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IV.—*Descriptive Note on a General Section from the Laurentian Axis to the Rocky Mountains north of the 49th Parallel.*

By GEORGE M. DAWSON, D. Sc., F. G. S., &c.

(Read May 26th, 1882.)

The section in relation to which these notes are presented is a diagrammatic one, intended rather to show the general arrangements of the rocks underlying the great plains, than the actual position of the beds on any definite line. The direction of the section is, however, almost exactly transverse to that of the main strike of the rocks, and that of the great interior continental valley which lies between the Laurentian Highlands on the east and the Rocky Mountains on the west. The section is about eight hundred miles in length.

The profile represented by it is that of a line drawn from the middle of Lake Winnipeg west-south-westward, passing through the Touchwood and Porcupine Hills, and reaching the base of the Rocky Mountains, midway between the 49th and 50th parallels. The vertical scale and thickness of formations are necessarily very much exaggerated.

Lake Winnipeg and the contiguous great lakes, with the low country about them, mark the outcrops of Silurian and Devonian rocks which lie at very low angles or are nearly horizontal. These rocks are, for the most part, magnesian limestones of pale buff colour, and resemble those representing these periods in the Mississippi Valley. They must have originally spread far up on the Laurentian plateau, and perhaps have inosculated with the similar rocks of the same age which border the basin of Hudson's Bay.

The great denudation which they have suffered, in times geologically very recent, is attested by the immense quantity of these peculiar rocks which, together with Laurentian and Huronian fragments, has been spread abroad over the surface of the great plains in the form of boulders and gravel. Rocks of Devonian age occupy the western portion of this region of the lakes, and Professor Hind has defined by observations in several localities a belt of them at least fifty miles in width. It is in connection with these rocks that the brine springs of the vicinity of Manitoba Lake occur. Salt has been manufactured from these for commercial purposes.

North of the Winnipeg Lakes on the Arctic slope of the continent, the Devonian rocks appear to become more important in regard to the area they cover than the Silurian, and they are found to yield petroleum as well as salt. The description of the bitumen and mineral pitch of the Athabasca region, by Sir J. Richardson, would seem to indicate that a very important oil region there waits to be developed.

The rocks consist of limestones and dark slates, and are referred by Meek—who has examined a considerable number of fossils from them—to the Hamilton and Genesee epochs.

The "black slate" of the Western and Southern States has been shewn to be the equivalent there of the latter, and, according to Meek, "holds exactly the same position with relation to the Hamilton beds as the Clearwater and Athabaska slates." The resemblance of the rocks in these northern and southern localities, and the continued association of salt and petroleum with them to the south, renders it not improbable that, if reached by borings

passing through the overlapping Cretaceous rocks, the upper part of the Devonian, in the Manitoba region, might prove valuable as an oil-bearing formation.

This suggestion was ~~entered~~ in the Report on the Geology and Resources of the 49th Parallel, but remains as yet unconfirmed.

The unconformable, though very horizontal overlap of the Cretaceous on the Devonian, just alluded to, entirely conceals the outcrops of any rocks of Carboniferous age, which may exist in this region. It is probable, however, from analogy with the Western States to the south, that these rocks consist almost entirely of limestone, and, even if exposed, would be found to yield no workable coal seams.

The waters of the ocean appear to have covered this portion of the continent during the Carboniferous period, and the conditions for the accumulation of coal did not occur till a much later stage in the series.

Rocks of Cretaceous age are those next found in the geological series in this region, and they constitute the substratum of by far the greatest area of the plains.

The typical section of the Cretaceous of the Missouri Valley and eastern portion of the interior continental basin generally is that worked out many years ago by Messrs. Meek and Hayden in the Nebraska region.

It may be summarized as follows, the order being descending:—

LATER CRETACEOUS.

No. 5.	*Fox Hill Beds.*—Grey ferruginous and yellowish sandstones and arenaceous clays. *Marine Shells*	500 feet.
No. 4.	*Fort Pierre Group.*—Dark grey and bluish plastic clays. *Marine Shells and Fish Remains*	700 "

EARLIER CRETACEOUS.

No. 3.	Niobrara Group.—Calcareous marls, marine shells, foraminifera, fish remains, &c..	200 "
No. 2.	Fort Benton Group.—Dark grey laminated clays, with some limestone marine shells.	300 "
No. 1.	Dakota Group.—Yellowish, whitish and reddish sandstones and clays, with occasional lignite coals. Marine and some freshwater shells and angiospermous leaves...	400 "

Adding together the approximate thickness given for the subdivisions above, a total of 2,600 feet is obtained, and it is possible that the Cretaceous system may in some places attain this thickness. It is probable, however, that in the eastern part of the region traversed by the section now under description the thickness is not so great, as this must originally have been near the margin of the Cretaceous sea. Owing, however, to the thickness of the drift covering, and the nearly horizontal position of the beds, the actual thickness of any of the subdivisions has not been ascertained here. It is probable that the lower subdivisions outcrop below the alluvium of the Red River Valley, and toward the base of the Cretaceous escarpment, west of the Winnipeg group of lakes, but neither the Dakota nor Benton groups have been observed in this region. In Nebraska thin seams of lignite are known in the Dakota beds and have, owing to the scarcity of other fuel, been to some extent ~~marked~~ worked. Similar lignites are also found in south-western Minnesota at this horizon but are not of economic value.

While it is therefore possible from analogy that workable lignite beds may occur in the representative of the Dakota in Manitoba, it is probable that, even if this formation were well exposed and easily accessible, the supplies of fuel it might yield would be of little or no economic importance.

The Benton group, though known in the Peace River country, has been recognized as yet with some certainty in a single locality in the Saskatchewan basin. The black shales of Cole's Falls in the main Saskatchewan, are supposed by Meek, who has examined fossils from them, to be of this period.

The Niobrara subdivision has been recognised in Manitoba, where the Boyne River cuts through the Pembina escarpment, where it precisely resembles, lithologically and in its included fossils, that of the Nebraska region. The rock is a cream-coloured limestone, chiefly composed of shells of *Inoceramus* and *Ostrea congesta*, but becomes in places a white chalky material, which under the microscope is resolved into a mass of foraminiferal shells, coccoliths, and allied minute organisms. Still further north, along the eastern outcrop of the Cretaceous, at Swan River and Thunder Hill, west of Lake Winnipegosis, and near the line of our section, limestone and marls, containing fossils like those of the last mentioned locality and evidently of Niobrara age, are again found.

The greater part of the Pembina escarpment, with its northern continuation west of the Winnipeg group of Lakes, is, however, composed of the dark shales and shaly clays of the Pierre group. On the plains, west of the escarpment of the Cretaceous, the drift covering is so thick that exposures of the Pierre are seldom met with. It is, however, found, wherever it can be seen, to be horizontal, and it probably immediately and continuously underlies the country as far west as the Coteau.

The Fox Hill subdivision of Meek and Hayden's section is scarcely known in the eastern part of the plains. It constitutes the highest of the marine beds, and is generally littoral and sandy in character. Rocks containing fossils referable to this subdivision have, however, been described by Hind at the elbow of the South Saskatchewan, not far from our line of section.

Still higher in the series are the beds of the Souris River region. These, on the northern continuation of the Fort Union group of the Missouri, and with their eastern boundary nearly coinciding with the Coteau or edge of the third prairie steppe, extend still further northward at least as far as the North Saskatchewan.

In the Souris region, where they have been much more closely examined than on the line of section, they consist of sandstones, shales and clays, with layers of ironstone concretions and numerous beds of lignite. On the Souris *Corbula mactriformis*, a shell of brackish or marine water, is found near the base, but with this exception all the molluscs are those of fresh water. These deposits have been accumulated in a great lake or series of lakes, with changing outlines, with the frequent local exposure of land surfaces on which coniferous and broad-leaved trees grew, and the débris of vegetation accumulated to produce beds of lignite. As the beds of the Souris region have already been fully reported on elsewhere,* it will be unnecessary to dwell at length on them here.

The section is, however, intended to illustrate one point which has, perhaps, so far not received sufficient attention. That is the possible occurrence of outliers of this formation in the chain of highlands which, beginning on the international boundary line with Turtle Mountain, is continued north-westward nearly parallel to the edge of the Coteau by Moose Mountain and the Touchwood hills. So far no exposures have been found in the more

* Report on 49th Parallel, Reports of Geological Survey.

elevated tracts, which clearly exhibit the character of the underlying rocks, and the drift covering appears to be exceptionally thick and uniform on them. Dr. Selwyn has particularly insisted, however, on the possible recurrence of the Souris series in these hilly tracts, and in view of the importance which would attach to the discovery of additional supplies of fuel far eastward of the main outcrop of this lignite-bearing formation, it will probably before long become desirable to test the question by actual borings in properly chosen localities.

So far as the examination of the country west of the Coteau, or edge of the third prairie steppe, to about the 110th meridian has yet gone, no new features of importance are found in the Cretaceous and Souris beds, the lower parts of the country being usually underlain by Pierre, while the higher are characterized by the representatives of the Souris series, and lignites are frequently found in these. The Fox Hill beds have been clearly recognised as an intermediate zone in a few places, and all the rocks are horizontal.

Still further west, however, where the section traverses the Bow and Belly River region, changes of considerable importance are found to occur. The upper beds, which have so far been referred to as the Souris or Fort Union series, become thicker and more varied in character, and may best be described under the general term, Laramie. The base of this division is now, as a rule, distinctly marine, or brackish water in origin, the beds so characterized often having a great thickness and representing those of the Judith basin of the Upper Missouri.

These pass gradually upward into a great fresh-water series, which, on lithological grounds, I have provisionally divided into the St. Mary River, Willow Creek and Porcupine Hill subdivisions.

The Laramie, as a whole, on approaching the mountains, contains much more frequent sandstone layers, and these are firmer in texture—facts due to the approach to the old shore line and the superior degree of alteration which the rocks have suffered in connection with folding. The Fox Hill beds blend so completely with the Laramie above and the Pierre below that it is often difficult to define them, but they may generally still be recognized as a zone of yellowish sandstone holding strictly marine fossils.

The Pierre, while probably not less in thickness than before, is less homogeneous, containing frequent sandstone intercalations, at least as far east as the Three Buttes, and where exposed on the Bow River, contains besides a considerable thickness of whitish or pale-coloured sandy and clayey beds which contrast markedly with its usual sombre colours.

It appears now certain that the Rocky Mountains have been here, even in the strictly Cretaceous times, a shore line, and that neither the Cretaceous nor the Laramie beds have passed completely over the present position of the range in this latitude, as they are known to have done further south. The broad undulations by which the beds are now affected also result in the exposure in different places of rocks underlying the Pierre, and these are now found to consist of sandstones, shales and clays, instead of the chalky material of the Niobrara of the east. These are usually of pale colours, and the fossils contained in them are at least in part distinctly freshwater in character. The subjoined table shows the provisional arrangement adopted for the rocks of this region and the parallel series described by me in former reports of the Geological Survey, as obtaining in the Peace River country, which, though several hundred miles north-westward, bears a similar relation to the mountains.

Laramie: (including Judith River series).	Beds of the Porcupine Hills; massive sandstones with shales, &c.	
	Willow Creek beds; reddish and purplish clays with grey and yellowish sandstones.	
	St. Mary River series; sandstone shales and clays of general greyish or greyish green colours.	
	Yellowish sandstones and shaly beds with a mingling of fresh water and brackish or marine molluscs.	Upper sandstones & shales (Wapiti River group).
Fox Hills.	Yellowish Sandstones with some shales, apparently irregular in thickness and character; molluscs all marine.	
Pierre.	Blackish and lead-colored shales, with occasional sandstone intercalation especially towards the mountains.	Upper shales (Smoky River group).
Niobrara.	Belly River series; sandstones, shales and sandy clays. Upper part generally greyish; lower, yellowish, and often banded by rapidly alternating beds; fresh and brackish water molluscs.	Lower sandstones (Dunvegan group).
Benton.		Lower, shales (Fort St. John group).

The Laramie and Cretaceous rocks are sharply corrugated and folded together for a distance of ten to twenty miles from their junction with the Palæozoic rocks of the mountains, a fact probably in connection with the great fault with downthrow eastward which here occurs. East of the belt of corrugation they form a well-marked broad, shallow synclinal, the centre of which is occupied by the Porcupine Hills, and thence gradually subside to the nearly horizontal attitude which is generally characteristic of the plains.

The lignites and coals are in the western region not confined to the beds overlying the Cretaceous proper, but recur at intervals in the Cretaceous itself.

Near the base the Laramie is a persistent lignite or coal-bearing formation.

A few miles north of the 49th parallel, on the St. Mary River, a coal bed of excellent quality, eighteen inches in thickness, is found, overlain by a bed holding *Corbicula occidentalis and Ostrea.* It is described in my report on the Geology and Resources of the 49th Parallel, pp. 132–172. Another coal outcrop, possibly on the same seam and about a foot in thickness, is found on the Upper Belly River. The seam at the Indian farm near Pincher Creek, is probably again not far from the same horizon, though perhaps a little higher in the series. Coaly streaks occur in the sandstones at the disturbed locality on the Oldman River, and a lignite at Scabby Butte may occupy the same position. Further north a seam on the Bow at Coal Creek, between Morleyville and Calgarry, and those in the vicinity of the Blackfoot crossing, appear to occupy the same horizon. A thin seam near the mouth of the Highwood River may possibly be higher in the Laramie and, from the character of the St. Mary River sub-division throughout, it is not improbable that other coal or lignite-bearing zones may occur locally.

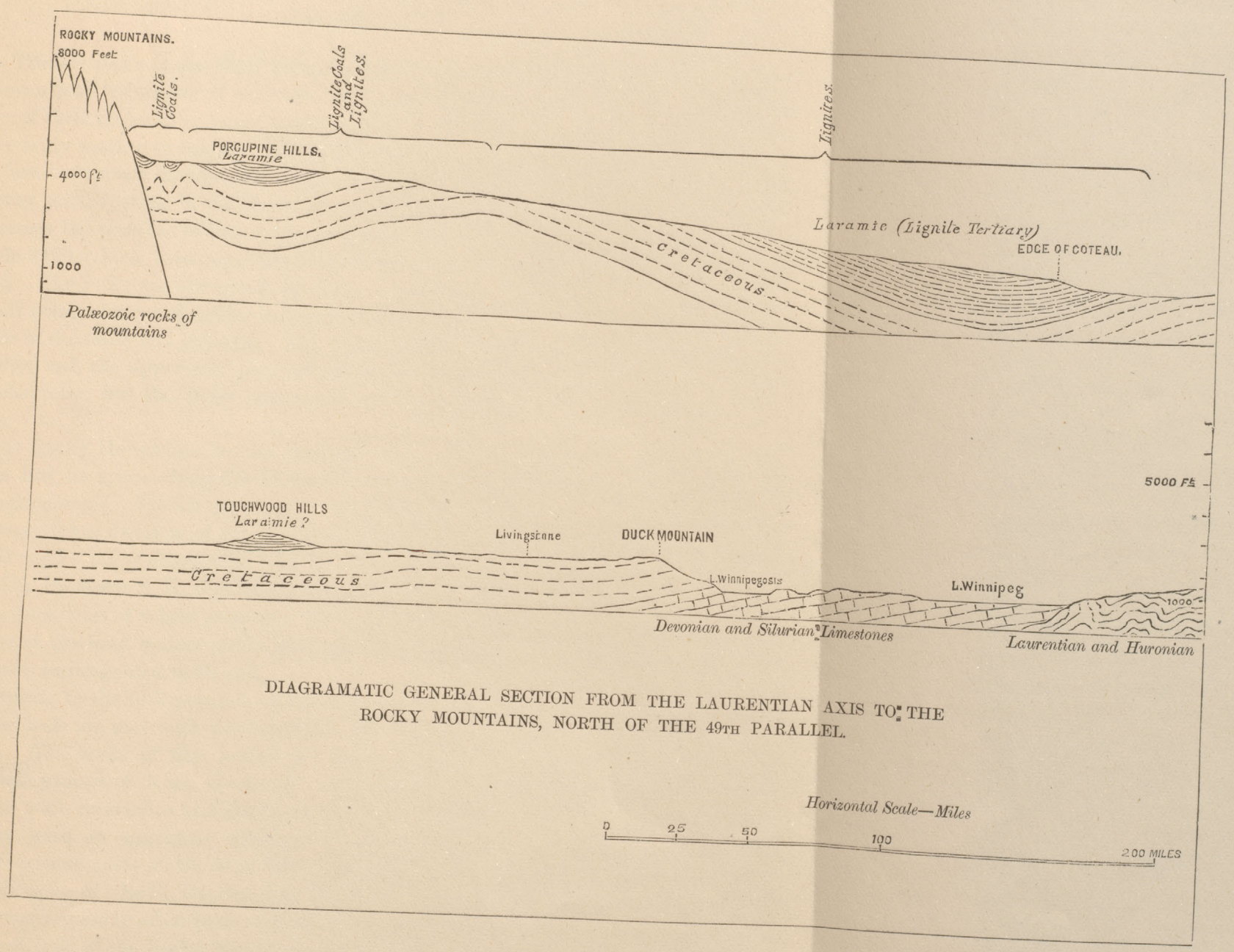
A seam of lignite coal occurs at the summit of the Pierre on the Bow River, at Horse Shoe Bend, while a persistently coal-bearing horizon characterizes its base, and is well exposed on both the Bow and Belly Rivers. Lignite coal also occurs in the beds above described as underlying the Pierre, and it is possible that further exploration may bring to light yet other fuel-producing horizons.

A further fact of great economic importance is the improvement in quality of these fuels on their approach to the mountains. Two causes operate in this sense: First, the greater age of the seams in the strictly Cretaceous rocks and the consequent superior degree

of pressure by overlying beds to which they have been subjected; second, the greater alteration, accompanied by flexure, to which the rocks in the vicinity of the mountains have been subjected. The second is, however, found to be much more influential than the first.

The belts of country characterized by different classes of fuels are indicated on the section. The eastern, over which the word *Lignite* appears, yields fuels which, though often containing little ash and well adapted for local use, hold generally more than 12 per cent. of hygroscopic water. The next, designated as that of *Lignite Coals*, frequently yields fuels containing less than 12 per cent. of water, and in some instances not half this amount, and also by their physical character better adapted for transport. The third, a narrow zone, co-extensive with that of great disturbance, affords fuels which contain little water, often give firm cokes on heating, yield abundance of highly luminous hydrocarbons, and are scarcely distinguishable from coals of the Carboniferous period proper.

This change is analogous to that found in passing from the bituminous coals of the western shales to the anthracites of the disturbed Appalachian region to the east.



DIAGRAMATIC GENERAL SECTION FROM THE LAURENTIAN AXIS TO THE ROCKY MOUNTAINS, NORTH OF THE 49TH PARALLEL.

V.—*Note on the Triassic of the Rocky Mountains and British Columbia.*

By GEORGE M. DAWSON, D.S., F.G.S.

(Read May 25, 1883.)

The Triassic rocks of the West present themselves under two very dissimilar aspects, their eastern part consisting of red beds, chiefly sandstones, while on the Pacific slope the character of their material is much more varied; they include numerous fossils, and are evidently truly marine in origin. The most complete comparison of these two classes of deposits has been made by Clarence King in the 40th parallel region. The red beds are there found participating in the Rocky Mountain uplift, but have originally passed completely across the position of this range, and extend westward to the Wahsatch Mountains (longitude 112°) which here constituted the western shore of the sea in which they were deposited. The rocks are described by King as consisting generally of sandstones, the upper half being always of lighter colours than the lower, and intercalated more or less with beds of dolomite and gypsum. The lower part of the series is usually from brick to vermilion red, the upper part pale red and buff. The dolomitic and gypsum beds are local in character, but the latter sometimes reach forty feet in thickness of pure calcic sulphate.

In the Rocky Mountains, in this latitude, the Triassic is from 300 to 1000 feet in thickness but, on approaching the Wahsatch shore, thickens to 2000 or 2500 feet, and holds some conglomerates. Fossils are almost completely wanting.

In many other districts of the western States and Territories, the Triassic beds are developed with similar characters. As far east as the Black Hills of Dakota, they are described by Professor N. H. Winchell as maintaining a thickness of over 300 feet, and holding great quantities of white gypsum. They have been observed by Dr. Hayden in the mountains at the head waters of the Missouri, and in addition to the deposits of gypsum are in places impregnated with salt.

Returning to the 40th parallel region, and passing westward from the Wahsatch range, no Triassic beds are met with till longitude 117° 30′ is reached, at a distance of nearly 300 miles. The rocks of this period are there found to be represented by the Star Peak and Koipsats groups of King, the former and upper subdivision consisting of fossiliferous limestones, with quartzites and slates, the latter of quartzites, argillites and porphyroids, the whole with an aggregate thickness of over 16,000 feet. Marine fossils are very abundant in some parts of the Star Peak subdivision, and are almost precisely similar in forms with those of the St. Cassian and Hallstadt beds of the Alps. The term Alpine Trias has consequently often been used in speaking of those rocks.

The red beds of the Rocky Mountain region clearly point to the conditions of deposition found in a shallow body of water, more or less completely shut off from the ocean or only in occasional and brief connection with it, while, for the most part, the sediments of the Nevada Triassic are, as unmistakably, such as might be produced under ordinary marine conditions in greater or less proximity to a coast line.

The distinction thus marked is clearly encountered much further south than the 40th parallel region, and it is with the purpose of tracing it to the north of the 49th parallel that the present note is presented.

Immediately to the north of the 49th degree of latitude, in the Rocky Mountains, about the South Kootanie Pass, the red beds are characteristically developed, with a thickness of about 300 feet. The upper portion of the section in this part of the mountains, is as follows, in descending order:—

Series H. Fawn-coloured flaggy beds, seen only at a distance, but from their appearance and analogy with Series F, probably thin-bedded dolomitic sandstones and limestones. Throughout 100 feet.

Series G. Beds characterized by a predominant red colour, but including some thin, greyish layers and dolomitic sandstones. The whole generally thin-bedded. Ripple marks sun-cracks, impressions of salt crystals. 300 feet. Passes gradually down into

Series F. Fawn-coloured flaggy beds of dolomitic sandstone and limestone, with ~~more~~ many red sandstone layers, which are especially abundant toward the top. 200 feet.

Series E. Amygdaloidal trap. 50 to 100 feet.

The last mentioned immediately overlies the compact bluish limestone of Carboniferous age, and, with the exception of the interruption caused by this contemporaneous sheet of volcanic matter, the whole of the series are conformable and pass gradually each into the next.

The conditions indicated are, in Carboniferous times, a somewhat deep sea gradually shoaling. The occurrence of an important volcanic outbreak, and shortly thereafter the more or less complete closure of the communication of this area with the ocean and the formation of the Triassic inland sea.

Westward from this region similar beds may be traced by information supplied by Mr. H. Bauerman, for about forty miles, but beyond this point they have nowhere been observed in British Columbia. Northward, along the main range of the Rocky Mountains, I have observed them for about fourteen miles only, beyond the 49th parallel. They were not seen by me in the Crow Nest Pass, in latitude 49° 30′, nor anywhere along the eastern base of the mountains from this point to the Bow Pass (latitude 51°) or in that pass. Neither have they been noted by Dr. Hector in any part of the Rocky Mountains to the north of the Bow which he traversed, or by Dr. Selwyn in the Yellow Head Pass. While, therefore, the evidence so far adduced is purely negative, it would appear that the Triassic inland sea in this longitude found its northern shore not far beyond the 49th parallel, and probably never extended west of the Selkirk and Gold Ranges of Central British Columbia.

Still further north, however, we meet with evidence of a more decided character. For, on the upper Pine and Peace Rivers, on the eastern flank of the mountains, a series of blackish shales and argillites, sometimes calcareous, occur, and hold characteristic Alpine Trias fossils. Beds containing similar forms are found in a number of places to the west of the Gold Range in British Columbia, and it is probable that the Triassic ocean, in the latitude of the Peace River, extended completely across the Cordillera belt eastward. No mountain boundary occurs between this region and that first described to the south, but a tract of probably low land must have separated these two areas in the Triassic period.

In the Queen Charlotte Islands Triassic rocks, holding fossils of the same strictly

marine character, are largely developed, and they also occur with abundant molluscous remains in the northern part of Vancouver Island. In the southern part of the interior of British Columbia, not far west of the Selkirk and Gold Ranges, rocks also occur unconformably overlying the Carboniferous series, from which a few fossils, with little doubt, belonging to the same Alpine Trias fauna have been obtained; and it is further probable that—as in California—the greater part of the auriferous shales are attributable to this or the succeeding Jurassic series.

In the Queen Charlotte Islands, Vancouver Island, and on the mainland of the province, however, the Triasic series is largely composed of rocks of volcanic origin, some of which have been lavas while others are agglomerate or ash beds, made up of fragments of igneous material, more or less perfectly stratified. These are mingled with schistose and slaty rocks, and in some places with massive bluish lime-stone, deposited during periods of tranquillity; and it will require the most careful and systematic examination to completely separate this from the underlying strata. I have little doubt that the so-called 'porphyroids' of King's Koipato group indicate an extension of similar volcanic activity over the 40th parallel region to the south.

A word may be added with reference to the climatic conditions implied by the Red Beds of the interior. The basin in which they were formed has not only been pretty completely cut off from the ocean, but the rate of evaporation of its waters must have been normally in excess of that at which they were re-supplied by precipitation or drainage from neighboring lands. It is probable that at that time, as at the present day, westerly winds prevailed in this part of the northern hemisphere, and, if the North Pacific Ocean then existed, these would carry, as they do now, an abundance of moisture and afford a copious rainfall on the west coast. As the land barrier of the inland sea to the west cannot have been of very great width, it must have been of such height as to cause the almost complete desiccation of these oceanic winds by precipitation before they reached the area occupied by the Triassic Mediterranean; and this old mountain range, must, in British Columbia, have occupied nearly the position of the Selkirk and Gold Ranges of to-day, at a time when the Rocky Mountain region proper was still a flat expanse of Palæozoic rocks.

To the north, at the present time, between the 54th and 56th parallels, the Gold Range almost completely disappears, and it is through this gap that the Triassic ocean must have flowed eastward to the upper Peace River country and, perhaps, much farther east—though the Cretaceous, and Laramie beds, occupying the flat country, render it impossible to trace its deposits in that direction.