

had been polished. As to the more difficult matter of developing the connections of the spirals, Mr. Glass has found that the only method giving any certainty of result is by limiting the use of the acid as described above and by scraping away the matrix and parts of the spirals until the connections of the spirals with the hinge-plate, and the connection of the spirals with each other are completely exposed.

Mr. Glass says that in his own operations he places no dependence upon the making of sections, though he has no doubt that those who have a preference for this mode may sometimes use it with good effect.

Since writing the above Mr. Whitfield has kindly forwarded to me a specimen of *Meristella arcuata* in which the spirals and their connections are silicified. Mr. Whitfield only partly prepared this specimen, so that the very delicate and fragile loop might be preserved during transit, and said in his accompanying note—"It will need careful working with acid in order to develop it so as to shew the loop rings and processes." Having sent the specimen to Mr. Glass he has successfully worked it out, and the rings of the loop appear very plainly as previously figured by Prof. Hall. Now as in *Meristella tumida* there are no rings it cannot properly belong to the genus *Meristella*. Mr. Whitfield agrees with me in thinking that it is identical with the American *Meristina Maria*. Certainly *Meristina Maria* agrees very closely with our *Meristella tumida* in external form, and Mr. Glass has just worked out a typical specimen of the American species sent to me by Prof. Hall which proves beyond doubt that the connections of the spirals with the hinge-plate and their connection with each other are identical in both species. In the American description of the interior of *Meristina Maria* the loop is said to be simple, but it is now proved that the end of the loop is bifurcated in exact agreement with the figure of the interior of *Meristella tumida* given in the first part of this paper.

Mr. Glass has worked out a specimen of *Meristella didyma*, which is probably identical with the American *Meristina nitida*. In this specimen Mr. Glass thinks he has developed a simple loop such as that described by Prof. Hall for his genus *Meristina*. I am not quite sure of this, however, and think it desirable that we should have further evidence, but if Mr. Glass's supposition should prove correct, then the genus *Meristina* should be retained for this and similarly organized species, and *Meristella tumida*, with its synonym *Meristina Maria*, should constitute a new genus which I would name *Whitfieldia*.

II.—SKETCH OF THE GEOLOGY OF BRITISH COLUMBIA.

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

TWENTY years ago the region now included in the Province of British Columbia was—with the exception of the coast-line—little known geographically, and quite unknown geologically. From the days of Cook and Vancouver, and the old territorial disputes with the Spaniards, this part of the west coast of North America

attracted little attention till the discovery of gold in 1858. As among the first in the field geologically may be mentioned Dr. Hector and Messrs. H. Bauerman and G. Gibbs. The observations of these gentlemen, though bringing to light many facts of interest, were confined to a comparatively small part of the area of the province, and it was not till the inclusion of British Columbia in the Dominion of Canada in 1871 that the systematic operations of the Geological Survey of Canada were extended to this region. Since this date a number of reports treating of the geology of British Columbia have been published, and on these, together with a personal knowledge of the country, obtained during five seasons' work in it in connexion with the Survey, I shall chiefly depend in giving a brief account of the main geological features so far developed.

British Columbia includes the whole breadth of a portion of the great Cordillera belt which forms the Pacific margin of the Continent. This here consists of four parallel mountain ranges running in general north-westerly and south-easterly bearings, which, beginning on the Pacific Margin, may be named as follows:—Vancouver Range, Coast or Cascade Range, Gold Range, and Rocky Mountain Range proper, the last constituting the western border of the great plains of the interior of the Continent.

The first mentioned, in a partially submerged condition, forms Vancouver and the Queen Charlotte Islands, and still rears some of its peaks to a height surpassing 6000 feet. The valley lying to the north-east of this is occupied by the sea, forming the Strait of Georgia, Queen Charlotte Sound, and Hecate Straits. The Coast Range is a rugged mountainous district with a width of about one hundred miles, and axial summits reaching in some places elevations surpassing 8000 feet. To the north-east of this stretches a region which may be called the Interior Plateau of British Columbia, the average width of which is nearly one hundred miles, and its mean elevation about 3500 feet. This plateau is, however, irregular, hilly, or even in some places mountainous, and is intersected by deep trough-like river valleys. It is only when it is occupied by Tertiary volcanic rocks that it assumes considerable uniformity of surface.

Bounding the plateau to the north-east is a third wide range, known locally as the Cariboo, Columbia and Purcell Mountains. It is broken to the north at the 54th parallel and resumes under the 56th as the Omineca Mountains. This mountain axis may be named the Gold Range, and it is probable that many summits in it surpass 8000 feet. Separated from it by a narrow but well-defined valley is the Rocky Mountain Range with an average width of fifty to sixty miles. This shows peaks of about 10,000 feet in height on the 49th parallel, is supposed to surpass 15,000 feet near the 52nd, and becomes comparatively low and narrow in the vicinity of the Peace River, about the 56th parallel.

Such are the main orographical features of British Columbia, a slight knowledge of which is necessary to render intelligible the description of its geological structure.

In describing the rocks, those of Tertiary and Cretaceous age of the coast will first be noticed, next those of the interior of the province referable to these periods, and lastly the older underlying metamorphic rocks.

Tertiary.—The Tertiary rocks do not form any wide or continuous belt on this part of the coast, 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.¹ 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 here some years ago extensively worked, 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 connexion 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.²

Much farther north, in the Queen Charlotte Island, the whole north-eastern portion of Graham Island has now been shown to be underlain 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.³

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

¹ Report of Progress, Geol. Survey of Canada, 1876-77, p. 190.

² 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 Journ. of Nat. Hist. vol. vii. No. 4. See also American Journal of Sc. and Arts, 2nd series, vol. xxvii. p. 359, and vol. xxviii. p. 85. Report on the Yellowstone and Niussain expedition, 1869, p. 166. Annals Lyc. of Nat. Hist. of N. Y., vol. ix. April, 1868.

³ Report of Progress, Geol. Survey of Canada, 1878-9, p. 84 B.

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.

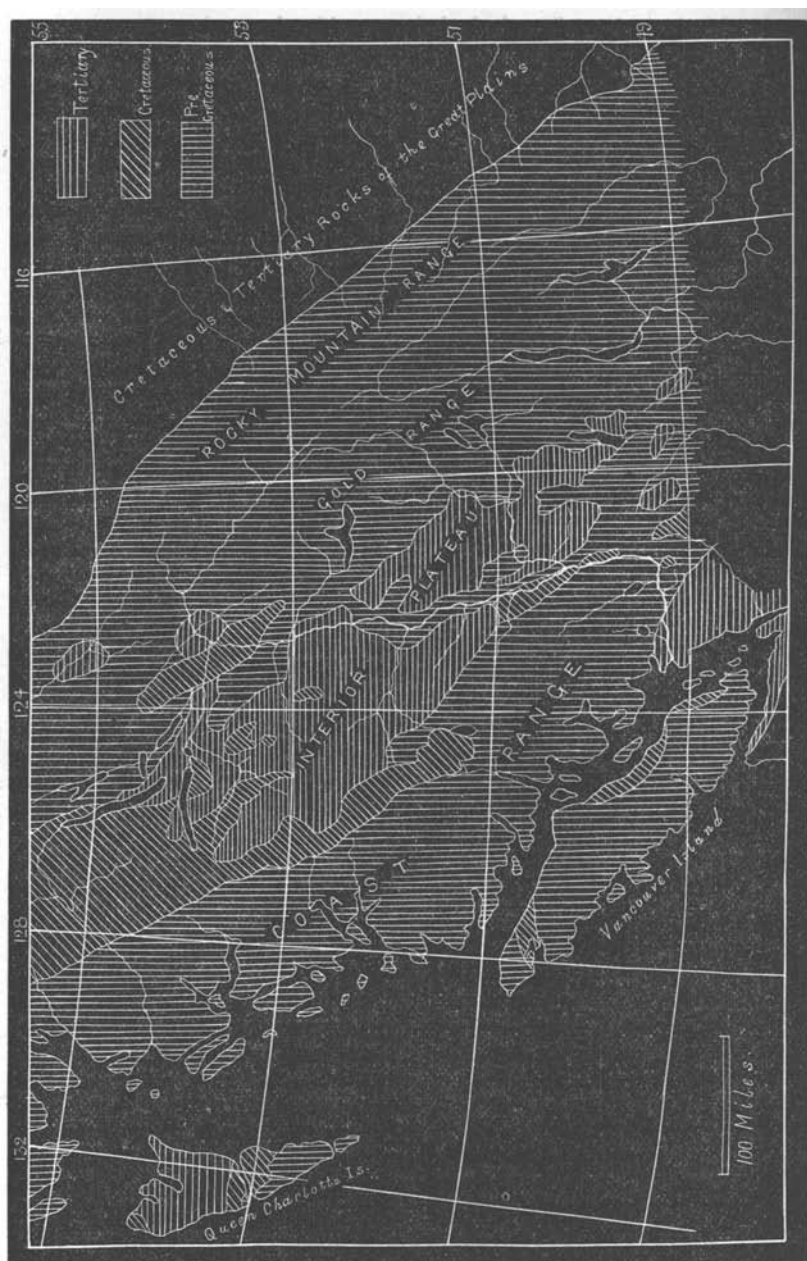
To the east of the Coast or Cascade Range, Tertiary rocks are very extensively developed. They have not, however, yielded any marine fossils, and appear to have been formed in an extensive lake, or series of lakes, which may at one time have submerged nearly the entire area of the region described as 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 very extensive volcanic action. The lower beds are sandstones, 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.

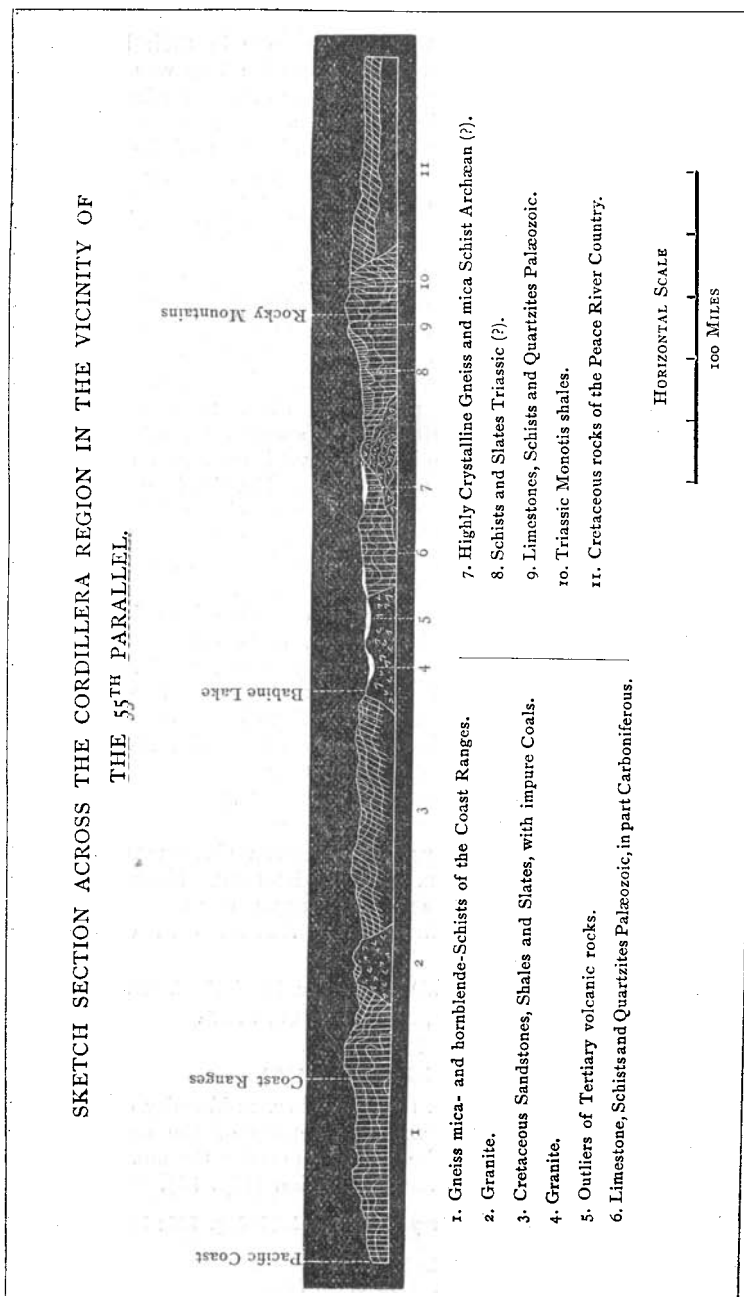
The southern part of the interior plateau is more irregular and mountainous. The Tertiary rocks here cover less extensive areas, and are much more disturbed, and sometimes over wide districts—as on the Nicola—are found dipping at an average angle of about thirty degrees. The volcanic materials are occasionally 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

GEOLOGICAL SKETCH MAP OF BRITISH COLUMBIA.



SKETCH SECTION ACROSS THE CORDILLERA REGION IN THE VICINITY OF
THE 55TH PARALLEL.



I have even heard a tradition of the Indians of the Rasse 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 freshwater 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*,¹ 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.²

(To be continued in our next Number.)

III.—ON A CASE IN WHICH VARIOUS MASSIVE CRYSTALLINE ROCKS INCLUDING SODA-GRANITE, QUARTZ-DIORITE, NORITE, HOENBLENDITE, PYROXENITE, AND DIFFERENT CHRYSOLITIC ROCKS, WERE MADE THROUGH METAMORPHIC AGENCIES IN ONE METAMORPHIC PROCESS.

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Part III.

(Concluded from page 119.)

THE extent of these bands, their number, uniformity of direction and apparently of dip, and the identity of the material constituting them with beds of the schist, especially the more northern, are such as to warrant the following section (Fig. 15).

¹ Reports of Progress, Geol. Survey of Canada, 1875-6, p. 266; 1876-7, p. 457; 1877-8, p. 175, B.

² 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.