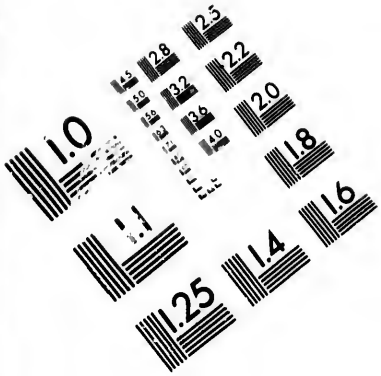

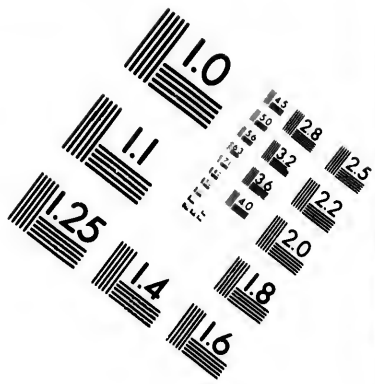

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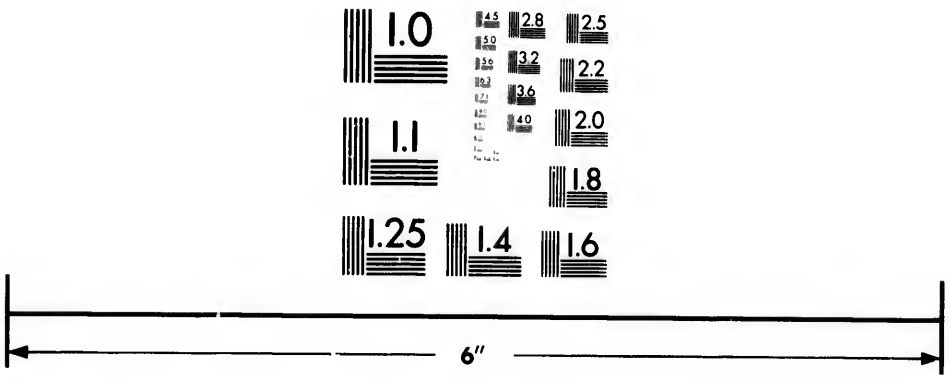

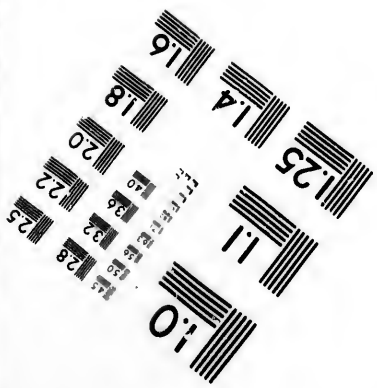

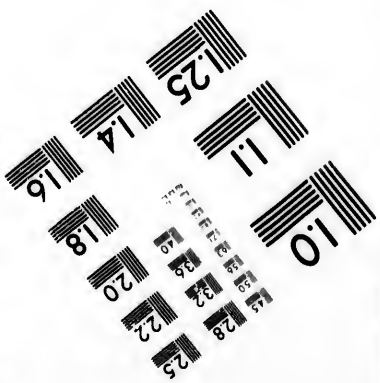

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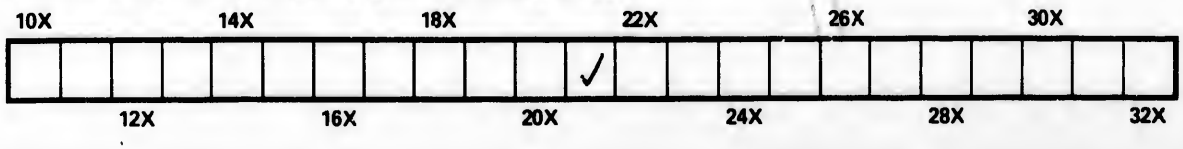

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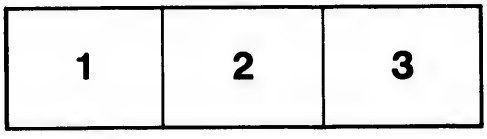

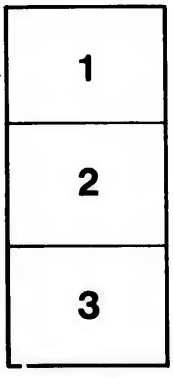

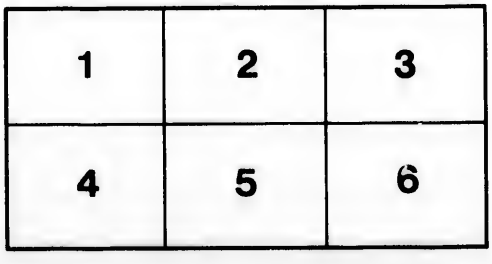

DESCRIPTIVE SKETCH

OF THE

PHYSICAL GEOGRAPHY AND GEOLOGY

OF THE

DOMINION OF CANADA.

BY

ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S.,
DIRECTOR OF THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA;

AND

G. M. DAWSON, D.S., F.G.S., F.R.S., Can.
ASSOCIATE OF THE ROYAL SCHOOL OF MINES.

MONTREAL:
DAWSON BROTHERS.
1884.

PREFACE.

In the following descriptive sketch of the physical geography and geology of Canada, which has been prepared to accompany a new geological map of the Dominion on a scale of forty miles to one inch, the country is divided into an eastern and western section, lying respectively east and west of the Red River valley. The areas may be approximately stated as 2,500,000 square miles for the eastern and 1,000,000 square miles for the western section.

The description of the Eastern Section, Part I., is by the writer and that of the Western Section, Part II., by Dr. G. M. Dawson.

The material is for the most part derived from the explorations and published reports of the Geological Survey, from its commencement in 1842 to the present date. Also, as regards the western division, from the Report on the Geology and Resources of the 49th parallel, by Dr. G. M. Dawson (Boundary Commission Report 1875).

ALFRED R. C. SELWYN.

OTTAWA, June, 1884.

PART I.

(EASTERN SECTION.)

CHAPTER I.

PHYSICAL GEOGRAPHY.

In considering the physical features of the eastern division of Canada, from the Valley of the Red River in longitude 97° west to the Atlantic sea board of Nova Scotia and Labrador, including the now geographically separated, but physically and geologically connected, island of Newfoundland, we find it comprises areas which present three very distinct aspects, both geographical and geological. These areas may be enumerated and described as follows. They are closely connected with the geological structure and are consequently indicated and outlined approximately by the geological color on the accompanying map.

1. The South-Eastern Area.
2. The Southern-and-Western Area.
3. The Northern Area.

1. The South-Eastern Area.

The South-Eastern area is bounded on the north-west by the river St. Lawrence from the Strait of Belle Isle to Quebec and thence by an almost direct line to the foot of Lake Champlain on the Vermont boundary. Within it are included the provinces of New Brunswick, Nova Scotia and Prince Edward Island, also the somewhat larger island of Anticosti, (the latter being, however, in its physical character an isolated portion of area number 2.), while Newfoundland constitutes its north-eastern limit. The main orographical feature has a course parallel to and only a short distance away from the St. Lawrence. It constitutes the north-eastern prolongation of that branch of the Appalachian Mountains of which the Green Mountains of Vermont and the White Mountains of New Hamphire form a part, and which in Canada takes the name of the Notre Dame Range.

To the south-east this area may be described as occupied by a succ
sion of subordinate and approximately parallel ridges. These have
general north-east and south-west course, and gradually diminish
altitude across the provinces of New Brunswick and Nova Scot
The most prominent are:—1. The granitic highlands of No
Scotia, extending in a broad sweep from Cape Sable to Ca
Canso, nowhere, however, attaining an elevation of 1200 feet. 2. T
Cobequid Range from Cape Chiegneeto to Cape St. George, then
extending through the highlands of Cape Breton to Cape North, a
continued from Cape Ray north-eastward through Newfoundlan
3. The granitoid and trappean ridges of central New Brunswick e
tending south-west from the Bay of Chaleurs; 4. The main ax
from Sutton Mountain (4000 feet high) on the Vermont boundary t
Cape Rosier in Gaspe where in the Shickshocks and neighbouring
mountains we again find numerous peaks ranging from 2500 to 400
feet in altitude.

I have elsewhere described the Gaspe-Peninsula as forming a block
of table lands about 1500 feet in height in which the river courses are
deep and narrow excavations. Rising from this, the Shickshock
Mountains form a conspicuous range extending about sixty-five miles
from the east side of the Ste. Anne des Monts to the Matane. It
occupies a breadth of from two to six miles at a distance of about
twelve miles from the St. Lawrence, and rises into peaks as already
stated attaining heights of between 3000 and 4000 feet. But though
the highest land. this range does not form any part of the water
parting of the peninsula; for the Ste. Anne des Monts, the Matane
and the Chatte, taking their sources in lower country to the south,
cut gorges through the range so deep that their channels where
crossing it are not more than 500 to 600 feet above the St. Law-
rence. The waters of one branch of the Matane have their source
on the lower land north of the range and flow south through a
profound gap to join the main stream, thus crossing the range twice
in their course to the great River.

On the northern slope to the St. Lawrence the rivers are comparatively short and rapid. The Etchemin, the Chaudiere, the St. Francis, the Yamaska and the Richelieu are the only ones of any importance. The valleys of these streams do not attain a greater elevation than from 500 to 1000 feet above the St. Lawrence, and like the streams cutting the Shickshock Mountains, they gather much of their waters from lands to the south, through valleys running with the strike of the ridges. Connected with these streams are a number of considerable lakes; Megantic and Spider form the head waters of the Chaudiere, 1,100 feet above the sea, and together cover an area of about

twenty square miles; St. Francis, Aylmer, Memphremagog, Little Magog and Massawippi are tributary to the St. Francis, and stand at elevations respectively of 890, 795, 634, 500 and about 600 feet, with areas of 12, 9, 37, 8 and 6 square miles. The extreme depth of Memphremagog Lake is stated to be upwards of 600 feet; the outlet is over strata of Siluro-Devonian shales and limestones, dipping at high angles, the strike being parallel with the length of the lake in its northern half. Neither the depth nor the nature of the basins of the other lakes named have as yet been fully ascertained. They all appear, unlike the lakes of the Laurentides, to occupy long and narrow, or trough-like depressions in the valleys, but whether they are rock-basins or drift-dam'd portions of the old valleys remains to be decided by future investigation.

Notwithstanding the general hilly and sometimes mountainous and thickly wooded character of Eastern Canada, there are many fine stretches of agricultural and pastoral lands, most of which are due to the modification the surface has undergone during the formation of the glacial and later deposits of Post-Tertiary Age, which have filled in and obliterated many of the irregularities of the surface of the ancient disturbed and corrugated rock formations.

These Post-Tertiary marine formations appear in all parts of the area in flats and terraced banks up to elevations of 500 feet above the sea, while similar deposits of fresh-water origin occur at elevations of more than 2000 feet.* They are fully described in chap. xxii. Geology of Canada, 1863.

2. The Southern-and-Western Area.

Adjoining the area to which the foregoing remarks apply, and bounded on the east by its north-western limit, is that which has been referred to as the Southern-and-Western Area. Excepting the isolated trap hills at and in the vicinity of Montreal island, which probably mark the sites of volcanic vents of the Siluro-Devonian period, this area is absolutely devoid of mountains, or even of prominent hills. It presents a broad, level or slightly undulating expanse of generally fertile country, with occasional step-like ridges or rocky escarpments, marking the outcropping edges of some of the gently inclined palæozoic formations which—but in a totally different physical condition—likewise occupy the south-eastern area. One of these escarpments occurs at the outlet of Lake Ontario, where the Birds-eye

* Thunder Cape, in Lake Superior, is strewn with pebbles derived from the palæozoic conglomerates of the region, and a large boulder of Laurentian gneiss was observed near the summit, of the Cape at a height of not less than 1800 feet above the sea level.

limestone formation rests on the Laurentian axis of the Th
Islands. Next is the well-known Niagara escarpment, over whi
waters of the Niagara River are precipitated in a vertical fall of 16
and which marks a somewhat sudden rise of 330 feet in the gener
vation of the country. This rise includes the combined outcro
edges of the Medina, Clinton, Niagara, Onondaga and Corniferou
mations in a horizontal distance of about twenty-four miles, bet
Niagara, on Lake Ontario, and Buffalo, on Lake Erie. The Sout
-and-Western Area may be generally defined as bounded on the
by the Laurentian gneisses of the Northern Area. It occupies an i
rupted belt of country of varying width, extending from the vicini
Quebec to the Manitoulin Islands. Limited patches belonging to
area occur also around the north shore of Lake Superior and in
Nepigon basin. Further to the north-west another similar area
mences in the valley of the Red River, on the 49th parallel, between
and 98° west longitude, and extends thence to the Arctic Ocean.
yond the archæan continental axis, other similar areas occur around
shores of Hudson's Bay. Of these, however, but little is yet known w
certainty, and even the limits of them, as given on the geological m
are more or less conjectural. They apparently include, in near
horizontal attitude, several members of the palæozoic series as reco
nized on the southern side of the archæan highlands, which divi
the waters of the St. Lawrence from those flowing to Hudson's Ba
The physical condition of the rocks in all these areas testifies to th
fact that the forces which operated so intensely in the South-Eastern
Atlantic coast Area throughout palæozoic and earlier ages, did no
appreciably influence any part, either of the interior, or of the arctic
palæozoic basin, and that their operation was practically limited in
palæozoic time by the line which follows the trough of the St. Law-
rence, Lake Champlain and the Hudson River, already referred to as
the great Saint Lawrence and Champlain fault. On these grounds
alone can we explain the physical and mineralogical diversities con-
current with palæontological correspondences, which characterize the
South-Eastern and the Southern-and-Western Areas. These diver-
sities have, however, doubtless been considerably enhanced by local
contemporaneous volcanic agencies of the operation of which at
intervals throughout the palæozoic age, there is abundant evidence in
both areas.

The main hydrographic feature of the Southern-and-Western Area
is the chain of great lakes, which together present a water surface in the
interior of the Continent of probably not less than 150,000 square miles.
They all constitute parts of one or other of the three great River systems
of the St. Lawrence, the Nelson and the Mackenzie, and their northern and

eastern shores are, with the exception of Lake Erie, bounded by the archæan rocks of the Northern Area, while their basins have been excavated chiefly in strata of palæozoic age. The bottom of Lake Huron is said to be in parts 1,200 feet, that of Lake Superior, 600 feet, and that of Lake Ontario about 360 feet beneath the level of the Atlantic, while the comparatively shallow waters of Lake Erie foreshadow the time when this lake will become a broad river valley, and the cataract of Niagara will then either be reduced to one half its present height, or entirely obliterated.

3. The Northern Area.

It is not easy to state precisely the extent of this great Northern Area. It embraces probably two-thirds of the whole area of the Dominion or more than two million square miles.

In the third chapter of the Geology of Canada, 1863, Sir W. Logan describes the southern limit of the Laurentian System with which that of the area now referred to may be said to coincide as follows: "With the exception of a narrow border of Silurian* strata on the Strait of Belle-isle, another at the mouth of the Mingan River and a third near the Seven Islands with the addition of two narrow strips running a few miles up the Murray Bay River and the Goulfre, the north shore of the St. Lawrence is the southern boundary of this ancient series of deposits from Labrador to Cape Tormentine. The distance is about 600 miles." . . . In the next 200 miles the boundary turns about west-south-west, and is distant from the St. Lawrence about thirty miles in the rear of Montreal. Beyond this for a hundred miles it follows the Ottawa in a bearing more nearly west, with a narrow strip of Silurian rocks between it and the margin of the river for the chief part of the distance.

Turning southwards at the upper end of Lac des Chats,† an expansion of the Ottawa River, it runs in a very irregular line between that lake and the St. Lawrence which it again reaches at the Thousand Islands, presenting in the interval several points projecting into the Lower Silurian plain to the eastward.‡ The Canadian part of the boundary runs in a a pretty straight line to Matchedash Bay, on Lake Huron, from the Thousand Islands whence the Laurentian expands into an area of 1000 square miles in the State of New York, forming the wild, rugged and rocky region of the Adirondack Mountains, which rise in some parts into elevations of 5,000 feet above the sea. Mount Marcy, in Essex county, is said

* Now called Cambrian and Cambro-Silurian.
† Near Arnprior.
‡ This is the Ottawa Valley Palæozoic basin of the Southern-and-Western Area.

to be 5,400 feet in height. Sir William continues: "From Matchedash Bay the east and north shores of Lake Huron complete the southern boundary, which terminates at Shebahahnahning."

At this point, now known as Killarney, the site of a thriving fishing industry and a port of call for the Lake Superior steamers, is the commencement of the "Huronian Series," described page 52, chapter iv, of the Geology of Canada, 1863."

For the purpose of this description, however, the Huronian system is included in the Northern Area, and the southern boundary of the latter must therefore be described as prolonged westward from Killarney along the shore north of the Manitoulin Islands, up the St. Mary River, and around the whole of the eastern and northern shores of Lake Superior to the vicinity of Port Arthur on Thunder Bay, and thence in a south-westerly direction to about fifty miles east of Otter Tail Lake at the source of the Red River. Here the crystalline rocks pass beneath the newer formations. The margin of these then forms the entire western boundary. This follows the east side of the Red River valley, keeping the east shore of Lake Winnipeg to its outlet, and thence in a nearly direct north-west course to the mouth of the Mackenzie in the Arctic Ocean. Much of this boundary is, however, deeply covered with drift which for many miles conceals the junction of the subjacent formations.

Except some of the higher peaks of the Laurentides in proximity to the shores of the Gulf, and perhaps some others in the Labrador Peninsula there are few points in all this vast area which attain two thousand feet in height, while the average elevation is probably less than 1,000 feet above the sea. It is pre-eminently a region of waterways. Lakes and rivers, tributary to one or other of the four great river systems of the Continent—the Mississippi, the Mackenzie, the Nelson and the St. Lawrence—form routes through every part of the region. A traveller starting in a canoe from the Gulf of St. Lawrence, can traverse the continent to the Arctic Ocean at the mouth of the Mackenzie; he can reach various points on Hudson's Bay; or, by the Red River and the Mississippi he can paddle on the waters of the Gulf of Mexico.

While in every part of this Eastern section of the Dominion the surface of the country has been greatly modified and unified by the superficial agencies of the glacial and later periods, still, the characters impressed on the ancient foundations of archæan and palæozoic rocks, by deep seated and long continued dynamic action are still apparent, and it is these latter which have so plainly individualised the three areas of the Eastern section of Canada, of which the main physical features have now been sketched.

CHAPTER II.

GEOLOGY.

I shall now proceed to give a brief outline of the geological features of each section. They may be conveniently designated.

1. The South-Eastern Palæozoic Basin.
2. The Central-and-Western Palæozoic Basin.
3. The Archæan Nucleus.

They are geographically coterminous with the physico-geographic areas, though within the limits of each there are included portions of the others. Thus the northern peninsula of Nova Scotia (Cape Breton Island) and some other axial ridges in the eastern Palæozoic basin belong to the Archæan nucleus. The island of Anticosti, the basins of Lakes St. John, Mistassini, Nipissing, Temiscamang and James' Bay, and probably others not yet observed, are geologically outliers of the Central-and-Western Basin. While in the South-Eastern Basin we have Carboniferous and Triassic formations which, not having been subjected to the action of those forces already referred to as having given rise to the general physical aspect of the region, are comparatively undisturbed, and where these occur, a level or gently undulating surface replaces the hills, ridges and mountains formed of the disturbed lower palæozoic and more ancient strata.

Except some doubtfully Triassic areas in Nova Scotia and Prince Edward Island there are—apart from Post-Tertiary deposits—no formations newer than the coal measures, in any part of the Eastern Section of the Dominion. Below the Carboniferous, all the larger divisions (systems) from Laurentian to Devonian are represented in the South-Eastern Basin, including many of the formations and groups into which these have been elsewhere locally divided.

On the geologically colored map of the Dominion, in explanation of which this sketch has been prepared, the scale—forty miles to one inch—is not large enough for these subdivisions to be indicated, though when possible to do so the supposed lower, middle or upper portions of the system have been shewn respectively by vertical, diagonal and horizontal lines.

1. The South-Eastern Palæozoic Basin.

In the geological map of Canada, 1866, the principal features of the South Eastern Palæozoic Basin are: 1st. The so-called Quebec group, occupying an area nowhere exceeding thirty miles in width, but extending from the Vermont boundary to Cape Rosier in Gaspe.

2nd. The broad Siluro-Devonian basin, forming the hilly country about the sources of the St. John, the Restigouche and the Matapedia, and extending from Cape Gaspe south-westerly into Maine and New Hampshire.

3rd. The belt of Cambro-Silurian and older strata with associated trappean rocks, and newer granites which constitutes the south-eastern margin of the Siluro-Devonian basin, from the vicinity of Bathurst, on the Bay of Chaleurs to the Atlantic coast of Maine.

4th. The central Carboniferous area of New Brunswick and Nova Scotia, cut by the shores of Northumberland Strait from Shippegan Island on the north-west to New Glasgow on the south-east, and,

5th. The gold bearing Atlantic coast series of Nova Scotia, of lower Cambrian age, with its associated belts of granitic and gneissic rocks, which are due to agencies operating in periods up to the commencement of the Carboniferous, and culminating at or about the close of the Devonian.

In 1863, the Quebec group was, divided into three formations, in ascending order, called Levis, Lauzon and Sillery, and these are represented on the map (1866) by three distinct colors, dark lilac, light lilac and yellow. The light lilac tint being also used to denote other large areas likewise supposed to belong to the same group, but in which the sub-divisions had not been recognized. In the report of 1869 a considerable portion of the Quebec group area east of the Chaudière River and mapped as Lauzon and Sillery in 1866, was re-mapped in 1869 as Potsdam, and described as lying unconformably beneath the lower or Levis divison of the group. This, I have elsewhere pointed out, was manifestly erroneous, and, that there are neither palæontological nor stratigraphical grounds for separating the rocks of the south shore of the St. Lawrence between the Chaudière and Trois Pistoles from those of the island of Orleans, where, along the south shore perfectly identical limestones, conglomerates, slates, quartzites and sandstones are well exposed. The whole of this red and black shale, quartzite and limestone conglomerate series may, and probably does, occupy a position inferior to that of the conglomerates of Point Levis and their interstratified graptolite slates, but if so, then these inferior beds cannot be limited, to the south-west, by the Chaudière Valley. And they must be made to embrace the larger part of the Quebec group from the Chaudière to the Gaspe Peninsula on the one hand, and also considerable areas between the Chaudière valley and the Vermont boundary on the other. In the present state of our knowledge, however, there appear no good grounds for any such distinctions, nor if made, would it be possible except theoretically to depict them on a map. Our knowledge does, however, enable us to

affirm, with a considerable degree of certainty, that within the limits of the highly disturbed folded and faulted lower Palæozoic belt of the St. Lawrence valley hitherto known and depicted on the map of 1866 as the Quebec Group, there are included areas of Hudson River, Utica, Trenton, and Chazy, as well as others of the still older Cambrian formations and that these lie uncomformably on or against an axis of Pre-Cambrian sub-crystalline rocks, hydro-mica slates, quartzites, crystalline dolomites, diabase, gabbro, olivinite, serpentine and volcanic agglomerates, the lowest beds of the axis being micaceous and granitoid gneisses. Many of these volcanic agglomerates and diabases are now serpentines of which large slabs can be seen in the geological museum, as well as specimens of all the other rocks named. This lower portion of the Quebec group is defined on the present map and colored as Pre-Cambrian. It extends from Sutton Mountain, on the Vermont boundary, to a point some miles north of the latitude of Quebec city where it becomes covered by the unconformable junction of the Levis formation with the Siluro-Devonian rocks of the Gaspe series.

To the north-east it again appears in some of the prominent peaks and ridges of the Shickshock Mountains, the northern flanks of which are occupied by the Cambrian and Cambro-Silurian formations of the Quebec Group, and the southern by those of the Siluro-Devonian system above referred to, as being in contact with the former a short distance to the south-west of the mountains.

Similar Pre-Cambrian rocks form also several subordinate ridges to the south-east, and as in the main axis, they are everywhere characterized by the presence of sulphuretted copper ores; also, hematites, magnetite, chromic iron and ores of antimony. The magnetite is, for the most part economically unavailable on account of the high percentage of titanic acid. The soap-stone, pot-stone or mica-rock, serpentine and asbestos, described in the Geology of Canada, also belong to the Pre-Cambrian belts. One of these belts crosses the St. Francis River between Sherbrooke and Lennoxville. It constitutes the high ridges known as the Stoke Mountains, between Lake Massawippi and Little Magog, and in it are the most extensively worked copper mines of Canada. No fossils of any kind have yet been found in the rocks of these belts, and they are presumed to belong to the Huronian System, not only because of the geological position which they apparently occupy, but also on account of their close correspondence with it in physical aspect, and in mineral and lithological characters.

The north-western boundary of the Quebec Group of the map of 1866, is likewise that of the Eastern Palæozoic basin under consideration, and is formed by the great break of the St. Lawrence valley, or the great

St. Lawrence and Champlain fault. The nature of this break or physical boundary has been variously described.

Sir William Logan thus refers to it.*

"The solid crystalline gneiss, in the case before us, offering more resistance than the newer strata, there resulted a break coinciding with the inclined plane at the junction of these with the gneiss. The lower Palæozoic strata pushed up the slope would then raise and fracture the formations above, and be ultimately made to overlap the portion of those resting on the edge of the higher terrace; after probably thrusting over to an inverted dip the broken edge of the upper formations. The shallow water strata of the higher terrace, relieved from pressure, would remain undisturbed, and then the limit of the more corrugated area would coincide with the slope between the deep and shallow waters of the Potsdam period. The resistance offered by the buttress of gneiss would not only limit the main disturbance, but it would probably also guide or modify in some degree the whole series of parallel corrugations, and thus act as one of the causes giving a direction to the great Appalachian chain of mountains. In Canada this is especially apparent in those parts which lie to the south-east of the St. Lawrence valley."

Whatever may be the nature of the origin of this break, there can be no doubt that the disturbances which have affected the whole region to the south-east of it have been far more intense and have been continued into much later periods than any of those which have affected the Southern-and-Western area, or interior continental palæozoic basin.

Dr. T. Sterry Hunt does not admit the existence of the great break of the St. Lawrence, Champlain and Hudson River valleys, and ascribes the observed relations and physical differences in the two areas to original unconformity, together with some subsequent and subordinate folding and faulting. Though the explanation given by Sir W. Logan—Geology of Canada 1863, p. 294-297—may, as regards the perfect conformity of the formations from the Potsdam to the Hudson River, be incorrect, it must be observed that while the evidence of the constant overlapping of these formations is everwhere abundant, that of any great unconformity can no where be clearly seen, and even if existing, would not suffice to explain the phenomena which he sought to account for. There is no need to suppose an enormous vertical displacement, but that a great break does exist along the line indicated, probably perfectly analogous to that along the eastern base of the Rocky Mountains, can not be doubted by any one who has carefully examined the structure from Cape Rosier to Lake Champlain. And not only so but it is now equally certain that there are, as has been stated, "a series

* Geology of Canada, 1863, Chapter ix., p. 297.

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Fig. 1.

Diagram Section of supposed Structure from Montmorenci Falls to the Island of Orleans.

a. a. *Trenton limestone.* c. c. *Utica and Hudson River.*

b. *Laurentian Gneiss.* d. d. *Levis Conglom: and Graptolite shales.*

e. e. *Red, green and black shales and sandstones; also, limestone conglomerate with primordial fossils in the pebbles—"Lauzon."—It is certainly below* d. d. *("Levis.")*

f. f. *Calciferous, Chazy, &c.*

Vertical Scale, 500 ft. to One Inch.
Horizontal Scale, 2 Inches to One Mile.

of such dislocations traversing eastern North America from Alabama to Canada." These have doubtless caused considerable vertical displacements, both of elevation and depression, but the present physical condition of the rocks of the south-eastern area is not due to these dislocations, but to the great lateral pressure, which must have preceded, accompanied and caused them.

Along the whole line of this great break from Lake Champlain to Gaspé, the newer formations apparently underlie the older, as on the Island of Orleans, but it is not always clear whether this is due to a series of more or less parallel and branching faults, or to a close and repeated folding of the strata in overturned synclinal and anticlinal forms. Probably both causes have contributed to produce the result referred to.

Between Montmorenci falls and the south side of West Point, on the Island of Orleans, there are three distinct and well exposed faults. The diagram opposite, Fig. 1, shews the supposed structure, the distance is three miles.

There is really no conclusive evidence to show on which side of these faults the movement has taken place. No. 1 is probably a down throw to the south-east, while Nos. 2 and 3 are up throws on the same side. No. 2 is the main fracture, while Nos. 1 and 3 are branches from it.

To the north-east of the Island of Orleans these faults apparently pass beneath the waters of the St. Lawrence. In their eastern prolongation they curve in conformity with the outline of the north shore and pass south of Anticosti Island, where the strata of the Cambro-Silurian and Silurian are wholly undisturbed and conformable, and dip at a low angle towards the fault, while on the opposite shore of the Gaspé Peninsula we find the same formations folded and faulted, and, as at the Island of Orleans, apparently dipping beneath the older Levis formation or upper Cambrian of the Quebec group. Of these rocks Sir W. E. Logan thus writes in his report dated 1st May, 1845: "The cliff exposing them is bold and lofty, but the strata are most violently twisted and broken; the greatest confusion prevails, and it is difficult to follow any individual bed for fifty yards, numerous cracks result from the disturbances," and again, "The coast from the Abour to the Magdalen—about 30 miles—exhibits numerous instances of contorted strata, and at the mouth of the chief valleys which terminate in deep bays upon the St. Lawrence, there are displayed several transverse sections in the sides of the mountains, which come close upon the shore and slope up to 800 and 1,000 feet. One of these instances is seen on the east side of the River Pierre, where the summit of the hill shews an overturn dip and the strata in the whole section appear to be arranged in the form of a very flat ∞." *

* Report of Progress, Geological Survey of Canada, 1844, p. 23.

Much more is given in the same report shewing the highly disturbed condition of these rocks which are, like those of the north shore of Anticosti, of Utica and Hudson River age, a fact which had not, however, then been ascertained, and the section from the coast to the summit of the mountains was considered to be, as indicated by the constant south easterly dips, an ascending one, and thus the Pre-Cambrian chloritic and micaceous schists, diorites, felsites and serpentines, which form the axis of the mountains, are depicted on the geological map of 1866, as Sillery and Lauzon, or the upper members of the Quebec group, a similar mistake having, as I have elsewhere pointed out, been made throughout the entire range.

Resting unconformably either on the rocks of the Levis formation, or on the older schists of the axis are those of the Siluro-Devonian basin, already referred to. Where unaltered they consist of dark-blue clay shales, grey sandstones and limestones often dipping at high angles and shewing, especially to the south-east, other evidence of repeated disturbance. They are interrupted by large areas of grey and white granite and in proximity to these the limestones are crystalline and the argillites changed to micaceous and staurolitic schists. These rocks are described in detail under the heading "The Gaspé Series" in the xvi chapter of the Geology of Canada 1863, to which the reader is referred for further information. The wooded, mountainous and generally inaccesible character of a large part of the area occupied by these Siluro-Devonian rocks, has prevented much further or closer investigation of the relations of the several members of the group, than that made prior to 1863. Recent explorations in the Gaspé Peninsula and northern New Brunswick have however shewn that the upper or Devonian members are somewhat more widely distributed than indicated in the geological map published in 1866, and an abundant and characteristic assemblage of fossil fishes, new to Canada, and plants has been discovered around the shores of the Bay of Chaleurs in these Devonian rocks. Many other smaller trough-like areas of Siluro-Devonian strata occur in southern New Brunswick and along the north-western limits of Nova Scotia, from the head of the Bay of Fundy to the Strait of Canso. These are for the most part in contact either with Lower Cambrian or with Pre-Cambrian rocks, while in some cases as at Nictaux they are limited and altered by the granitic and dioritic masses of Devonian age, which also form the central highlands of Nova Scotia from Cape Sable to Cape Canso.

It must be observed that though for the purpose of the present sketch the Silurian and Devonian strata have been grouped together, there exists between them almost everywhere a very distinct break and unconformity, and they are further distinguished by a very character-

istic and abundant fossil fauna and flora as described* by Logan, Billings, Dawson, Honeyman, Hartt, Bailey, Whiteaves and others. Whether the Gaspé limestones are to be considered to belong to the base of the Devonian or the top of the Silurian seems to be palæontologically uncertain. Stratigraphically they are conformable and therefore both are now regarded as Devonian and so colored on the present map.

The main Siluro-Devonian Area is limited to the south-east by the belt No. 3, already referred to, of Cambro-Silurian and older strata. This area, 150 miles in length and 30 to 50 miles wide, occupies the centre of the province of New Brunswick, and is for the most part densely wooded and difficult of access. Hence it has been impossible accurately to define the limits of the several groups of strata. No very characteristic fossils have been found in it and none sufficiently perfect for specific determination. Graptolites of Utica types are abundant in some parts, also fragments of crinoids, brachiopods, gasteropods, &c. The following notes by Mr. Ells from the recently published geological map which embraces the north-western part of the area, give a general idea of its structure and character, and for further detail the maps and reports must be consulted.†

The rocks of Cambro-Silurian age, as in the south-western portion of the province, present great lithological differences. The great bulk of them, however, though somewhat altered, lack the highly metamorphic character so marked in those of the Pre-Cambrian system. Black graptolitic and ferruginous shales and slates, with reddish and manganese stained beds; also greenish-grey sandstone, with imperfect remains of fossils, are intimately associated with hard and often schistose metamorphic beds. The separation of these from the Pre-Cambrian has been made both on lithological and stratigraphical grounds, though the boundaries are necessarily to some extent conjectural, because from the nature of the country they cannot be traced continuously. Indications of copper ore were noted on the Nipisiguit and North-West Miramichi Rivers, but not in sufficient quantity to be of value. Galena and manganese were observed in small quantities at several points. Ridges of good farming land occur between the principal rivers.

The Pre-Cambrian system in this area consists largely of very felspathic schists and gneisses; they are all highly metamorphic, and apparently form two axes, running roughly parallel to each other in a north-easterly direction. These are separated by rocks of presumed

* Geology of Canada, 1863. Canadian Naturalist. Acadian Geology, 1868. Jourl. Inter. Geological Society. Transactions of the Nova Scotia Institute. Progress Reports of the Geological Survey of Canada, etc., etc.

† Geological Survey of Canada 1879-80-81-82, Reports D.

Cambro-Silurian age. The country occupied by the pre-Cambrian rocks is for the most part unsuited for agricultural purposes, being very rough and hilly, especially about the head waters of the Nipisiguit and Miramichi Rivers. It is also subject to severe frosts, both early and late. The soil where not completely burnt off is generally thin and scanty, and often strewed with large boulders.

The granites of this area resemble very closely the granites of the southern part of the province, and are probably of the same age. They are generally red and coarse-grained, often with crystals of felspar from an inch and a-half to two inches in length. They make an excellent building stone, and have been extensively used in the construction of the immense bridges on the Intercolonial railway.

We now come to the consideration of the great Carboniferous basin of New Brunswick, and the associated and economically, far more important coal basins of Spring Hill, the Joggins, New Glasgow and Pictou, in Nova Scotia. The New Brunswick area forms a prominent feature in the geological map. The strata are everywhere nearly horizontal, and while they occupy an area of not less than
square miles, their total thickness nowhere much exceeds 600 feet, included, in which there is only one workable seam of coal. This is near the summit and has an average thickness of only 20 inches. In the other basins mentioned the superficial areas of which are so small as to be scarcely noticeable on the map, the exposed thickness of the measures at the Joggins, only 30 miles distant, reaches, as measured by Sir W. E. Logan,* 14,500 feet with 81 coal seams, while in the other basins there are numerous coal seams of thicknesses varying from a few inches up to that of the main Albion Mines seam which reaches the enormous thickness of 36 feet. Full details of the Pictou-and-New Glasgow basin are given by Sir W. E. Logan and Mr. Hartley in the Report of Progress, Geological Survey of Canada, 1866-69. And the very rapid changes both in the thickness and in the characters of the measures on their horizontal extension are there described. The Sydney and other Cape Breton Carboniferous basins are described in detail by Messrs. Robb and Fletcher in the annual Reports of the Geological Survey, from 1872 to 1882.

A few remarks may now be made respecting the area No. 4 occupied by the "Altantic Coast series of Nova Scotia." The greater part of it was cursorily examined by the writer in 1871. And the marked similarity of these rocks to the lower part of the auriferous Cambrian rocks of Merionethshire, in North Wales, was then pointed out. Up to that date except the doubtful fossil named Eospongia from Waverley, nothing

* Report of Progress, Geol. Survey of Canada, 1844.

resembling an organic form had been found in this series. In the dark slates at the Ovens in Lunenburg county, however, I detected markings which the late Mr. Billings determined to be Eophyton Linneanum, elsewhere characteristic of the same low horizon. Since then no advance has been made in precisely determining the position of this series. But, as similar markings are quite common in the lower Cambrian slates (Menevian) of St. John, New Brunswick, there is every reason to suppose that the position assigned to this group in Nova Scotia is correct. About the centre of the south-western coast, however, in the vicinity of Yarmouth, there are a set of strata which differ considerably, in many respects, from those of the Atlantic coast series as developed in the vicinity of Halifax and elsewhere, and resemble very closely some of the Pre-Cambrian rocks of Cape Breton and of the Eastern Townships; but the details of the geology of south-western Nova Scotia, have yet to be investigated, and in the meantime the whole of the slaty series so well exposed on the coast between Cape St. Mary and Cape Tusket has been assigned to the Lower Cambrian, instead of, as in the map of 1866, to the Silurian (Upper Silurian) system.

2. The Central-and-Western Palæozoic Basin.

The general geological features of this basin have been referred to in Chapter I. They areas it includes are exclusively occupied by formation older than the Carboniferous and one or more of therecognized American subdivisions of the Lower Palæozoic age are found in each of them, but there are often considerable gaps in the series, arising probably not from any actual interruption in sedimentation, but from the fact that the subdivisions themselves are really more or less local and limited, and that they are subject to rapid changes on their horizontal extension, both as regards thickness, lithological characters and palæontological contents. No formation is perhaps more persistent in this respect than the Trenton. Its distribution in Canada, from the Mingan Islands and Murray Bay on the Lower St. Lawrence, to the islands of Lake Huron, as well as that of the other closely associated Cambro-Silurian formations, Chazy, Black River, Utica and Hudson River have been so fully described in chapters VIII, IX and X Geology of Canada, 1863, that it is unnecessary now to enter further into details respecting these formations. Stratigraphically and palæontologically they are intimately connected, and though the upper members frequently overlap the lower, or parts of the series are locally absent, and there are considerable local differences in the grouping of the fauna, yet there does not appear to be any decided

break or unconformity and the stratigraphy entirely bears out the views of the late Mr. Billings who says:—* "From the top of the Hudson River down to the base of the Chazy there is no break, but all is occupied by a single immense, highly characteristic and compact fauna."..... "At the base of the Chazy, in Canada and New York, there occurs a great break, the importance of which has only become apparent during the last six years. The Lower Silurian of America can be divided into two principal groups, the one above the break at the base of the Chazy, the other below."

In the present sketch, the terms Cambrian and Cambro-Silurian are used to indicate this break, also distinct tints on the map, except in the south-eastern disturbed area, where, owing to the folding and faulting to which, as already stated, this area has been subjected, it has not yet been possible to determine the respective limits of the two systems. The Cambro-Silurian formations are, however, represented, for the most part, by those beds which are referred to by Logan as the lower or underlying black slates, pp. 240 and 241 Geology of Canada, 1863. They are well developed on the St. Francis and Nicolet Rivers, also at Farnham and Bedford, and again on the Etchemin River as well as at various points on the south shore of the St. Lawrence below Quebec. Their distribution shows that they are quite unconformable on the older red and green slates and sandstones, called Lauzon and Sillery, while, in some cases, they occur as small outliers intimately associated, by folding and faulting, with the Pre-Cambrian schists, as at Tingwick, Melbourne Ridge, Danville, &c. § The most conspicuous geographical divisions of the Southern and Western Basin are:—1. The Island of Anticosti. 2. The Ottawa and St. Lawrence Basin, extending from Quebec to the Thousand Islands. 3. The region between Lakes Erie, Ontario and Huron, extending from Kingston south-westerly, 300 miles to Lake St. Clair, and thence along the eastern and northern shores of Lake Huron to Sault St. Mary. 4. The Cambrian basin of Lake Superior. 5. The basins of Lake Winnipeg and Hudsons Bay. Subordinate to these are the outliers of Palæozoic rocks, which have been found in various parts of the great Northern area such as those of Lakes St. John, Nipissing, Abittibbe and Temiscamang. These are highly interesting relics which show that the present limits of the Palæozoic formations do not even approximately indicate those of the Ocean in which they were deposited. And it may yet be demonstrated, by the discovery of more such outliers in the vast unexplored northern regions of Canada, that the whole of the Archæan Continental Nucleus has, more than once, been entirely submerged during the Palæozoic ages.

*Catalogue of the Silurian Fossils of the Island of Anticosti, 1866, p. 79.

One to four of the above enumerated divisions of the southern and western area have been closely studied and are fully described in the publications of the Geological Survey, more particularly in the Geology of Canada, 1863, and in subsequent Reports to 1869, among which may be especially mentioned, "Catalogues of the Silurian Fossils of the Island of Anticosti," 1866, by the late E. Billings, F.G.S. Except in division 4, the Cambrian basin of Lake Superior, no further investigations have been made, either by the writer or by any member of the Geological corps, and there are therefore no new facts to add to those already published respecting the divisions 1, 2 and 3.

In the Geological Map of 1866, the rocks of division 4 are assigned to the horizon of the Chazy and the Quebec Group. While in the Geology of Canada, 1863, Chap. V, after fully describing these rocks, Sir W. Logan concludes with the following remarks:—"The affinities of the red sandstone of Sault St. Mary would thus appear to bring it into the position of the Chazy rather than the Potsdam formation; and if this were established, the copper-bearing portion of the Lake Superior rocks might reasonably be considered to belong to the Calciferous and the Potsdam formations." Recently these upper copper-bearing rocks of Logan have been divided by Dr. Hunt into three series, named by him Animikie, Nipigon and Keweenian* with certain suggestions as to their relative position which are wholly untenable, viz., to the effect that the Keweenian series is Pre-Cambrian and the Nipigon and Animikie post-Cambrian and perhaps Mesozoic." After a somewhat careful though still incomplete examination of these rocks there is in the, opinion of the writer, no reasonable doubt of the age of the whole being Lower Cambrian, as supposed by some of the earlier investigators—Whitney, Foster and others. Between Thunder Bay and the east end of Nipigon the three series follow each other without apparent unconformity and dip at a generally low angle towards the lake. Up to the summit of the Nipigon series, which extends around and partly fills the basin of Lake Nipigon, there are many large interstratified beds of columnar diabase, then follows the Keweenian series, consisting of red and white sandstones, coarse conglomerates and a great thickness of amygdaloidal lava (melaphyre) and other volcanic ejectamenta, the whole, from the base of the Animikie to the summit of the Keweenian, being cut by trap dykes, masses of diabase-porphyry, dolorite, &c. The dykes sometimes present a very perfect columnar structure at right angles to their dip.

This great volcanic series of Lake Superior bears a precisely similar relation, to the Archæan system—Huronian and Laurentian—on the

*Azoic Rocks, part 1, 2nd Geol. Survey of Pennsylvania, Report E.

one hand and to the overlying Trenton group on the other, to that which the upper and lower Potsdam and the still older Menevian formations of St. John, &c., do in the eastern provinces. And, apart from the almost total absence of contemporaneous igneous rocks in the one area and their great preponderance in the other, together with the comparatively undisturbed condition, characteristic of all the Western Palæozoic areas, the succession of the Lake Superior Lower Cambrian series corresponds even more closely with the eastern series than it might be expected to do, in areas more than 600 miles apart. The absence of palæontological evidence of age may perhaps be in a great measure accounted for by the great and repeated manifestation of volcanic activity over the whole region during the accumulation of the sediments, producing conditions highly unfavorable for the existence of animal life. While, as already stated, there is no marked unconformity, there is here, as in the St. Lawrence and Ottawa basins, a constant overlapping of the upper members, giving rise to the statement that east of Black Bay the Animikie series of dark argillites is wanting. This, however, is not the case, as is clearly proved by the fact that these argillites have been sunk through in the Silver Islet mine to a depth of nearly 1,000 feet below the waters of the lake. And there can be little doubt that the great dark argillite silver-bearing series of Lake Superior underlies the greater part of Black Bay, and the peninsula between it and Nipigon Bay, as well as St. Ignace, Simpson and other islands to the eastward, in some of which it is exposed in fine sections, associated as at Thunder Cape with massive columnar diabase, and conformably overlaid by red and white dolomitic sandstones and rather coarse pebble conglomerates.

On the east shores of Hudson's Bay there appears to be an almost similar series of traps, dolomites, argillites, sandstones and amygdaloidal lavas, resting in almost undisturbed attitude on the Pre-Cambrian gneisses. A similar series occurs also in the Rocky Mountains —though, so far as known, without the volcanic associations—which I have elsewhere predicted, will eventually be proved to occupy the same Lower Cambrian horizon.

The Red River and Lake Winnipeg Palæozoic area is described on a subsequent page, and referred to as forming the eastern margin of the great interior continental basin. Physically, the rocks of this area are closely connected with the Central-and-Western Palæozoic Basin, and it is not impossible that they are also geographically connected beneath the overlying Cretaceous rocks of Dakota with those of the extreme western extension of the Cambro-Silurian and Devonian systems of southern Minnesota. Their supposed distribution northward is shown on the accompanying map, and also that they constitute the western limit of the

great Archæan Nucleus. Of their former north-eastern extension we have at present no evidence, but as a similar Palæozoic group occurs around the shores of Hudson's Bay, it seems not improbable that the present geographical separation of the Winnipeg, Lake Superior and Hudson's Bay Palæozoic areas is the result of denudation in Post-Palæozoic ages. The very considerable outliers already known in the as yet little explored region, lying north of the St. Lawrence and Ottawa River and south of Hudson's Bay, lend support to this supposition, and to the view that the larger part of the great Archæan Nucleus was more than once entirely submerged during Palæozoic time.

3. The Archæan Nucleus.

The enormous area, probably, as already stated, over 2,000,000 square miles, underlaid by the ancient crystalline rocks which constitute the continental nucleus, extends through about eighty-two degrees of longitude from Demarcation Point, on the Arctic Ocean, west of the mouth of the Mackenzie River, to the Straits of Belle Isle, on the Atlantic.

It will be readily understood that the area over which the rocks constituting this great Archæan crystalline series, known as the Laurentian and Huronian Systems, have been examined in detail must be comparatively small, and that we have yet much to learn respecting them.

In Chapter II. Geology of Canada, 1863, they are very fully described by Sir W. E. Logan. Recent investigation has added nothing of importance to what is there given respecting these rocks. But it has greatly enlarged the area over which they were then known to extend, though it has not yet afforded any more satisfactory evidence of the relations of the Huronian rocks to the Laurentian. In all cases the supposed junction of the strata of the two systems either shews them vertically side by side or the Huronian strata apparently dipping under the Laurentian, while both present a very constant northeasterly strike. Notwithstanding these facts, their exceedingly different mineralogical characters and general appearance, broadly viewed, render it almost impossible to suppose that the superposition, as indicated by these dips, is the true one, or that the Huronian is not newer than the Laurentian. If so, then we must admit that both systems are presented in a constant succession of enormously thick overturned folds, with perhaps many dislocations and slips on the lines of the anticlinal axes. And as such a character would correspond with that of the Eastern Palæozoic Basin, already described, it is probably the

explanation that must be adopted. No better or more continuous section of these Archæan rocks—Laurentian and Huronian—could be seen anywhere than that recently exposed by the cuttings on the Canada Pacific Railway from Pembroke northwest to the Spanish River north of Lake Huron. These exposures are most interesting. The Laurentian rocks, which occupy the whole of the country from Pembroke to the east bank of the Wahnahpitae River, are for the most part highly characteristic red, grey and dark banded gneisses felspathic and hornblendic, and frequently garnetiferous and micaceous. There are also some large bands of grey and white crystalline limestone, but none of these are exposed along the line of the railway west of Mattawa, where it leaves the valley of the Ottawa River.

After passing the Wahnahpitae River bridge the Huronian rocks commence with a series of flinty felsites or felsitic quartzites, succeeded by dark grey quartzose conglomeratic beds; also massive crystalline diorites, red, fine-grained syenites and a great variety of highly altered volcanic agglomerates, felspathic and dioritic. At the Vermilion River bridge, 285 miles west of Ottawa, there are good exposures of a series of dark grey, almost black, felspathic quartz grit or sandstone, with thin bands of dark argillite. These are regularly bedded and not more altered than the Lower Cambrian rocks of the Atlantic coast of Nova Scotia, which they very closely resemble, as they also do the coarse grit and sandstone which underlie the Lévis formation of the Quebec group, or the so-called Sillery sandstone. It may be that they represent the uppermost part of the Huronian system, though here we again find an almost constant easterly dip, and the present attitude of the strata, on the above supposition, must be the result of an overturned folding, as already referred to. The present sketch does not admit of much detail, even if the facts were available, but the following succession may be given as the general result of recent observations along the line of the Pacific Railway from Ottawa westward :—

Laurentian.

1. Red, grey, and white orthoclasegneiss in great variety, distinctly banded, the bands often curiously twisted and contorted.

2. Black hornblende and mica gneiss often garnetiferous and cut by veins of red and white oligoclase.

3. Pyroxenic gneiss, banded, like eozoon.

4. Large bands of crystalline limestone.

Such rocks occur in constant alternations for 260 miles, or from Ottawa to the Wahnahpitae River bridge. They may be regarded as the typical rocks constituting the great Laurentian system. They are

very distinctly stratified, and dip generally easterly at all angles from almost horizontal to vertical. Crossing the Wahnahpitae River bridge a very marked change occurs. The dip, however, still continues easterly, and the general succession is as follows:—

Huronian.

1. Felsites or felsitic quartzites, red and white, weathering, and at a distance scarcely distinguishable from the Laurentian, but on examination these shew no gnessic structure.

2. Thick and thin bedded, dark, sometimes almost black quartzites; if not repeated by folding these must be of great thickness. They are followed in descending section—according to dip—by dark to grey or black siliceous beds, holding angular fragment and pebble of white granite or gneiss.

3. Diorite and diabase with a series of coarse and fine fragmentary beds, sometimes felspathic, sometimes chloritic or hornblendic in character, and varying in texture from a fine laminated ash to a coarse agglomerate; following these are massive beds of diorite or diabase alternating with red, fine-grained syenite. After an interval of about five miles of flat drift-covered country, the Vermilion River sandstones commence, and beyond these again a somewhat similar succession recurs of felsite, quartzite, conglomerate, diorite, agglomerate and syenite, with some bands of argillite. One of these is well exposed a short distance south-east of Bannerman station.

The entire breaath of the belt in a west north-westerly direction is about eighty miles, after which the typical Laurentian gneiss again makes its appearance. Further west, along the north shore of Lake Superior, and again on the Lake of the Woods, the Laurentian gneiss is interrupted by belts of similar Huronian strata, and connected with these are large areas of granite and syenite which seem to be of later origin than the adjacent schistose and fragmentary Huronian rocks. Some of these are indicated on the present map, but there are probably many more not yet recognized.

As regards the so-called Norian or Upper Laurentian formation, I have no hesitation in asserting that it has, as such, no existence in Canada, its theoretical birth-place. Wherever these Norian rocks have been observed, they are either intimately and conformably associated with the ordinary orthoclase or pyroxenic gneisses, or they occur as intrusive masses when they present no gneissic or bedded structure. They clearly cut the surrounding gneiss, and are probably due to volcanic or other igneous agency in the Laurentian Age. Such masse

may not unreasonably be supposed to mark the sites of the Laurentian volcanoes, while the bedded labradoritic gneisses and other associated strata may with equal probability represent the eruptive rocks—lava-flows, etc.—which emanated from them, and were locally interbedded with the ordinary sediments of the period, as rocks of similar origin and composition certainly were in the Huronian and in all later geological ages, a fact which has been singularly overlooked or ignored by most writers on American geology.

At present we have in Canada no evidence which would warrant us in making more than two great divisions in the Archæan crystalline rocks. In many parts, especially in the eastern provinces, it has been found impossible to define even these clearly. Rocks of typical Laurentian character are there so intimately associated with others of equally typical Huronian characters, and in such constant alternations, that in mapping them they could not be separated, and are therefore all classed as Archæan or Pre-Cambrian.*

* For details respecting these Pre-Cambrian rocks, see Reports Geological Survey of Canada, 1879-80 and 1882-83, where they have been fully described by Mr. Fletcher.

PART II.

(WESTERN SECTION.)

CHAPTER I.

PHYSICAL GEOGRAPHY.

NOTE.—The facts for the following sketch of the physical geography and geology of the western portion of the Dominion of Canada, are largely derived from the Reports of the Geological Survey. In compiling these notes, I have, however, quoted at length from summaries previously published by me, of which the most important are in Geology and Resources 49th parallel. (Boundary Commission Report) and Geology of British Columbia, Geol. mag, vol. viii.

The northern part of the North American continent is geologically, and to a great extent also physically divisible into two great portions. In the first, extending from the Atlantic coasts to the south-eastern edge of the Laurentian axis,—which is marked by a chain of great lakes stretching from the Lake of the Woods to the Arctic Ocean,—the Archæan plateau is the dominant feature, the succeeding formations arranging themselves about its edges or overlapping it to a greater or less extent in the form of bays or inlets, but,—with the single exception of limited tracts of Triassic rocks,—no mesozoic or tertiary strata are represented in it. In the second, stretching westward to the shores of the Pacific, the Archæan rocks play a very subordinate part, and Mesozoic and Tertiary rocks are abundantly represented and alone characterize the whole area of the great plains. Correlated with the difference of age in the formations represented, is the fact that at a date when the flexure and disturbance of the eastern region had practically ceased, and it was set and firm, the western Cordillera belt continued to be the theatre of uplift and folding on a gigantic scale.

Where the great region of plain and prairie which occupies the whole central part of Mexico and of the United States passes the forty-ninth parallel of latitude, which constitutes the political boundary between the last named country and the Dominion of Canada, it is included in longitude between the 96th and the 114th meridians. It narrows pretty rapidly northwards, by the encroachment on it of its eastern border, but continues as a great physical feature even to the shore of the Arctic Ocean, where it appears to have a breadth of between 300 and

400 miles. Beyond the North Saskatchewan River, however, it loses its essentially prairie character, and, with the increasing moisture of the climate, becomes, with limited exceptions, thickly covered with coniferous forest.

The north-eastern boundary of this interior continental plateau, north of latitude forty-nine, is formed, as above stated, by the south-western slope of that old crystalline nucleus of the continent which extends north of the St. Lawrence and Great Lakes from Labrador to the Lake of the Woods; with a general east and west course, and then, turning suddenly at an angle of 60° to its former general direction, runs with a north-north-west course to the Arctic Sea. The eastern barrier is rather a rocky plateau than a mountain region. It presents no well defined height of land, and the watershed-line follows a very sinuous course among the countless lakes, small and great, which cover its surface. Northward from the Lake of the Woods, it divides the waters flowing into Hudson's Bay from those draining directly into the Arctic Ocean, with one important exception. The Nelson River, carrying the accumulated waters of the Saskatchewan, the Red River and innumerable smaller streams, breaks through the Laurentian plateau at the north end of Lake Winnipeg, and empties into Hudson's Bay at York Factory. The Churchill or English River, a not inconsiderable stream, passes through the same gap.

Near the 49th parallel, the Rocky Mountains on the west rise abruptly from the elevated plain at their base, and often present to the east almost perpendicular walls of rock. A short distance farther north, however, they become bordered by an important zone of foot-hills composed of crumpled Mesozoic rocks, and these continue with varying breadth at least as far north as the Peace River region. Between the fifty-first and fifty-second parallels the Rocky Mountain range appears to culminate, and to the north gradually decreases in elevation till on the borders of the Arctic Ocean it is represented by comparatively low hills only. With this decrease in height the mountains become a less complete barrier, and the streams flowing eastward across the plains rise further back till in the cases of the Peace and Liard Rivers the waters from the central plateau of British Columbia completely traverse its range.

The whole interior region of the Continent slopes gradually eastward from the elevated plains lying near the base of the Rocky Mountain, to the foot of the Laurentian highlands, and though the inclination [illegible] more abrupt in approaching the mountains, it is not so much so [illegible] attract special attention. Between the fifty-fourth and forty-ninth degrees of latitude, however, along the lines which are in a general way parallel and hold a north-west and south-east course across the

plains, very remarkable step-like rises occur. These escarpments form the eastern boundaries of the two higher prairie plateaus, and the most eastern of them overlooks the lowest prairie level or that of the Red River valley. The three prairie steppes thus outlined differ much in age and character, and have been impressed on the soft formations of the plains by the action of sub-aerial denudation of former great lakes and probably also of the sea. They may be considered as of primary importance among the features of the country and were first clearly described by Dr. Hector.

The actual increase of elevation accounted for in the two escarpments, however, is slight compared with that due to the uniform eastward slope of the plains. The direction of greatest inclination is toward the north-east, and a line drawn from the intersection of the 49th parallel and the mountains to a point on the first prairie-level north of Lake Winnipeg, will be found to cross the escarpments nearly at right angles, and to have an average slope of 5.38 feet to the mile. From the same initial point, in a due east line to the lowest part of the valley of the Red River—a distance of 750 miles—the plains have an average slope of 4.48 feet per mile.

The first or lowest prairie-level is that of which the southern part lies along Red River, and which northward embraces Lake Winnipeg and associated lakes and the flat land surrounding them. A great part of its eastern border is conterminous with that of Lake Winnipeg, and formed by the rocky front of the Laurentian, while east of Red River it is bounded by the high-lying drift terraces surrounding the Lake of the Woods and forming a part of the drift plateau of northern Minnesota. To the west it is limited by the more or less abrupt edge of the second prairie level, forming an escarpment, which, though very irregular in some places, is scarcely perceptible where the broad valley of the Assineboine breaks through it. The escarpment where it crosses the 49th parallel is known as Pembina Mountain, and is continued northward by the Riding, Duck, Porcupine and Basquia Hills. The average height above the sea of this lowest level of the interior continental region is about 800 feet, the lowest part being that including the Winnipeg group of lakes which have an elevation of about 700 feet. From this it slopes up southward, and attains its greatest elevation—960 feet—at its termination about 200 miles south of the international boundary. The edges of this plain are also, notwithstanding its apparent horizontality, considerably more elevated than its axis where this is occupied by the Red River. Its width on the 49th parallel is fifty-two miles only. Its area north of the same line may be estimated at 55,000 square miles, of which the great system of lakes in its northern part occupies about 13,900 square miles. A great part of

this prairie-level is wooded more or less densely, particularly that portion adjacent to the lakes. The southern part, extending southward from Lake Winnipeg, includes the prairie of the Red River valley with an area north of the 49th parallel of about 6,900 square miles.

The superficial deposits of this area are chiefly those of a former great lake, which has been named by Mr. Warren Upham Lake Agassiz, and which occupied it toward the close of the glacial period. In Minnesota the shore-lines and beaches of this lake have been carefully traced out by Mr. Upham, and it has been shewn by General Warren, the writer and the first named gentleman, that its outflow was southward to the Mississippi. The fine silty material now flooring the Red River plain and constituting its soil of unsurpassed fertility was laid down in its deeper waters. The Red and Assiniboine Rivers have not yet cut very deeply into these superficial deposits, having already nearly reached a base level of erosion, and the surface of the plain is level and little furrowed by denudation.

The second steppe of the plains is bounded to the west by the Missouri Coteau, and its northern continuation constitutes the edge of the third steppe. Its width on the 49th parallel is two hundred and fifty miles, and on the 54th about two hundred miles, though it cannot there be so strictly defined. Its total area between these two parallels is about 105,000 square miles, and includes the whole eastern portion of the great plains, properly so called, with an approximate area of 71,000 square miles. These occupy its southern and western portion, and are continuous westward with those of the third steppe. To the south, the boundaries of this region appear to be more indefinite, and in the southern part of Dakota the three primary levels of the country, so well marked north of the line, are probably scarcely separable. The present rivers have acted on this region for a much longer time than on the last, and with the advantage of a greater height above base level, and now flow with uniform though often swift currents, in wide trough-like valleys excavated in the soft material of the plains, and frequently depressed from one hundred to three hundred feet below the general surface. In these valleys the comparatively insignificant streams wander from side to side in tortuous channels, which they leave only at times of flood. The surface of this steppe is also more diversified than the last, being broken into gentle levels and undulations, partly due to the present denuding agencies, but in part also to original inequalities in the deposition of the drift material which constitutes the superficial formation. The average altitude of this region may be stated at 1,600 feet, and the character of its soil and adaptability for agriculture differ considerably in its different portions.

The third or highest steppe of the plains may be said to have a gen-

eral normal altitude of about 3000 feet, though its eastern edge is generally little over 2000 feet, and it attains an elevation of over 4000 feet at the foot of the Rocky Mountains. Its area between the parallels above defined, and including the high land and foot hills along the base of the mountains, is about 134,000 square miles, and of this by far the greater part, or about 115,000 square miles, is almost entirely devoid of forest, the wooded region being confined to a small area of its northern and north-western extension near the North Saskatchewan River and its tributaries. Its breadth on the 49th parallel is four hundred and sixty-five miles, and its eastern boundary is there well-marked, being the broken hilly country known as the *Côteau de Missouri*, or Great Coteau, which crosses the International boundary near the 104th meridian, and thence runs east of the Old Wive's Lakes to the South Saskatchewan. It is then continued to the north by a range of high lands, of which the Eagle Hills constitute a part, to the elbow of the North Saskatchewan, and beyond that river probably to the Thickwood Hills.

This portion of the great plains is much more diversified than either of those before described. It has been elevated to a greater height above the sea level, and acted on to a much greater extent by the eroding forces, both in later Tertiary time and subsequent to the glacial period. Those portions of its surface which still remain but little modified, form table-lands such as those of the Cypress Hills and Wood Mountain. The universal denudation which has taken place is evidenced by the size and depth of the valleys of rivers and streams, both of pre-glacial and post-glacial age, the great ravines and "coulées" which have been cut and are still extending themselves among the soft sandstones and clays of the Cretaceous and Laramie formations, and the isolated plateaus and buttes which now stand far out on the plains of lower level, seamed with newer systems of gorges. Deposits belonging to the glacial period, with transported boulders and gravel, are found over almost the entire area of the highest steppe, but are spread less uniformly than on the lower levels, and the surface is often based almost immediately on the Cretaceous and Laramie beds. There is ample proof that previous to the glacial period the surface was much more rugged and worn than it now appears; the glacial deposits have since filled many of the deeper hollows and given rounded and flowing outlines to the whole. In the foot-hills of the Rocky Mountains the previously nearly horizontal beds of the plains are thrown into wave-like flexures and compressed folds, which the surface participates in to a lesser degree, assuming the form of crest-like parallel ridges which frequently possess considerable uniformity. The nature of the soil and prospective agricultural value of this great district are too varied to allow of generalization. Though it must be regarded rather as a grazing than a

farming region, it presents frequently an excellent soil, and when the rainfall is sufficient and the altitude not too great, considerable connected tracts may yet be brought under cultivation.

North of the North Saskatchewan no extensive treeless plains occur in the central region of the continent, and the forest country of the east forms a wide unbroken connection with that of the northern part of British Columbia, and though prairies of very attractive character are found near the Peace River, they are limited in area and isolated by belts of woodland. The width of the Mesozoic and Tertiary plain gradually diminishes to the north, being less than 400 miles near the 56th parallel, and it is possibly completely interrupted north of the 62nd parallel by the inosculation of the palæozoic rocks of the east and west. The three steppes of the southern plains cannot be defined in this northern region, but its features are yet little known. In the basin of the Peace, the lower areas are covered superficially by fine silty deposits resembling those of the Red River valley, and doubtless indicating a former great lake or extension of the sea in the time immediately succeeding the glacial period.

Though thus so remarkably simple and definite in its grand features the interior region of the continent shows many irregularities in detail. The second steppe has some elevations on its surface as high as the edge of the third plateau, and that part surrounding the Assiniboine River and its tributaries is abnormally depressed, causing some portions of the eastern edge of this prairie-level which overlook Manitoba Lake, more to resemble outliers than integral parts of it.

The transverse water-sheds which bound the drainage area of the Saskatchewan and Red Rivers to the south and north, though comparatively low and diffuse, and insignificant as geological boundaries, are important geographically. Taken as a whole, however, the central portion of the Dominion may be regarded as a great shallow trough, of which the western edge is formed by the Rocky Mountains, the eastern by the Laurentian axis, but in which the western portion of the floor is now, (probably as the result of Post Tertiary elevation,) higher than its eastern rim. Of the area as at first defined, extending from the 54th to the 49th parallels, the great Saskatchewan River and its tributaries drain by far the largest part, or about 139,000 square miles. The Red River and its tributary the Assiniboine drain 70,500 square miles, and the valleys of the numerous small streams flowing into the Winnipeg group of lakes, including the area of the lakes themselves, drain 52,800 square miles. The upper branches of the Missouri, and especially those of its tributary the Milk River, drain a considerable area to the south, embracing about 22,800 square miles, while to the south of the first named parallel the tributaries of the Mackenzie

drain an area of about 10,000 miles only. The total area of prairie country between the same limits, including that of all three steppes, may be estimated at 192,000 square miles. Though much of this vast area is not absolutely treeless like its south-western part, the aggregate treeclad area is quite insignificant as compared with that of the open plains.

From the western edge of the great plains to the Pacific, between the 49th and 56th parallels, the Cordillera belt of the west coast has an average breadth of about 400 miles. Geologically, it may be considered throughout as a region of flexure and turmoil, and orographically, as one of mountains. As compared with its development in the Western States, the Cordillera belt may here be considered as constricted and narrow. To the north of the 56th parallel it is very imperfectly known topographically and almost completely unexplored geologically. It appears probable, however, that a wide bay of comparatively undisturbed Cretaceous rocks may penetrate it in the region of the upper Liard River, which the eschelon range bordering the lower part of this stream and the Mackenzie may bound to the east. A southern prolongation of such a range, beneath the newer rocks, may probably be indicated by the remarkable parallel flexures of the great rivers of the northern plains, the Liard, Peace, Athabasca and Saskatchewan.

Between the 49th and 56th degrees of latitude the Cordillera belt is composed of four great ranges, the Rocky, the Gold, the Coast and the Vancouver Mountains, which are in the main nearly parallel and run in north-west and south-east bearings.

In its southern part, the Rocky Mountain range has, an average breadth of about sixty miles, which decreases near the Peace River to forty miles or less. Near the 49th parallel several summits occur with elevations exceeding 10,000 feet, but northward few attain this elevation till the vicinity of the Bow River and Kicking Horse is reached. About the head waters of the North Saskatchewan the range appears to culminate, and Mount Murchison is credited with an altitude of 13,500 feet, though this has not been accurately determined. Near the Peace few summits exceed 6,000, so far as known, though more or less extensive snow-fields occur in many places, true glaciers appear only about the head waters of the Bow, North Saskatchewan and Athabasca. Wherever the line of junction has been closely examined, great faults with eastward downthrow separate the Mesozoic rocks of the eastern foot-hills from the palæozoic of the mountains, and other similar dislocations occur in the heart of the range parallel to its general course. With the exception of a single small area above Jasper House, reported by Dr. Hector, no crystalline schists have been found in this

range, which consists in great part of Devonian and Carboniferous limestones. A few Cretaceous basins, resembling in their character isolated features of the eastern foot-hills, are included in the southern part of the range. Some of the valleys penetrating the range on the east are lightly timbered or in part prairie-like in character, but, as a rule, these mountains are thickly wooded wherever sufficient soil exists for the support of trees, and, owing to the greater rainfall on the western slopes, the forests are there often very dense and additional species of trees are represented.

From the boundary line northward, the principal passes are as follows:—South Kootanie Pass, elevation, 7,100 feet; North Kootanie Pass, eastern or main summit, 6,750 feet; Western summit, 6,800 feet; Crow Nest Pass, summit, 5,500 feet; Kanaskis Pass, 5,700 feet; Bow River and Kicking Horse Pass, 5,300; Howse Pass, 5,210 feet; Athabasca Pass, elevation unknown; Yellow Head Pass, 3,733 feet; Smoky River Pass, —— feet; Pine River Pass, 2,850 feet; Peace River Valley, 2,000 feet. With the exception of the route selected for the Canadian Pacific Railway, these passes are traversed only by rough mountain trails, practicable for pack animals.

The western edge of the Rocky Mountain range is defined by a very remarkable straight and wide valley, which can be traced uninterruptedly from the 49th parallel to the head waters of the Peace—a distance of 700 miles—and may eventually be found to extend much further. This valley is occupied by the upper portions of several of the largest rivers, the Kootanie, Columbia, Fraser, Parsnip and Findley.

The Gold Ranges, which name may be applied as a general one to the next mountain region, is composed of a number of more or less clearly defined subsidiary ranges, the Selkirk, Purcell, Columbia and Cariboo Mountains. Crystalline schists, including gneisses and traversed by intrusive granitic masses, enter largely into the composition of these mountains, and there is ground for the belief that this is geologically the oldest of the ranges of this part of the Cordillera. It is probable that many of its summits exceed 8,000 feet, but their outlines are generally more rounded and flowing than those of the Rocky Mountains, and owing to its dense and tangled forests it is extremely difficult to penetrate and has been less explored than the others. Its width may be stated as about eighty miles, but north of the Cariboo district, about the head waters of the Peace, it dies away completely, though probably again resuming in the Omenica district still further to the north-west.

Between this and the Coast Ranges, stretches a region which may be called the Interior Plateau of British Columbia, with an average

width of one hundred miles, and mean elevation of about 3,500 feet. Its height, on the whole, increases to the south, while northward, it falls gradually towards the group of large lakes, and the low country about the head waters of the Peace. It has over a great part of its area been covered by widespread flows of basalt and other volcanic rocks in the later Tertiary period, but is now dissected by deep and trough-like river valleys into most of which water standing at an elevation of 3,000 feet above the present sea level would flow, dividing its surface into a number of islands. In some places the plateau is pretty level and uniform; but usually it is only when broadly viewed that its character is apparent. It is practically closed to the north about latitude 55° 30′ by the ends of several intercalated mountain ranges of which some of the summits attain 8,000 feet. Nearly coinciding with the 49th parallel is a second transverse mountains zone, formed in a similar way, which may be considered as limiting it to the south, though traversed by several river valleys, of which that of the Okanagan in longitude 119° 30′ is the lowest. The southern part of the plateau includes much open country, constitutes the best grazing region of British Columbia and offers besides some good agricultural land, though the rainfall is so deficient as to render irrigation generally necessary. To the north, with increasing moisture, it becomes generally forested.

The Coast Ranges, with an average width of one hundred miles, are frequently named the Cascade Mountains, but this term is a misleading one, as they are both geologically and orographically distinct from the well-known Cascade range of Washington Territory and Oregon. These mountains are largely composed of gneissic and granitic rocks and crystalline schists. The average altitute of their higher peaks is between 6,000 and 7,000, while some exceed 9,000 feet. Glaciers are of frequent occurrence and large size in their northern part, and on the Alaskan coast are known in several instances to descend to the sea level. These mountains are, as a rule, densely forested and extremely rugged, the flora of their seaward slopes being that characteristic of the west coast and co-ordinated with its excessive humidity, while on their northern and eastern flanks it resembles that of the inland ranges.

The name, Vancouver Range, may be applied to the fourth great mountain axis, which, in a partially submerged, condition constitutes Vancouver and the Queen Charlotte islands, is continued to the south in the Olympic Mountains, and to the north in the peninsular portion and Islands of Alaska. The highest mountain of Vancouver Island reaches an elevation of 7,484 feet, while there is a considerable mountainous area in the centre of the island which surpasses 2,000 feet in average altitude. Several summits in the Queen Charlotte Islands

exceed 4,000 feet. This range, while still to a considerable extent formed of crystalline rocks like those of the Coast Range, includes notable areas of newer beds, of which the most important are those of the Cretaceous coal measures.

The most remarkable feature of the coast are its fjords and passages which, while quite analogous to those of Scotland, Norway and Greenland, probably surpass those of any part of the world, (unless it be the last named country), in dimensions and complexity. The great height of the rugged mountain walls which border them also gives them a grandeur quite their own. The long river-like lakes of the interior of the Province reproduce the features of these fjords in a smaller scale, and hold a homologous position to the inland ranges.

CHAPTER II.

GEOLOGY.

The main geological features of the central and western portion of the Dominion having already been alluded to in connection with its physical structure, it remains now merely to present in such synoptical form as may serve to explain the accompanying map, a systematic outline of its component formations.

The eastern margin of the great interior continental basin is composed of Silurian and Devonian rocks, which, resting almost horizontally on the upturned edges of the Laurentian and Huronian, form a belt of varying width which appears to extend from Minnesota to the shores of the Arctic Sea. Prof. Hind has recognized the Chazy formation on Lake Winnipeg, while in Manitoba and Winnepegosis Lakes Devonian rocks occur, and it is probable that the intervening formations will be found to be extensively developed in the Lake Winnipeg region as it is more fully examined. Fossils obtained at East Selkirk, on the Red River, have enabled Mr. Whiteaves to fix the horizon of the rocks at that place as that of the Galena limestones of the west, equivalent to the Utica shales. Similar beds are found in Stony Mountain, near Winnipeg, but appear there to pass up into the Hudson River formation.

The Cambro-Silurian and Devonian rocks of the Red River and Winnipeg Lake region, are for the most part pale grey or buff-coloured magnesian limestones. From Methy Portage northward, according to Sir J. Richardson's observations and from collections made by Mr. Kennicott, it would appear that Devonian rocks constitute almost the entire width of the Palæozoic belt. They appear on the Clearwater and Athabasca Rivers as bituminous limestones and shales, which are referred by Meek, from their fossils, to the Hamilton and Genesee formations. In this region these rocks yield large quantities of petroleum, which, exuding from them, saturates the overlying superficial materials and gives rise to "tar springs" along the tracks of the rivers. Salt springs also occur, and these are found to characterize the Devonian rocks southward to Red River, though no indications of petroleum have yet been observed south of Methy Portage.

The limits of the present sketch will not permit any detailed description of the Cretaceous and Tertiary rocks which characterize the entire breadth of the interior continental region from the belt of Cambro-Silurian and Devonian limestones last noticed, to the eastern edge of the Cordillera belt. These rocks, however, correspond in their

widespread, and homogeneous general character, to the uniformity of the great plains which they underlie, and may be characterized in a few words.

North of the 49th parallel, the Systems represented—so far as at present known—are the Cretaceous and Tertiary, with the intervening Cretaceo-Tertiary Laramie series, Laramie and Miocene. In the eastern portion of the region, the Cretaceous—owing to the mantle of glacial deposits, is generally poorly exposed, but appears to resemble very closely the strata of the same age, studied by Messrs. Meek and Hayden on the Missouri in the corresponding portion of the Western States. The following is Messrs. Meek and Hayden's general section, the series being arranged in descending order:—

	FEET.
No. 5. *Fox Hill Beds.*—Grey, ferruginous and yellowish sandstones and arenaceous clays. *Marine Shells*....	500
No. 4. *Fort Pierre Group.*—Dark-grey and bluish plastic clays. *Marine shells, gypsum* and *fish remains*....	700
No. 3. *Niobrara Group.*—Calcareous marls. *Marine shells, fish remains, foraminifera,* &c.....	200
No. 2. *Fort Benton Group.*—Dark-grey laminated clays, with some limestone. *Marine shells*.....	300
No. 1. *Dakota Group.*—Yellowish, reddish and whitish sandstones and clay, with occasional lignites. *Marine and some fresh-water shells and angiospermous leaves*.....	400

Of the lowest or Dakota group, no rocks have yet been clearly recognised in our region. The Benton group is stated by Prof. Hind to occur on the Saskatchewan near Fort à la Corne, but this is the only locality in the eastern portion of the region where it is supposed to occur. Shales, probably of this age, occur at the base of the section in the vicinity of the Upper Milk River, and they are pretty extensively developed on the Peace River, where they have been called the Fort St. John group. They also come to the surface in the disturbed foot-hill country at the base of the Rocky Mountains.

Beds of the age of the Niobrara or third division of the Cretaceous of Messrs. Meek and Hayden, occur in the escarpment of Pembina Mountain, west of the Red River Valley, on the Boyne River. They are also probably shown on the Assiniboine, and have again been recognized on Swan River, west of Manitoba Lake. Their character in these places closely corresponds with that found in the typical section above referred to, the beds being largely calcareous and marly, and repeating to some extent the character of the chalk of the old world. Further west no beds have been distinctly recognised as referable to the Niobrara, though it is probable that the Belly River and Dunvegan series, subsequently referred to, are nearly on this horizon.

The Pierre or next overlying group is in point of extent the most important of the sub-divisions of the Cretaceous in the North-West, its characteristic dark shales or shaly-clays underlying a great part of the prairie country. The shales frequently contain ironstone nodules, and in some places arenaceous layers also appear and are generally found to become more important in approaching the mountains. The lithological character of this group is, however, on the whole remarkably uniform and beds are occasionally found in it which are highly fossiliferous. The highest beds of the Cretaceous system proper, the Fox Hill, are closely related to the Pierre, and form in many places a series of passage beds between the Cretaceous and the overlying Laramie formation. When most characteristically developed they consist of sandstone and yellowish sandy shales.

Overlying the Cretaceous proper in perfect conformity is a great series of estuarine and fresh-water beds which may collectively be referred to the Laramie formation. No question in western geology has given rise to so much discussion as that of the Cretaceous or Eocene age of these beds. It is one which depends almost entirely on the apparently conflicting evidence of the vertebrate, molluscan and vegetable fossils which they contain, and one which cannot here be entered into. On the accompanying map this formation is indicated by a separate colour, because of its lithological difference from the underlying Cretaceous, its influence as a cause of plateaus and other features, and its importance in connection with the fuel supply of the country.

The most eastern locality of these beds is Turtle Mountain, on the 49th parallel, where they form an extensive outlier. On the Souris River they are largely developed, and constitute the superficial formation of the whole country. The Laramie of this region is, however, an extension of that special development of the formation on the Missouri which has long been known as the Fort Union series. The rocks are generally soft sandy clays and sandstones, of pale colours, and on the Souris hold ironstone and many seams of lignite of fair quality. Further west the typical Laramie covers a vast area and becomes a distinctly estuarine formation at the base, and the connection between this and that of the Souris beds yet remains to be clearly established. The western Laramie, particularly in the vicinity of the mountains, is largely composed of sandstones which are frequently quite hard. This formation has a thickness of several thousand feet in the country about the Bow and Belly Rivers, where it has been sub-divided into three groups which are enumerated in tabular form on a subsequent page.

A small area of Miocene Tertiary rocks was discovered in 1883 in the Cypress Hills, where it overlies Cretaceous and possibly, in some places, Laramie beds. The rocks are chiefly pebble-beds, or conglome-

rates composed of coarse rolled shingle which has had its origin in the Rocky Mountains. These are associated with soft sandstones and sandy clays, and have yielded a few vertebrate remains which seem sufficient to fix the age of the formation.

It has already been stated that the Cretaceous rocks of the extreme west differ from those of the typical section first quoted. In the region of the Bow or Belly Rivers, the Pierre is underlaid by an extensive fresh-and-brackish-water series, consisting of sandy argillites and sandstones; the upper portion is characteristically pale in tint, the lower generally darker and yellowish or brownish. This has been called the Belly River series, and appears to correspond precisely to that occupying a similar stratigraphical position on the Peace River, and there designated the Dunvegan series. These indicate the existence of a prolonged interval in the western Cretaceous area, during which the sea was more or less exclud[illegible] from the region, and its place occupied for long periods by lagoons or [illegible]ter lakes. Below these, both in the region of the Bow and Belly a[illegible]n the Peace Rivers, is a second series of dark shales which may probably represent the Benton group of the Missouri sections.

The subjoined table shows more clearly the relations of the Cretaceous and Laramie beds, so far as they are at present known:—

Missouri Section. Meek and Hayden.		District of Bow and Belly Rivers.	Peace River District.
Laramie and Fort Union.	Laramie.	Porcupine Hill beds. Willow Creek beds. St. Mary River beds.	Wapiti River group.
Fox Hill beds.		Fox Hill (inconstant).	
Pierre group.		Pierre group.	Smoky River group.
Niobrara group.		Belly River group.	Dunvegan group.
Benton group.		Benton group?	Fort St. John group.
Dakota group.			

The Cretaceous and Laramie beds of the whole eastern portion of the interior Continental region are almost absolutely horizontal, or affected

by such slight inclinations that no dip is observable in individual sections. The beds of both series have, however, participated in the western uplift of this part of the Continent, and are found at ever increasing levels on approaching the Rocky Mountains. Near the base of the range they are also found to show more pronounced undulations, and in a narrow belt along the foot of the mountains are sharply folded and contorted. Isolated areas of these newer rocks have also been found in the Rocky Mountains themselves, and in one of these the anthracite of Cascade River, in the Bow Pass, occurs.

The most important question depending on the study of the Cretaceous and Laramie rocks of the North-West, is that of the fuel supply. In the eastern region, lignites of fair quality and workable thickness occur in the Laramie rocks of the Souris district, but have so far not been found in the underlying Cretaceous. Further west the Cretaceous also becomes a coal-bearing formation, and in the vicinity of the Bow and Belly important lignites or coals have now been found in the Belly River series (Medicine Hat, etc.): base of the Pierre (Coal Banks, etc.): top of the Pierre (Bow River) and in the lower subdivision of the Laramie (Blackfoot Crossing, etc.). In the Peace River district seams which may prove to be of a workable character have been found only in the Dunvegan series. The precise horizon of many of the lignites and coals of the western part of the plains and foot-hills has not yet been fixed. The fuels found in the area of the plains may be characterized generally as lignites, but on approaching the mountains these are found to contain a decreasing percentage of water, and eventually, in the foot-hills and areas included within the first limestone range frequently become true coking bituminous coals, and in one instance, as above stated, have actually been converted into an anthracite which contains 86 per cent. of fixed carbon.

In treating of the rock structure of the Cordillera belt, it will be most convenient to outline that of each of its great component regions, in so far as the older formations are concerned. The Cretaceous and Tertiary of the entire belt, which rest upon these in a comparatively little disturbed or altered state, may then be considered.

In the Rocky Mountains we have the broken western margin of the undisturbed palæozoic strata which underlie the great plains. These are here sometimes sharply flexed and lying at high angles, but very generally elevated in block-like and nearly horizontal masses. In British America our geological knowledge of the ranges is confined to the observations of its extreme northern part by Sir J. Richardson, of its southern portion by Dr. Hector, a traverse on the Peace River by Dr. Selwyn and the observations of the writer in the last named locality and in the region between the Bow River Pass and the 49th parallel.

The most complete section so far examined is that in the vicinity of the South Kootanie Pass and Waterton Lake. This may therefore be briefly referred to and some reference then made to such points of difference as occur between it and those in the north-western continuation of the range. The total thickness of the beds here seen, or of that part of them which was measured or estimated, is about 4,500 feet, the section being as follows in descending order:— (*)

H. Fawn-colored, flaggy beds, chiefly composed of magnesian sandstones and limestones..... 100 feet.

G. Beds characterized by a predominent red colour, and chiefly red sandstone, but including some thin greyish beds, and magnesian sandstone. The whole generally thin-bedded though sometimes rather massive.... 300 feet.

F. Fawn-coloured, flaggy beds of magnesian sandstone and limestone. Some red sandstones occur throughout, but are especially abundant toward the top. Apparently a continuation upward of the limestone D., and separated from it only by the trap overflow..... 200 feet.

E. Amygdaloidal trap, dark coloured and hard..... 50 to 100 feet.

D. Compact bluish and grey limestone, often somewhat magnesian and weathering brownish. This forms some of the boldest crags and peaks of the mountains, and rests unconformably on series C..... 1,000 feet.

C. Sandstones, quartzites and slaty rocks of various tints, but chiefly reddish and greenish-grey. The individual beds seldom of great thickness, and the colour and texture of approximate beds often rapidly alternating. In this series occurs a band of bright-red rocks of inconstant thickness, also occasional zones of coarse magnesian grit..... 2,000 feet or more.

B. Limestone, pale-grey, cherty and highly magnesian, hard, much altered, and weathering white. It includes at least one band of coarse magnesian grit like that found in the last series..... 200 feet.

A. Impure dolomites and fine dolomitic quartzites, dark purplish and grey, but weathering bright brown of various shades..... 700 feet or more.

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* Geology and Resources, 49th parallel, p. 67.

Of the foregoing section the subdivisions G and H, doubtless represent the Trias or Jura-Trias which with similar lithological characters is very extensively developed in the Rocky Mountain region further south. The conditions indicated are those of an inland lake, and the occurrence of mud-cracks, ripple-marks, and the impressions of salt crystals show that considerable surfaces were at times dry, or but lightly covered by water. These beds have not been found further north in the range than the North Kootanie Pass, and it would appear probable that this is about the ancient limit of the Triassic inland sea. About the Peace River, Triassic beds have been found, but they are dark shales and sandstones quite different in character, and hold marine fossils of the age of the 'Alpine Trias' of the Western States. The Permian is not certainly known, though subdivision F may represent it. The trap E is evidently a contemporaneous flow, and has not been found further north than the Triassic beds. The massive limestones, D., are the most characteristic beds of this range and appear to be persistently so throughout its whole extent. From fossils elsewhere found they are known to be Devonian or Devono-Carboniferous. They must vary much in thickness, as on the Crow Nest Lake, forty miles to the north-west, they have a volume of 9,600 feet.

The unconformably underlying divisions C., B. and A. may now be provisionally classed as Cambrian, on the evidence of a few fossils found in the Columbia valley, and from analogy with beds described in the Western States since this section was first published, though it is quite possible that Silurian beds may also be included. In some places, west of the Flathead River, the red beds included with these are characterized by sun-cracks, ripple-marks and prints of salt crystals precisely resembling those of the Trias and indicating similar conditions of deposit, though of vastly greater antiquity. Contemporaneous flows of diorite or diabase are also found at some horizons, and in tracing this series of rocks, which must in the aggregate be of great thickness, from point to point in the range, its lithological character is found to be very varied, and the subdivisions worked out in the neighbourhood of Waterton Lake, would appear to be inconstant.

In the Peace River district, on the 55th and 56th parallel, the axial mountains of the range are composed of massive limestones of Devonian and probably also of Carboniferous age, associated with saccharoidal quartzites. On the west side these were believed to underlie a series of argillites which occasionally becomes micaceous schists and slates, and also includes quartzites. These are known to occupy a long trough east of the Parsnip river, and cross the Misinchinca with considerable width. The Triassic shales, with *Monotis*, &c., being

developed on the eastern slopes of the range at this place, it was supposed that the beds above alluded to might represent them in a more altered state. From the knowledge now gained of the Cambrian in the southern part of the mountains it is not improbable that they may eventually be relegated to this systems.

As before observed, the geological structure of the Gold Ranges, or second mountain axis, is little known. Cambrian rocks like those of the Rocky Mountains characterize its eastern portion near the 49th parallel, while its western portion is largely composed of highly crystalline rocks, including gneiss, and intrusions of a granitic character are abundant. These are complicated, where they have been observed, by the occurrence of areas of much altered rocks resembling those of the interior plateau region, next to the west. Among these is a series of dark slates or schists which are the auriferous rocks in the Cariboo district and elsewhere. The age of these has not been determined, but there is reason to suppose that a portion at least are Triassic.

The district coloured as Archæan on the accompanying map, while therefore probably in large part composed of rocks of this period, is much more heterogeneous in character than can be indicated with our present information. The thickness of the crystalline rocks displayed on Shuswap Lake, has been estimated at about 32,300 feet. An isolated area of gneissic rocks doubtless belonging to a contraction of the main axis, as shown on the map, occurs at Carp Lake, west of McLeod Lake.

The Carboniferous rocks of the interior plateau region are very varied in lithological character. They belong for the most part to the upper and lower Cache Creek groups of the original classification, and may be said as a whole to consist of massive limestone and compact or shaly quartzites. They also include, however, a great proportion of diorites or diabases, felspathic rocks and agglomerates, and some serpentines. The last named material occurs in association with the contemporaneous volcanic materials, and doubtless represents the alteration product of olivine rocks. It is in beds of considerable thickness, and wide-spread, and is of interest as being of a period so recent as the Carboniferous. The limestones are not unfrequently converted to coarse-grained marbles, and together with the quartzites, appear in greatest force on the south-western side of the area they occupy. They have now been traced, maintaining their character pretty uniformly throughout, from the 49th to the 53rd parallel. Schistose or shaly argillite rocks, which may represent those folded with the Gold Range series, also occur, and a portion of these probably belongs to the overlying Triassic or Jurassic division.

In regard to the evidence of the age of the great mass of these rocks, forming the so-called upper and lower Cache Creek groups, the following points may be stated. A portion at least of these rocks was, in 1871, shown, by fossils collected by Dr. Selwyn, to belong to a horizon between the base of the Devonian and summit of the Permian; additional fossils have since been procured, of which the most characteristic is the peculiarly Carboniferous foraminifer *Fusulina*, which has now been found in several localities scattered over a wide area. While it is therefore quite possible that distinctively Devonian, or even Silurian or Cambrian rocks may yet be identified in the interior plateau, there is as yet no proof that any of a date earlier than the Carboniferous occur, and the association of the other beds with the fossiliferous limestones is such as to show that a great part of them must be approximately of this age.

In the southern portion at least of the Interior Plateau region, there exist besides the Palæozoic rocks above described, and in addition to the probably in part Triassic argillites extensive, but as yet undefined areas of Triassic rocks of another character. These are largely of volcanic origin and have been designated the Nicola series. They have generally a characteristically green colour, but are occasionally purplish and consist chiefly of felspathic rocks and diorites, the latter often more or less decomposed. These rocks are in some cases quite evidently amygdaloidal or fragmental, and hold towards the base beds of grey sub-crystalline limestone intermingled in some places with volcanic material and containing occasional layers of water-round detritus. The distinctly unconformable junction of this series with the Câche Creek rocks is seen on the South Thompson, a few miles above Kamloops.

The older rocks of the Coast and Vancouver Island ranges may, in the present state of our knowledge, be treated of together, those of Vancouver Island being first described, as being the best known.

In 1872 the late Mr. J. Richardson described a section across the centre of Vancouver Island,* comprising a great thickness of beds which have been closely folded together and overturned. These consist of limestones, generally crystalline, but varying in texture and colour, interbedded with compact amygdaloidal and slaty volcanic rocks of contemporaneous origin. These are classed generally as "diorites" in the report cited, but admit of separation into several different species of igneous rocks, not here necessary to detail. Argillites also occur, but are apparently not prominent in the section. Fossils are found abundantly in some of the limestones, and though invariably

* Report of Progress, Geol. Survey of Canada, 1872-73, pp. 52-56.

in a poor state of preservation, the late Mr. Billings was able to distinguish, besides crinoidal remains, a *Zaphrentis*, a *Diphiphyllum*, a *Productus*, and a *Spirifer*, and pronounced the beds to be probably Carboniferous in age.

Rocks belonging to the older series, unconformably underlying the Cretaceous, have now been examined in many additional localities on Vancouver Island, and, while no palæontological facts have been obtained to prove that they are older than those of the section above described, much circumstantial evidence has been collected to show that rocks even much more highly crystalline than those of the above section, and which, judged by standards locally adopted in Eastern America, would be supposed to be of great antiquity, represent approximately, at least the same horizon.

At the south-eastern extremity of the island, in the vicinity of Victoria, a series of rocks occurs which was placed by Mr. Selwyn, in his provisional classification of the rocks of British Columbia, under the title of the *Vancouver Island* and *Cascade Crystalline Series.*"* Dr. Selwyn, in speaking of these, remarks on their lithological similarity to the Huronian rocks, or those of the altered Quebec group of Eastern Canada. A somewhat detailed examination of this series has since been made, and shows it to be built up in great part of dioritic and felspathic materials, which in places become well characterized mica-schists, or even gneisses, while still elsewhere distinctly maintaining the character of volcanic ash-beds and agglomerates. With these are interbeded limestones, and occasionally ordinary blackish argillites. No more certain palæontological evidence of the age of these beds than that afforded by some large crinoidal columns which occur in the limestones has yet been obtained. These, however, suffice to show that they cannot be referred to a pre-Silurian date, and it is highly probable that they are actually a more altered portion of the series represented in the first described section, from which their greatest point of difference is found in the smaller proportionate importance of limestoues. They occur in the continuation of the same axis of elevation at no very great distance, and the greater disturbance which they have suffered would serve to account for the higher degree of alteration in materials so susceptible of crystallization as those of volcanic origin.

Elsewhere, in the vicinity of Vancouver Island, rocks holding fossils, which seem to be Carboniferous, and formed in part of volcanic materials, occur; and on Texada Island beds probably of the same age are found, consisting of interstratified limestone or marble, magnetic iron ore, epidotic rock, diorite and serpentine.

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* Report of Progress, Geol. Survey of Canada, 1871-2, p. 52.

Passing northwestward, along the same mountainous axis, to the Queen Charlotte Islands, we find the rocks there underlying the Cretaceous Coal series to present, in the main, features not dissimilar to those of Vancouver Island. Massive limestones, generally fine-grained, grey, and often cherty, are folded together with felspathic and dioritic rocks, sometimes so much altered as to have lost the evidence as to whether they were originally fragmental or molten. In other places they are still well-marked rough agglomerates, or amygdaloids.

No characteristic fossils have been obtained from these rocks, but at the summit of this part of the series, and adhering closely to a limestone which apparently forms its upper member, occurs a great thickness of regularly-bedded blackish calcareous argillite, generally quite hard and much fractured, but holding numerous well-preserved fossils, including *Monotis subcircularis* and other characteristic forms of the so-called "Alpine Trias" of California and the 40th parallel region, which represents the Hollstadt and St. Cassian beds of Europe. The resemblance of the lower unfossiliferous rocks first described to the probably Carboniferous beds of Vancouver, leads to the belief that these may also be of the same age, while any slight unconformity between these and the Triassic may be masked by subsequent folding and disturbance.

In the extreme northwestern part of Vancouver Island Triassic rocks like those of the Queen Charlotte Islands occupy extensive but yet undefined areas, while the slaty auriferous rocks of Leach River, near Victoria, may also represent the Triassic argillites in a more altered state.*

As already mentioned, Dr. Selwyn, in his provisional classification, unites under one title the older rocks of Vancouver Island, above described, and those which form the greater part of the Cascade or Coast Ranges. The progress in the investigation of the country seems to favor the correctness of this view, and to show a blending and interlocking of such characters of difference as the typical or originally examined localities of the two series present. Tracing the rocks eastward from the shores of Vancouver Island, we find them becoming more disturbed and altered, the limestones always in the condition of marbles, and seldom or never showing organic traces, the other rocks represented chiefly by grey or green diorites, gneisses—generally hornblendic—and various species of felspathic rocks, such as may well be supposed to have resulted from the more complete crystallization of the volcanic members of the series. Recurring in a number of places, and folded with these rocks, is a zone of micaceous schists or argillites.

The rocks classed as the Anderson River and Boston Bar series† in

* Reports of Progress, Geol. Survey of Canada, 1878-79, p. 46 B; 1876-77, p. 95.

† Reports of Progress, Geol. Survey of Canada, 1871-72, p. 62.

the provisional classification represent one fold of these schists, which may be supposed to be more or less exactly equivalent to the Triassic flaggy argillites of the first mountain axis.

The Coast range constitutes an uplift on a much greater scale than that of Vancouver and the Queen Charlotte Islands to the southwest of it, a circumstance which appears to have resulted in a more complete crystallization of its strata, and has also led to the introduction of great masses of hornblendic granite. These may in many places represent portions of the strata which have undergone incipient or complete fusion, in place. There is every evidence that in the Appalachian-like folding of this region the same rocks are many times repeated. East of the lower part of the Fraser River, the folds have been completely overturned to the eastward.

These rocks of the Coast Range have with other features of the country a great extension in a north-east and south-east bearing, stretching, with an average width of 100 miles at least, from the 49th parallel to Alaska, a distance of 500 or 600 miles. The exact relations of the rocks of the Coast Range to those of the Interior Plateau yet remain to be determined, but there is reason to believe that the latter are represented, in a highly metamorphosed state, quite extensively in this range. Older rocks may also probably occur locally, but no extensive areas of gneissic rocks lithologically resembling those of the Gold Ranges have been found.

Lying everywhere quite unconformably upon the older beds so far described are the Cretaceous rocks, which constitute on the coast the true Coal-bearing horizon of British Columbia. These rocks probably at one time spread much more widely along the coast than they now do, but have since been folded and disturbed during the continuation of the process of mountain elevation, and have been much reduced by denudation. Their most important area, including the coal-mining regions of Nanaimo and Comox, may be described as forming a narrow trough along the north-east border of Vancouver Island, 136 miles in length. The rocks are sandstones, conglomerates and shales. They hold abundance of fossil plants and marine shells in some places, and in appearance and degree of induration much resemble the true Carboniferous rocks of some parts of Eastern America. In the Nanaimo area the formation has been divided by Mr. J. Richardson as follows, in descending order:—

Sandstones, conglomerates and shales	3290 feet.
Shales	660 "
Productive Coal-measures	1316 "
	5266 "

The last named consists of sandstones and shales, and holds valuable coal-seams near its base. In the Comox area seven well-marked subdivisions occur, constituting a total thickness of 4911 feet.

Upper conglomerate	320 feet.
Upper shales	776 "
Middle conglomerate	1100 "
Middle shales	76 "
Lower conglomerate	900 "
Lower shales	1000 "
Productive Coal-measures	739 "
	4911 feet.

The fuel obtained from these measures is a true bituminous coal, with—according to the analysis of Dr. Harrington—an average of 6·29 per cent. of ash and 1·47 per cent. of water. It is admirably suited for most ordinary purposes, and is largely exported, chiefly to San Francisco, where, notwithstanding a heavy duty, it competes successfully with coals from the west coast of the United States, owing to its superior quality. The output of 1883 amounted to 213,000 tons, and is yearly increasing.

In addition to the main area of Cretaceous rocks above described, there are numerous smaller patches, holding more or less coal, in different parts of Vancouver Island, some of which may yet prove important.

On the Queen Charlotte Islands, Cretaceous rocks cover a considerable area on the east coast, near Cumshewa and Skidegate Inlets. At Skidegate they hold true anthracite coal, which, besides being a circumstance of considerable geological interest, would become, if a really workable bed could be proved, a matter of great economic importance to the Pacific coast.

At Skidegate, where these rocks are most typically developed, they admit of subdivision as follows, the order being, as before, descending:

A. Upper shales and sandstones	1500 feet.
B. Coarse conglomerates	2000 "
C. Lower shales with coal and clay ironstone	5000 "
D. Agglomerates	3500 "
E. Lower sandstones	1000 "
	13,000 feet.

The total thickness is thus estimated at about 13,000 feet. With the exception of the agglomerates, the rocks in their general appearance and degree of induration compare closely with those of Vancouver Island. The agglomerates represent an important intercalation of volcanic material, which varies in texture, from beds holding angular

masses a yard in diameter; to fine ash rocks, and appears at the junction to blend completely with the next overlying subdivision. These beds are generally felspathic, and often more or less distinctly porphyritic.

At the eastern margin of the formation the rocks lie at low angles, but become more disturbed as they approach the mountainous axis of the Islands, showing eventually in some cases overturned dips. It is in this disturbed region that the anthracite coal has been found, and from the condition of included woody fragments in the eastern portion of the area it is probable that any coal seams discovered there would be bituminous, like those of Vancouver Island.

Though it was originally supposed that the anthracite occurred in several beds, it has, I believe, now been shown* that this appearance is due to the folding of a single seam which immediately overlies the agglomerate beds of subdivision D. The coal is associated with carbonaceous shales holding a species of *Unio*, but is succeeded, in ascending order, by beds charged with marine fossils, and fresh-water conditions are not known to have recurred at other horizons. It was where opened nearly vertical, and after about 800 tons of anthracite had been obtained the mine was abandoned; the locality, however, still appears worthy of further and closer examination.†

In regard to the geological horizon of the different Cretaceous areas above described, the most complete information has been obtained for the Nanaimo and Comox basins. Large collections made by Mr. Richardson, in connection with the work of the Geological Survey, have been described by Mr. J. F. Whiteaves.‡

These fossils are all from the lower portion of the formation, which is conclusively shown to represent the Chico group of the Californian geologists, which, with the locally developed Martinez group, is considered to be equivalent to the Lower and Upper Chalk of Europe. The highest subdivision of the Californian Cretaceous, the Tejon group, is supposed to represent the Maestricht, and in the absence of fossils from the upper portion of the Vancouver Island formation, it is possible that it may be equally young. The flora of the Vancouver Cretaceous consists largely of modern angiospermous and gymnospermous genera, such as *Quercus, Platanus, Populus* and *Sequoia:* several of the genera and a few of the species being common to it and to the Dakota group of the Middle Cretaceous of the interior region of the continent.

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* Report of Progress, Geological Survey of Canada, 1878-79, p. 72 B.

† For further information on the Cretaceous rocks of the coast, see Dr. Hector's report in Palliser's Exploration in North America, and Quart. Journ. Geol. Soc., vol. xvii., p. 428. Reports of Progress, Geological Survey of Canada, 1871-72, p. 75; 1872-73, p. 32; 1873-74, p. 94; 1874-75, p. 82; 1876-77, p. 160; the last reference being Mr. Richardson's complete report on the Nanaimo and Comox Basins,—also pp. 119 and 144, 1878-79, p. 63B, a detailed report on Queen Charlotte Islands by the writer.

‡ Mesozoic Fossils, vol. i., part ii.

The botanical evidence, while yet imperfect, is therefore by no means in contradiction to that afforded by the animals and the stratigraphy.

A number of fossils from the Queen Charlotte Islands have also been described and figured from Mr. Richardson's collections made during a visit to the islands in 1872. Additional collections made by the writer in 1878 have since considerably increased the fauna.* There are few cases of specific identity between the forms in the Vancouver Cretaceous, previously described, and those of the Queen Charlotte Islands, the latter representing a lower stage in the Cretaceous formation. The plants found in these rocks, embracing numerous coniferous trees and a species of Cycad, also indicate a greater age than those of Vancouver.

The coal-bearing beds at Quatsino Sound, on the west coast of Vancouver Island, have also yielded a few fossils. These consist chiefly of well-characterized specimens of *Aucella Piochii*, which occurs but sparingly in the Queen Charlotte Islands, and brings the rocks into close relations with the Aucella beds of the mainland of British Columbia, and in Mr. Whiteaves' opinion probably indicate an "Upper Neocomian" age. The rocks of the Queen Charlotte Islands and Quatsino may therefore be taken together as representating the upper and lower portions of the so-called Shasta group of California, which in British Columbia can now be readily distinguished by their fossils.

On the mainland, developed most characteristically along the north-eastern border of the coast range, is a massive series of rocks first referred to by Dr. Selwyn, in the provisional classification adopted by him in 1871, as the Jackass Mountain group, from the name of the locality in which they are best displayed on the main waggon-road. The age of these rocks was not known at this time, but fossils have since been discovered in the locality above mentioned, and in several others, the most characteristic forms being *Aucella Piochii* and *Belemnites impressus*.† The rocks are generally hard sandstones or quartzites, with occasional argillites, and very thick beds of coarse conglomerate. A measured section on the Skagit River includes over 4,400 feet, without comprising the entire thickness of the formation. Behind Boston Bar, on the Fraser River, the formation is represented by nearly 5,000 feet of rocks, while on Tatlayoco Lake it probably does not fall short of 7,000 feet. At the last-named place these beds are found to rest on a series of felspathic rocks, evidently volcanic in origin, and often more or less distinctly porphyritic. On the Iltasyouce River, near the 51st parallel, and in similar relation to the

* Mesozoic Fossils. Vol. i, parts i and ii.

† See on this and other older Cretaceous rocks. J. F. Whiteaves, Trans. Roy. Soc. Canada, 1882, section iv, p. 81.

Coast Range, an extensive formation characterized by rocks of volcanic origin, and often porphyritic, has also been found. Its thickness must be very great, and has been roughly estimated at one locality at 10,000 feet. It has been supposed, on lithological grounds, to represent the porphyritic formation of the vicinity of Tatlayoco Lake, and fossils found in it have been described as Jurassic. From analogy since developed with the Queen Charlotte Island fauna, however, Mr. Whiteaves now believes that the Iltasyouco beds are also Cretaceous.

Still further north the Cretaceous formation is not confined to the vicinity of the Coast Range, but spreads more widely eastward, being in all probability represented by the argillites and felspathic and calcareous sandstones of the Lower Nechacco; and, as the explorations of 1879 have shown, occupying a great extent of country on the 55th parallel about the upper part of the Skeena and Babine Lake. They here include felspathic rocks of volcanic origin similar to those of the Iltasyouco, which are most abundant on the eastern flanks of the Coast Range, and probably form the lower portion the group. Besides these volcanic rocks, there is, however, a great thickness of comparatively soft sandstones and argillites, with beds of impure coal. The strata are arranged in a series of folds more or less abrupt, and have a general north-west and south-east strike. It is not impossible, from the general palæontological identity of the rocks of the interior with the older of those of the coast, that the Skeena region may eventually be found to contain valuable coal-seams, but this part of the country is at present very difficult of access, and there is no inducement to explore it.

The Tertiary rocks do not form any wide or continuous belt on the coast of British Columbia, as is the case farther south. They are found near Sooke, at the southern extremity of Vancouver's Island, in the form of sandstones, conglomerates, and shales, which are sometimes carbonaceous.* Tertiary rocks also probably occupy a considerable area about the mouth of the Fraser River; extending southward from Burrard Inlet, across the International boundary formed by the 49th parallel, to Bellingham Bay and beyond. Thin seams of lignite occur at Burrard Inlet. Sections of the Tertiary rocks at Bellingham Bay are given in Dr. Hector's official report. Lignite beds were extensively worked here some years ago, but the mine has been abandoned owing to the superior quality of the fuels now obtained from Nanaimo and Seattle. About the estuary of the Fraser the Tertiary beds are much covered by drift and alluvial deposits, and are consequently not well known. Lignites, and even true coals, have been found in connection

* Report of Progress, Geol. Survey of Canada, 1878-9, p. 84 B.

with them, but so far in beds too thin to be of value. Fossil plants from Burrard Inlet and Bellingham Bay have been described by Newberry and Lesquereux, and these are supposed to indicate a Miocene age for the deposits. *

Much farther north, in the Queen Charlotte Islands, the whole north-eastern portion of Graham Island has now been shown to be underlaid by Tertiary rocks, which produce a flat or gently undulating country, markedly different from that found on most parts of the coast. The prominent rocks are of volcanic origin, including basalts, dolerites, trachytic rocks, and in one locality obsidian. Numerous examples of fragmental volcanic rocks are also found. Below these, but seen in a few places only, are ordinary sedimentary deposits, consisting of sandstones or shales, and hard clays with lignites. At a single locality on the north end of Graham Island, beds with numerous marine fossils occur. These, in so far as they admit of specific determination, represent shells found in the later Tertiary deposits of California, and some of which are still living on the north-west coast; and the assemblage is not such as to indicate any marked difference of climate from that now obtaining. †

The Tertiary rocks of the coast are not anywhere much disturbed or altered. The relative level of sea and land must have been nearly as at present when they were formed, and it is probable that they originally spread much more widely, the preservation of such an area as that of Graham Island being due to the protective capping of volcanic rocks. The beds belong evidently to the more recent Tertiary, and though the palæontological evidence is scanty, it appears probable from this, and by comparison with other parts of the west coast, that they should be called Miocene.

To the east of the Coast or Cascade Range, Tertiary rocks are very extensively developed. They have not, however, yielded any marine fossils, and appear to have been formed in an extensive lake, or series of lakes, which may at one time have submerged nearly the entire area of the region described as the interior plateau. The Tertiary lake or lakes may not improbably have been produced by the interruption of the drainage of the region by a renewed elevation of the coast mountains proceeding in advance of the power of the rivers of the period to lower their beds; the movement culminating in a profound disturbance leading to a very extensive volcanic action. The lower beds are sand-

* Report of Progress, Geol. Survey of Canada, 1876-77, p. 190.

† In the geology of the U. S. exploring expedition, Prof. Dana describes some Tertiary plants from Birch Bay. These were afterwards reported on by Newberry, Boston Journal of Natural History, vol. vii., No. 4. See also American Journal of Science and Arts, 2nd series, vol. xxvii., p. 359, and vol. xxviii., p. 85. Report on the Yellowstone and Niusain expedition, 1869, p. 166 Annals Lyceum of Natural History of N. Y., vol. ix., April 1868.

stones, clays, and shales, generally pale-greyish or yellowish in colour, except where darkened by carbonaceous matter. They frequently hold lignite, coal, and in some even true bituminous coal occurs. These sedimentary beds rest generally on a very irregular surface, and consequently vary much in thickness and character in different parts of the extensive region over which they occur. The lignites appear in some places to rest on true "underclays," representing the soil on which the vegetation producing them has grown, while in others—as at Quesnel—they seem to be composed of drift-wood, and show much clay and sand interlaminated with the coaly matter.

In the northern portion of the interior the upper volcanic part of the Tertiary covers great areas, and is usually in beds nearly horizontal, or at least not extensively or sharply folded. Basalts, dolerites, and allied rocks of modern aspects occur in sheets, broken only here and there by valleys of denudation; and acidic rocks are seldom met with except in the immediate vicinity of the ancient volcanic vents. On the Lower Nechacco, and on the Parsnip River, the lower sedimentary rocks appear to be somewhat extensively developed without the overlying volcanic materials.

The southern part of the interior plateau is more irregular and mountainous. The Tertiary rocks here cover less extensive areas, and are much more disturbed, and sometimes over wide districts—as on the Nicola—are found dipping at an average angle of about thirty degrees. The volcanic materials are occasionally of great thickness, and the little disturbed basalts of the north are, for the most part, replaced by agglomerates and tufas, with trachytes, porphyrites, and other felspathic rocks. It may indeed be questioned whether the character of these rocks does not indicate that they are of earlier date than those to the north, but, as no direct palæontological evidence of this has been obtained, it is presumed that their different composition and appearance is due to unlike conditions of deposition and greater subsequent disturbance.

No volcanic rocks or lava flows of Post-glacial age have been met with, though I believe that still farther to the north-west the rocks are of yet more recent origin than any of these here described, and I have even heard a tradition of the Indians of the Nasse River which relates that, at some time very remote in their history, an eruption covering a wide tract of country with lava was witnessed.

The organic remains so far obtained from these Tertiary rocks of the interior consist of plants, insects, and a few fresh-water molluscs and fish scales, the last being the only indication of the vertebrate fauna of the period. The plants have been collected at a number of localities. They have been subjected to a preliminary examination by

Principal Dawson, and several lists of species published. While they are certainly Tertiary, and represent a temperate flora like that elsewhere attributed to the Miocene, they do not afford a very definite criterion of age, being derived from places which must have differed much in their physical surroundings at the time of the deposition of the beds. Insect remains have been obtained in four localities. They have been examined by Mr. S. H. Scudder, who has contributed three papers on them to the Geological Reports, in which he describes forty species, all of which are considered new. None of the insects have been found to occur in more than a single locality, which causes Mr. Scudder to observe that the deposits from which they came may either differ considerably in age, or, with the fact that duplicates have seldom been found even in the same locality, evidence the existence of different surroundings, and an exceedingly rich insect fauna.

Though the interior plateau may at one time have been pretty uniformly covered with Tertiary rocks, it is evident that some regions have never been overspread by them, while, owing to denudation, they have since been almost altogether removed from other districts, and the modern river valleys often cut completely through them to the older rocks. The outlines of the Tertiary areas are therefore now irregular and complicated.*

* For additional information on the Tertiary rocks of the interior, see the following Reports of Progress, 1871-2, p. 56; 1875-6, pp. 70 and 225; 1876-7, pp. 75 and 112, B.