally in consequence when the "Oregon" boundary was settled with the United States.

The yield of alluvial gold reached its maximum in 1863, and thereafter, as in all mining regions of this kind, began steadily to decline. But of late years, and consequent on the introduction of means of communication, a remarkable development has begun. The conditions in this disturbed region of the continent are so varied, that it is difficult to name many metallic minerals which do not occur in it; but silver, gold, lead and copper have already begun to be produced in important quantity where certain districts in its southern part have been prospected, while the placer mining of gold had extended very far to the north in the Yukon valley and to the border of Alaska. Coal mining has continued uninterruptedly since its first beginning, and the product is now exported to many countries on the Pacific seaboard, but more particularly to California.

The Cordilleran region of Canada is undoubtedly destined to become one of the most important mining countries of the world, and probably before many years the value of its output will more than equal that of all other parts of the Dominion combined.

Glaciation of Western Canada. Like the eastern part of Canada, the western has been largely affected by the events of the glacial period. Most of the superficial deposits can be explained only by reference to this period, and to it also the diversion of many rivers and streams and other important changes are due. It is not yet possible to give a connected account of these events which will meet with general agreement, but, as in the east, the main facts have already been made sufficiently plain.

At an early time in the glacial period, the Cordillera, standing probably at a relatively high elevation, became covered by a confluent ice-sheet, extending

approximately from latitude 48° to latitude 63°, with a total length, at its maximum, of some 1,200 miles. The form of the surface prevented the ice from discharging in all directions like that of Greenland, and forced the bulk of the outflow to move south-eastward and north-westward, in conformity with the direction of the ruling mountain ranges, from a central neutral gathering-ground or nevé, situated approximately between the 55th and 59th parallels. The southward-moving portion of the great glacier filled the Interior Plateau of British Columbia, while its opposite extremity in the main flowed into the Yukon basin. Smaller streams from the main mass undoubtedly crossed the Coast Range by transverse valleys, to reinforce secondary, but large glaciers, which reached the sea to the south and north of Vancouver Island, while others extended through the Bow River valley and similar depressions in the Rocky Mountains to the western margin of the Great Plains.

This Cordilleran glacier, as shown by late observations in the western part of the Great Plains, was the first to affect that region, and may perhaps prove to be the first notable ice-cap developed during the glacial period in North America. At a later time it became gradually very much reduced, but subsequently, at least once, again extended to dimensions in some places approaching those first held by it. Rock striation and the transport of erratics, show that the southern part of the Cordilleran glacier, when at its maximum, passed uninterruptedly over projecting points between 6,000 and 7,000 feet in height above the sea.

In the opinion of the writer, there is evidence such as to render it probable that the first retreat of the Cordilleran glacier was contemporaneous with a depression of the Cordillera to the amount of 4,000 feet or more, enabling water at the level of the sea to reach such elevations on both sides of the Rocky Mountains.

Subsequently, during the second spread of the glacier-ice, the land is supposed to have risen; and at a still later date, there is fairly conclusive evidence to the effect that it stood about 2,500 feet lower relatively to the sea than it now does.

The above hypotheses are stated under all reserve and subject to further enquiry, but the main facts and the evidences of glaciation of a very pronounced type, rock-scoring, boulder-clay, moraines, terraces, kames and eskers are abundantly evident throughout the greater part of British Columbia and the Yukon district.

In the area of the Great Plains, as above noted, the first recognized evidences of glacial conditions are those connected with the eastward spread of comparatively limited tongues of glacier-ice from the Rocky Mountains, and the deposit, on the western plains, of boulder-clay and rolled gravels attributed to what it has been proposed to name the Albertan stage. Subsequently, at least two more distinct boulder-clays, separated by important interglacial deposits, have been laid down over the whole western part of the Great Plains, ending above in silty, sandy and gravelly beds, with large scattered superficial erratics. In connection, doubtless, with one of these boulder-clays, is the remarkable monument of the Glacial period known as the Missouri Côteau (crossed by the Canadian Pacific railway west of Parkbeg station), which may be regarded either as part of a continental moraine or as the marginal accumulation of an ice-laden sea. These later boulder-clays differ from those of the Albertan stage in being largely composed of debris of the Laurentian and Huronian rocks and Palæozoic limestones found in places on the eastern side of the interior continental plain. The direction of transport of these erratics has been from the north-east or north-northeast. The manner of their carriage and that of the deposition of the beds in which they occur, is still a subject of discussion; but

there can be no doubt that great relative and absolute changes in elevation have occurred in the region, while terraces occurring at heights of 5,300 feet in the Porcupine Hills, near the base of the Rocky Mountains, show that that part of the plains at least was flooded to a corresponding height, which is practically identical with that previously found in the mountain region of British Columbia. To the writer there appears to be strong presumptive evidence that this water was in more or less direct communication with that of the sea, but other hypotheses have been advanced, and it remains for future investigation to determine that which may eventually prevail. It is with hesitation that we are prepared to admit great succeeding changes in level of large areas of the continent, but the alternative explanations, attributing as they must the most extraordinary effects to glacier-ice, seem to present at least equal difficulty.

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