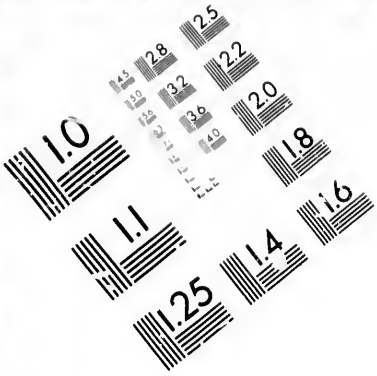

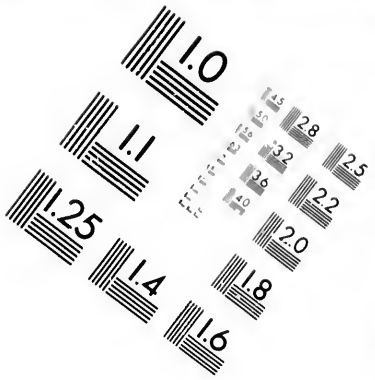

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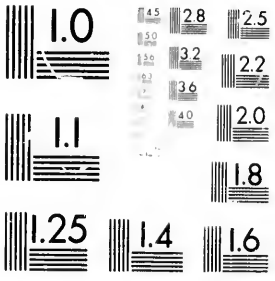

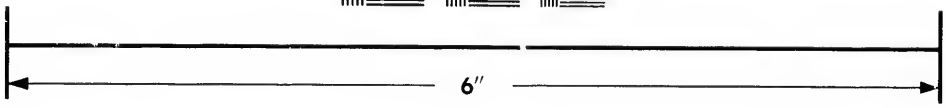

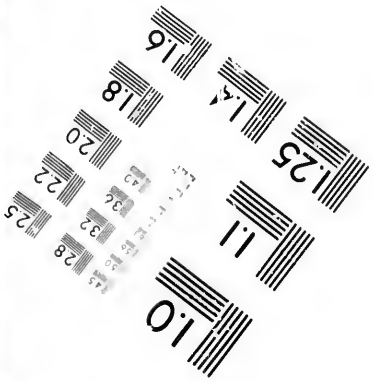

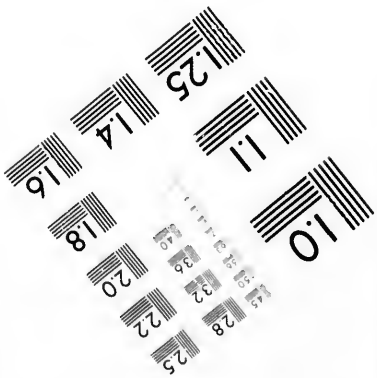

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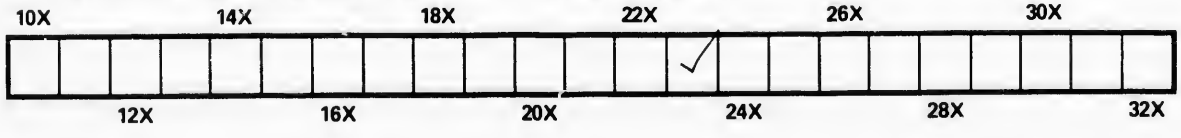

Bauerman, H.

Report on the geology of the country near the forty-ninth parallel of north latitude west of the Rocky Mountains

[redacted]

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

REPORT

ON THE

GEOLOGY OF THE COUNTRY

NEAR THE

FORTY-NINTH PARALLEL OF NORTH LATITUDE

WEST OF THE ROCKY MOUNTAINS.

FROM OBSERVATIONS MADE 1859-1861.

BY

H. BAUERMAN, F.G.S.

GEOLOGIST TO THE NORTH AMERICAN BOUNDARY COMMISSION.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL.
DAWSON BROTHERS.
1884.

NOTE.

The Geological Survey is indebted to Mr. H. Bauerman for the privilege of publishing his report on the geology of the country near the 49th parallel west of the Rocky Mountains. This report, though prepared by Mr. Bauerman in connection with the Boundary Commission Expedition of 1859-1861, has never been printed, which accounts for the fact that no reference has been made to it in the reports of the Geological Survey on British Columbia, the first of which appears in the Report of Progress for 1871-72. The western portion of the country in the vicinity of the 49th parallel, described by Mr. Bauerman, is included in the area of the map accompanying my report of 1877, and while some pages of Mr. Bauerman's report, such as those describing the travelled route from Hope to Vermilion Forks and the valley of the Similkameen, refer to lines examined by me and described in 1877, it has been thought best, on account of the priority of his observations, to print Mr. Bauerman's report in its entirety. Even in this western portion of the country, however, Mr. Bauerman gained access, by means of trails cut by the Commission, to many points in the immediate vicinity of the boundary-line, which have since been practically inaccessible; and if his report had been available at the time of the publication of the map above referred to, it would have enabled the geological boundaries along its southern edge to have been drawn with considerably greater accuracy.

The report is here printed almost exactly as prepared by Mr. Bauerman, though, with his permission, a few alterations and corrections in names of places, distances, etc., have been made. The bearing of the more recent systematic observations on the geology are indicated, where it appears desirable, in foot-notes. In reproducing Mr. Bauerman's sections, his originals have been exactly followed in the outlines and accompanying notes, but the colouring has been changed so as to conform to that adopted on the adjacent maps already published by the Geological Survey. This change also enables the Cretaceous and Tertiary age of parts of the series,—points rendered evident by the subsequent examination of the country to the north of the 49th parallel—to be brought out clearly. In addition to the study of Mr. Bauerman's report, it may be added, that the writer has had the opportunity of examining his original suite of specimens, now in the museum of the Geological Society of London, which has facilitated the exact correlation of the rocks referred to by him with those described in the reports of the Geological Survey.

GEORGE M. DAWSON.

REPORT

ON THE

GEOLOGY OF THE COUNTRY

NEAR THE

FORTY-NINTH PARALLEL OF NORTH LATITUDE

WEST OF THE ROCKY MOUNTAINS.

Principal orographic features.

The country immediately adjacent to the 49th parallel of north latitude, on the western side of the continent of America, which forms the subject of the present communication, is in the first place remarkable for its excessively rugged profile, as with the exception of a belt of terraced plains bordering the sea and extending for a short distance inland. it presents a continuous succession of steep mountain ridges, which are furrowed by the deep, narrow and tortuous valleys of the Fraser and Columbia Rivers and their tributaries; the former flowing from east to west, while the latter usually follow a general north and south course.

The most important among the mountain ranges, orographically considered, are two in number. First, the main chain of the Rocky Mountains which forms the eastern terminus of that portion of the boundary-line which the commission was instructed to define, and divides the Pacific waters from those of Hudson's Bay and the Gulf of Mexico. Second, a western chain containing a few snowy summits, which occasionally rise to a height of about 9,000 feet above the sea level. This is situated on the northerly prolongation of the Cascade Mountains of Oregon, and divides the waters of the Fraser River, and in part, of the streams flowing into the Gulf of Georgia from those discharging into the Pacific in much lower latitudes through the basin of the Columbia River.

Rivers.

The streams of the western slope of the Cascade Mountains are mostly small, consisting of one principal tributary of Fraser River, the

Similkameen. Chilukweyuk, and some unimportant brooks which empty themselves into Semiahmoo Bay. On the eastern face, the tributaries of the Columbia are of more importance. The first of these which is encountered after crossing the chain, is the South Similkameen, which originates in three small lakes fed by the melting of the snow on the Hozamen Mountains, at a height of nearly 5,000 feet above the sea level, and flows in an easterly and northeasterly direction for forty-two miles, when it joins the Tulameen, a stream of about the same size, which rises in latitude 50°, a little to the eastward of Fort Hope. The united waters of these two streams form the main Similkameen, which takes a southeasterly direction, receiving one principal affluent, the Ashtnoulou, in its passage, and joins the Okanagan, after a course of about sixty-two miles, at a point about three miles south of the lower

Okanagan. end of Osoyoos Lake. The Okanagan is one of the most considerable of the northern tributaries of the Columbia. It rises in latitude 50° 25′, and flows through several long and comparatively narrow lakes, the largest of which is about sixty-nine miles in length. At the crossing of the 49th parallel the waters of Osoyoos Lake are 757 feet* above the sea level. This is the lowest ground found in the basin of the Columbia within British territory.

Kettle River. To the eastward of the Okanagan three great tributaries discharge into the main stream of the Columbia on or near to the boundary-line, one of them coming from the west, the other two from the east. The first of these is the Newhoialpitku or Kettle River, which rises in latitude 49° 40′, near the Okanagan, and has a total length of one hundred and five miles. For a considerable distance it follows a very tortuous course, crossing the boundary-line three times; but for the last twenty miles it flows nearly due south, and joins the Columbia

Pend D'Oreille and Kootanie. about two miles above Fort Colville. The two streams coming from the eastward are the Pend D'Oreille or Flathead River or Clark's Fork of the Columbia, of which the mouth is nearly opposite to Fort Shepherd and close to the boundary-line; the other is the Kootanie or Flatbow River, which falls into the Columbia about twenty-three miles further north. The courses of these two rivers form irregular serpentine curves, the longer portions being generally parallel in direction to the main chain of the Rocky Mountains, while, in the shorter ones, the passage through the numerous parallel ridges is generally effected by a continued succession of small falls and rapids. That portion of the boundary-line which lies between the Columbia at Fort Shepherd and the western crossing of the Kootanie River, a distance of about fifty miles, is the most inaccessible part of the whole. There is no practicable route

*880 feet by more recent barometric observations.

available between these points other than the circuitous one *via* Fort Colville and the Spokan Valley, a distance of 220 miles. The total length of the course of the Pend D'Oreille River is about 370 miles, that of the Kootanie about 350 miles.

Wooded character of country.

As the whole of the country is more or less thickly wooded, the most noticeable of the physical features, next to the shape of the ground and the direction of the water-courses, is the character of the forest growth. On the western plateau and seaward face of the Cascade Range, as well as in the valley of the Skagit—a small river which flows through the heart of that chain—the forest is composed principally of the Douglas spruce (*Abies Douglasii*), several large species of pines and the western cedar (*Thuja gigantea*), all very densely packed together, with a thick undergrowth of willows and vine-maple. There is no open grass land in this section of the country other than the marshy alluvial plains bordering Sumass Lake, which are subject to annual overflow from the flood-waters of Fraser River. In the valley of the Similkameen, the characteristic tree is the large red-barked yellow pine (*Pinus ponderosa*), which flourishes up to about 4,000 feet above the sea level. At lower levels it is usually found in scattered groups of three or four trees on a dry gravelly soil, which supports a growth of coarse bunch-grass. On the Okanagan, at Osoyoos Lake, large timber-trees are almost entirely absent. The ground is sandy and covered with alkaline efflorescences, with a growth of small cactus, sage and other plants characteristic of the lava-covered desert of the Columbia, further to the south. On the hills lying to the eastward of Osoyoos Lake, the larch, (*Larix occidentalis*) is first seen in quantity, and it is found abundantly from this point eastward, in the Kettle and Columbia valleys, associated with *Abies Douglasii* and *Pinus ponderosa*, grouped in small clusters as noted above. The last mentioned species is found as far eastward as the head of Tobacco River, beyond the eastern crossing of the Kootanie, where it is seen for the last time at about 4,000 feet above the sea level. It attains its western limit at about the same altitude on the eastern face of the hills above Similkameen River on the road to Fort Hope. The thickest forest on the line is found between the Columbia and the western crossing of the Kootanie River, in the district already noticed for its inaccessible character. Most of the hills that rise to a greater height than 4,000 feet above the sea level, are distinguished by particular species of conifers, which are not as a rule found in the lower grounds. In the Ashtnoulou and Rocky Mountains, the upper limit at which forest trees are found is about 6,500 to 7,000 feet, a belt of stunted larches being usually present between these levels.

Limits of forest growth.

Mountain ranges.

In addition to the two great mountain ranges which shut in the basin

of the Columbia, there are others of minor importance within that area; and it will here be convenient to refer to the whole of them by name, in order from west to east.

Cascade Range. First, the Cascade Range, which, as has already been stated, is the northerly extension of that bearing the same name in Oregon, and is divided into two principal parts by the Skagit River. The western portion contains the highest summits, and may be called the Chilukweyuk chain, after the name of the principal stream to which it gives rise. The eastern part may be conveniently distinguished as the Hozamen chain, that being the Indian name for its most prominent peaks.

Ashtnoulou Mountain. Next in order come the Okanagan or Ashtnoulou Mountains, which first diverge from the eastern face of the main Cascade Range near the Yakima Pass, in Lat. 47°, but are about fifty miles distant from it on the boundary-line. They reach a height of nearly 8,000 feet on the line, but do not appear to rise to any great height or to be easily distinguished north of the Similkameen River. The mountains between the Okanaga and Columbia Rivers do not appear to form

Eastern ranges. parts of any of the great north and south systems of lower latitudes; and the same may be said of those lying between the Columbia and Pend D'Oreille Rivers, as in both cases they abut southward against the high table-land of the Spokan. The latter chain is, however, situated nearly on the northerly prolongation of the Blue Mountains of Oregon. These ridges, in spite of their low elevation, not exceeding 6,000 feet at the highest points, are very inaccessible. They possess no practicable passes leading to the eastward, and the whole traffic of the district is deflected by them through the Spokan Valley. Between the western and eastern crossings of the Kootanie River, the mountains rise in places to a height of nearly 8,000 feet, but like those last mentioned they are without any good east and west valleys. The range bordering the eastern side of that river is a very important one. It is parallel to the main chain of the Rocky Mountains, and contains several large, bare and snowy peaks, in the district south of the second Kootanie Crossing; further to the north it is called, on Blackiston's map, Galton's range. It divides the Kootanie waters

Rocky Mountains. from those of the Flathead River. The last and most easterly of the ranges is the main chain of the Rocky Mountains, which divides the Columbia waters from those of the Saskatchewan, and is accompanied by a smaller parallel ridge which does not extend north of the eastern entry of the South Kootanie Pass, and encloses the basin of Chief Mountain or Waterton Lake. The smaller ridge contains the peak known as the Chief's Mountain, and forms another important watershed, namely of the Saskatchewan and Missouri Rivers.

The following rough list of the principal differences of level on the line gives a fair idea of the more considerable undulations of the ground*:— List of elevations.

1.	Cascades, Chilukweyuk or western range, (highest)	8,700 feet
2.	Skagit Valley	1,600 "
3.	Cascades, Hozamen or eastern chain, (highest)	7,500 "
4.	Sources of Similkameen River, (about)	4,800 "
5.	Ashnoulou or Okanagan Mountains (highest)	7,500 "
6.	Okanagan Valley, Osoyoos Lake	750 "
7.	Kettle River Mountains (highest)	5,000 "
8.	Columbia Valley, Fort Shepherd	1,400 "
9.	Pend D'Oreille Mountains (highest)	6,500 "
10.	Kootanie River, western crossing	1,700 "
11.	Mountains east of Yakh River (highest)	8,400 "
12.	Flathead Valley at the Boundary Crossing	4,000 "
13.	Rocky Mountains, highest peaks near line	10,000 to 12,000 "
14.	Watershed at eastern end of Boundary Line	7,446 "

Snow patches.

With the exception of a few of the highest points in the Cascade and Rocky Mountain chains the mass of the mountains come within the thickly wooded region. Very little snow remains on any of the peaks after the middle of July. There are, however, a few small glaciers in the Chilukweyuk and Skagit mountains. In the former they are seen on slopes having a northerly exposure down to within about 4,500 feet of the sea level. On the Skagit side the lower limit is about 5,000 feet. In the Rocky Mountains the glaciers do not come below the level of 7,000 feet and are if possible more insignificant than those of the Cascades.

General character of rocks.

The country the physical features of which have been noticed in the preceding paragraphs, presents, with the exception of drift and superficial deposits, and a few patches of Tertiary and Cretaceous sandstones, a succession of unfossiliferous, slaty and crystalline rocks, most of the former being more or less metamorphosed. Besides these two small masses of fossiliferous limestone of Carboniferous or Devonian age are seen in the Kootanie and Upper Flathead valleys.

General sections.

The probable order of succession among the slaty and other rocks, is shown in the two accompanying diagram sections. They have been constructed by the combination of observations made on the lines of travel in the vicinity of the 49th parallel. The difference of distance between the various points measured on an east and west line is employed instead of the actual road distances, as the latter are in many cases nearly parrallel to the apparent strike of the rocks, and would

* Mr. Bauermann writes that these, with other elevations in the report, having been obtained barometrically, and without comparative readings elsewhere, must be regarded as approximate only.

therefore, if employed, render it necessary to represent the beds as unduly flattened. The dips projected are somewhat steeper than those acually seen, in order to correct the thickness for the five-fold vertical amplification of the scale. The longer section follows the Hudson's Bay Company's brigade-trail from the Fraser River at Fort Hope to the South Kootanie Pass of the Rocky Mountains, while the shorter one includes that portion of the boundary-line which lies between the sea coast and the Similkameen River, where it joins the former.

Description of shorter section.

At the western end of the shorter section the sandstones of Cretaceous age, which contain coal at Nanaimo, are seen in the cliffs of Galiano Island, which, like the majority of the adjacent islands off the coast of Vancouver Island, presents a steep mural face on the western side, while on the eastern shore there is a thinly wooded plain sloping down to the water at an angle of about 10° or 12° in the direction of the dip of the beds. On the mainland, these sandstones are hidden by drift clay, which is seen in vertical cliff-sections at Point Roberts rising to a height of about one hundred and fifty feet, accompanied by large transported boulders of granite, syenite and other crystalline rocks. A similar boulder-drift is seen at various points along the shores of the Straits of Fuca. The clay is somewhat calcareous and of a light blue colour when freshly exposed, but generally bleaches under the action of the atmosphere. The sections are often of considerable height, forming cliffs which when seen at a little distance, bear a certain resemblance in form and colour to the chalk headlands of the English Channel.

Point Roberts and Sumass.

To the eastward of Point Roberts, the country lying between Semiamoo and the Sumass Mountain is covered with a thick forest, growing on coarse drift gravels which rest on blue boulder-clay. The ground, for the whole distance of thirty-five miles between these points, is for the most part flat and swampy. The gravels are arranged in broad, flat terraces, the clay below being exposed only in the beds of the streams. The Cretaceous rocks of Nanaimo are probably present beneath the drift covering. The evidence in support of this view is, however, but small, the only known section being a patch of quartzose sandstone which is exposed in the bed of a brook about a mile north of New Westminster on the Fraser River. Further to the north, on the shores of Burrard Inlet, similar coal-bearing sandstones have been found, some of the beds containing dicotyledonous leaves.*

Sumass Mountain.

After leaving the coast plateau, the first of the metamorphic rocks are seen in the curious isolated mountain that lies on the western side of Sumass Lake. This is made up of dark green sandstones, in which

*These are of Tertiary age.

almost all the sedimentary characters have been effaced, the apparent dips being very contradictory and rarely persistent in the same direction for more than a few yards. These rocks have been altered by greenstone dykes which are exposed on the sides of the hill in great numbers. The same kind of altered rock forms the western side of the ridge dividing Sumass from Schweltza Lake, where a few bands of hard siliceous black slate are associated with the dark-green sandstones; the intrusive rocks being also represented by numerous dykes of syenitic greenstone. The cliff sections on the western shore of Schweltza Lake present a series of hard white sandstones with alternations of blanched clay-slates and white felspathic conglomerates, the whole dipping north-north-west, at a very high inclination (from 70° to 85°). On the opposite or eastern shore of the lake, regularly stratified rocks are seen for the first time. They are thinly laminated, black, sandy-shales and sandstones, and are exposed in very large quantities, showing sections from 1,500 to 3,000 feet in vertical height. The dips are very regular in a south-south-easterly direction at slopes of 30° to 40°. The same series of black shaly beds is continuously exposed in the cliffs of the Chilukweyuk Valley for about twenty miles to the eastward of Schweltza Lake. In the higher parts they are associated with beds of a bluish-grey limestone, which presents a less perfectly laminated character, being like the limestones in the metamorphic rocks of Vancouver Island, somewhat concretionary in structure. They dip with great regularity to the eastward at slopes between 30° and 10°. There does not appear to be any passage between the lower part of the series at Schweltza Lake, and the highly metamorphic and uptilted rocks on the western shore, though they are only about half a mile apart. The latter are probably unconformable and inferior in position to the former. No fossils have been found after a search in three of the most likely-looking spots among the finer grained portions of the black shales at Schweltza and the Chilukweyuk Valley. Patches of carbonaceous matter and minute gypsum crystals are very commonly present, and the joints of the harder beds are generally covered with a powdrey incrustation of allophane or some allied hydrated silicate.*

Schweltza Lake

Chilukweyuk Valley.

The Chilukweyuk, in the valley of which sections of the slates are seen, is the most rapid of all the streams in the country. It flows out of a lake about five miles long and a mile broad, situated in the western range of the Cascades, and after falling through a height of 2,000 feet in about thirty miles, joins the Fraser River near the head of the tidal waters. Near the lower or northern end of the lake, the slaty rocks

Chilukweyuk River.

* It is probable, from fossils since obtained on the Chilukweyuk, that a part at least of these rocks are of Cretaceous age.

are interrupted by a great mass of syenite, the contact between the two being marked by a hard laminated black and white quartzose slate, of somewhat gneissic character.

Chilukweyuk Lake.

The syenite of Chilukweyuk Lake forms a belt of between four and five miles in breadth, measured from west to east. It is remarkable for its hardness and regularity in mineral composition, being a finely crystalline mixture of white and pink felspar, with a small quantity of quartz and well-formed crystals of hornblende, of a somewhat slender columnar type. Crystals of black mica are seldom seen. In some places the syenite is divided by a system of joints, which are arranged so as to produce a kind of imitative stratification, having a regular northwesterly dip of about 45°; but no well-defined lamination or foliation is anywhere visible. It is from this mass, or others of similar composition, that the principal part of the erratic blocks which are found scattered over the coasts of the mainland and the southern portion of Vancouver Island have been derived. The Chilukweyuk syenite is, in this latitude, the nearest point to the coast presenting a supply of the requisite material*.

Chilukweyuk Mountain.

The highest granite peak in the mountains surrounding Chilukweyuk Lake is on the western shore. It rises to a height of 6,570 feet above the sea level, the summit presenting a nearly vertical cliff-face of about 1,200 feet in total height. In this cliff two thin black dykes are seen penetrating the syenite. From fragments picked up at the foot of the slope they appear to be dark quartzo-felspathic porphyries or elvans containing large white felspar crystals, and similar in character to the elvan dykes found in the gneiss of the lower part of the Columbia Valley.

Watershed ridge west of Skagit.

After crossing the syenite, the next rock encountered to the eastward is near the latitude-station of the Chuckchehu a. It is a hard, highly micaceous and quartzose gneiss, showing irregular wavy laminations, which have their principal inclination toward the east. On the top of the dividing ridge between the Chilukweyuk and Skagit waters, a kind of outlying mass of slaty rocks is seen above the gneiss. These rocks are chiefly earthy clay-slates with conglomerates of gneiss, sandstone and slate pebbles; and purple slates, containing epidote and calcite.† The structure of this outlier is not well seen, for at the top of the ridge and for some distance on each side, the rocks are hidden by a thick talus of rubbish, in addition to which the height (4,700) is insuffi-

* (Note by Mr. Bauerman) In 1858 syenitic boulders were visible in extraordinary numbers in and near the town of Victoria. Since that time they have been largely drawn upon for a supply of building material owing to the great ease with which they can be blown to pieces, and the absence of any other suitable building stone in the immediate vicinity.

† These doubtless represent an outlyer of the Lower Cretaceous rocks, which commonly occur in similar positions in parts of this region further to the north.

cient to clear the dense forest. The latter inconvenience has, however, been in part obviated by bush fires, which have burnt off the whole of the trees for about two miles, exposing a fine section of the mountains on the opposite side of the pass, on which there are three small glaciers on northerly slopes, all very much furrowed and broken. Immediately to the south of this point the mountains rise to great heights, and the largest observed glacier, estimated at about a mile in length, descends from them, giving rise to a stream along the valley of which the descent to the Skagit is effected. The gneiss is continuously exposed nearly down to the river, where it is concealed by the gravels of the valley.

Skagit River.

The Skagit, on the boundary-line is a small stream, only fifty yards wide. It rises about fifteen miles east of Fort Hope and flows through a narrow opening between the highest summits. Its course is at first south, then eastward, and it falls into the northern part of Puget Sound.

Mountains east of Skagit Valley.

The ford on the trail is about 1,650 feet above the sea level. The mountains on the west side of the river rise to a height of nearly 9,000 feet. Their sides show seven small glaciers, the lowest being about 6,000 feet above the sea level. The river flat is about two miles in width and is covered by a thick growth of timber, principally cedars of large size, with an undergrowth of willows. After crossing the river-flat, which shows a few low terraces, the trail rises up the side of a steep hill covered with thick small brush and burnt timber for more than 4,000 feet, when it reaches the watershed and follows the tops of the ridges on the north side of a steep-sided ravine in which the Similkameen River rises. On the opposite or southern side are several bold mountains of black slate. In the hollows between them are three small glaciers which are remarkable for the brilliant blue colour of their ice. The lower extremity of one of these glaciers is wasted into a hollow or cavern. Immediately above the crest of the ridge at their head of the pass, are two very remarkable peaks of black slate, which rise precipitately to a height of about 1,800 feet above the watershed. They are called by the Indians "Hozamen" which name has been adopted for the pass and the ridge of which they are the culminating points. The rocks of this district are principally black slates ranging in texture from soft earthy shales to the hardest lydian stone. In the Skagit Valley the exposed sections show north-westward dips at angles varying between 75° and 60°, the lower angles prevailing as the trail rises above the river. On the watershed they have turned over and incline at an angle of 60° towards the north-east, a direction of dip which is persistent for some distance along the pass, after which the beds are bent into smaller and more irregular curves. About the middle of the pass the slates are pierced by dykes of a compact rock, which appear as if interstratified, but their true nature is seen in cross

section, which shows them splitting and ramifying across the laminations among the older rocks. At this point a few black and irregular impressions somewhat resembling plant stems were found in a bed of sandstone. They are probably pseudomorphs after staurolite or andalusite crystals. The contortion seen to the east of this point is accompanied with (as far as can be seen) a general westerly inclination. As far as the mouth of Roche River, cherty or hornstone-like metamorphic beds, probably originally sandstones, and conglomerates of a green colour are seen.* The same rocks are continuously exposed in the valley of the South Similkameen, with a southerly dip, up to within five miles of the Peseyten river junction, where they are succeeded by a small mass of grey syenite which preserves its massive character for a mile and then becomes gneissic. The gneiss is flanked by soft talcose and micaceous slates at the junction of the two streams. The mouth of Roche River is 3,458 feet, and that of the Peseyten 3,060 feet above the sea level. The valley between these points is filled with thick masses of gravel containing a large quantity of pebbles of the green conglomerates. They are cut through in many places by the river, forming nearly vertical cliffs from fifty to eighty feet in height.

South Similkameen Valley.

After receiving the Peseyten the valley of the South Similkameen takes a nearly northerly course, but in order to continue along the boundary-line the trail turns to the eastward, crossing a steep hill 6,330 feet in total height above the sea level, known to us as Ptarmigan Hill. This summit is the culminating point of the ground lying between the Peseyten, South Similkameen, Ashtnoulou and main Similkameen. It is made up of stratified masses of blue trachytic porphyries, with a few brecciated beds of a similar mineral composition, dipping north-north-west at a slope of 50°. †

Mountains east of Similkameen

The junction of the porphyries with the talcose micaceous slate of Peseyten is not seen, the nearest dips, however, indicate considerable unconformity. The western side of the hill is very swampy and covered with burnt and fallen timber. On the eastern side it is covered by a coating of a remarkably fine gravel, and a forest of small dead pine sticks which conceals all the rocks on the descent to the Ashtnoulou River which is struck at a point 3,550 feet above the sea level. In the Ashtnoulou Valley, green, red and grey quartz-porphyries are seen in large quantities. They are well stratified, having a west-north-west dip of 50° which nearly corresponds in direction and inclination to that of the porphyries of Ptarmigan Hill. They are underlaid by beds

Ashtnoulou Valley.

* The rocks east of the Skagit, above described, form the southern extension of a considerable area of Lower Cretaceous. See Report of Progress, 1877-1878, p. 105. B.

† This is the western edge of a basin of Tertiary volcanic rocks, which are more fully described in the succeeding paragraph.

of a very coarse conglomerate, the largest of the included masses being granitic. Several of the smaller pebbles are crusted with a thin coating of chalcedony resembling dried gum. The same kind of incrustation is seen on the pebbles in the gravels of the lower Columbia Valley at Fort Vancouver.

Ashtnoulou granite mass.

The conglomerate last mentioned rests upon the western edge of the Ashtnoulou granite, a mass which is exposed along the boundary-line for a breadth of fourteen miles and forms in this latitude the whole of the mountains called in a preceding paragraph the Ashtnoulou or Okanagan chain. In a northerly direction it is seen in undiminished magnitude in the main Similkameen Valley; and to the south it is exposed almost continuously on the western side of the Okanagan Valley, down to the junction of that river with the Columbia, a distance of about sixty miles. Unlike the syenite of Chilukweyuk Lake, the Ashtnoulou granite is of an exceedingly variable composition. Near the mouth of the Ashtnoulou it contains red and white felspar, quartz, black mica and hornblende. The micaceous portions are the softest and offer least resistance to the action of the atmosphere. In the valley leading up to the latitude-station, many masses of mica-slate and other metamorphic rocks are seen. The largest one is of a dark green hornblende-slate with nearly vertical laminations, into which the granite sends off many small veins. In some of the veins the hornblende present appears to be derived from the altered rock, as the crystals of that mineral are developed in dense masses near the wall of the vein, which is filled with a granular mixture of red felspar and hyaline quartz. In the mountains immediately above the Ashtnoulou latitude-station, which rise to a height of about 7,500 feet above the sea level, the granite changes into a mixture of quartz and felspar. The quartz occurs principally in large black or white crystals, some of them measuring three inches across the basal plane. The felspar is usually found in dull cleavable masses of a dirty pink colour, and more rarely in small, well-developed red crystals. A compact variety of the same quartzo-felspathic substance is found filling small veins in the rotten reddish-grey syenite which surrounds the coarsely crystalline mass noticed above. From the top of the Ashtnoulou Mountains the granite is seen to the eastward forming low and occasionally flat-topped hills, which terminate in a tremendous cliff-face between 4,000 and 5,000 feet in vertical height on the western side of the Similkameen Valley, opposite to Hayne's House.* The flat-topped form of the intermediate hills is produced by a set of nearly horizontal divisional planes, which render the granite liable to scale off in flaggy masses when

* Now abandoned, the custom house being situated further west at Osoyoos Lake.

exposed to the action of the atmosphere. A few "tors" and projecting blocks are also seen, but they are mostly small and insignificant.

The shorter section terminates at the Similkameen River by a junction with the longer; the western portion of the latter showing a similar class of rocks which are exposed on the brigade trail—in part the new waggon road—from Fort Hope by the Similkameen. It is constructed in a similar manner to the first.

Description of longer section.

The town of Fort Hope, where the long section commences, is situated on a small gravel flat about one hundred and forty feet above the sea level, at the southern end of the great gorge made by the Fraser River in its passage through the mountains. The cliffs at the back of the town are composed of gneiss and mica-slate of very finely laminated character and usually syenitic. The probable dip of lamination is about 50° in a northerly direction. There are many small granite veins intruded nearly in the planes of lamination. About two miles out, on the waggon road, a grey felspathic granite is seen in large masses. This rock resembles the Chilukweyuk syenite in colour and hardness, but it is associated with another variety which is often largely crystalline from the presence of coarse plates of mica. The granite is seen sending off small veins from its eastern edge into a mass of black clay-slate, altering the latter for a short distance into a dark bluish-grey quartz rock. A line joining the syenite of Chilukweyuk Lake to the granite of Fort Hope, would if prolonged in the same direction pass through the granitic and gneissic rocks exposed in the gorge of the Fraser River between Fort Hope and Fort Yale. The distance between these points is about fourteen miles in a nearly north and south line. From Fort Yale to Chilukweyuk Lake is about thirty-five miles.

Rocks east of Fort Hope.

Intrusive granite.

About twenty miles from Fort Hope, another mass of syenitic granite is seen, and between it and the former one the black metamorphic slates are disposed in a flat anticlinal arch, the dips near the western granite being towards the south-west, while near the 17th mile post on the waggon road, their direction is between south-east and east-north-east. The eastern granite is a nearly compact white syenite, which is rendered porphyritic by a few small hornblende crystals. There is a thick bed of limestone in the slate which is altered at the contact into a kind of laminated black and white quartz rock, and a little further away from the junction into a mixture of carbonate of lime with white radiating masses of tremolite or actinolite. After leaving the syenite, which forms a boss of about one mile in width, a great thickness of dark green slaty rocks is seen arranged in a synclinal fold* in the mountains to the

Basin of Cretaceous rocks.

* This is the eastern edge of the Lower Cretaceous area previously alluded to. The route here followed is that described in the Report of Progress to which reference has already been made.

eastward of the Skagit River. The dips of these beds appear to increase in steepness towards the centre of the synclinal, the highest inclination being about 70°. The uppermost bed is a conglomerate made up of green and black slate and quartz pebbles, all well rounded. On the eastern side of the axis the dip is to the north-west, the inclinations being somewhat less than those of the western side, and continually diminishing until we reach a small swampy flat about 4,400 feet above the sea level, situated nearly midway between the Skagit and Similkameen valleys, where the slates are underlaid by a finely crystalline syenitic gneiss, which does not appear to be associated with any granite veins, or to show any other symptoms of the vicinity of a granite mass.* The eastern face of the slope on the descent to the Similkameen is covered, nearly to the top, by a smooth coating of gravel, chiefly made up of porphyritic fragments, which entirely conceals the rock beneath except where a few dykes of felspathic porphyry and some hypersthenic greenstones form small projecting ridges. This gravel covering continues nearly down to the level of the South Similkameen River, where there are exposed beds of a dark green altered rock, with a few thin interstratifications of a blue argillaceous limestone, the whole having a south-easterly dip. These green beds are very compact, showing no granular texture. They contain a few hornblende crystals. It is probable that the hypersthenic greenstone seen higher up on the hill may be a more completely metamorphosed condition of the same rock.

Gneissic and crystalline rocks.

The Similkameen River is formed by the junction of two smaller streams, the South Similkameen and the Tulameen. The junction takes place near the point where the brigade-trail reaches the valley and is locally known as the Vermilion Fork. Near this place sections of unaltered sandstone, containing the remains of land plants, are seen in both of the tributary valleys, and will be noticed in a subsequent paragraph. About a mile below the junction, vesicular green and grey felspathic rocks are seen in the main valley, dipping at 60° to the north-north-east. Some of the beds are rudely columnar, and large masses of quartzose and red felspathic porphyries, also apparently stratified, are associated with them. This series of beds is probably the representative of the quartz-porphyries and other trappean rocks seen in the Ashtnoulou Valley, and on the top of Ptarmigan Hill, and it occupies a similar position with reference to the granite which comes to the surface further to the eastward.† The latter rock is penetrated by several red felspar-porphyry dykes near its western edge.

Rocks of Similkameen River.

A considerable extent of the main Similkameen Valley is occupied by the northerly prolongation of the Ashtnoulou granite, as the river cuts

Granitic area.

* This junction is a faulted one. See Report of Progress 1877-78, p. 63 B.

† These rocks and the sandstones above referred to are now known to be Tertiary.

obliquely across it. The total length of the exposed section is about nineteen miles, which distance is divided into two unequal portions of fourteen miles and two miles, the intermediate space of three miles being filled by a small and disturbed synclinal of slaty rocks.* The larger or western mass of granite is of a hard and finely crystaline character, containing both mica and hornblende with white and red felspar. The smaller mass is also syenitic, and both are penetrated by numerous felspar-porphyry dykes. The trough of black slaty rocks occurring between the two granite masses differs from the included fragments seen in the Ashtnoulou district, the disturbance being chiefly mechanical, with but a slight amount of mineral alteration. It consists chiefly of black pyritous slate, with some thin bands of blue limestone at the eastern side. These limestones have been considerably affected by the granite at their contact with the smaller mass. The junction is marked by a semi-crystalline quartz-rock containing crystals of tremolite and mica. Further away from the intruded mass the limestone is converted into a mass of crystals of carbonate of lime. This is for the most part pale in colour, but still shows irregular streaks and patches of its original tint. Associated with it are thin radiated masses of actinolite and a few brown lime garnets. The coarsely crystaline portions of the limestone are very slightly coherent. From the readiness with which the constituent crystals of calcite are cleaved, they are very readily acted on by the weather, and run down into a kind of coarse sand, forming a talus which lies at a much lower angle than those of the harder rocks surrounding it. In addition to the chemical changes, there appears to have been a considerable amount of mechanical disturbance, as the lower beds of the limestone are much broken up and recemented into a kind of breccia by carbonate of lime and brown iron ore, the former mineral sometimes occurring in large crystals in the cavities between the fragments. The dip of the limestone beds at the eastern contact is 34° in a direction of N. 30° W.; but the slates above them are turned up at a much higher angle, and toward the middle of the trough they appear to be folded back upon themselves, the contortions being rendered very apparent by several thin bands of white quartz-rock interstratified among the hard black slates. The latter are often much stained with iron rust from the decomposition of the contained pyritic nodules. From the fact of the occurrence of the greatest amount of metamorphism with the smallest amount of inclination at the eastern edge, it may be that the principal disturbing force has been exerted by the granite on that side, the beds being compressed and driven back upon the portion lying to the westward. Porphyritic dykes are also

Trough of metamorphic rocks.

* See Report of Progress, 1877-1878, p. 84 B.

seen in the black slates, one of them, a fine-grained greenstone, occurring in the middle of the synclinal, and probably filling a fault, as the slate is broken up into a coarse breccia cemented by thin quartzose strings along the planes of contact.

Similkameen Valley east of granite mass.

That portion of the Similkameen Valley which lies between the eastern edge of the granite (a point six miles west of the mouth of the Ashtnoulou River) and Hayne's house near the boundary crossing, is filled with great masses of slaty rocks which are mostly very siliceous, comprising black lydian-stone and hornstone of various colours, usually red or purple with green and white bands in less quantity. The dips, as far as they can be trusted, show a south-easterly inclination, but this is accompanied by a considerable amount of contortion as seen in the small transverse gullies. There are also in places two systems of strongly developed divisional planes which make more prominent features than the supposed original bedding. A few fragmentary patches of limestone are seen high up in the hillside near the lower end of the valley, and from their similarity in position with those seen in the Chilukweyuk Valley, they may be taken as marking the upper part of the slaty series.* Near Hayne's house the granite of the Ashtnoulou mountains crosses the river, and appears under the form of a fine-grained white syenite full of small strings of epidote. Fibrous serpentine of a bright green hue has also been found in the mountains near this place.

Osoyoos Lake and vicinity.

In the hills lying between the Similkameen and Osoyoos Lake, in the Okanagan Valley, the sections show the black siliceous slates lying in a trough of contortion, on beds of gneissic mica-slate, the latter occupying the high ground in the centre of the hills. On the western shore of the lake are seen thick beds of a coarse granitic conglomerate with a dip of 70° in a direction E. 25° S.; about a quarter of a mile back they have been sharply folded over, and lie at nearly as high an inclination in a westerly direction. A thin band of extremely hard felspathic porphyry is intruded in these beds near the boundary crossing. On the same side of the lake a bed of sandstone is found which is stained bright green for a short distance. This is produced by carbonate of copper resulting from the decomposition of a minute quantity of copper pyrites scattered through the rocks. No defined copper lode could be found in the immediate neighbourhood. In the Similkameen Valley, below the boundary crossing and nearly down to its confluence with the Okanagan, black and green slaty rocks are exposed continuously. They are contorted in a similar manner to

* The rocks above described are supposed to belong to the Cache Creek series of the provisional classification of 1871.

those seen on the hill trail, but no gneissic rocks come to the surface.

Larch Tree Hill

On the eastern side of Osoyoos Lake, which is about two miles wide, there is a total change in the nature of the rocks, a very coarsely laminated gneiss, full of large crystals of felspar, prevailing. The dip of the lamination is north-west about 25°. About a mile further to the eastward, at a point about a thousand feet above the lake, it changes to 15° in an easterly direction.* The summit of the ridge dividing the Okanagan from the Newhoialpitku or Kettle river is known as "Larch Tree Hill" from its being the first point on the line at which *Larix occidentalis* is seen in quantity. It is about 3,900 feet above the sea level. The slope for nearly the whole distance from Osoyoos is covered with fine gravels and blown sand. On the eastern side, on

Rock Creek.

the descent to Rock Creek, the black slates with a few thin bands of quartzose conglomerate are occasionally exposed, but over the greater part of the ground they are hidden, only a few hard porphyry dykes projecting through the superficial deposits. At Rock Creek the Colville trail first strikes the Newhoialpitku, which river, as has already been stated, follows a very tortuous course, crossing the boundary-line three times, and finally falling into the Columbia about two miles to the

Highly metamorphic rocks.

north of Fort Colville. This area is remarkable for the extreme character of the metamorphism of the rocks, as well as for the great profusion of intruded porphyritic dykes, greenstones, syenites and elvans which are found penetrating the slaty and gneissic rocks indifferently throughout this entire portion of the valley. In the narrow gorge of Rock Creek the black slates are exposed in steep cliffs with a south-westerly dip. Further to the eastward, they are associated with some thin shaly and irregular bands of limestone, which are seen dipping first about 5° to the north-north-west and about four miles further on 4° in an easterly direction. Opposite to the town, of Rock Creek,† large masses of a very finely crystalline greenstone in an obscurely stratified condition, are found. They are somewhat like the interstratified greenstone seen in the Rocky Mountains, but bear very little resemblance to the rocks of a similar character in their immediate vicinity. About eight miles east of Rock Creek, a hard dark-green quartzose conglomerate in a highly metamorphosed condition is accompanied by a bed of imperfectly columnar greenstone. The position of these beds is above the slates of Rock Creek. The comparative position of the rocks in this district is, however, very obscure, as the sections rarely give good dips, from the prevalence of

* These rocks resemble some of those on the Shuswap Lakes, and are probably Archæan.

† A mining camp, long since abandoned.

irregular joints and secondary divisional planes masking the true lines of stratification. In the case of the greenstones of Rock Creek the evidence appears to be about equally divided between intrusion and interstratification.

Gneissic rocks.

About three miles below the first boundary crossing of Newhoialpitku River, gneissic rocks again make their appearance, and they are seen continuously for about forty miles, up to within about twenty miles of the mouth of the river. They include examples of almost every variety of granitic and syenitic gneiss, quartz rock in thin bands and a dark-green hornblende slate, the whole being finely laminated, and arranged in numerous small and irregular contortions. For a short distance, near the centre of the mass, a dip of lamination is observable at low angles of inclination, and ranging in direction between south-west and north-north-west, and in this part of the section most of the dykes of porphyry and greenstone, which are exceptionally numerous, are intruded in the lines of lamination. Some of the more homogeneous of these intruded masses weather out into thin tile-shaped laminæ due to irregular cleavage-planes which cross the mass obliquely to the walls of the vein. Near the eastern edge of the gneissic rocks, dykes of granite and micaceous porphyries are more abundant than the purer felspathic varieties seen further to the westward. In some places the granitic dykes are so well laminated, that they appear, when seen along a line of strike, to form part of the gneissic beds themselves. A remarkable example of this kind of structure is seen in the great bend of the Kettle River, where, in a cliff of well laminated and thinly bedded mica-slate, interstratified with bands of a white quartz-rock of a prismatic structure, and irregular masses of dark-green hornblende slate, thin beds of a finely crystalline gneissoid rock containing garnets are seen near the top of the section. When seen on a transverse section, the bands of this rock are observed to cross every one of the other beds in the section at a considerable angle, thus proving them to be merely intrusive masses. The dip of the lamination, and probably of the original stratification of the latter, is north-north-west at an angle of about 10°, while that of the dykes is much higher and is oblique to the walls. The appearance of this cliff with its regular alternations of quartz-rock and nodular masses of hornblende, is strangely suggestive of its original sedimentary character, quartzose and siliceous bands standing for siliceous sediments of various degrees of purity, while the lenticular hornblendic masses may be taken to represent alternating and irregular patches of clay. Instances of gneissic lamination in dykes, have been observed in a few other places in the same neighbourhood, but it is nowhere so strongly marked as it is in the example cited

Dykes.

above. At the third boundary crossing of Kettle River, the gneiss is hard and firmly laminated without much contortion, after which a dark rotten mica slate, full of garnets, and very much contorted, prevails.

Lower Kettle Valley.

After leaving the gneiss a great mass of slaty and calcareous rocks is encountered in the lower part of the Kettle River valley. It extends in a south-easterly direction for about fifty-five miles across the Columbia to the head of the Chemikane Valley, the beds forming an irregular synclinal with a considerable amount of contortion on the western side. The lowest members of this series are beds of rather silicious slates and slaty limestones of a light green colour, which are occasionally variegated with white and black lines of lamination. The dip is to the south-east at about 50° inclination. Further to the eastward and next in order in the series, comes a mass of black and bluish-grey slate of a somewhat sandy texture, containing well formed crystals of iron pyrites. Associated with these are a few thin limestone bands, resembling those seen in the lower part of the Similkameen Valley. These beds are more contorted than the green series below them, and are occasionally nearly flat. At the mouth of the river the dip is again to the south-east. On the right bank of the Columbia opposite Fort Colville there is a thin bed of a pure white crystalline marble, at the top of the black slates, which is seen at intervals occupying the same position higher up the river towards Fort Shepherd. Above the white limestone comes the quartz-rock of the Kettle Falls. This is a white micaceous and quartzose slate, divided by well marked planes of stratification and nearly vertical joints, into flaggy or prismatic blocks. The finer laminations of the individual beds are, however, extremely contorted in very small and sharp turns. In some instances the laminæ are twisted into serpentine curves, in which case the straight ends are usually broken through at the tails of the S-curved portions, such fractures being generally accompanied by a small vertical dislocation. The total thickness of this rock is about 500 feet. It occupies both banks and the bed of the Columbia at the Kettle Falls, and is seen in small ridges sticking up through the alluvium of the plain on which Fort Colville is built, for about half a mile to the eastward of the river. In the cliffs of the left bank of the Columbia Valley, in the hills above them, and in those above the north side of the Colville Mill Valley, the rocks exposed are argillaceous and sandy slates and sandstones, with a few thin slaty breccias and conglomerates, and a number of thick limestone beds of a more or less impure or concretionary character occurring at intervals throughout the whole series. The following is a more detailed list of the apparent succession in ascending order in a line

Slaty and calcareous rocks.

Colville.

Remarkable contortion.

Section in Colville Mill Valley.

from north-west to south-east from the gneiss of Kettle River to the top of the synclinal in the Mill Valley :—

1. Green slates and limestones.
2. Black and bluish-grey slates with included crystals of iron pyrites and some thin limestone bands, dipping first to S.S.E., then S.W., then flat, and finally dipping S.E. near the mouth of the river.
3. White crystalline marble with silicious leaf-like films, or very thin beds.
4. Slaty quartz rock of the Kettle Falls.
5. Green shaly limestones and calcareous shales (left bank of the Columbia).
6. Fine-grained bluish-grey shales with irregular cleavage and thin beds of fine slaty conglomerate.
7. Bluish-grey slaty limestone with some bands of black slate.
8. Thickly bedded and contorted blue argillaceous limestones, with a few thin intermediate beds of a calcareous breccia.
9. Fine-grained hard yellow sandstones apparently made up of granitic or gneissic debris.
10. Blue argillaceous limestone, very impure and slaty, the upper beds much hardened by infiltration of silica.
11. Hard slaty breccia containing fragments of black silicious slate, white quartz-rock in clay slate.

The same kind of contortion in lamination accompanying regular stratification that is seen at the Kettle Falls, occurs in the higher parts of the section, more especially in the thick limestone beds in Nos. 8 and 10. The beds in Nos. 5 and 6 form a small flat anticlinal arch at the eastern edge of the Columbia Valley. They are broken through by numerous greenstone dykes which usually follow a north and south course. The largest of these intruded masses is about 200 yards wide, forming a prominent ridge for about two miles along the valley to the south of the falls.

The conglomerate, No. 11, is the highest bed in the synclinal. It is very hard and is much altered by silicious infiltration and affected by cross jointing. Further up the Mill Valley the dips assume a westerly direction, bringing the limestones again to the surface. The beds have, however, changed in mineral character, a nearly uniform mass of finely laminated, white, slaty and calcareous rock taking the place of the thick blue limestones with interstratified sandstones and conglomerates seen in the western side of the trough. About two miles south of the United States military post of Colville, a small granitic mass breaks through the limestones, and is exposed on a very oblique section as far as the Little Pend D'Oreille River. The rock is remarkable for its extremely rotten character, due to the rusted and decomposed state of the felspar of which it is chiefly composed. The lower or slaty members of the series are exposed below the limestones in the upper part of the

Granite mass.

Colville Mill Valley. They are nearly vertical, having been apparently compressed between the Little Pend D'Oreille granite and that of the Spokan lying further east. The supposed equivalent of the quartz-rock of the Kettle Falls, appears as a band of pure white quartz. The slates are mostly very silicious. The higher beds are covered with rusty stains from decomposed pyrites, the lower ones are chiefly black, brown and purple jaspidions slates or lydian-stones, bearing a considerable resemblance to the beds seen in the Similkameen Valley. The granite of the Spokan, like that of the Little Pend D'Oreille, is very rotten and concretionary, weathering down into rudely spheroidal blocks. At Chemikane bridge a small needle or obelisk projects from the face of the cliff. It is formed of a pile of soft decomposing blocks, which are held together by a number of small interlacing veins filled with a compact mixture of felspar and quartz. Similar veins are seen at intervals along the Chemikane Valley down to its junction with the Spokan. In the valley of the Columbia River, to the north of Fort Colville, the black pyritic slates form the mass of the river-cliffs as far as Fort Shepherd, and in the lower part of the Pend D'Oreille Valley they are in a very much disturbed condition, and the intruded greenstone and syenitic masses are more numerous than they are at Colville. The limestone series appears in its proper place on the Pend D'Oreille and is largely developed in the thickly wooded mountains to the eastward of Salmon River. At the Pend D'Oreille latitude-station, the dip is towards the south, and it is probable that the lower boundary of the series follows a direction nearly parallel to, and a little to the eastward of, the Columbia from Colville to this district. A curiously speckled, black and white sandy bed appears to be of common occurrence in the upper part of the thick limestones.

Columbia Valley.

In passing from the valley of the Chemikane to that of the Spokan River, the trail crosses a low pass, with a marshy flat at the summit between the low granite hills. The granite is of a rotten and concretionary character, presenting many overhanging and perched blocks which are very slighly coherent and scale off into a kind of coarse sand under a very feeble pressure.

Chemikane to Spokan.

The Spokan River flows through a broad valley resembling an old estuary, bordered by hills of 1,500 to 2,500 feet elevation. Toward the south the great lava covered table-land of the Columbia extends in an unbroken stretch for about 250 miles. The basaltic lavas forming the greater part of the surface of the plain, are represented on the Spokan by some large outlying patches which flank the granite mountains up to about 400 feet above the river level. They are also seen in smaller masses at various points along the Chemikane Valley, and one small fragment is found within the drainage area of the Colville Mill Stream.

Spokan River.

Basalts.

Following the course of the Spokan River, the concretionary character of the granite continues up to the neighbourhood of Plant's house. Here the rock becomes harder and a gneissic, structure is developed, accompanied by the separation of large mica and felspar crystals.

Gneiss. Near the edge of the wood on the Spokan prairie, the same coarse gneiss is seen and a finer variety is found on the eastern side of the Pend D'Oreille Valley opposite to Sinyakwateen, the ferry at the lower end of the Pend D'Oreille Lake. The dip of the gneissic lamination is S. 30° W. at Plant's house. On the Pend D'Oreille the direction is S. 15° E.

Sinyakwateen to Kootanie River. In the district between the Sinyakwateen Crossing and the first ferry on the Kootanie River, there is a very small amount of evidence as to the nature of the rocks. The pass is in a wide valley filled with gravel and blown sand, between low hills which are rarely visible from the trail. The gneiss is seen at the top of the highest hill on the north side of the valley near the watershed of the two rivers. The country bordering the Pend D'Oreille Lake near Sinyakwateen is one of the most thickly wooded parts of the line. The ground is flat, and is intersected by deep and sluggish streams which are liable to sudden overflow from summer rains. The largest timber on the line is seen in the thick wood at Pack River, where the Californian sugar-pine (*Pinus Lambertiana*) attains a height of 310 feet, and cedar trees are found rivalling those of the Cascade Mountains.

Chelemto Crossing of Kootanie. At the first or Chelemto Crossing of the Kootanie River, the gneiss is of a more granitic character, containing irregular micaceous laminations and much felspar. The prevailing dip of the lamination is towards the south-east, but this direction is not constant, being combined with much contortion. At the mouth of the Mooyie River the slaty rocks of the Kootanie Valley are seen for the first time.* They are bluish-grey and green finely granular silicious slates, and form steep cliffs from 150 to 200 feet in height, the laminations dipping 60° in the direction E. 10° S. On the right bank of the Mooyie, a curious boss of hypersthenic greenstone is seen, intermediate in position between the slates and the gneiss. A similar case of a greenstone dyke being intruded at the immediate contact of the slates and gneiss is seen about five miles below (north) of Chelemto, where hardened black slates are altered into a kind of mica-slate, the mica forming small dark green rounded masses, in a lighter coloured base. From the Mooyie River eastward as far as the Kootanie trading post, the sections present a succession of unfossiliferous slaty rocks and sandstones which are arranged in large folds of contortion as shown in the section. Many of the changes in dip are so sudden that they are probably accompanied by fracture

Slaty series.

Mooyie River to Kootanie Post.

* As the result of observations in 1883, these rocks are probably Cambrian.

and dislocation of the rocks. After passing the green silicious slates between Mooyie and Yakh Rivers, the beds become darker in colour and more argillaceous, containing nodular masses of iron pyrites and showing cavities where these have been removed by decomposition.

Ripple-marked surfaces.

A feature seen for the first time in these beds is the presence of ripple-marked surfaces which are of almost constant occurrence throughout the Kootanie Valley as far as the trading post. At the second crossing of the Kootanie, some beds of hard, green sandstone are seen. They appear to be perfectly homogeneous on a fresh surface, but show small irregular false-bedding in green and white quartzose sediment, with included fragments of slate, on a weathered face. There are associated with these beds some laminated white and black shales with small concretionary points of carbonate of lime, which pass into an impure limestone, in which the carbonate of lime is intermingled with argillaceous patches in folds resembling the markings in the molar tooth of an elephant. There are very few intrusive dykes in this part of the country, only a single one having been observed to the east of the Mooyie River. There are, however, several apparently interstratified

Trappean rocks

beds of amygdaloidal and compact trappean rocks, between the second crossing and Kootanie post. The most remarkable of these is a compact felspar-rock containing crystals of mica, hornblende and magnetite. Near the Kootanie post the slates are green and silicious, and are arranged in broad inclined steps across the valley dipping at an angle of 20° in the direction N. 60° E., all with ripple marked surfaces.

Tobacco Plains.

At the Kootanie trading post the valley suddenly widens, the hills receding for about four miles from the river. The intermediate space is filled with flat-topped gravel terraces, which are known as the Tobacco Plains. In the mountains lying between the Tobacco Plains and Chelemto, and in the upper part of the Mooyie Valley, the rocks are similar in character to those seen in the Kootanie Valley and are probably arranged in a somewhat similar manner, the sections are, however, of small value, as they are only seen at rare intervals, owing to the thick growth of small timber which is almost universally present and is nearly as effective in concealing the rocks as the drift gravels in other places.

The high mountain which rises about 6,000 feet above the river on the west side of the Kootanie at the Tobacco Plains crossing, is made up of bluish grey slates with a belt of crystalline rock containing large starry masses of actinolite near the summit, probably a representative of one of the interstratified traps seen at a lower level further

Tobacco Plains to Flathead River.

to the eastward. To the east of the Tobacco Plains, between the Kootanie post and the Flathead River, bluish-grey, green and purple clay slates are seen along the gorge of the Tobacco River, through which the

trail is carried. The dips are chiefly north-east, slope 30°. The flaggy surfaces of the beds are covered with ripple-marks and impressions of sun cracks. Near the summit of the dividing ridge, they are very red and sandy, containing numerous pseudomorphic impressions of salt crystals and some fossil-like markings, which have however been pronounced by Mr. Salter not to be of organic origin. The top of the pass is flat and swampy on the Flathead side of the slope. The dip of the red beds is 20° in the direction N. 10° W. About 300 feet below the watershed on the descent to the Flathead, the trail suddenly crosses a series of bluish-grey limestones which are exposed continuously on the slope to within a short distance of the alluvial gravels of the Flathead River. They are very hard, thickly bedded, and are divided into large blocks by open joints which are often filled with quartz crystals. The dip is 8° to 10° in an easterly direction. Mr. Salter's remarks on the fossils from these beds are appended as a note to this report.

Limestone outlyer.

They were chiefly found in a very compact bed in the middle of the section, where they are exposed on the weathered faces. At the lower end of the section, the limestones rest on a thin patch of false-bedded quartzose sandstone. Near the top of the hill they are lying unconformably on the red beds containing salt crystals. The limestones are cut through by the brook that runs down to the Flathead River, forming vertical cliffs varying in height from about twenty-five feet at the bottom of the hill, to about 200 feet about half way up, where the fossils are principally found.

Fossils.

Other beds of Carboniferous age are seen in the Kootanie Valley north of the Tobacco Plains, overlying the green slates with interstratified traps. They differ very much in appearance from the Flathead limestones, being principally argillaceous, the limestones occurring only in thin rubbly seams of a black colour. Only a few fossils have been found in them. The dip is north-east about 30°. The highest observed beds of the section are coarsely laminated quartzose shales with bands of black chert, possibly representing the millstone grit. At this point the trail turns off into the Mooyie Valley, but as Dr. Hector found the Carboniferous limestone further north in the Kootanie Valley, it is probable that it is continuous over the intermediate space.

Carboniferous beds.

The main chain of the Rocky Mountains lying to the eastward of the Flathead River, is made up of slaty and sandy beds resembling those seen north of the second Kootanie crossing, and in the pass of Tobacco River. The transverse valleys of the Akamina Brook and the South Kootanie Pass follow the strike of synclinal folds in the rocks. In the former the cliffs rise on each side of the stream like walls in particol-

Rocky Mountains.

oured masonry, and are cut back at intervals into semicircular hollows which usually contain small lakes. The projecting ridges which divide these basins may be taken to represent the buttresses, while, to complete the analogy, the mural cliffs are crowned with masses of red shales standing for pinnacles or buttress-caps.

Mounts Yarrell and Kirby and Spence.

The highest mountains near the pass are those named Mount Yarrell and Mount Kirby and Spence on Blackiston's map, near the western face of the range.* The first named rises about 6,500 feet above the Flathead River and is entirely composed of well stratified materials, principally shales and sandstones, the highest beds being of a brilliant red colour. At the final latitude-station on the watershed, the rocks bear a strong resemblance to those seen in the ridge dividing the Kootanie and Flathead Rivers. They are green and red argillaceous shales and sandstones with subordinate bands of limestone. Some of them are cleaved, but all are ripple marked and covered with the impressions of sun-cracks. The limestone is of a very peculiar character, being made up of spheroidal concretions which present on faces of weathering a confused series of irregularly concentric ringed masses, in which a stellar or radiated structure is occasionally developed from the presence of actinolite crystals. At the top of the hills above the limestone at the latitude-station, a height of 8,500 feet above the sea level, very red sandy shales resembling those of Mount Yarrell are found. They are in many places thickly coated with micaceous hæmatite.† Near the base of these red rocks three interstratified beds of a columnar greenstone or diorite are seen. The higher ones are very compact in texture and of a dark-green colour. They are occasionally vesicular, having crystals of hæmatite (iron glance) in the cavities. The lower bed is an amygdaloid of a dark reddish colour, the vesicles being filled with carbonate of lime crusted with green earth. Pseudomorphous crystals of rock salt are also found in the red beds, together with some concretiary nodules bearing a rough resemblance to fossils, none of which can, however, be pronounced to be of organic origin. A curiously furrowed slab from this locality has been submitted to Mr. Salter, who is of opinion that the markings have not been produced by burrowing annelids.

Akamina Valley.

On the nothern side of the synclinal forming the valley of the Akamina, the red beds are seen at the tops of the hills opposite the latitude-station, but the limestones are not exposed, being hidden by the rough talus of the upper beds.

At the summit of the Indian trail in the South Kootanie Pass, about 7,000 feet above the sea level, fragments of one of the greenstone

* See Geology and Resources of the 49th Parallel, 1875, for a more detailed account of the rocks eastward from this point. The sections include beds from the Cambrian to the Triassic.

† These are probably Triassic.

bands are thickly scattered about the surface. They are probably nearly in place. In the descent from this point to the Buffalo Plains, the trail crosses a mass of blue, concretionary limestone at about the same level as that seen at the summit latitude-station. It is probably the same bed brought up by the longitudinal anticlinal of the main chain. Lower down the hill a peculiar condition of the red beds is seen, in the form of hardened clays of a blood-red colour, alternating with thin partings of a greenish-grey quartz-rock studded with small cavities containing grains of quartz and flakes of micaceous hæmatite. The whole resembling an altered mass of red marls with their green partings. They are overlaid by a thin bed of very crystalline greenstone.* East slope of Kootanie Pass.

At Chief Mountain Lake, the cliffs in a north and south direction, along the eastern shore, expose the folds of the transverse synclinals in the plane of the concretionary limestone, which is contorted into a W-shaped curve between the eastern mouth of the South Kootanie Pass and the south end of the lake. The limestone is here underlaid by beds of purple and green silicious clay-slate much contorted, with an intercalated limestone which contains fragments of quartz and large nodular masses of chert. Ripple-marked surfaces are commonly seen in both slates and lower limestone. This is the last and most easterly section which was examined by the North American Boundary Commission. Chief Mountain Lake.

The probable thickness of the upper beds of the mountains, *i.e.*, the concretionary limestone and overlying red and green beds and dioritic lavas, is about 2,200 feet.

In comparing the rocks seen at different points along the line of the larger section, the most apparent and striking difference is that between the unaltered beds of shallow-water origin on the eastern side of the Spokan gneiss, and the generally metamorphic sedimentary masses lying to the westward of that axis. In the Fraser River district, the rocks of the Chilukweyuk Valley, which are the least altered of any of those lying to the west of the Columbia River, have probably been deposited in deep water, as shown by their very thin laminations and the fineness of the sediment. The black slates and crystalline limestones on the Fort Hope road are sufficiently near in resemblance to the Chilukweyuk beds, setting aside the metamorphism produced in the latter by intruded greenstone and granitic masses, to allow of the assumption of these two being equivalent.† Comparison of rock series.

The black and varigated siliceous slates of the Similkameen Valley, are probably again representatives of the lower part of the

* See section *op. Cit.* These lower red beds are at a different horizon, and are probably Cambrian.

† A paragraph, in which the age of the green beds forming a synclinal east of the Skagit is discussed, is here omitted, as they have since been shown to be Lower Cretaceous. See Report of Progress, 1877-78, and Trans. Royal Soc. of Canada, 1882, Sec. IV., p. 81.

Comparison of rock series.

Chilukweyuk slates, as they are of a similar fine texture, being altered by silicification into a black chert, and do not contain any of the thin bands of limestone by which the upper part of that series is distinguished. The limestones that are present on the Similkameen are very thin and concretionary. To the eastward of Larch Tree Hill everything is hidden by sands and gravels, but the black slates of Rock Creek are probably equivalent in position to those of the western valleys, as they are similar in texture and contain thin limestone seams. This part of the section is, however, much confused by the presence of intruded rocks and other marks of disturbance. On the east side of the great bend of Kettle River, the mass of rocks in the Colville basin is equal if not larger in amount than that in the Chilukweyuk Valley. The succession is also a similar one, the gneiss being overlaid by green slates with thin limestones, which are succeeded by sandstones and shales containing thick beds of limestone resembling those in the upper part of the western series, with this difference, that they have probably been deposited in shallower water, as they are less purely calcareous and there is a more rapid alternation in the mineral character of the intermediate beds from clays to sandstones and conglomerates, than is usual in the western district. The variable character of the limestones is further shown by the change of the thick blue beds of one side of the synclinal into white and shaly ones on the other.

On the eastern side of the Spokan gneiss, the slaty rocks of the Kootanie Valley have only one feature in common with those of the Columbia—the presence of interspersed crystals of iron pyrites. The great limestone beds are entirely wanting. This is most likely due to the shallow-water origin of the Kootanie beds, which is abundantly proved by the presence of ripple-marked surfaces, and as the higher parts of the section contain large quantities of thin false-bedded sandstones, it is probable that the shallowing went on as these were deposited. The concretionary "elephant's tooth" limestone of the second Kootanie Crossing appears to mark a new set of deposits, as it is above this point that amygdaloidal and other lavas are found interstratified with red sandy shales, containing hæmatite and numerous impressions of salt crystals.

Beds of the Rocky Mountains.

A similar mineral character and order of arrangement prevails in the upper beds of the Rocky Mountains, and if we assume them to be equivalents,* we must suppose that the greater part of the Kootanie Valley

* The conclusions stated in this paragraph, are based on the assumption of the identity in age of the Red rocks of the vicinity of the Kootanie Valley, with those of the upper parts of the Rocky Mountains near the 49th parallel. The remarkable lithological resemblance of these rocks might fully justify this hypothesis, which was, indeed, at one time entertained by the writer. It has, however, been proved by the exploration of 1883 that these red rocks are widely separated in age, the former being, as stated in a previous note, probably Cambrian, the latter Triassic.

rocks are actually present in the Rocky Mountains; the mountains on the western side showing a pile of stratified deposits more than 7,000 feet in height. In Dr. Hector's map, in the Geological Society's Journal, (1861) Carboniferous rocks are marked as occurring in the South Kootanie Pass, but there does not appear to be any evidence for this view, as the red beds, &c., forming the mass of the rocks in that district certainly contain no fossils of Carboniferous or any other age. The Carboniferous rocks of the Kootanie Valley north of the Tobacco Plains, in addition to their very argillaceous character, are only conformable to the Kootanie slates in amount of dip and not in direction. The great outlier of the Flathead Valley, which is the nearest mass of Carboniferous rocks to the main chain of the Rocky Mountains, is markedly unconformable to the red beds on which it rests, is very compact and uniform in composition, and is of deep-water origin, presenting no indications of concretionary structure, false-bedding, or ripple-marked surfaces, all of which are seen in the concretionary limestones of Chief Mountain Lake.

Probable age of slaty series.

As to the age of the slaty rocks, it is impossible at present to form a positive opinion. In Dr. Hector's map, the Kootanie slates are assigned to the Huronian period, probably from the fact of their containing no fossils. Sir W. E. Logan has also (in conversation) suggested that probably most of the western beds are of that age. By comparison of the collection of Canadian rocks made by Dr. Sterry Hunt, of the Canadian Survey, now placed in the Museum of Practical Geology, with that of the North American Boundary Commission, the following points of resemblance and difference have been obtained:—

1. The gneiss of the Spokan strikingly resembles the typical Laurentian gneiss of Canada, both being very coarsely crystalline and porphyritic with red felspar. The presence of garnet crystals is also common to the Canadian specimens and those from the great bend of Kettle River. On the other hand, the grey porphyritic gneiss of Osoyoos Lake, and the finely laminated variety of the same rock from Moodie's prairie, are conditions that are not represented in the Canadian collections.

Comparison with Huronian.

2. The Huronian series of Canada is mostly composed of quartz-rocks, while the supposed beds of that age on the Pacific side are principally slaty. In some cases, however, as in the Similkameen Valley, they are sufficiently silicious to be only distinguishable from quartz-rock by their slaty structure and dark colours.

3. The interstratified greenstones of the Rocky Mountains are very much like those that occur in a similar manner among the Huronian rocks of Canada, and do not at all resemble those found under similar circumstances in the Lower Silurian rocks.

4. The manner in which micaceous hæmatite occurs as a component of the red beds of the Rocky Mountains is to a certain extent paralleled in the itabiarite, or slaty rocks of Canada, which are in places entirely composed of that mineral. These latter are, however, of Lower Silurian age.

The following are the estimated thicknesses of some portions of the metamorphic rocks in those areas in which it is possible to give them:

1. Schweltza to Chilukweyuk Lake, black slates and thick limestones about 24,000 feet, estimated at an average slope of 10° for twenty-eight miles.

2. Western limb of the Colville synclinal, from the Kettle Falls quartz-rock to the top conglomerates, about 14,000 feet. Estimated at an average of 30° for eight miles. Probably with the thickness of the black and green slates below them, which are contorted, the amount of these beds is equal to those in the Chilukweyuk Valley.

3. Kootanie slates from Mooyie River to the concretionary limestone at the second crossing, 15,000 feet. This is a very rough estimate obtained by prolonging the curves of contortion obtained from the observed dips. It is very probable, from the rapid change in the dip which occurs near the middle of the valley, that there are dislocations of the beds in this area.

4. Concretionary limestones red beds and dioritic lavas, about 2,200 feet, an estimate obtained from the mountains of the South Kootanie Pass.

Tertiary series. *Tertiary deposits.*—The most considerable deposit of fresh water beds of Tertiary age occurring within the basin of the Columbia, is that seen at the confluence and in the valleys of the two branches of

Vermilion Forks. the Similkameen River at Vermilion Fork.* They are coarse sandstones made up of very slightly worn detritus of the neighbouring Ashtnoulou granite, above which are beds of fine white sandstone containing twigs and fragments of the wood of coniferous trees, and earthy carbonaceous shale or imperfect coals, containing plant remains and masses of retinite or amber similar to those seen in the Cretaceous coal of Nanaimo in Vancouver Island. The dip of these beds in the Tulameen Valley, at the Forks, is about 8° in a north-east direction. No other Tertiary beds are seen in the Similkameen Valley below this point.

Kettle River. In the Kettle River Valley, about eleven miles east of Rock Creek, another patch of supposed Tertiary deposits is exposed on the north side of the river by an accidental slip of the covering gravels, in a place where the bank has been cut down to form a waggon road. The

* See Report of Progress, 1877-78, p. 129 B.

rock—which contains carbonaceous fragments—is a coarse shaly sandstone made up of the waste of a felspathic rock, probably furnished by one of the intruded porphyries in the adjacent metamorphic rocks. The height of the section is about twenty feet. The beds dip 60° south-east, and are exposed for a clear length of about fifty yards, when they are completely hidden by the superficial deposits. It may, therefore, be supposed that these rocks are present over a considerable portion of the Kettle River Valley, although hidden by deposits of a more recent period. No Tertiary rocks are seen in the Columbia Valley in the neighbourhood of Fort Colville.

Spokan Valley.

In the Spokan Valley, on the eastern face of the low pass that comes from Chemikane, a small outlier of sandstones is seen about 300 feet above the river. The sediment appears to have come from some distance, as it contains small rounded and angular grains of quartz and flakes of clay slate and mica. The cementing material is carbonate of lime. This outlier is very small as the rock is only slighly coherent and has in great part been decayed by the action of the atmosphere.

Another fragment of loosely coherent sandstone is found on the Spokan River, close to the mouth of the Little Spokan. It is made up of the debris of the adjacent coarse rotten granite, and scarcely differs in appearance from the rocks from which it has been derived except by the presence of irregular planes of stratification.

Superficial deposits.

Superficial Deposits.—The superficial deposits of the Fraser River and its tributaries near the sea, are principally derived from the redistribution of the blue boulder-clay of the northern drift period. This is especially the case in the Chilukweyuk Valley, where blue clay hills, with an occasional thin coating of coarse granitic gravels, form secondary ridges bounding the river and rising to a height of 400 to 600 feet. In Vancouver Island, about 200 feet of sand and gravel, getting coarser in the higher beds, is found resting on the eroded surface of the boulder-clay. These gravels are in many places covered by raised beaches made up of fragments of broken shells exactly resembling those forming the modern beach. They are found close to the shore at heights varying between six and ten feet above the present high-water lines. Further inland they are seen at higher levels up to about fifty feet, at a distance of nearly a mile from the present shore line. At New Westminster, raised shell beaches are found in a similar position, capping gravels and clay cliffs about thirty feet above the river. Boulders of grey syenite are found in great numbers at New Westminster and Point Roberts. On the western face of the ridge dividing Schweltza Lake from Sumass, there are a few boulders of a jaspidious and serpentinous rock which have their outer faces polished. They are perched on the hillside about 500 feet above the prairie. Probably many

Vicinity of the coast.

similar blocks are scattered along the face of the hill, but they cannot be seen from a distance on account of the thick forest which prevails.

Columbia Valley.

In the valley of the Columbia, and in those of its principal tributaries, the gravels bordering the rivers rise to considerable heights on the flanks of the bordering mountains. They are usually arranged in steep flat-topped terraces. At the mouth of Methow River, a stream which falls into the Columbia about four miles below the confluence of the Okanagan, there are thirteen principal lines of terraces, the greatest difference of height between any two being about one hundred and twenty feet. The total height of the whole series is about 1,000 feet. The individual terraces are rarely continuous at the same level for more than 400 or 500 yards without breaking down into smaller or secondary terraces. On the Okanagan River, which flows through the widest valley in the country, measuring in places about twelve miles from cliff to cliff, the terraces bordering the river up to about 200 feet above it, are often from two to three miles in breadth and continuous at the same level for eight or ten miles. These great flats are usually impregnated to a considerable depth with alkaline salts. There are a few small lakes upon them in the spring time, which later in the year are dried by the sun, leaving a white crust of carbonate of soda.

Terraces.

In the widest part of the Similkameen Valley, broad terraces are also seen on the left bank of the river. Near the Ashtnoulou the gravel banks are steep, narrow, and slope at a small angle down stream. They are only seen in the hollows between projecting points of rock and are strikingly like railway embankments. In the Columbia Valley, at Fort Colville, in addition to well marked lines of terraces bordering the river, traces of older ones are visible on the right bank up to a height of nearly 1,800 feet above the present water-level. The lower ones and those bordering the plain on which the Hudson Bay Company's establishment is built, are formed of a finely laminated marl filled with nodular concretions, some of which assume the very unusual forms of crescents and perfect rings. This clay is usually only exposed at low levels, and is covered by a coarse gravel made of fragments of slaty and crystalline rocks, above which is a coating of blown sand. At the river-level the blown sand is from four to eight feet thick, forming a smooth surface, but on the left side of the valley, near the Kettle Falls, about 250 feet above them, there are curious indications of old sand dunes, the surfaces of which have become compacted and are now overgrown with large trees, but the steep-sided gullies in the drift hillocks are still plainly discernible.

The frontal slopes of the gravel terraces at Colville, are continually undergoing alterations from the action of the atmosphere. The greatest amount of modification is effected by the sliding of great masses of

snow over them during the spring thaws. A few transported boulders of syentic granite are seen at various points in the hills on the north side of the Colville Mill River, and in two places the rocks are faintly scored with fine irregular groovings. Their direction, as far as can be seen, is from north to south. The height of these points is about 2,000 feet above the sea-level. One other instance only of ice-marking was observed. It is on the Okanagan River, about midway between Osoyoos and the mouth of the river in about the same latitude as Colville, but at a much lower level. The markings are seen on the face of a white limestone cliff. They follow the course of the valley. Glacial striation.

On the Spokan plateau several small boulders of granite are seen among the basaltic gravels about twenty miles south of the Chemikane granite hills, the nearest source from which they could have been derived. On the left bank of the Similkameen, about six miles below the Ashtnoulou, a very peculiar arrangement of the cliff-falls is worthy of notice. The cliffs, which are formed of a purple silicious slate, nearly quartz rock, are faced for more than two-thirds of their height by conical mounds of fragments. The highest is about 900 feet high. The larger masses that have reached the lower gravel terraces in the bottom of the valley, are extended in long lines along the front edge of the terrace for about 600 yards down the valley. Some of the blocks are of great size, measuring from 6,000 to 8,000 cubic feet. In the main chain of the Rocky Mountains there are a few small glaciers. The lowest is about 6,000 feet above the sea-level, but no ice-markings or transported blocks are anywhere apparent in the South Kootanie Pass. Erraties. Talus.

Auriferous gravels.—Gold is generally present in the lower level gravels of the Fraser, the Similkameen, Pend D'Oreille, Kettle and Columbia Rivers. The principal points at which workings have been carried on are as follows:—1. In the gorge of Fraser River, north of Fort Hope. 2. In the south branch of the Similkameen, near Vermilion Forks. 3. In the lower part of the Similkameen Valley, between Haynes' House and the Okanagan. 4. At Rock and Boundary Creeks, two small tributaries of the Kettle River. 5. In the lower part of the Pend D'Oreille Valley, near Fort Shepherd, and 6th, at various points on the Columbia between Fort Shepherd and Fort Colville. Gold bearing regions.

At Rock Creek the ground worked was the gravel filling the bed of the stream, the greatest thickness being about sixteen feet, with an average breadth of twenty-five feet. The claim allowed to each digger was one hundred feet, following the bed of the stream, and including the whole breadth of the valley. Three or four adjacent claims were usually worked as one adventure by the united strength of the claimants. The method of working is very simple. After Rock Creek mines.

Mode of working.

diverting the stream to one side in order to get at the gold-bearing ground, a rectangular trough of boards called a sluice is set up in an inclined position on rough stone piers, and a stream of water is kept constantly flowing through it. The gravel taken out of the bed of the stream is thrown on a rough grating made of bars of pine wood placed about two inches apart, which is fixed at the upper end of the sluice. The larger stones are kept back by the grating, and are removed from time to time by the filler, by means of a four-pronged steel fork. The floor of the sluice is lined with similar longitudinal gratings. The gold and other heavy materials fall into the hollows between the bars of the gratings where they are protected from the scour of the current of water passing over them. In some cases boards with shallow transverse notches which are filled with mercury are used in addition to and alternately with the gratings; an arrangement which is locally known as the Hungarian riffle. In order to get out the whole of the gravel it is necessary to provide some means of drainage as the hole gets deep. This is effected by a small undershot wheel placed in the free current of the exit water of the sluice, which lifts the water from a sump at the lower end of the claim, by means of a chain of buckets. The sluices are usually set up at much higher slopes than are generally employed in dressing machinery in European mines, the primary object being to obtain a rapid current and consequently power to work over large quantities of material in a short time, irrespective of the loss produced by such a method of working.

Some of the Rock Creek miners estimated the loss of gold at about half the total contents of the rough ground. The washing is carried on continuously for a period varying from three to six days according to the richness of the stuff worked, when the water is stopped off and the contents of the sluice are collected. They are of two kinds, fluid amalgam, from which the gold is obtained by filtration through buck-skin and ignition of the solid alloy of gold and mercury remaining; and auriferous black *schlich* or sand, which is cleaned from magnetite and other heavy minerals by hand-washing in a wrought-iron pan, in the usual manner. In the month of September, 1861, about 300 men were at work at Rock Creek, their average earnings were stated to be about twenty to thirty-two shillings each, daily, but in the following September the place was deserted. At Boundary Creek, about seven miles below Rock Creek, the workings were commenced a little later, but were abandoned at about the same period, all the miners being drawn away by reports of the extremely rich deposits of the Cariboo country near the head of the Fraser River, and on the Salmon River in Oregon. The diggings on the South Branch of the Similkameen were

Boundary Creek mines.

chiefly carried on by Chinamen and were also abandoned at the beginning of the winter in 1861. On the Lower Similkameen and other large rivers, the period of working is limited to the early spring and the autumn and early winter months, before and after the annual floods. The ground washed is that lying between high and low water-mark and as much of the ordinary bed of the river as can be laid bare by running out wing-dams from the shore. On the Pend D'Oreille River a considerable quantity of gold has been obtained from the small and irregular deposits brought down by the river in flood time, and lodged in the hollows on the roughened edges of the slaty rocks. The dressing machinery employed is the ordinary California cradle or rocker, in which from two and a half to three tons of rough gravel can be dressed daily. In order to collect fine gold when using the rocker, it is customary to use plates of copper covered with a thin film of mercury, or when this is not obtainable to cover the tail-board of the rocker with silver half-dollar pieces amalgamated in a similar manner. In the Pend D'Oreille Valley, during the season of 1858, the gravel terraces lying above the present high-water level were successfully worked for gold, as much as £20 per man per diem having been realized by working sluices on ground about twenty-five feet above the river. On the Columbia River near Fort Colville the lowest level gravels only are worked, and even to reach these it is necessary to strip off the overlying cover of blown sand. At Hills Bar, in the gorge of Fraser River near Fort Yale, high level gravels are worked. At this place a rude stone mortar of unknown Indian workmanship was found in one of the gravel terraces, it is said at about thirty feet below the surface and about forty feet from the face of the slope. In the gold drifts of Thompson River elephant remains are found. A single molar tooth from this locality is in the possession of a surgeon in Victoria, Vancouver Island.

Lower Similkameen.

Pend D'Oreille River.

Other auriferous localities.

The gold dust obtained on the Fraser River is principally of a low degree of fineness, about $\frac{860}{1000}$ representing the average of the assay value, or percentage composition 86 gold, 10 silver, 4 copper and oxidisable substances. The alloy is principally silver and copper. The samples from the higher parts of the Fraser Valley are associated with osmiridium, platinum, rutile, magnetite, black spinel and garnet. The three latter minerals are often found in distinct but minute crystals. The scales of gold are, in the southern localities, mostly of small size, rarely exceeding one tenth of an inch in diameter, and are generally very much smaller. This very fine variety is called by the miners "float gold," and can only be collected with great difficulty, as it particularly liable to be carried away by a rush of water, instead of sinking, owing to the large surface of adhesion presented by the scales as com-

Character of the gold.

pared with their individual weights. Another and more formidable source of loss, lies in the fact that many of the scales are covered by a coating of rust, which protects them against the solvent action of the mercury when amalgamation is used.

Relations to rock series.

There does not appear to be any direct relation between the mineral character of the rocks forming the walls of the valleys, and the greater or less abundance of gold in any of the localities noted above; thus, in the lower diggings on Fraser River, the country is formed of gneiss and granitic rocks, at the Chinamen's diggings, near the Vermilion Fork, of Tertiary or Cretaceous clays and sandstones; at Rock Creek and the lower part of the Similkameen of black slate; and at the mouth of the Pend D'Oreille of the black slates, limestones and syenitic greenstones of the Colville series. This fact, together with the generally small size of the scales of gold obtained, leads us to suppose that most of these gravels are only the remains of older drifts lying further to the north, a supposition that is well born, out by the increase in size of the fragments of gold in higher latitudes. Thus the gold dust of the Cariboo country, in latitude 53° north, is made up of coarse lumps often $\frac{1}{2}$ to $\frac{3}{4}$ of an inch in diameter and equal in size to the bulk of the selected nuggets obtained in the preceding years at Quesnel River and at points near the head of Thompson River. It is also difficult to suppose that the gold can have been derived from the slaty rocks, as the quartz veins in them are few and insignificant, unless it had resulted from the decomposition of the contained iron pyrites, which is not a very probable source.

Argentiferous galena.

Very pure galena of a moderately argentiferous character occurs on the Kootanie Lake, yielding by assay 83 per cent. of lead with 20 oz. of silver to the ton. The specimens were obtained from Mr. A. C. Anderson, of the Hudson's Bay Company at Victoria. The locality is, however, practically inaccessible, the only means of approach being by the Kootanie River, which is barred by falls and rapids near the mouth and can only be navigated by light canoes.

Silver at Hope.

At Fort Hope a large quartz vein has been found on the right bank of the Fraser River. It contains at the outcrop a small quantity of iron and copper pyrites associated with an earthy black copper ore (probably resulting from the decomposition of an argentiferous fahlerz) some of which yields about 40 ounces of silver to the ton. A level was commenced on this lode in September, 1861, but was subsequently abandoned, owing, I believe, to the high price of driving, from the hardness of the ground. In the Harrison River Valley, Dr. Forbes, R. N. reports the presence of traces of silver in many places, but neither the native metal nor any of the known precious ores of silver had been discovered in quantity up to the end of 1861. Many so-called silver ores

were brought down to Victoria from this locality during the autumn of 1861 by a travelling Mexican miner. The bulk of the specimens, however, were ordinary crystalline rocks, such as hornblende slate with a little iron pyrites, hornblende crystals, &c., and as a silver mania prevailed in the town at the time, it was difficult to persuade the would-be speculators, even by actual assay, that these so-called ores were utterly worthless.

Basaltic Plateau.

Basalts of the Columbia.—The table-land that extends southward from the Spokan River down to the Dalles of the Columbia, and eastward from the inner face of the Cascade Mountains nearly to the head of the Snake River, is entirely covered with volcanic substances, basaltic and trachytic lavas, tuffs and conglomerates. The most abundant of these rocks is a species of scoriaceous basalt which extends, without any marked change in mineral composition, over a space measuring 220 miles by 150 miles, or about 33,000 square miles. The best sections in this country are those seen on the road from the Dalles to Fort Okanagan* by the right bank of the Columbia, the basalts and ashes being well seen in the transverse ridges dividing the valleys of the Nachess, Yakima and other tributary streams. At the Dalles, the white chalk-like ashes are seen above the basalt, the lower beds containing thin bands of hard red conglomerate. These white beds contain remains of diatomaceæ, but it does not seem to be quite clear whether they are of fresh-water or marine origin. On the right bank of the Columbia the ashes form a grassy hill about 2,500 feet high, the higher beds containing fragments of opalized wood, which are thickly strewn over the surface. The conglomerate beds at the bottom of the series contain large fragments of a grey trachytic porphyry often several tons in weight. On the high ground between the Yakima River and the Columbia, at Wenatchee River, the basalt and ashes together make up a mountain mass 7,000 feet in height. This is probably about their maximum thickness. On the Spokan plateau, the basalt forms a gently inclined plane between the Spokan Valley and Walla Walla, having a southerly slope of about one in 500. The sections exposed in the ravines and water-courses show a nearly horizontal or slightly undulating stratification, combined with an irregularly columnar structure. Where the beds are undulated, the columns are usually arranged in a radiated manner, the rays diverging from the inner to the outer face of the curve. The white ashes are seen on the lava-plain about half way between the Spokan Ferry and Walla Walla, forming rounded outlying hills from 200 to 500 feet in height. They are entirely covered with grass, so that the rock can only be obtained by digging. It resembles the

Section at the Dalles.

Thickness of volcanic materials.

* See Geology of Central Washington Territory by Gibbs in Pacific Railway Reports. Vol I. and Geology of U. S. Exploring Expedition by J. D. Dana.

white ashes of the Dalles, but usually contains angular fragments of the underlying basalt. The presence of these white ash outliers, as well as the basaltic ones noticed in the Spokan and Chemikane valleys, furnish, as well, a measure of the enormous amount of denudation to which this country has been subjected in recent times. The basalt is of comparatively modern date, as it overlies Miocene Tertiary strata at Walla Walla and it is evident that the valleys of the Spokan and Chemikane had been excavated before its eruption, as the outliers are found at the lower levels as well as high up on the hillsides. The presence of marine infusoria in the white bluffs, necessitates a great amount of subsidence for their deposition—at least 2,500 feet at the Dalles—and it is probably during re-elevation that they have been removed from the Spokan plateau and that the terraced gravels of the higher valleys have been arranged in their present forms. After the removal of the ashes, the denudation of the basalt has probably been effected by the streams, as it is easily decayed away owing to its columnar structure. Very fine examples of these valleys of erosion are seen on the Yakima and Untenun (?). The latter, a small brook only about ten feet wide, is bounded by vertical walls about 500 feet high. Many old river courses are also found on this rock. The most important is the well-known Grande Coulée or old channel of the Columbia, which is fifty miles long, eleven wide at the north end, and bounded by nearly vertical cliffs 800 to 1,000 feet in height.

Erosion.

Courses of rivers.

There is one curious feature in the eastern tributaries of the Columbia which is deserving of special notice. The Colville Mill River, the Pend D'Oreille and the Kootanie all flow in a generally northerly direction for the latter part of their courses, and force their passages into the Columbia over great obstacles;—thus the Colville Mill Stream has a fall of seventy feet over rocks about two miles above its mouth, the Pend D'Oreille presents a succession of step-like falls and rapids for about five miles above its month, and the Kootanie is not navigable at its northern end from similar obstacles. The watersheds between these streams, on the other hand, are almost imperceptible, not being marked by transverse rock-ridges or any salient feature in the north and south valleys. It may, therefore, be urged with a fair show of probability, that at some former period the two former rivers, and perhaps, also the latter, discharged their waters through the Spokan Valley, which, from its great size, far exceeding that of the Columbia at Colville, appears to have performed a more important office in the drainage of the country in former times than it does at present.

Mr. Gibbs, of the United States Commission, has suggested the probability of a similar change of drainage having taken place in the

Okanagan Valley by the diversion of waters which now discharge by the Fraser and Thompson Rivers. Such a change would account for the great size of the valley, which is now occupied by a comparatively insignificant stream.

Terraces.

The question of the probable origin of the terraced gravels of the Columbia, as well as those of the Sacramento River is discussed in the geology of the U.S. Exploring Expedition, pp. 171-2. Prof. Dana, however, does not appear to have been aware of the great height of the terrace-levels in the higher part of the Columbia Valley.

Palæontological note.

LIST OF FOSSILS FROM THE CARBONIFEROUS OUTLIER IN THE FLATHEAD VALLEY, BY J. W. SALTER, ESQ., F.G.S.

Retzia Verneuiliana (Hall Geology of Iowa, pl. 23, fig. 1.)
Rhynchonella mutata (" " " pl. 23. fig. 2.)
Athyris subtilita.
" (allied to *A. squamosa.*)
Spirifer Keokuk (Hall Geology of Iowa, pl. 24, fig. 4).
" *setigerus ?* (Hall Geology of Iowa, pl. 27, fig. 4).
Productus semireticulatus.
" (a small spiny species like *P. aculeatus* or *P. spinulosus*).
Flat bryozoon (resembling *Ptilodictya*).
Pleurotomaria.
Euomphalus (impression of a small form resembling *E. carbonarius*, probably young of *E. latus.* (Hall Geology of Iowa, pl. 12, fig. 7*a*).
Archeocidaris (spine).
Actinocrinus (stems).
Platycrinus (coral plate).
Lithostrotion, *Zaphrentis*, *Aulophyllum* } Fragments, mostly transverse sections.

Most of the fossils are very fragmentary, the best being procured from weathered blocks of a very hard and compact grey limestone. The *Retzia* at the head of the list, has been identified by Mr. Davidson, but with a mark of doubt, as there is a depression down the centre of the dorsal valve, and the foramen and beaks are larger, so as to give a somewhat more oblong shape to the shell than that of the figured specimen from Iowa. The striations agree closely. The *Spirifer* referred provisionally to *S. setigerus*, is a small transverse species, smooth, with a very slightly raised sinus and numerous short interrupted impressed strie. Hall's *S. setigerus*, ? has no defined sinus, whereas it is well defined in the specimen from Flathead Valley. The striation is, however, much the same in the specimens from both localities.

Only three specimens were obtained from the limestone in the Kootanie Valley north of the Hudson's Bay Company trading post. They are only fragments, such as a spirifer (like *S. alternatus*) with a very slightly raised, but well defined sinus. *Rhynchonella*, a large coarsely-ribbed species. *Streptorhynchus* resembling *Orthis robusta* (Hall, Geology of Iowa, pl. 5, fig. 28).

In accordance with a very general character of American mountain limestone fossils, all the specimens are of small size. Crinoids are remarkably rare.

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Explanation of Colours.

- Miocene (Chiefly volcanic)
- Miocene (Sedimentary)
- Cretaceous.
- Palæozoic (General colour.) Includes Nicola Group of Geol. Survey Reports and Triassic at Summit of Rocky Mountains
- Palæozoic (Metamorphic.)
- Archæan (probably.)
- Igneous Rocks (Acidic.)
- Igneous Rocks (Basic.)

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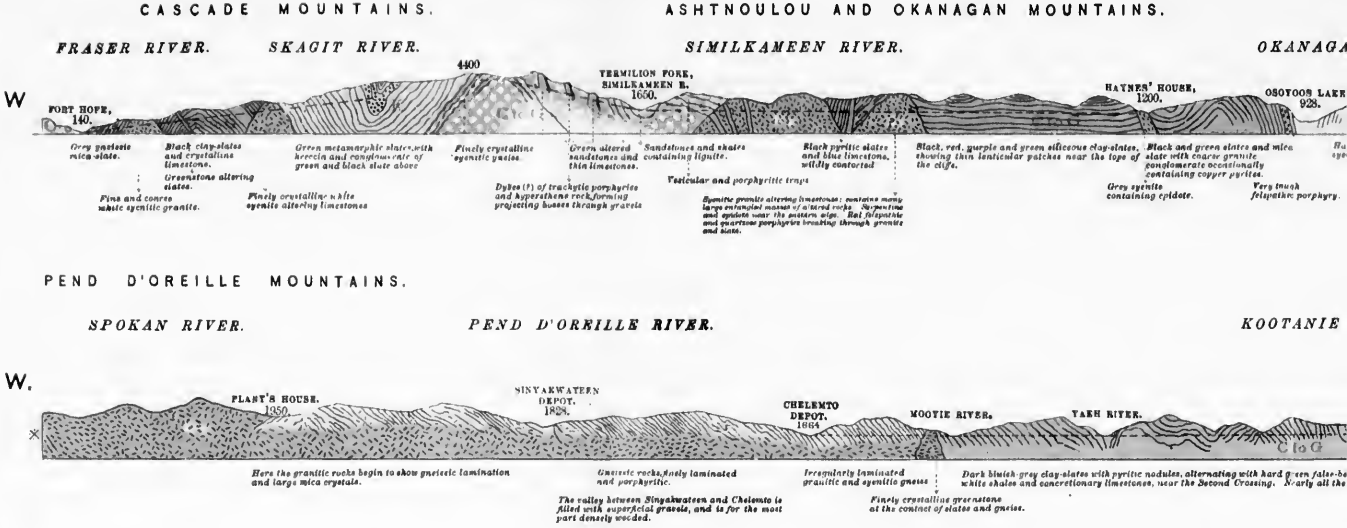
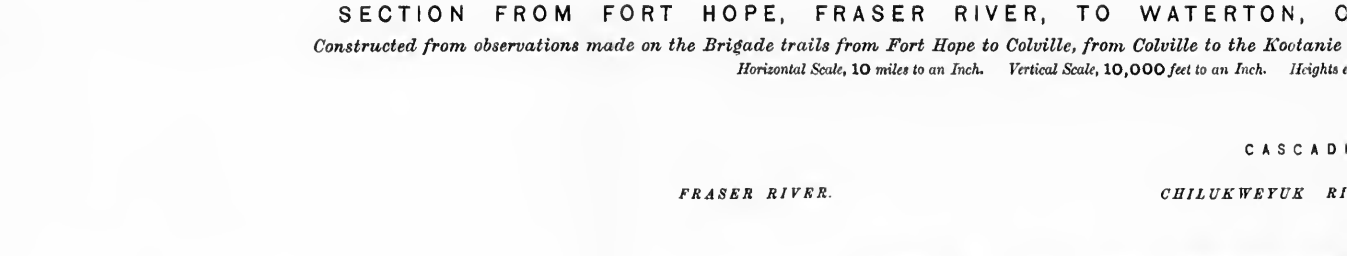


SECTION FROM FORT HOPE, FRASER RIVER, TO WATERTON, C

Constructed from observations made on the Brigade trails from Fort Hope to Colville, from Colville to the Kootanie

Horizontal Scale, 10 *miles to an Inch. Vertical Scale,* 10,000 *feet to an Inch. Heights*



SECTION FROM POINT ROBERTS, ON T

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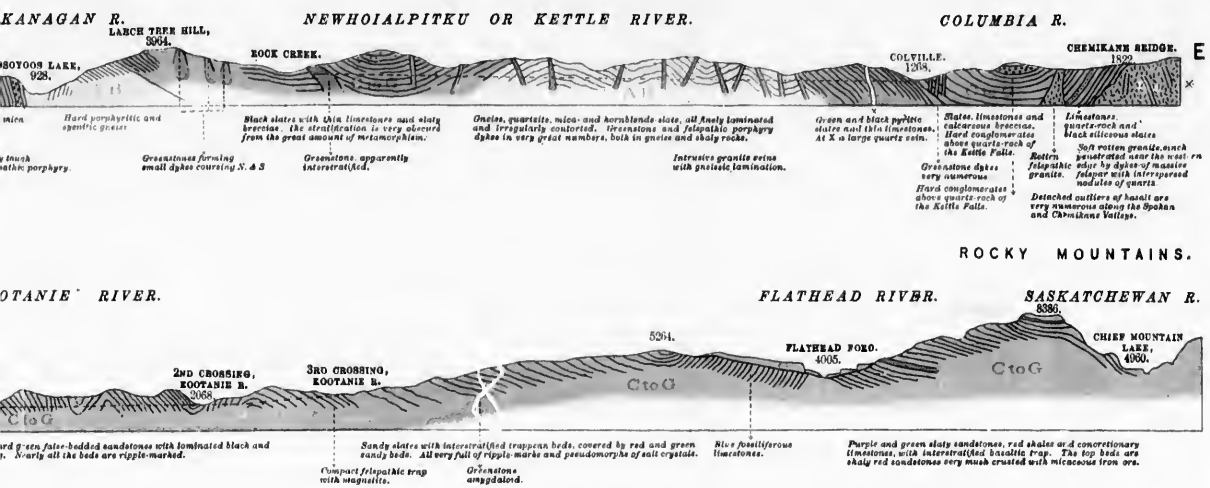
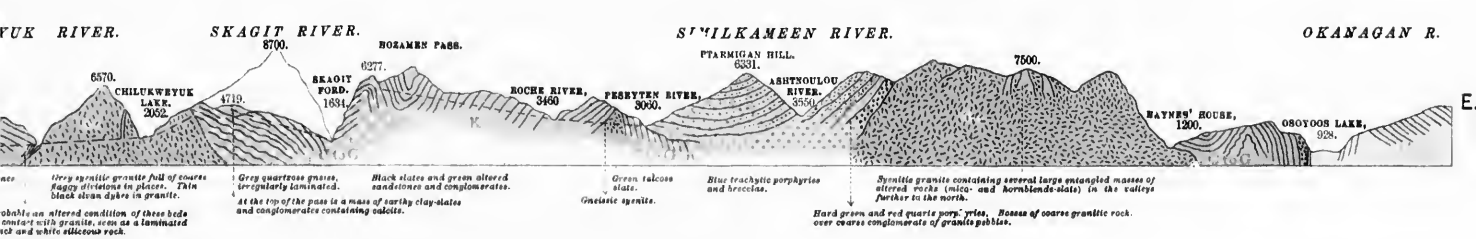


ON, OR CHIEF MOUNTAIN LAKE, ON THE BUFFALO PLAINS.

Kootanie Post and the South Kootanie Pass of the Rocky Mountains. Projected into an East and West Line.

Heights expressed in feet above the sea level. Broken lines represent water-courses.



ON THE GULF OF GEORGIA, TO OSOYOOS LAKE.

NG REPORT BY H. BAUERMAN, ESQ., F. G. S.

THE BURLAND LITHOGRAPHIC CO MONTREAL