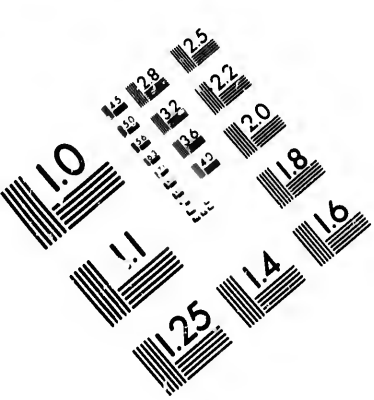

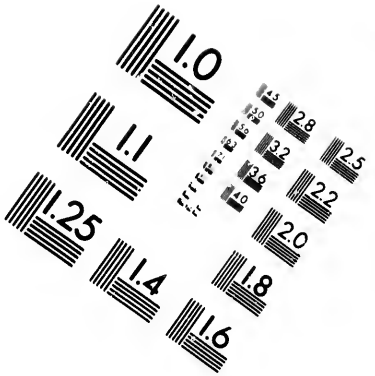

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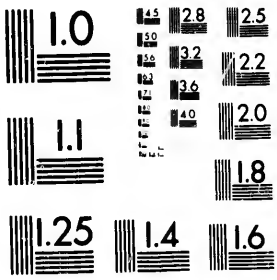

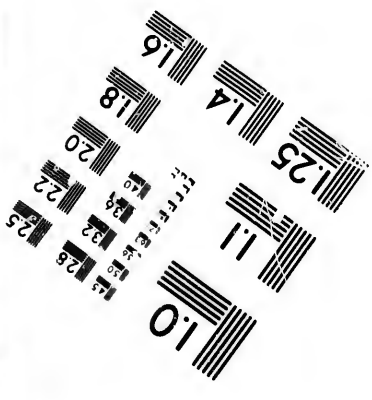

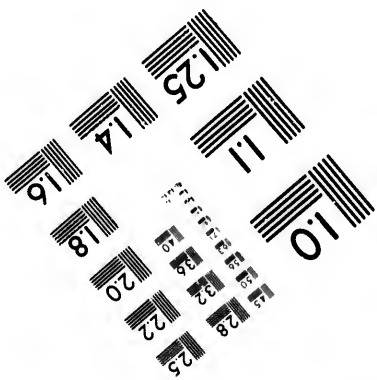

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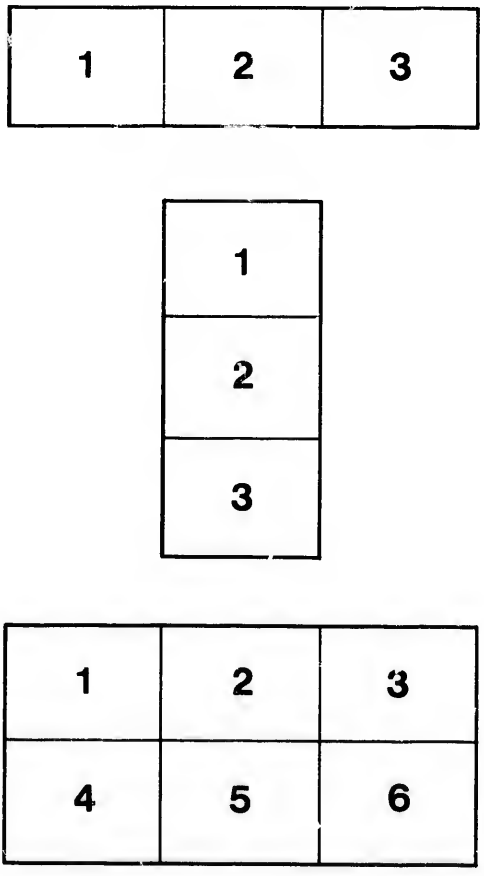


[*From the* Quarterly Journal *of the* Geological Society *for February* 1878.]

On the Superficial Geology *of* British Columbia.

By George Mercer Dawson, Esq., D.Sc., F.G.S., Assoc. R.S.M., Assistant Director of the Geological Survey of Canada.

[Plate V.]

Contents.

The following notes give, in a summarized form, the chief observed facts of the Glacial period in British Columbia, obtained during the season's work in that province on the Geological Survey of Canada. They are offered as an extension to the Pacific coast of the observations carried in a former paper* to the Rocky Mountains.

1. Outline of Physical Geography.

For the purposes of this paper the eastern boundary of British Columbia may be regarded as coinciding with the Rocky-Mountain range, from which the province stretches westward to the Pacific, including Vancouver and the Queen-Charlotte Islands. Southward, the 49th parallel separates it from Washington Territory and parts of Idaho and Montana. To the north the Province-line is drawn on the 60th parallel. The area of British Columbia is roughly computed at 330,000 square miles, its extreme length, from corner to corner, being about 900 miles (see Map, Pl. V.).

The Rocky Mountains, many peaks in which surpass 9000 feet, are defined to the south-east by a remarkably deep and straight valley, in which are considerable portions of the courses of several of the largest rivers of the country. South-westward, beyond this great valley, is a second and broader mountain region, called by various names in different parts of its length, but which may be generally named the Selkirk or Gold range. Many of the summits of these mountains are scarcely less in altitude than those of the Rocky Mountains; and in many places they appear to be broad and plateau-like,

* Quart. Journ. Geol. Soc., Nov. 1875, vol. xxxi. p. 603.

with comparatively narrow intervening valleys. Nearly parallel to these two great ranges is the Coast or Cascade range, in which the average altitude of the higher peaks is between 6000 and 7000 feet, while some exceed 9000 feet. A fourth range may be traced, in a partly submerged condition, in the mountains of Vancouver and the Queen-Charlotte Islands. Between the Coast range and the Selkirk or Gold range lies the great interior plateau of British Columbia, with an average width of 100 miles, and a mean elevation of about 3500 feet. Its height, on the whole, increases to the south, while northward it falls gradually towards the cluster of great lakes, and the low country of the Peace-River valley. This plateau region has over a great part of its area been covered by wide-spread flows of basalt and other igneous rocks, in the later Tertiary period. It is now dissected by deep and trough-like river-valleys, into most of which water standing at 3000 feet above the present sea-level would penetrate, dividing its surface into a number of islands. In some places the plateau is pretty level and uniform; but usually it is only when broadly viewed that its character is apparent. The best published maps of British Columbia but imperfectly indicate even its grander physical features; but I believe, from information received, that the north-western end of the plateau is blocked by high mountainous country, formed by a coalescence of the three great ranges in latitude 55° 30'*. Nearly coincident with the 49th parallel is a second transverse mountainous zone, formed in a similar way, which may be considered as bounding the plateau to the south, though traversed by several great river-valleys, of which that of the Okanagan, in longitude 119° 30', is the deepest.

No modern glaciers have been seen in the Rocky Mountains, near the 49th parallel, though much snow lies among the higher peaks, and northward, about the sources of the Saskatchewan, true glaciers are found. It is probable that some glaciers may also exist in parts of the Selkirk range. In the Coast range glaciers abound from the 49th parallel north-westward. To the south they are summit-glaciers, but northward, about latitude 51°, fill long valleys, and still further north are reported as coming down nearly to the sea-level in some places.

Three main structure-directions serve to account for the greater part of the depressions of the surface now occupied by rivers, lakes, and the fjords of the coast:—1, a north-westerly and south-easterly series of hollows, dependent on the general direction of folding of the rocks of the country; 2, a north and south, or meridional series, due, where I have had the opportunity of examining it, to systems of parallel cracking; 3, an east and west, or transverse series, occupied by many lakes and rivers, but the cause of which has not yet been determined. There are also traces, indicated by valleys in some parts of the map, of structure transverse to the main direction of folding. It is, of course, not intended to affirm that the causes mentioned produced these features directly, but merely that certain structural lines of weakness

* Called the Peak Mountains on old maps.

thus indicated were those on which eroding agencies afterwards shaped the country.

The arrangement of the lakes in British Columbia, and their long river-like forms, are very remarkable, suggesting at least the action of glacier ice, which, though it may possibly have formed rock-basins in some places, has generally, I believe, been instrumental in causing lakes by the arrangement of the drift-material in preexisting hollows. To the mode of formation of lakes in British Columbia I hope, however, on a future occasion to return, when more information may have been collected.

The fjords and passages of the coast, while quite analogous to those of Scotland, Norway, and Greenland, probably surpass those of any part of the world (unless it be the last-named country) in dimensions and complexity. They also appear to differ from those of Scotland and Norway in their narrower and more parallel-sided forms, and in the height of the walls which bound them. They are, no doubt, the valleys of rivers worn out when the coast stood at a greater elevation, and are all continued inland by deep gorges, in which streams still flow. The upper end of each inlet usually shows a small area of low swampy land, formed of material brought down by the river. It is continued seaward by a shallow flat for a short distance, and then dips steeply down, like the front of a terrace, into deep water. The arrangement of the material shows that the waters of the sea have long maintained nearly their present level. In following the inlets down they are found to be very deep, often as much as 150 fathoms, and sometimes over 200, though in most cases they are marked on the charts as 50 or 100 fathoms and no bottom. On arriving at the mouth of the fjord the water shoals—just as described in Scotland by Mr. Geikie. This I believe to be caused by the banking-up of sediment by the tidal currents, which run with great fury up and down the coast, but flow with decreased power into the sheltered fjords. There may be instances of true rock-basins; but the exact evidence required to put this question beyond doubt has not been obtained. In view of the deep and narrow chasms or cañons, in which many of the western rivers now run, and the difficulty, even if the whole outlet of a fjord is seen to be over rock, of proving the non-existence of drift-blocked channels in other directions, it is well to be cautious in the assumption of deep rock-basins when other causes quite competent to the explanation of the facts are at hand.

An elevation of the coast of British Columbia to a height of 150 feet above its present level, would now convert the inlets of the western part of Vancouver Island into a number of deep lakes, lying among the mountains, with their lower ends stretching out on a level, as a gently sloping plain of detrital material, over which their rivers would seek the ocean. The analogy of this state of affairs to that now obtaining with the strings of lakes following the slopes of some of the mountain-chains of the interior, will be evident from a glance at the map.

The highest mountain at Vancouver Island (Victoria Peak) attains

an elevation of 7484 feet, while there is a considerable mountainous area in the centre of the island, which surpasses 2000 feet in average altitude.

2. Vancouver Island and the Coast.

a. Glaciation of Rock-surfaces.

The glaciation of the rocks in the vicinity of Victoria, Vancouver Island, is so well marked, and presents itself so immediately to any one arriving in the locality, that it has been mentioned by most writers on the country, and has been made the subject of remark by several geologists*. The rocks protruding from the soil, and projecting along the shores, are generally compact, coarser or fine-grained diorites and felsites, bedded or intrusive, which, while offering great resistance to abrasion, are well suited to preserve forms impressed on them. The direction of the ice-markings here has been variously given—a circumstance arising, I believe, chiefly from a want of attention to the magnetic variation, and the isolated character of the observations made. I am now, however, in a position to state, as the result of several hundred observations of the course of the striation, that but one general direction of movement is indicated in the whole south-eastern peninsula of Vancouver Island, the average bearing of which is about S. 11° W.†, and from which, except under certain special local circumstances mentioned below, there is seldom a departure of more than a few degrees on either side. At Sooke River, fifteen miles west of Victoria, the only distinct grooves seen have a course S. 18° W., which agrees closely with the above average direction, but is also parallel with that of the hills bounding the river valley. Grooving and striation are equally apparent at all elevations in the neighbourhood of Victoria, from low-water mark upward. The summit of Mount Douglas, or Cedar Hill, a rocky eminence 696 feet high, is quite distinctly glaciated, the direction being, as nearly as can be ascertained, due south. On looking northward from this hill on the wide expanse of the Strait of Georgia, no higher land appears for about fifteen miles, and then only as summits on scattered islands. Suitable localities for observation at greater altitudes are wanting in the vicinity; or ice-work could no doubt be traced to a yet higher level.

Rocks which, from their prominence, have been exposed to the full force of the ice, are generally grooved and fluted in the most remarkable manner (fig. 1), have been worn into boat-bottomed shapes, marked with parallel hollows often a foot or more in depth

* The glaciation of the southern part of Vancouver Island has been referred to by the following gentlemen:—H. Bauerman, "On the Geology of the South-eastern part of Vancouver Island," Quart. Journ. Geol. Soc. vol. xvi. p. 198. C. Forbes, M.D., 'Prize Essay on Vancouver Island,' 1862. R. Brown, "On Supposed absence of Drift on the Pacific Slope," Am. Journ. Sci. and Arts, 1870. George Gibbs, "On Physical Geography of the North-western Boundary of the United States," Journ. Am. Geog. Soc. 1874. A. R. C. Selwyn, "Report of Progress, Geol. Survey of Canada," 1871–72, p. 52.

† This and other bearings given are with reference to the true meridian.

and width, and show in all respects traces of having been subjected to the action of a great glacier. Where rocky hills are remarkably abrupt, their northern slopes only have received the full force of the

Fig. 1.—*Ice grooved Rocks at Finlayson Point, Victoria, Vancouver Island.*

ice, which, borne up to some extent by their summits, has marked the southern slopes slightly and irregularly. A comparatively slight decrease in steepness of descent has, however, been sufficient in other cases, to enable the ice-mass to follow the contour of the rock, impressing the southern slopes with grooving almost as well marked as that of the northern. This is generally the case with the rocks forming the southern shore of the peninsula, where the furrows may be traced running regularly down beneath the sea. Here there is evidence of great lateral as well as downward pressure, vertical and nearly vertical surfaces being frequently as well polished as horizontal ones. Instances where rocks have actually been fluted and undercut at the sides are not uncommon (fig. 2). Another circumstance noticed in many places, dependent, no doubt, on combined vertical and great lateral pressure, and consequent "plasticity" of the ice, is the manner

in which it has been made to fit to the rock-surfaces. Where a sudden drop of a few feet occurs to the south, a detached tongue of ice has moved obliquely beneath the general sheet on the lower side

Fig. 2.—*Sections transverse to Direction of Glaciation of Rocks undercut and fluted.* (Scale 5 feet to 1 inch.)

a. Coast-section between Victoria and Esquimalt.
b. West of Ogden Point, Victoria.
c. Esquimalt, face of cliff, 40 feet above sea-level.

[These and the following figures are facsimiles of the author's drawings.]

of the step, for some distance, till again carried onwards by the main flow. In one case, at Finlayson Point, divergence from the chief direction amounts to forty degrees. This point is on the west side of a large bay, continued northward by low ground, which must have formed the channel for a great mass of ice. The oblique grooves are so well worn as to be quite semicircular in the outline of their transverse sections. Here is also noticeable a very general tendency to slight divergence of furrows at the northern ends of rock-masses, and convergence round points to the south. In a few cases well-worn furrows showing this convergence are seen to be crossed at a small angle by comparatively light scratches, showing a "falling-off" of a few degrees from the normal course, due to the motion of the last portion of the retreating edge of the ice-mass, when, though forward movement still continued, lateral pressure had almost ceased. Selective erosion is a well-marked feature; and quartz sand being

the hardest cutting-material available to the ice, portions of rock containing quartz in their composition show great powers of endurance compared with those consisting of felspar and hornblende only, though the latter may be quite as compact. Instances where quartzose intrusions protect long southward-pointing ribs or pencils of diorite are not rare.

There appears to be no escape from the conclusion that a glacier swept over the whole south-eastern peninsula of Vancouver Island at some time during the Glacial period; and on consideration of the physical features of the country it becomes apparent that the entire Strait of Georgia between the island and the mainland must have been filled with a great glacier, with a width, in some places, of over fifty miles, and a thickness near Victoria of *at least* considerably over 600 feet. With all this, however, there has been very little general wearing-down of the rock-surface of the country; all its main features, and, in many cases, even the most minute, are clearly of preglacial origin. The valleys generally follow bands of limestone and softer schistose and shaly beds, and run as often transverse to, as parallel with, the direction of glaciation; and besides the general forms of the smaller hills, little rocky knolls and projecting points of rock, while worn and rounded to the north, preserve rough unpolished southern faces. This feature is more marked than I have elsewhere observed, and would seem to indicate, even allowing that glaciers do not very rapidly abrade solid rocks, that the ice did not long rasp over this portion of the country, and possibly that it never extended much beyond this point.

Mr. George Gibbs mentions the occurrence of glacial grooving running from north-east to south-west, on San-Juan Island, in the southern part of the Strait of Georgia, which would appear to show that the glacier must have pushed southwards towards the low country of Puget Sound, while a part may also have discharged westward into or through Fuca's Strait. Glacial striation is also reported on the mainland shore of the southern part of the Strait of Georgia.

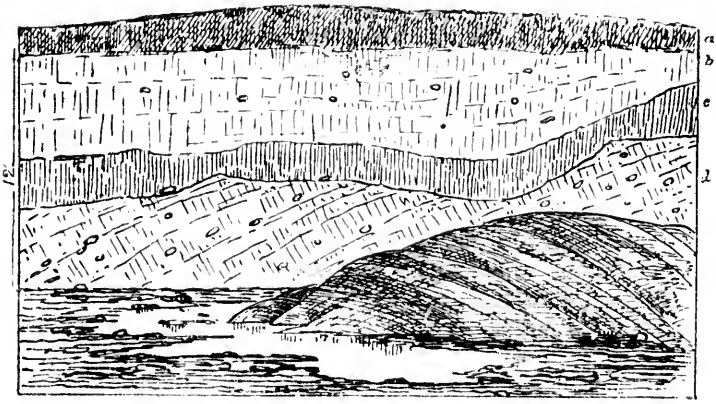
b. Superficial Deposits.

The detrital deposits overlying these glaciated rocks are of a comparatively simple character. In the immediate neighbourhood of Victoria, near the sea-level, a material which I believe to represent *moraine profonde* occurs in a few localities, as a hard mass of sandy clay and stones, wedged into crevices in the rock, or protected by its overhanging ledges. Further inland, in the valleys of the Goldstream, Leech, and Sooke rivers, and small brooks tributary to them, a very similar material forms the greater part of the drift, and rests on rock-surfaces which, though generally smoothed, have only been observed to show direction of movement in the single locality already mentioned. Those valleys are deep, V-shaped in cross section, generally surrounded by rocky hills, and often transverse to the course of the ice; and they must have formed receptacles which, in course of time, were more or less completely filled with bottom-moraine, the remnants of which I believe the material above mentioned to

represent, though possibly in some cases with the addition of pre-glacial river-gravels and alluvium. It is a very hard greyish-yellow sandy clay, crowded with subangular stones of varied origin, but generally quite small.

The ordinary deposits of the low south-eastern peninsula differ from these in being less consolidated and finer, and frequently show evident signs of stratification. The material most largely represented may be described as a hard, yellowish or pale yellowish-grey sandy clay, often having weather-stained cracks traversing it in all directions. This is frequently quite massive, and contains scattered stones and boulders, which are generally more or less rounded, and comparatively seldom show signs of glaciation, but occasionally do so very distinctly. In other places the deposit is more sandy and gravelly, and the bedding, which is often inclined, quite distinct. A very fine blue clay, which rests immediately, or with the intervention of a thin layer of gravel, on the rock-surface in sheltered hollows, is only a finer form of the same deposit, it being impossible to draw any line between this and the other classes of material. The deposits are occasionally very irregular, as though they had been stirred up by the grounding of floating ice, or some such cause; while false-bedding and appearance of water-disturbance are more frequent on points and the localities which must have been most exposed (fig. 3).

Fig. 3.—*Deposits overlying Glaciated Rocks, Victoria, Vancouver Island.*



a. Soil.
b. Yellowish-grey sandy clay.
c. Hard bluish clay, rusty cracks.
d. Sand and gravelly clay.

The drift-deposits frequently form cliffs or steep banks 30 or 40 feet in height, along the shore. Large boulders are found throughout, but are most abundant towards the top of the deposit, the clayey

portion of which generally terminates rather abruptly above, and is often surmounted by a few feet of sand, gravel, and boulders much coarser than the rest, and probably, in part at least, due to rearrangement of the lower material along a coast-line during emergence. The mounds forming Beacon Hill, and those heaped on the north-east side of Spring Ridge behind the town of Victoria, are probably thicker masses of this surface-layer, though it is possible that portions of these, and similar mounds elsewhere, may represent remnants of moraines, terminal or lateral, left at different stages in the retreat of the glacier. They resemble much more closely, however, the deposits of stranding ice, considerably modified by currents. The materials in sections at Spring Ridge are coarse sands and gravels, with many boulders of all sizes. The largest boulders are nearest the surface, with their interstices filled with finer material, which also often forms the superficial layer of the deposit, as though, submergence still continuing, the supply of ice capable of transporting large blocks had failed.

Extensive banks of coarse sand and gravel have accumulated on the southern or lee side of Mount Douglas, before referred to, giving it a crag-and-tail form. At the head of Cadbury Bay, about 100 feet above the sea-level, a road-side cutting shows stratified false-bedded sands and gravels, the inclination of the beds, which is very regular, indicating north and south currents like those of the tides still running in the Strait of Georgia, the southward or ebb current being the stronger, and having most frequently left traces of its action. The boulders near Victoria are very frequently of diorites and granitic rocks, derived probably from the Cascade Mountains of the mainland to the north and east. Large masses of the Cretaceous coal-bearing rocks, and especially of the conglomerates, of Nanaimo are also not unfrequently met with. The boulders, as well as the finer materials, are occasionally found forming accumulations behind rocky ridges. The largest erratic mass observed lies near Cedar-Hill church, and measures 17 feet long, 9 feet 11 inches wide, and 7 feet in thickness, though partially imbedded in the soil.

Mr. Bauerman mentions the occurrence of casts of *Cardium* and *Mya* in these deposits, an observation which for a long time I was unable to confirm; but eventually several localities were discovered where molluscous remains are tolerably abundant. These shells were not noted in the lowest portions of the drift. They are generally contained in hard fawn-coloured sandy clay, almost without stratification, and are frequently quite decayed and crumbling, though found with the valves united in the position of life. Granitic fragments included in the clay are also very frequently more or less decomposed, and sometimes completely rotten, showing that carbonated surface-waters here long acted on the mass since its elevation. This action may probably account for the comparative scarcity of the shells, while its continuance for a period somewhat more prolonged would without doubt have resulted in their total removal. The beds so affected are at a height of only a few feet above the sea; and this, coupled with their resemblance in texture to many inland

drift-deposits, suggests one means of accounting for the apparently complete absence of marine remains over areas which on other evidence appear undoubtedly to have been at one time submarine, but which from their elevation must have been much longer exposed to the percolation of surface-waters.

The following species have been recognized among the fossils hitherto found:—

Cardium islandicum.
Leda fossa.
Saxicava rugosa.
Natica clausa (probably).
Balanus crenatus (probably).

In localities where the upper sandy and gravelly layer of the drift is not developed, the change from deep water to littoral conditions appears to be marked by the rather sudden introduction of carbonaceous matter, changing the clayey deposits from their usual pale tints to dark brown. In some places marine shells, and especially the *Cardium* above named, appear sparsely in the highest layers of the pale clays; while in other localities, near the present shore-line, the lowest layers of the shell-heaps, and burnt stones used by the Indians in cooking, coincide with those of the brown earth, showing apparently that the last movement of elevation by which the land attained about its present level was rather sudden, and that habitation by a race resembling the present natives followed closely on the termination of the glacial conditions.

The general appearance of the deposits of this part of Vancouver Island, resting, as they do, on planed and polished rocks perfect in every detail and necessitating glacier-action for their explanation, and yet consisting of water-bedded and often current-driven materials mingled in places with sea-shells, leads to the belief that they were formed along the retreating foot of a glacier which had extended some distance beyond the margin of the land. The withdrawal of the ice may have been caused or accompanied by subsidence; and some species of shells must have followed its front pretty closely in its retreat. The somewhat irregularly terraced form of the deposit is probably due to action during emergence; and the general tendency of many facts is to show that a slight sinking of the coast is at present in progress or has lately occurred.

Occasional artificial sections at New Westminster, at the mouth of the Fraser river, on the opposite side of the Strait of Georgia, show deposits quite similar in general features to those seen near Victoria; but no molluscous remains have been found. These beds pass under the modern flat and wide delta of the river, which extends many miles seaward. Some of the higher parts of the irregular terraces about Victoria may be correlated in a rough way with the edge of the sloping ground on which New Westminster is built; and several islands in the southern part of the Strait show cliffs of similar materials and about the same height. St.-James Island may be specially mentioned, its white cliffs, probably eighty feet high, forming a prominent landmark. Vancouver Island has

probably been united at one time to these smaller islands and the mainland by a floor of deposits at about this level, though there is nothing to show that it has ever formed an actual land connexion.

c. Observations northward in the Strait of Georgia and at Bute Inlet.

One hundred miles northward in the Strait, deposits similar to those last described form scarped banks along the shores of Savory, Hernando, Mary, the southern portion of Valdez Island and the low eastern shore of Vancouver. Fragments of a terrace, estimated from a distance to be from sixty to eighty feet in height, are seen on the inner side of Stuart Island in the entrance of Bute Inlet, and at one other place some miles up the inlet on the west side. No higher terraces or accumulations of detrital matter were seen on this part of the coast; but Mr. Richardson mentions terrace-deposits at heights between 100 and 200 feet in Kitemat Inlet, further north. The remarkable rarity of terraces, however, and absence of drift-material on the western slope of the coast-range, are among its most striking features, contrasting strongly with the condition of its inland margin.

My opportunities for examining the remarkable fjords by which the coast of the mainland is indented have been limited, the only one ascended to the head being Bute Inlet. This chasm, forty miles in length, and running into the centre of the coast-range, is surrounded by mountains which, in some places, rise from its borders in cliffs and rocky slopes to a height of from 6000 to 8000 feet. It must have been one of the many tributaries of the great glacier of the Strait of Georgia, and accordingly shows evidence of powerful ice-action. The islands about its mouth are *roches moutonnées*, polished and ground wherever the original surface has been preserved. In Sutil Passage, near its entrance, grooving appears to run about S. 30° W. A precipitous mountain on Valdez Island, opposite Stuart Island, and directly blocking the mouth of the inlet, though 3013 feet high, has been smoothed to its summit on the north side, while rough towards the south. The mountain-side above Arran Passage, shows smooth and glistening surfaces at least 2000 feet up its face; and in general all the mountains surrounding the fjord present the appearance of having been heavily glaciated, with the exception of from 1000 to 2000 feet of the highest peaks. The high summits are rugged and pointed, and may either never have been covered by glacier-ice, or owe their different appearance to more prolonged weathering since its disappearance. In some places parallel flutings high up the mountain-sides evidence the action of the glacier; while in others it is only attested by the general form of the slopes, or detected under certain effects of light and shade. The mountain sides are wonderfully bare, and even when wooded have a very scanty covering of soil; so that after the natural forest has been destroyed by fire the naked rock everywhere appears. At the mouth of the Howatheo river discharging into the head of Bute Inlet, striation shows a

direction of movement S. 22° E.; but in every case the motion appears to have been directly down the valley, and to have conformed to its changes in course. Glacier-ice may still be seen shining bluely from some of the higher valleys at the head of the inlet, and further up the Howatheo river there are many glaciers in lateral valleys, some of which descend almost to the river-level.

Mr. James Richardson, who has had an opportunity of examining many of the inlets north of Vancouver Island, writes as follows* —"Throughout the whole of the inlets and channels which were examined, wherever the surface of the rock is exposed, the ice-grooving and scratching is very conspicuous, from mere scratches to channels often several feet in width, and from a few inches to as much as two or three feet in depth. Often they can be distinctly seen with the naked eye, from the surface of the water to upwards of 3000 feet above it on the sides of the mountains. They run in more or less parallel lines, and are not always horizontal, but deviate slightly up or down."

3. Interior of British Columbia.

The region lying between the Cascade or Coast Mountains on the west, and the Selkirk or Gold range and Rocky Mountains to the east, though it may be regarded in a general way as a great plateau sloping gradually to the north, from its broken and diversified character offers a problem with many additional elements of complication. The phenomena may be divided as before, under the heads of rock-marking or striation, and overlying detrital deposits. The striation, however, admits of subdivision into many different systems; and the superficial deposits may be classed as unmodified and modified drift and moraines, between which lines can be drawn in a manner which, though even here not always absolutely definite, could not be attempted with the drift covering the southern part of Vancouver Island.

a. Striation and Rock-polishing.

In several cases I have observed grooving at such heights and with such bearings as to preclude the possibility of its being attributed to glaciers moving from any of the present mountain-systems, and seeming to require for its explanation ice-action on a very much greater scale. As few localities offer, however, where traces of this character can be observed under quite unequivocal circumstances, it may be proper, in view of their interest, to treat of the more important in some detail.

Tsa-whuz Mountain (lat. 53° 40′), on the direct trail from Blackwater Bridge to Fort George, is an isolated basaltic outlier, rising about 800 feet above the higher parts of the surrounding hilly plateau, about midway between the valleys of the Fraser and Chilliaco rivers, which lie east and west of it. Its approximate

* Report of Progress Geol. Survey of Can. 1874-75. p. 8.

elevation above the sea is 3240 feet; and standing on the summit, one commands a very extensive view in all directions. Westward, at a distance of about fifteen miles, across the deep Fraser valley, hills surpassing this in altitude are seen. Southward no part of the surface of the country is so high till beyond the valley of the Blackwater river, at a distance of over thirty miles. Westward and south-westward, with the exception of one hill of about equal height, the plateau stretches for from fifteen to twenty miles; while through more than a quadrant of arc to the north, the whole country appears to slope gradually away from the foot of Tsa-whuz, towards the low region about McLeod Lake and the Parsnip river, and forms a level sea-like horizon. No high mountains appear in any bearing. The rocks of the summit of Tsa-whuz are for the most part roughened by the weather; but in several places indistinct striation is seen; and in one spot, within a few feet of the highest point, a slightly overhanging surface of basalt was observed to be distinctly shaped and polished by ice, the direction indicated being a few degrees west of south. The surface of the northern ridge of the mountain shows miniature rock-basins, with their longer axes parallel to the same direction, and some of them holding small pools. The ridges which diversify the surface of the plateau below are seen to conform very generally to north-and-south bearings; and this is especially observable immediately to the south of Tsa-whuz, where a succession of small ridges are closely packed together, with their longer axes running S. 25° W. Some of these hillocks probably owe their form to that of the underlying rock, while others are no doubt composed of gravel; and the general form of these and of Tsa-whuz is as though the glaciating agent had moved from north to south.

Traces of glaciation were also noticed in several places at high levels on the basaltic plateau in the vicinity of the Fraser valley, in positions not allowing their being referred to local action. In two cases very distinct grooving was observed. In one of these localities, about twenty miles north of the Chilcotin river, and several miles distant from the trough of the Fraser, the direction is nearly true north and south, the approximate elevation being 3350 feet. In a second instance, also on the summit of the plateau, on the northern brink of the Chilcotin valley (lat. 52°), at an elevation of about 3650 feet, with a direction of S. 23° W., or N. 23° E., being transverse to the present great gorge of the Chilcotin river, the surface of the narrow basaltic plateau forming the summit between the south-western tributaries of the Nechaeco and some of the north-western branches of the Blackwater, at an elevation of 3730 feet, is ice-smoothed, but the direction of motion is undeterminable.

On the summit of a hill which we may call Sinter Knoll, rising about 250 feet above the general level of the country, or 3550 feet above the sea, north of Gatcho Lake, near the south-eastern sources of the Nechaeco river, glaciation occurs with a bearing about S. 8° E. The rock of the hill is a remarkably brecciated siliceous material—hard, but much jointed. The striation was only found

on one spot, protected by a foreign boulder, which had to be overturned before it could be observed. The glaciated surface is considerably inclined and beautifully polished, with faint scratches crossing each other at small angles. The abrupt southern face, and the more gentle northward slope of the hill, appear to show that the ice must have moved southward. From N. 30° E., round to N. 18° W.; and beyond, the highest country within many miles is a ridge with an elevation from 100 to 300 feet greater than that of the Sinter Knoll; and beyond this only low blue hills are seen at a distance estimated at from fifteen to twenty miles.

One of the most remarkable localities in which glaciation referable to this system was found, is a rocky hill south of the Salmon or Dean river, isolated from the higher parts of Tsi-tsutl Mountain, of which it forms an outlier, by a shallow valley about a mile wide. The altitude of this point is 3700 feet. Westward the view is across the lower broken country of the Tahyesco river to the snow-clad eastern parts of the Coast range at a distance of from twelve to fifteen miles. A line drawn south-westward would cross obliquely this wide valley for many miles before higher country would be reached. To the north, the lower region and minor elevations, mentioned in connexion with the last locality, are overlooked. The rocky surface of this hill has been smoothed and striated by ice moving S. 37° W., forced apparently somewhat out of its usual course by the flank of Tsi-tsutl Mountain, and passing between it and the Coast range.

Near Hatty Lake, nearly 1000 feet lower than the last locality, and sixteen miles north-east of it, in a narrow pass between cliffs of hard Mesozoic rocks, ice has left unmistakable traces of its passage south-westward, glaciating not only horizontal, but nearly vertical rock-surfaces. It has conformed in its direction to the tributary valley of Salmon river, in which it is seen, the valley being nearly parallel to the main direction of that of the Salmon river, which runs towards the Coast range, and through it to the sea.

Glaciation clearly referable to ice spreading from the Cascade or Coast Mountains, and other ranges, is met with in many places; and generally speaking, wherever circumstances admit of their observation, grooving and striation parallel to the main courses of the valleys, and depressions radiating from or passing through all the higher mountains, may be found. These facts, however, possessing only a local interest, need not be detailed here. Other features of local glaciation will be again referred to.

b. Superficial Deposits.

Preglacial Gravels.—It is quite probable that in many localities deposits of Preglacial date, but newer than the basalt-flows which appear to have closed the Miocene period, may occur, especially in deep and steep-sided valleys. A hasty examination of the Cariboo gold-mining district appears to show that while in some valleys, especially those facing northward (*e. g.* Mosquito Creek), Boulder-

clay lies directly on the rock surface, in others the rich gold-bearing gravels are quite distinct from and below this deposit. In Lightning Creek, the material filling the bottom of the old stream-course, often from 50 to 100 feet below the present brook, is a water-wasted gravel, with little clay and no cementing matter, but much compacted by pressure. This is richly auriferous, and has been followed by extensive mining-operations. Above it, in the valley-bottom and clothing the sides of the surrounding hills, is Boulder-clay, which yields little gold; and on this again are recent modified deposits of gravel, over which the stream of to-day finds its course. These last are generally also more or less auriferous, forming "shallow diggings."

Unmodified Drift.—The whole interior of British Columbia, up to elevations of over 5000 feet, may be said to be more or less thickly mantled with unmodified or scarcely stratified deposits, which I shall refer to as *Boulder-clay*. Over considerable areas this material is concealed beneath later accumulations, which form terraces and low-level flats, in relation to present and former lake- and river-valleys. There is a remarkable uniformity about these Boulder-clays in every locality in which I have examined them. In many places they form low rolling and broken hills, between the river-troughs, above the level of the higher terraces. In this case they appear sometimes to be spread in a comparatively thin layer over a rocky substratum; while in others they are of great depth, and, by the irregularity of their arrangement, themselves produce many of the minor features of the surface. They frequently show a tendency to form more or less well-defined high-level plateaux, and are spread almost universally over the elevated basaltic region of the interior, in most places so uniformly, notwithstanding minor irregularities, as to allow the underlying rock to be very seldom seen. The Boulder-clay is quite typically developed on the basaltic plateau crossed by the main waggon-road between Clinton and Bridge Creek. This plain, isolated by deep river-valleys, is traversed by the road for a distance of about thirty-five miles, and has an elevation of from 3900 to 4200 feet. The Boulder-clay may be described as consisting of a paste of hard clay, always more or less arenaceous, and generally with a very considerable proportion of fine sandy material, through which stones of all sizes are irregularly scattered. Its usual colour varies from light-brown to pale greyish-brown and fawn colour, but in freshly exposed sections is sometimes bluish-grey. It very often, over extensive regions, forms the soil in which the trees are rooted, without the intervention of any modified material, and is frequently so arranged as to surround larger or smaller depressions which hold lakes and swamps. The greater part of the stones and boulders contained in the clay or scattered over its surface, are almost invariably rounded and waterworn, and sometimes very perfectly so; yet a proportion showing distinct glacial striation, and some glaciated fragments worn flat on one or more sides, may always be found. The quantity of distinctly glaciated material varies much with locality, and, no doubt, depends in part on the nature of

the rocks themselves. The pebbles and boulders very generally show a clear relation to the rocks of the country over which they lie, being composed in great part of these rocks, but mingled always with some proportion of foreign material. The surface of the basaltic plateau above described shows, for instance, not only basalt of varied texture in great abundance, but a considerable quantity of fragments from the Lower Cache Creek Series of the Geological-Survey Reports; some, pretty certainly derived from the Cascade Crystalline Series; and others, of which it is not always possible to trace the source, but which certainly do not occur on the plateau. Where those varieties of basalt which easily break on weathering into polygonal fragments occur, the overlying Boulder-clay is filled with them, so that in many places, after prolonged subaërial weathering, the surface appears to be absolutely composed of blocks of stone.

The general direction of movement of the travelled constituents of the Boulder-clay appears to have been southward, though the diversity of the rock formations, and our present ignorance of the details of their distribution, preclude, to a great extent, the use of erratics in this inquiry.

Boulder-clay has been noted in the Cariboo country up to over 4500 feet, though the stony materials appear near this elevation to be becoming more angular. The state of the weather during my visit to the region prevented the examination of higher levels. Between Quesnel and Blackwater Bridge it forms an undulating plateau, of which many portions surpass 3000 feet, levelling up the irregularly hilly surface of the hard old rocks below. Between Blackwater Bridge and Fort George it appears at all heights up to over 3400 feet. Waterworn transported pebbles are found on the summit of Tsa-whuz mountain, above mentioned, while on its northern slope a great collection of larger erratics appears. North of the Blackwater, in longitude 124° 30′, several broad ridges with elevations of from 4000 to 4300 feet are entirely covered with drift-material, with the addition of great numbers of boulders larger than are elsewhere seen. Two high hills passed over by the trail from Fraser to Stuart Lake, with elevations of 3792 and 4910 feet, are covered to the summit with Boulder-clay of the usual appearance, but holding more well-glaciated stones than usual, some of which have evidently been derived from the north. In the Chilcotin country similar deposits overlie the basaltic plateau at elevations above 3000 feet. These instances may serve to illustrate the distribution of the Boulder-clay without entering further into details or attempting to describe the numerous localities in which it has been examined.

In one place only have I found what I believe to be the upward limit of these deposits. This is on the northern slope of the Il-ga-chuz Mountain, at an elevation of 5270 feet, where it coincides with the highest known shore-line.

In the mixed character of the stones of the Boulder-clay and their very generally rounded and waterworn aspect, though enclosed in material with little or no stratification, the action of water-borne ice, whether iceberg, floe, or shore-ice, seems to be indicated.

Modified Drift.—As already mentioned, extensive areas of the boulder-clays are entirely concealed by newer overlying deposits. It may be almost stated as a rule that, in regions lying lower than 3000 feet, the superficial materials are entirely of this more recent date. These are often clearly traceable to ancient lakes, of which they yet define the outlines, but in other cases are due merely to the successive rearrangement of material by rivers slowly cutting down their valleys. The extent of surface below the above-mentioned limit in the southern part of British Columbia is comparatively small; and the more or less isolated later deposits present varying local characters. To the north, however, the general lower elevation of the country has allowed the formation of beds more wide-spread and important. I have examined the southern portion only of this lower area, the northern extension of which passes in a wide belt along the Parsnip and through the Peace river-depressions in the Rocky Mountains to the great Mackenzie river-basin*.

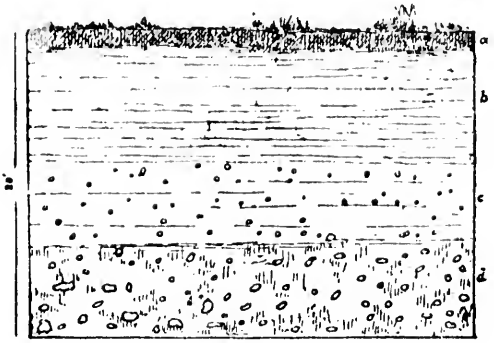
The best sections of the deposits of this northern area are found in the Lower Nechacco basin, between lat. 53° 30′ and 54° 10′, and long. 123° and 124° 40′. They reach a height of about 2400 feet at the edges of their basin, and where seen lowest (near Fort George) have an elevation of 1900 feet. Their known area is about 1000 square miles; but they may extend far northward. They seem to represent an interesting epoch of the Glacial period, and are composed of nearly white, greyish or pale chocolate-grey arenaceous clay, divided by distinct stratification-planes into layers an inch or two in thickness, and very uniform in this respect. When dry the material is hard, but not sufficiently homogeneous to break regardless of bedding-planes. Under the microscope it is seen to be made up of very fine angular quartzose particles, mingled with a little formless argillaceous material. It is usually calcareous, and is filled in many sections with calcareous nodules, generally lenticular, but often confluent, forming grotesque aggregations. These are especially abundant on the shore of Stuart Lake near Fort St. James, and in some of the Nechacco-River sections. I have called these deposits the *White Silts*.

The beds are sometimes seen to be disturbed, and even more or less contorted—an appearance which has, I think, often been produced by "slides" in the banks of the river of comparatively recent date. Contortion, however, sometimes seems to have been caused by the contemporaneous action of floating ice, the presence of which is proved by the occasional occurrence of large subangular boulders, which generally lie in groups, and are often as much as two feet in diameter. The portions of the formation holding many boulders seldom show distinct bedding, though composed of material similar to the rest, and not mixed with much gravel or beds of coarse detritus intermediate in character between the fine matrix and the erratics. In some cases the White Silts are found to have been deposited in gently inclined beds on preexisting sloping surfaces. They

* Selwyn, Report of Progress Geol. Surv. of Canada, 1875–76.

are occasionally seen on the Nechacco below Fraser Lake to rest on false-bedded sands and clayey gravels (which may here probably represent a part of the Boulder-clay), and were observed to overlie in one section a hard yellowish sandy clay with few stones. The White Silts are also found to rest directly on denuded Tertiary beds and other older rocks. In one section on the Lower Nechacco, their relation to well-marked Boulder-clay is very distinctly seen (fig. 4).

Fig. 4.—*Section on Lower Nechacco River.*



a. Soil. *b*. White Silt.
c. Hard, grey, sandy clay, with rounded and subangular stones, some glaciated.
d. Bluish sandy clay, with boulders and pebbles generally somewhat water-rounded, but nearly all glaciated more or less distinctly.

The lowest bed exposed here is a hard bluish arenaceous clay, with small boulders, and pebbles of all sizes, mostly more or less water-worn, but nearly all showing traces of glaciation. There is little or no appearance of stratification. This is separated by a distinct horizontal line from the next layer, which is paler in colour, harder, and somewhat more arenaceous, and charged with smaller pebbles less evidently glaciated. The stratification is obscure. A second sharp horizontal line separates this bed from the overlying White Silts—hard pale arenaceous clays of the usual character, which become disintregated above to form the soil.

The thickness of the White Silts must be over 100 feet in some sections and might very probably, if fully exposed, be found in many parts to exceed 200 feet. The deposit shows a close general resemblance to the thick argillo-arenaceous or loess-like material of the plains of the Red River in Manitoba; and very similar conditions may probably have led to the formation of these beds in the two localities. In both Manitoba and the Nechacco basin the material is generally calcareous, and in both places it forms a most fertile soil. In the Nechacco country it seems probable that the silts were laid down in the bottom of a great lake, at a time when all the pre-

sent smaller basins were united, which may possibly have allowed the access of the sea to some extent. They have the appearance of being the deposit from water charged with fine glacier-mud, or flour of rock; while the presence of glaciated boulders proves either that some of the glaciers yet extended far enough from their sources to reach the waters of the lake, or that heavy coast-ice existed.

In approaching the mouth of the Nechacco, gravelly deposits of great thickness are found, forming exposures in some banks over 200 feet in height. The gravels alternate irregularly with sands; and the whole is quite frequently false-bedded on such a scale as to imply very strong current-action. The material of the gravels here too ceases to bear so close a relation to the country rock, becoming mixed with a considerable proportion of quartzite shingle, the origin of which will be referred to hereafter. These sandy and gravelly beds appear in the main to intervene between the Boulder-clay and the White Silts, but are most closely related to the latter. They may indicate the course of stronger currents coming from the north with much shingle-laden coast-ice, the upper part of the Nechacco basin being at this time a great sheltered bay in which the more typically developed White Silts were being formed. With the exception of the Fraser valley, which may have been filled with the earlier drift deposits, the lowest gap in the southern rim of the White-Silt basin is found near the southern sources of the Chilacco, at an elevation of 2660 feet; and here a wide belt of country shows coarse and fine superficial sandy deposits, with little gravel, forming low mounds and ridges, which evidently owe their forms to moderately powerful current-action, and may show the southern continuation of the current above indicated.

Shore-lines, Terraces and Benches.—The interior of British Columbia shows water-marks in different stages of preservation, from a height of 5270 feet down to the present sea-level. Some facts bearing on this division of the subject have already been given in connexion with other matters; it will be necessary here to give only a brief review of the more important features, mentioning a little more fully a few of the most remarkable. It is necessary, though sometimes difficult, to distinguish as far as possible between shore-lines of the sea or former great lakes, and terraces which are due to the gradual lowering by erosion of river-beds in their valleys, which bear a quite different significance.

The highest observed beach is that of which the elevation (5270 feet*) has already been given as probably the upward limit of the Boulder-clay; it was found on the northern slope of Il-ga-chuz Mountain. The undulating and more or less broken plateau stretching eastward from this mountain, with a general elevation of about 4500 feet, appears to owe the form of its surface in great part to the arrangement of drift upon it, and shows much foreign material. On

* This height may be regarded as fixed with some accuracy, the figures being the mean obtained from two barometric observations made on the terrace and simultaneously at a neighbouring station, of which the elevation had been instrumentally fixed.

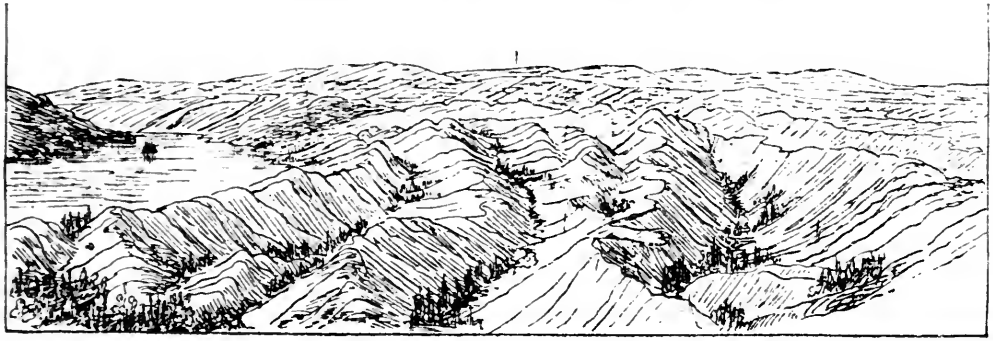
July 22nd we camped on the north-east slope of the mountain, in the valley of a little stream which, after running between high sloping banks for about a quarter of a mile, opens widely north-eastward, in which direction the whole surface at the same time slopes away. Here distinct though somewhat worn terrace-marks occur in the sides of the little valley; and in travelling a short distance westward along the mountain-side, these may be observed to spread quite beyond the valley of the brook, and form an extensive, nearly level or only gently undulating, flat on its northern slope. The material of the flat is evidently rolled and water-rounded, like beach-shingle, and, though in great part derived from the volcanic rocks or the mountain itself, has a considerable percentage of travelled stones, some of which are as much as a foot in diameter. At higher levels on the mountain-side this rounded material does not appear, and, as far as observed, no fragments not referable to the rocks of the mountain occur. Northward, with the possible exception of one peak forty miles off, no land equal in height to this terrace is in sight. The average elevation of the country is probably 2000 feet less. I have not had the opportunity of examining other parts of this mountain or the ranges east and west of it with care; but from a distance the south-east side of this one shows a well-marked line, separating the higher peaks from the low sloping base. This was noted and sketched as a marked feature before the existence of the shore-line above described was known (fig. 5). In height the two must nearly if not exactly agree; and it is more than probable that the different appearance of the lower and upper parts of the mountain is largely owing to the distribution of the drift upon it.

The general evidence of the submergence of the interior during the formation of the Boulder-clay to an extent of from 4000 to 5000 feet, depending on the composition and appearance of that deposit, has already been given. The tendency of the Boulder-clay to form elevated undulating plateaux, even when unsupported by the basaltic plateau and resting on an uneven surface, has also been referred to. When terraces occur in series upwards from river- or lake-valleys to the summit of the plateau, the highest generally consist not of water-washed sands and gravels, but of Boulder-clay, little or not at all modified—a circumstance seeming to prove the formation of the Boulder-clay to have been still in progress while the water passed through the first stages of its retreat. In ascending from the Blackwater, these Boulder-clay terraces appear at about 3150 feet.

The north-eastern or upper end of Tatlayoco Lake touches the plateau-country, while its south-western stretches into the Coast Mountains, through which its waters eventually pass to the sea. Its elevation is 2747 feet; and terraces quite well marked appear on its south-eastern side to a height estimated at 1500 feet above its waters, or 4250 feet above the sea. Fraser and François Lakes are bordered by terraces, the best-marked being estimated at 100 and 200 feet above the lakes respectively, which, allowing for their difference in height, no doubt represent the same water-line, the approximate elevation of which above the sea is 2350 feet. The hills

Fig. 5.—*Distant view of Il-ga-chuz Mountain from the South-east, showing probable upward limit of drift-deposits.*

Fig. 6.—*Moraines on the Nechacco River near outlet of Na-tal-kuz Lake.*
(Lat. 53° 25′ N., long. 125° 10′ W.)



between Fraser and Stuart Lakes, already mentioned, show a succession of water-marks in some places to an elevation of at least 3800 feet. They stand in a low country as spurs or outliers in the basin of the White Silts. Mr. Smith, of the Canadian Pacific-Railway Survey, gives the general height of the highest well-marked beaches of the Fraser and its tributaries, which he has observed in different localities more than 150 miles apart, at from 2400 to 2500 feet. To this stage the Fraser and François Lake-terraces no doubt belong.

Some beaches, remarkable from the nature of the material composing them, occur on the direct trail to Fort George, between Tsa-whuz Mountain and that place. The aspect of the country from Tsa-whuz, and its general northern slope, have already been described. In gradually descending the slope, towards the basin of the White Silts, Boulder-clay, previously forming the surface, nearly disappears, and is replaced or covered by shingly deposits composed of well-rounded stones, which are for the most part very compact quartzites of various pale tints, almost precisely resembling the quartzite drift formerly described as occurring on the higher levels of the plains east of the Rocky Mountains *, and would appear probably to have been derived from the same series of rocks. The shingle beaches or mounds have no very uniform general direction, but form low gently-swelling undulations which bear forests of scrub-pine, separated by swampy hollows densely filled with black spruce. The shingle-beds may, I think, be pretty safely correlated with the thick gravelly deposits seen at a lower level near Fort George, and, if so, probably represent the margin of the White-Silt sea at one stage. Their approximate average elevation may be stated as 2100 feet. An interesting question occurs with regard to the origin of their materials. No rocks similar in character to their quartzites have been found in this part of British Columbia. It is probable that they have been far transported across the northern low country, or derived from exposures on the northern spurs of the Cariboo range.

The materials of the lower terraces of the river-valleys, though sometimes interesting, are more local in their character, and not significant in tracing the origin of the drift-deposits as a whole. The terraces in the bottoms of the valleys, and nearest the bed of the stream, usually show the coarsest gravels. The rivers being in almost all cases rapid streams, subject to great floods in the early summer, constant transport of material is still going on in their channels; and in consequence the river-gravels do not bear nearly so close a relation to the local formations as those higher up the slopes of the valleys and on the plateau. In passing in a canoe down those parts of the Fraser which are considered navigable, one is constantly struck by the peculiar sharp hissing noise caused by the grinding and onward movement of the gravel in the river-bottom. This may be heard in all the "riffles," or little rapids, even at low water, and evidences the extensive transport and consequent corrosion in pro-

* Quart. Journ. Geol. Soc. Nov. 1875, vol. xxxi. p. 616, and 'Geology and Resources of the 49th Parallel,' p. 231.

gress. As a result of this action in the Fraser, the quartzite drift developed in the vicinity of Fort George has been dragged down stream in great quantity, and can still, I believe, be recognized as an important constituent of the gravel banks to near tide-water.

The display of terraces or "benches" on the Fraser and Thompson rivers and some of their tributary streams is probably as imposing as can be seen anywhere. In some cases they may show merely stages in the descent of the rivers to their present levels through the wide-spread deposits of the Glacial period; but as many of them, and especially those of the higher levels, are seen to leave the immediate valleys of the rivers, attach themselves to the bases of the hills, and fringe at similar elevations all the ramifications of the streams into the plateau, it would seem that some at least must owe their origin to the general inundation of the country, and its subsequent gradual drainage. Such an overflow may have been the result of a general depression of the land, or of the stoppage of the southern outlets, more especially of the Fraser valley, and, for the higher terraces, those also of the streams running southward across the 49th parallel. Partial movements of upheaval and depression might also account for the damming-back of water in valleys previously formed; but of this no evidence has yet been found *.

In travelling up the Fraser valley through the Coast-range, one has the widest opening anywhere existing through these mountains at one's back; yet, step by step, the terraces can be followed from near the sea-level to the highest water-marks observed. At Yale, on the outer border of the range, 160 feet above the sea, are terraces with narrow treads, composed chiefly of angular débris, but forming well-marked horizontal lines on the mountain-slopes. One of these, barometrically measured by my friend Mr. A. Bowman, was found to have an elevation of 800 feet above Yale. The highest perfectly distinct line was estimated to reach 1500 feet. It may be open to question whether these benches may not be remnants of lateral moraines of an old great glacier which has filled the valley. They look, however, like shore-lines, caused by the accumulation and horizontal arrangement below the water-line of débris from the mountain-slopes.

Following the gorge or cañon of the river through the Coast-range, besides lower terraces from 100 to 200 feet above the stream, everywhere visible, occasional fragments of benches bearing a close resemblance to those at Yale, may be seen perched far up on the mountain-sides. About a mile above the Stoyoma River of the Admiralty Map (25 miles above Yale) some of these were estimated to be as much as 2000 feet above the water, or about 2450 feet above the sea. At Boston Bar terraces estimated at about the same height were seen. Near Lytton the Thompson river joins the Fraser, the valleys become wider and the terraces well-defined and broad. One, baro-

* Mr. Selwyn discusses some of these points in the Report of Progress Geol. Surv. of Canada, 1871-72 (p. 55). Sir Matthew Begbie has also published some account of the terraces of the Fraser; but I have not been able to refer to his paper.

metrically measured, is 1680 feet above the sea; others stand at estimated heights of from 1780 to 1880 feet. Further up the Thompson a terrace, again barometrically measured, was found at 1600 feet, and a second, well defined, estimated at 1900 feet. These are no doubt the same as the two last mentioned. On the Bonaparte river (tributary to the Thompson), four miles north of Cache Creek, a terrace estimated at 2820 feet occurs, and further on, at Maiden Creek, one barometrically measured at 2680 feet. On ascending the plateau beyond Clinton (already mentioned) ill-defined "Boulder-clay terraces" are seen, in some places, above 3000 feet*. On entering the Thompson Valley the material of the terraces becomes much finer and more argillaceous than on the lower Fraser. In some places several hundred feet of nearly horizontal clay beds are exposed in transverse ravines, and seem to form the material of the terraces running along the sides of the valley. The lower terraces, which are always the best-preserved, are seen in many places to spread quite widely, and their deposits (shown in sections both parallel and transverse to the valley) to lie in beds nearly horizontal, or with a slight sag towards the centre. Individual gravel beds can sometimes be traced in the banks for a mile or more.

Carefully noting the aspect of the terraces in ascending the Fraser and Thompson rivers, which flow in the main-drainage valley of the great interior of British Columbia, tracing them from point to point with scarcely any break, and upward to the higher streams and most secluded nooks among the mountains, where denudation has been least effective, the conclusion is forced on the mind, that, while many of the higher are accumulations along the shore of a great sheet of water, most of the lower have been carved out of deposits which at one time filled the valleys from rim to rim, and more or less completely levelled up the broken surface of the country, by the gradually receding waters of a lake or of the sea, and eventually by the rivers themselves deepening their channels to their old Preglacial levels.

Moraines.—In some cases it is not easy to distinguish between certain fragments of high-level terraces and old lateral moraines. Much doubt may also obtain with regard to the origin of moraine-like forms when in the last stages of degradation from subsequent water-action and subaerial decay. A further difficulty is frequently found in British Columbia in ridges simulating moraines, formed where successive slides have taken place in great beds of drift-deposits surrounding rivers and lakes. Disregarding, however, all cases in which there can be the least doubt, there still remains abundant evidence of the great extension of glaciers from the present mountain-centres, and their sporadic appearance in many parts of the highlands and hills of the plateau. These appear to be the

* The terraces above enumerated occur in the vicinity of the main waggon-road. The measurements lay no claim to accuracy, being in many cases merely eye estimates aided by the known elevations of certain localities and the barometer. They may serve, however, to show the succession met with in travelling inland.

last indications of glacial action on a large scale, and to have been followed by the retreat of the ice to its present limits.

There are, however, a few cases where some traces seem to remain of older moraine-like accumulation, which, whether due to glaciers proper or to pack-ice, are probably of the date of the north-to-south ice-movement which the rock-striation proves to have occurred. The most marked instance of this I have seen is in the broad depression between the Il-ga-chuz and Tsi-tsutl volcanic ranges, through which the upper part of the Salmon river flows northward. These ranges, as before mentioned, lie transverse to the general direction of the plateau-country of the interior. The depression between them is about fifteen miles in width, and is thickly heaped with material not unlike the general Boulder-clay covering, but arranged, with greater or less regularity, in mounds and ridges with general east-and-west bearings, separated from each other by intervening swamps. In the lowest part of the depression the Salmon river cuts through a steep gravelly ridge which, though tortuous, has a general course about N. 70° E., and runs for a mile and a half or more. This may be of the nature of an esker; but, from its association with the morainic ridges above, in which the size of the boulders quite precludes this explanation, this does not seem probable. If water-borne ice, whether iceberg or pack-ice, be supposed sufficient to account for the north-and-south glaciation of rocks, these and other moraine-like accummulations may represent localities where heavy ice stranded and forced up bottom-material; while in places more exposed to open water and less to great accumulations of ice, shingle-deposits, like those described on Fort-George trail, may have been in process of formation.

Of the later outflow of ice from the present mountain-systems, I have had most opportunity of studying the traces of that which moved eastward from the Coast or Cascade range. It is evident, however, that a similar movement must have occurred from the Selkirk and Gold ranges and Rocky Mountains, though perhaps not to so great an extent, as the precipitation of moisture in these regions is much less.

The glaciers moving eastward from the Coast range appear in all cases to have followed the present river-valleys pretty closely; and though they must have overlapped the higher country in some places, it is in the immediate vicinity of the great transverse depressions now occupied by the rivers that their traces are most evident. Naming these valleys in succession from south to north, but without entering into particulars, the main facts may be stated as follows:—

Nicola Valley.—The river flows westward; but the drift-material, consisting of boulders and gravel, is largely, in some cases chiefly, composed of granitic and syenitic rocks derived from the coast-mountains, which have been carried eastward, and now overlie volcanic rocks quite different lithologically. This is the case to the lower end of Nicola Lake, where the drift assumes a more local character. No distinct moraines were observed.

Thompson Valley.—The river flows south-westward to its junction with the Fraser at Lytton. Fragments of the rocks of the Cascade mountain-series, in the form of large and small boulders, produce a rather irregular but evident moraine overlying rocks of a different character, twenty-four miles above Lytton.

The glacier, in both the above cases must have crossed the deep valley of the Fraser; but the localities to which it has here reached can scarcely be said to be beyond the eastern flanking mountains of the Coast range.

Chilcotin Valley (lat. 52°).—Moraines can be traced here with certainty as far as the lower end of Tatla Lake, and with great probability to the outflow of Puntzee Lake. The former locality is situated twenty-five miles from the eastern base of the Coast range, and fifty miles from its central region; the latter forty miles from the eastern base. There is considerable reason to believe that the moraines of these places have been formed by a glacier pushing out into water, and somewhat modified by water-action, either contemporaneously or immediately after their formation. A congeries of small ponds, lakes, and swamps, called the Buckhorn Lakes, owes its existence to the steep-sided hollows, cup-shaped, trench-like, or crescentic, enclosed between moraine ridges. Many of these ponds have no visible outlets. A sheet of water six miles in length, called Eagle Lake, is dammed at its eastern end by moraine-material, in which very large angular blocks, evidently derived from low rocky hills at the sides of the valley, form a prominent ingredient. The watershed between the Homathco river, flowing directly through the Coast range to the sea, and branches of the Chilcotin, flowing eastward to the Fraser, lies just within the eastern foot-hills of the Coast range, is low, and apparently composed altogether of drift-material, more or less evidently morainic. It is probable that before the Glacial period the waters of a great extent of country now draining towards the Fraser, flowed by the gorge of the Homathco through the Coast range. Lakes and pools without outlet, irregular morainic hummocks and ridges, projecting to a greater or less height through flat or gently undulating deposits formed from their waste, characterize equally the sources of the east and west branches of the Homathco. A general movement eastward from the valleys of the mountains can be proved from the composition of the drift.

Blackwater and Salmon-River Valleys (approximate latitude 55°).—The tributaries of these rivers interlock about the 125th meridian, the former flowing eastward to the Fraser, the latter westward, through the Coast range. Moraines which appear, without doubt, to belong to the Coast-Mountain glaciers, occur beyond the low watershed on the tributaries of the Blackwater, at a distance of forty-five miles from the eastern base and sixty-five from the central peaks of the range. These are seen in the neighbourhood of Tsi-toe, Klootch-oot-a, and other small lakes of the same group. Sixteen miles further westward, at Uhl-ghuk Lake, glaciation with a course of N. 80° E., evidently referable to this period, occurs. In

the valley of the Salmon river, and in the nearly parallel one occupied by Tanyabunkut Lake (before referred to), moraines, in some cases nearly parallel to the sides of the valleys, in others more or less completely transverse to them, occur, with constant evidence of the carriage eastward in quantity, but not to a very great distance, of rock-fragments—granitic rocks, for instance, having been moved some miles eastward and left scattered on the glaciated surfaces of basalt-flows. The evidence of a previous movement of ice *westward* down the Tanyabunkut valley and towards the coast through the Salmon-river gap, owing to its sheltered position, has not been obliterated by the subsequent eastward flow, which all the evidence tends to show must have been of short duration.

South-western or Main Branch of the Nechacco River (lat. 53° 25′, long. 125° 10′).—The river here issues from a large lake called Na-tal-kuz by the Indians. The lake lies transversely in a range of hills which has a general north-west and south-east course, parallel to the Coast range and other main features of the country, but rising in the centre of a plateau region. To the south-east these hills become mountains about 2000 feet in height above the plateau in some instances. The lake is dammed by moraine-material with rocks cropping in its sides; and the surface of a small isolated rocky hill near its lower or eastern end shows heavy glaciation from west to east, parallel to the general course of the valley. East of the end of the lake the Nechacco cuts through a mass of moraines which covers a stretch of country probably at least five miles square. The moraines are very little modified, and wonderful in size and state of preservation (fig. 6). The most prominent form ridges miles in length, which, though wavering a little in direction and of variable height, sweep round to the north-eastward in broad curves, to the direction of which the river conforms for some time. The ridges are steep-sided, sloping frequently at an angle of 30° to the bottoms of the narrow sinuous valleys which separate them, and are from 100 to 200 feet in height. The best-marked ridges are evidently the successive lateral moraines of a glacier-tongue gradually decreasing in width. Besides these, however, there are occasional fragments of transverse ridges, blunter and broader, apparently remnants of terminal moraines formed when the glacier nearly equalled the valley in width.

It cannot be certainly affirmed that the glacier causing this display of moraines did not owe its origin to the low range above mentioned. Taking, however, all the local circumstances into account, and especially the small gathering-ground afforded by this range, it appears more probable that the Coast-Range glaciers must at one period have pushed a short distance through the gap in which the lake lies.

Still further north, on the 54th parallel, the valley containing, from west to east, François and Fraser Lakes and the lower portion of the Nechacco river, runs from near the eastern base of the Coast range to the Fraser in a remarkably direct line. François Lake, further west, is, by my track-survey, fifty-seven miles and three-

quarters in length, with a width of from one to two and a half or three miles. It is slightly sinuous, the opposite sides generally remaining parallel, deep, and in part surrounded by steep hills, especially toward the lower end. The stream discharging François Lake runs eastward to Fraser Lake, eleven miles in length; and this, again, sends its waters by a very short stream to the Nechacco at its Great Bend. There is a remarkable absence of traces of ice-action in the valley of François Lake; and though both shores were carefully examined, no more certain sign of glaciation than the general form of some rock-masses was seen. The nature of the rocks may to some extent explain this; but the material of the lake-shore is remarkably local in character, being composed almost invariably of the immediately underlying rock. Following the valley eastward, however, at the lower end of Fraser Lake, on hard dioritic rocks, marks of very forcible glaciation are found. Ice has here evidently been pushing up out of the lake-bed, over a rock-surface, under great pressure, and has been forced in some instances through little rocky valleys at a considerable angle to its mean direction, which is remarkably constant at S. 88° E. to S. 93° E. On nearly vertical rock-faces on the northern side of the lake parallel grooving may be seen to run eastward, and slope upward at a considerable angle to the water-line. On flat surfaces near the shore, many instances of preglacial rock-hollows, with rough western and rounded eastern margins, were found. The glaciation continues apparent for some miles beyond the eastern end of the lake; and its direction is also shown by the fact that blocks of the diorites have been carried eastward until they overlie the newer basalts.

I do not think any of the hills bordering Fraser Lake reach an elevation of 1000 feet above it; and its western half is surrounded by low country. It is difficult, if not impossible, to account for the glaciation, unless it be supposed that a glacier stretched thus far from the Coast range, nearly one hundred miles distant. The absence of boulders from the mountains in the immediate vicinity of François Lake is singular; but that of the ordinary erratics, so plentifully distributed over all this region, is equally exceptional. These facts may perhaps be explained by supposing that the glacier swept the valley completely clear of the débris due to the earlier drift, while for some reason the material moving with the glacier itself was very small in amount.

This case and that of the Upper Nechacco do not give such indubitable proof of the action of ice from the Coast range as those before described in the region further south; yet, taking into account the circumstances in both instances, they scarcely seem explicable otherwise. From many other localities, however, in which moraines of greater or less importance are preserved, it would appear probable that at one time accumulations of ice sufficient to produce moraines by their movement lay as well on the more elevated portions of the interior plateau.

In all the moraines observed, the normal material differs little from that of the Boulder-clay; or when a difference obtains, it is in

the direction of greater water-agency in its preparation. The stones are rounded and waterworn as a rule, heavily glaciated in a few instances, and mixed with large angular fragments only when these have been abundantly produced by some hill or cliff near at hand. There is also much evidence, especially about Tatla Lake, the Mazco watershed, and on the Nechacco, tending to prove that the gradually retreating glaciers piled up some, at least, of these gravelly moraines in water, which was decreasing in depth at the same time with the diminution of the supply of ice. This evidence is chiefly derived from series of flat-topped or water-wasted moraines in such localities and so arranged as entirely to preclude their being referred to esker ridges.

4. Mode of Glaciation and Formation of the Superficial Deposits.

In the foregoing I have endeavoured to give a short account of the glacial phenomena and superficial deposits of British Columbia, so far as I have examined them, entering into some detail in a few important and typical cases only, with the view of bringing the facts as they occur, in this hitherto little-known region, to the notice of geologists. Some uncertainty has been expressed as to the action on a large scale of glacial ice on the north-west coast of America, which may now, I hope, be removed, at least so far as regards British Columbia.

Professor Whitney, in the 'Proceedings of the Academy of Natural Sciences of California,' 1868, says that there is no evidence in California of a general glacial epoch, such as that which affected the Eastern States. He extends this conclusion to Nevada and Oregon, and, following information received from Messrs. Ashburner and Dall, further remarks that no evidence of northern drift has been detected even so far north as British Columbia and Alaska. Professor Dana, in the last edition of his 'Manual,' quotes Whitney's statement of the absence of northern drift, at least as far north as Oregon, but alludes to the grooving on Vancouver Island as possibly indicating general glaciation there. Professor Le Conte, however, speaks of northern drift near the Columbia river, east of the Cascade range*; while Gibbs writes of the country in the vicinity of Puget Sound, somewhat further north, that it is "one vast mass of modified drift"†, which he further asserts to have, at least in part, a northern origin, on account of the nature of the erratics. These must have been deposited in connexion with the southward extension of the Strait-of-Georgia glacier, or by floating ice after its retreat.

Dr. R. Brown, in a paper "On the supposed Absence of Drift on the Pacific Slope"‡, combats the statements of Whitney and others, quoting especially Mr. Bauerman's observations on the coast- and

* Am. Journ. Sci. and Arts, March and April, 1874.
† Journ. Am. Geol. Soc. 1874.
‡ Am. Journ. Sci. and Arts, 1870, p. 318.

glacial phenomena which came under his own notice on Vancouver and as far north as the Queen-Charlotte Islands.

In regard to Alaska, Dall writes*, after describing his route across the breadth of that territory:—"I have carefully examined the country over which I have passed for glacial indications, and have not found any effects attributable to such agencies;" and again†, "Three years' exploration, with a strong disposition to develop the facts of the case, failed to obtain on the shores of Norton Sound, or in the valley of the Yonkon, any evidence whatever of such action." If Alaska has indeed escaped glaciation, while British Columbia and the adjacent regions have been so shaped by it, the fact is an extremely remarkable one. It must be observed, however, that Mr. Dall has failed to notice the evidence of glacial action in the inlets of the coast, and, indeed, affirms that no traces of such appear‡; while my own observations, confirmed and extended to a wider area by those of Mr. Richardson, show that glacier-work on a gigantic scale has occurred in them. In endeavouring to explain by any satisfactory scheme the sequence and cause of the phenomena, one meets with many elements of uncertainty and complication, arising not only from the very pronounced and varied physical features of the country, but from our as yet very imperfect knowledge of great regions of the interior. It may, however, be well to give such conclusions bearing on these points as a study of the region has enabled me to form.

There is little doubt that the glaciation from north to south is the earliest fact of the ice-age of which any record has yet been found; and the question arises as to whether this should be attributed to glacier-ice as such, or to floating ice. If to the former, it cannot be due to local action of any kind, as some of the localities where grooving is observed are elevated above the whole surrounding country, and the direction of movement required is contrary to the general inclination of the broken central plateau, and towards a region in the vicinity of the 49th parallel which is nearly blocked with irregularly traversed mountain-ranges. For reasons stated in a former investigation of the glacial phenomena of the Great Plains, I do not believe the theory of a polar ice-cap to be applicable to the western part, at least, of North America; but it must be confessed that the indications noted in some places in British Columbia more nearly answer to the kind of traces which such an ice-cap would be expected to leave than any thing I have elsewhere seen. The portion of the supposed ice-cap entering the central plateau must, however, be imagined to have passed as a preliminary across the mountainous region to the north of the Skeena and about the Findlay river, the Peace-river gaps lying obliquely to its course, and being besides not sufficiently large to admit the requisite quantity of glacier-ice, even if the pressure was so applied as to push it directly through the hollow.

* Am. Journ. Sci. and Arts, vol. xlv. p. 96.

† "Observations on the Geology of Alaska," pub. in 'Alaska Coast Pilot,' 1869, p. 196.

‡ *Op. cit.* p. 195.

It is, however, possible that in one other manner a great glacier, moving from north to south, may have filled the central plateau. Owing to the warm water of the great Japan current, with the prevailing westerly and south-westerly winds and mountainous character of the coast, the annual precipitation of moisture is very great, especially to the north. At Sitka (southern end of Alaska) the average annual depth of rain and melted snow (from sixteen years' observations) is 82·66 inches, or within a fraction of seven feet; while the average number of days on which rain, snow, or hail fell, or heavy fogs prevailed, is two hundred and forty-five, or two days out of three. It may be supposed that, under certain not improbable combinations of conditions, the mountainous country to the north, above referred to, became preeminently the condenser of the Northern Pacific, and, from the mere accumulation of snow and ice, the focus of glacier-action and point of radiation of great glaciers. If the central plateau was ever filled thus by a great glacier-mass, the ice must have poured southward through the gaps on the 49th parallel, and westward across the Coast range, in a manner similar to that in which the ice supposed by Professor Geikie to have filled the Gulf of Bothnia must have crossed the Scandinavian peninsula*.

If the first glaciation of the central plateau is due to the action of glaciers as such, we should, however, expect to find remnants at least of deposits like those elsewhere ascribed to such gigantic ice-sheets, and not precisely resembling that noticed on a former page under the name of Boulder-clay. If these exist, they have not fallen under my observation; and in any case it appears necessary to call in the action of water with floating ice to account for the formation of the Boulder-clay, with its rounded pebbles and irregularly distributed erratics. It cannot have been laid down by glacier-ice; for it is difficult to imagine the formation of material which is found not only over plains but on exposed hill-slopes and summits, beneath a great glacier which we find in other places engaged in scooping rock-basins in the bottoms of valleys. It rests immediately on the well preserved glaciated surfaces, and, on the above suppositions of an extension of the ice-cap, or great central-plateau glacier, may have been formed during the gradual retreat northward of the decaying front of the ice while the country was submerged to a depth of over 5000 feet, either by access of the sea, due to general depression, or by the formation of a great lake covering the plateau region, the passes of the Coast range—those to the south, and those of the Rocky Mountains to the east, being still blocked by local accumulations of glacier ice. The movement of icebergs would explain the irregular distribution of the foreign mixed materials of the deposit. Water-action, sufficient to account for the rounding of the pebbles, may have occurred; and the gradual diminution of the glaciers in the various mountain-ranges may be supposed to have allowed the slow drainage of the lake, and given rise to the great systems of terraces.

* Great Ice Age, p. 404.

The stoppage of all the gaps to so great a height, however, in the various ranges would imply a coordination scarcely within the bounds of probability; and on grounds which are stated in the preceding pages, and others which will shortly be referred to, it appears to me more probable that it was by depression of the land as a whole, or elevation of the ocean, that the waters attained the level they are known to have reached in the interior.

To explain the facts by the action of floating ice, icebergs or pack-ice must be supposed to have entered the central plateau by the low gap through the Rocky Mountains in the Peace-River region, and, reinforced, no doubt, by ice from local glaciers, to have travelled southward under the influence of currents, which found exit by the Fraser river-valley and other southern openings. A depression of 3000 feet would open a wide strait from the Arctic Ocean to the Pacific, by the valleys of the Peace-River country, continued southward by that of the Fraser; while sea-water standing at a height equal to the maximum above stated would give depth enough for very heavy ice, and would besides open other avenues in the Rocky Mountains, and many and wide ones through the Coast range and to the south. If such palæocrystic ice as that met with by the late Arctic Expedition may be supposed to have filled the central basin, it will not be necessary to invoke the action of icebergs to account for the simultaneous, or nearly simultaneous, production of the north-and-south grooving, and deposition of the Boulder-clay. It is worthy of mention that in most places where striation referable to this system occurs, the country to the north is low, suggesting that the localities may have formed islands on the southern margin of a sea in which great ice-pressure may have occurred from time to time.

On the supposition of a submergence of three thousand feet or more, very important results might follow with regard to the distribution of ocean-currents. The Kamtschatka branch of the warm Japan current would, no doubt, be greatly augmented in size, and flow north-eastward through a widened Behring's Strait, possibly accounting for the apparent absence of glacial traces in Alaska. The outflow of ice-laden polar water would be to the same amount increased, causing a wide arctic current to flow southward in the region now forming the Mackenzie river-valley. A part of this would find exit across the great plains and by the Red-River hollow, while a second branch, traversing the Rocky Mountains by the Peace-River gap, would flow down the length of the plateau of British Columbia, accounting for the great transport of material and heavy glaciation found to have occurred in both these regions.

On any of the above theories the second advance of glaciers from the various mountain-ranges must be supposed to be the last phase of which we have any record. These glaciers appear to have pushed out among the water-rounded materials of some of the lower terraces, after a period of somewhat greater warmth, and before the reelevation was complete, or while a lake, or series of lakes, dammed by glaciers existed. The latter is not an unreasonable supposition when the comparatively small height of water required at this period is

taken into account. As these latest glaciers retired, after their short advance, the waters also appear to have fallen, the partly water-modified moraine-mounds remaining as evidences of this joint action.

If glaciation of the mainland by a great northern ice-cap, whether of polar origin or arising within the country itself, ever occurred, Vancouver Island and the region of the Strait of Georgia must have been buried under a still greater accumulation of ice; but if the glaciation of the continent was effected during a submergence of 4000 or 5000 feet, very little of the island would remain above the surface of the sea, and the hollow between it and the Coast range would be below the level and sheltered from the action of the floating ice. In either case, however, the dimensions attained by the glaciers during their latest extension, taking into account the favourable position with regard to gathering-grounds of the Strait of Georgia, would appear to be quite sufficient to explain the formation of the great glacier of the Strait.

The supposed general submergence of the region to a maximum depth of 5270 feet may at first seem a very startling hypothesis, though it may be softened by such reference to its insignificance when compared with the diameter of the globe as that used by some of the advocates of a great northern ice-cap. It may, however, I think, be said to have been shown in the course of a former examination of the facts of glaciation of the Great Plains to be extremely probable, if not absolutely certain, that the whole interior of the continent, from the Laurentian axis to the Rocky Mountains, was submerged, and that the sea reached a height of at least 4400 feet on the flanks of the latter range*. With this terrace, and some of those described by Dr. Hector, those of Tatlayoco Lake, in the Coast range of British Columbia, correspond as closely as can be expected, taking into account the distance apart of the two localities (500 miles). Is it, then, surprising that, in a region further north and better suited for their preservation, water-marks should be formed at a yet greater elevation of about 900 feet? To explain some of the features of the last Glacial period, we are called upon to reproduce mentally conditions of which we can scarcely hope to appreciate the magnitude; but it does not appear that even 5000 feet of water should be considered so vast a conception as the like thickness of glacier ice. In Eastern America few localities present themselves where the effects of subsidence to an amount equal to this can be studied. We find terraces, however, to a height of 1425 feet on the Laurentian axis†; and it is worthy of remark that a depression of about the amount above indicated would serve to account for the glaciation and erratics of the higher mountains of the New-England states.

* Quart. Journ. Geol. Soc. vol. xxxi., 1875, p. 663; 'Geology and Resources of the 49th Parallel,' p. 244.

† Geology and Resources of the 49th Parallel, p. 256.

5. Summary.

1. The character of the rock-striation and fluting on the south-eastern peninsula of Vancouver Island shows that at one time a great glacier swept over it from north to south. The glacier must have filled the Strait of Georgia, with a breadth, in some places, of over 50 miles, and a thickness of ice near Victoria of considerably over 600 feet. Traces of the glacier are also found on San-Juan Island and the coast of the mainland.

2. The deposits immediately overlying the glaciated rocks, besides hard material locally developed, and probably representing *moraine profonde*, consist of sandy clays and sands, which have been arranged in water, and in some places contain marine shells. These, or at least their lower beds, were probably formed at the foot of the glacier when retreating, the sea standing considerably higher than at present.

3. Observations in the northern part of the Strait of Georgia, and the fjords opening into it—where the sources of the great glacier must have been—show ice-action to a height of over 3000 feet on the mountain-sides. The fjords north of the Strait of Georgia show similar traces. Terraces along the coast of the mainland are very seldom seen, and have never been observed at great elevations.

4. In the interior plateau of British Columbia there is a system of glaciation from north to south, of which traces have been observed at several localities above 3000 feet. Subsequent glaciation, radiant from the mountain-ranges, is also found.

5. The superficial deposits of the interior may be classified as unmodified and modified. The former, representing the Boulder-clay, hold many water-rounded stones, with some glacier-marked, and occurs at all heights up to over 5000 feet. The latter characterize nearly all localities below 3000 feet, and are most extensively developed in the northern low country, where they appear as a fine white silt or loess.

6. The interior is marked with shore-lines and terraces from the present sea-level up to 5270 feet, at which height a well-marked beach of rolled stones occurs on Il-ga-chuz Mountain.

7. Moraines occur in great numbers. Some of the moraine-like accumulations may have been formed in connexion with the north-to-south glaciation. Most of those now seen, however, mark stages in the retreat of glaciers towards the various mountain-ranges. The material of the moraines resembles that of the Boulder-clay, but with water-rounded stones even more abundant.

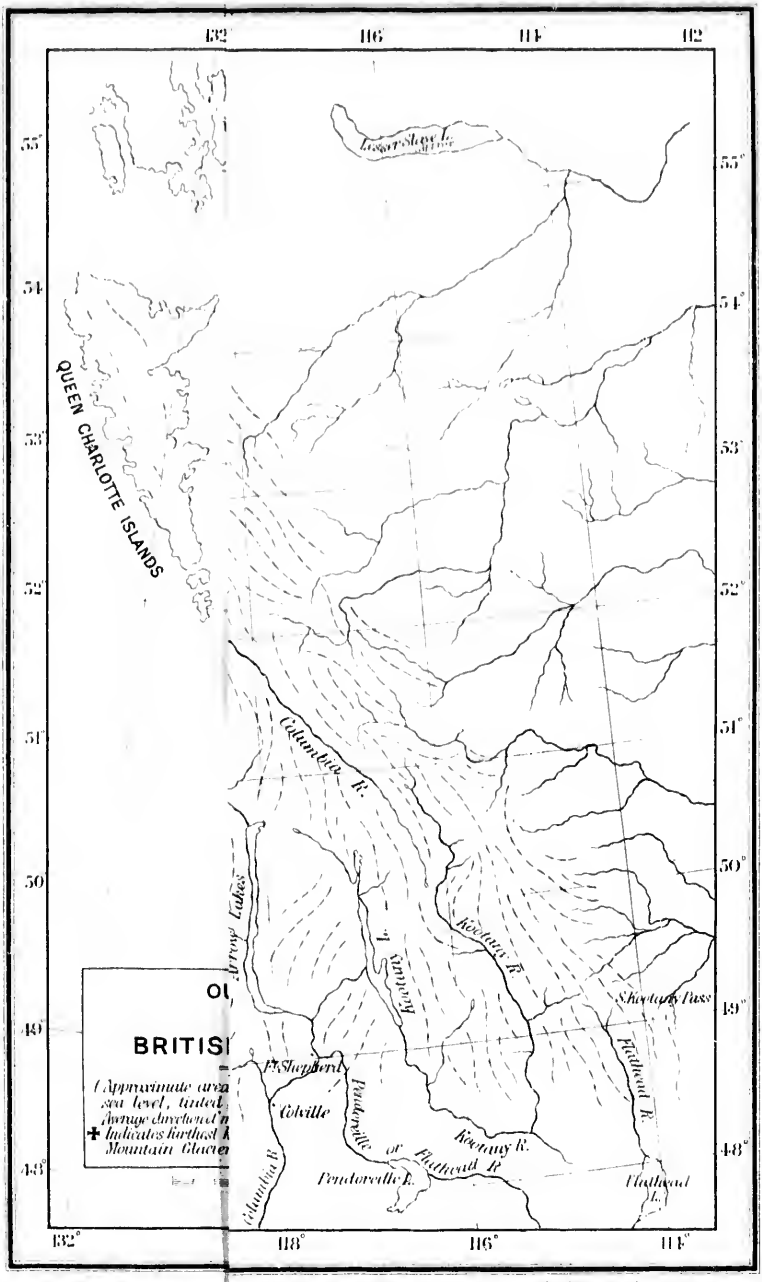
8. The sequence of events in the interior region has been:—glaciation from north to south, with deposit of Boulder-clay; formation of terraces by lowering of water-surface, accompanied or followed by a warm period; short advance of glaciers from the mountains contemporaneously with formation of lower terraces; retreat of glaciers to their present limits. Glaciation of Vancouver Island may have occurred during both the first and second cold periods, or during the second only.

9. If the north-to-south glaciation has been produced by glacier-ice, it must have been either (*a*) by the action of a great northern ice-cap (against which grave difficulties appear), or (*b*) by the accumulation of ice on the country itself, especially on the mountains to the north. In either case it is probable that the glacier filled the central plateau, and, besides passing southward, passed seaward through the gaps and fjords of the Coast range. The Boulder-clay must have been formed along the front of the glacier during its withdrawal, in water, either that of the sea, or of a great lake produced by the blocking by local glaciers of the whole of the valleys leading from the plateau, to a depth of over 5000 feet.

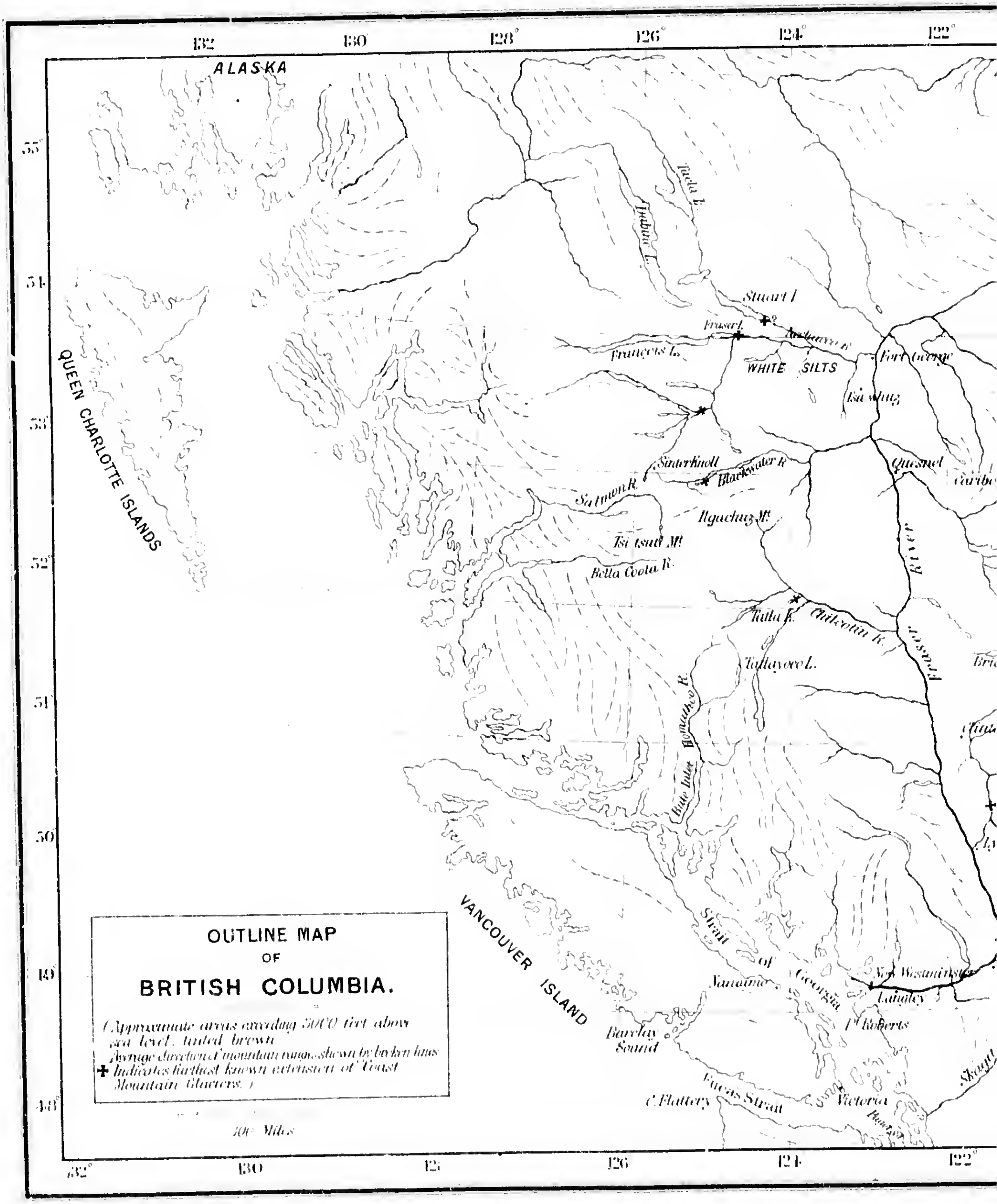
10. If general submergence to over 5000 feet be admitted, the Japan current would flow strongly through Behring's Strait, and over part of Alaska, while arctic ice-laden water, passing south across the region of the Great Plains, would also enter the central plateau of British Columbia, accounting for the north-to-south glaciation and simultaneous formation of the Boulder-clay.

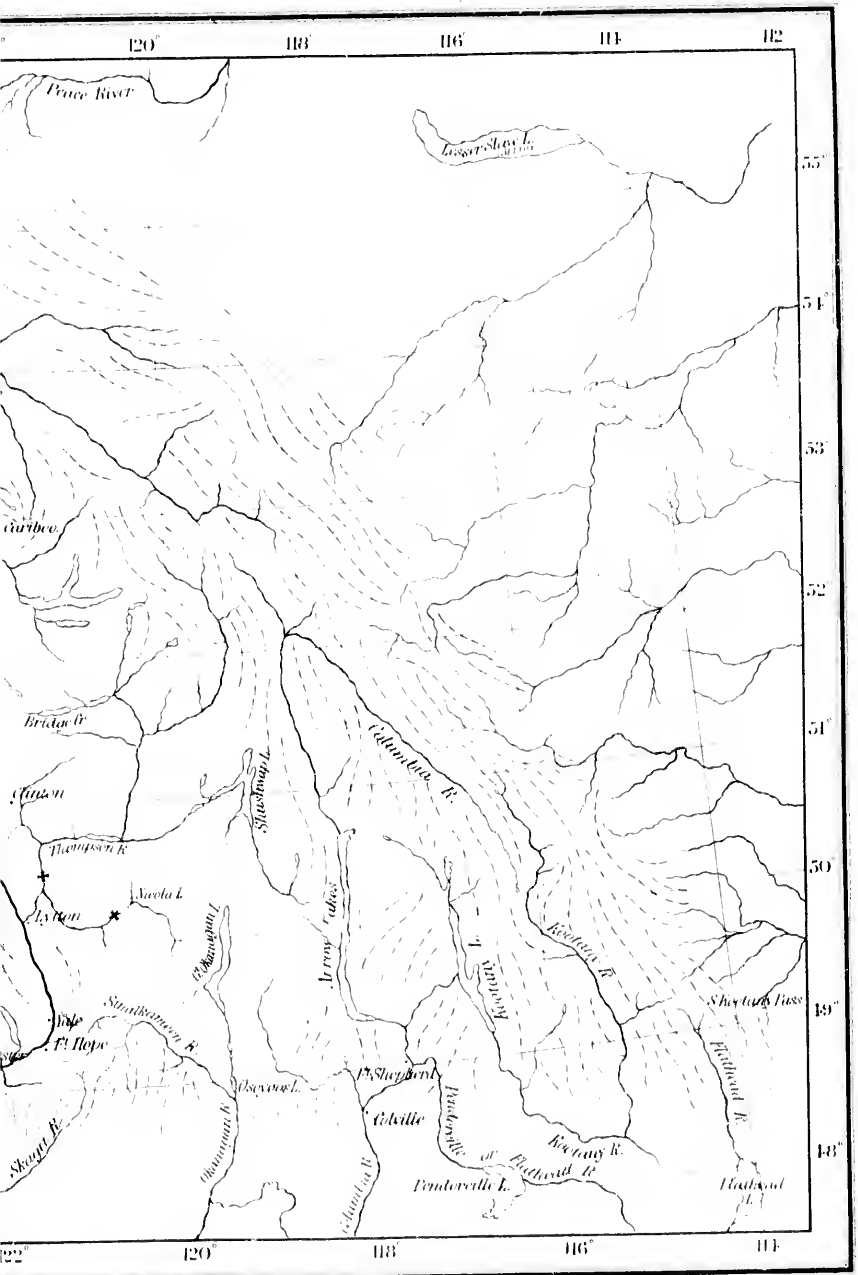
EXPLANATION OF PLATE V.

Outline Map of British Columbia, showing the portions exceeding an elevation of 3000 feet above the sea-level, the general direction of the principal mountain-ranges, and the former extension of glaciers from the Coast Mountains.



DAVIS & REED LITH. 22, BISHOPS ST. COVENT GARDEN


OUTLINE MAP
OF
BRITISH COLUMBIA.
ALASKA
QUEEN CHARLOTTE ISLANDS
VANCOUVER ISLAND
Stuart L
Fraser L
Francois L.
WHITE SILTS
Fort George
Quesnel
Blackwater R.
Salmon R.
Bella Coola R.
Chilcotin R.
Tatla L.
Homathco R.
Bute Inlet
Strait of Georgia
Nanaimo
New Westminster
Langley
Pt Roberts
Barclay Sound
Fucas Strait
Victoria
C. Flattery
Fraser River
100 Miles


120°
118°
116°
114°
112°
55°
54°
53°
52°
51°
50°
49°
48°
Peace River
Lesser Slave L.
Cariboo
Bridge Cr.
Clinton
Thompson R.
Shuswap L.
Columbia R.
Nicola L.
Lytton
Okanagan L.
Arrow Lakes
Kootanie L.
Kootanie R.
Similkameen R.
Yale
Ft. Hope
Osoyoos L.
Ft. Shepherd
Colville
Pend d'Oreille or Flathead R.
Kootany R.
Pend d'Oreille L.
Flathead R.
Flathead L.
Skagit R.
Okanagan R.
122°
120°
118°
116°
114°