Report Can. Pacific Railway 1880.

APPENDIX No. 7.

REPORT ON THE CLIMATE AND AGRICULTURAL VALUE, GENERAL GEOLOGICAL FEATURES AND MINERALS OF ECONOMIC IMPORTANCE OF PART OF THE NORTHERN PORTION OF BRITISH COLUMBIA, AND OF THE PEACE RIVER COUNTRY, BY GEORGE M. DAWSON D.S., A.R.S.M. F.G.S., ASSISTANT DIRECTOR GEOLOGICAL SURVEY OF CANADA *

(1.) *Climate and Agriculture.*

The climate of the coast of the northern part of British Columbia, while not subject to great extremes of temperature, is excessively humid, with much rain at all seasons of the year and occasional heavy falls of snow in winter. Neither Esquimalt nor New Westminster, which are the only regular meteorological stations maintained near the coast of the Province, give any criterion by which to arrive at a knowledge of the climatic conditions of other districts; for both these places—but especially Esquimalt—are sheltered from the excessive precipitation which occurs where the moisture-bearing winds first strike the high coast line. Observations maintained by myself while engaged in a geological examination of the Queen Charlotte Islands, during the summer of 1878 (published as an Appendix to the Report of Progress of the Geological Survey, 1878–9), fairly represent the climate of that region during a few months. Observations kept up during many years at Sitka, two and a-half degrees north of Port Simpson, and considerably further west, doubtless represent a climate considerably worse than that of the northern part of the coast of British Columbia. It may, however, be useful to extract from these the following facts. The latitude of Sitka is 57° 3′, or about one degree north of Glasgow (Scotland). Temperature observations extend over a period of forty-five years with little interruption. "The mean temperature of spring is 41·2°; for summer, 54·6°; for autumn, 44·9°; for winter, 32·5°, and for the entire year, 43·3, F°. The extremes of temperature for 45 years are 87·8° and –4·0°. However, the mercury has fallen below zero of Farenheit in only four years out of the 45, and has risen about 80° during but seven years of that period. The coldest month is January, the warmest August; June is slightly warmer than September." The mean of the minima for seven years of the above period is 38·6°, and of the maxima for seven years, 43·9°, shewing a remarkably equible climate. The average annual amount of rain, melted snow and hail from 1847 to 1864 (with the exception of the year 1855) was 82·66 inches, or within a fraction of seven feet; and the average annual number of days on which rain, snow or hail fell, or heavy fogs prevailed, was two hundred and forty-five, or two days out of three, while it does not follow that the other days have a clear sky. Tables by Lütke, from observations in 1828 and 1829, show that on an average each year there were 170 days calm, 132 days moderate winds, and 63 days with strong winds.†

The average annual precipitation of moisture at the mouth of the Columbia River, eleven degrees of latitude further south, is stated to be five inches greater than at Sitka, and it is therefore probable *a priori* that in the vicinity of Port Simpson and about the mouth of the Skeena, on that part of the coast of the mainland

* Transmitted for publication in advance of the forthcoming detailed Report on the Explorations of 1879, by permission of A. R. C. Selwyn, F.R.S., F.G.S., Director Geological Survey of Canada.

† Alaska Coast Pilot, 1869, and Pacific Coast Pilot, Appendix 1, 1879, p. 30.

lying open to the westerly winds between Queen Charlotte and Vancouver Island, and on the west coasts of these islands, that the precipitation is at least equally great, and amounts to between 80 and 90 inches per annum. This amount of precipitation, though small in comparison with that of a few exceptional places on the earth's surface, is greater than that characterizing even the western coasts of the British Islands, with the exception of a few peculiarly situated mountainous localities, where it is exceeded, and little less than the heaviest rainfall on the Norwegian coast (90 inches).

Recently published observations for Fort Tongass, though covering a period of but little over two years, must represent the climate of the region in the vicinity of Port Simpson and of the Queen Charlotte Islands pretty closely, as Tongass is situated on the north side of Dixon Entrance, little over fifty miles from Port Simpson in a direct line. The mean temperature is here 46·5°, or considerably warmer than Sitka. "This may be due," Mr. W. H. Dall writes "to the reception in the open throat of Dixon Entrance of the warm waters of the Alaska Current, fresh from the great north Pacific Gulf Stream."Fort Tongass is the locality of greatest known precipitation in Alaska, the rainfall averaging during the years of observation 118·3 inches, on which Mr. Dall remarks, that observations point to the Queen Charlotte Islands, and the region about Dixon Entrance as the most rainy part of the north-west coast. At Tongass about 200 days a year are either rainy or snowy, a proportion agreeing nearly with that observed at Sitka.*

The excessive rainfall, considered in conjunction with the fact that the sky throughout the year is essentially cloudy, preventing rapid evaporation and keeping the dew point near the actual temperature of the air, accounts for the peculiar character of the vegetation, and the fact that ordinary cereals cannot be grown in the districts exposed to these conditions. At Fort Simpson, on the west coast of the Queen Charlotte Islands, and elsewhere, many of the hills are but partially covered with forest, the remainder of the surface being occupied by sphagneous moss several feet in depth, and saturated with water even on steep slopes. The low north-eastern part of the Queen Charlotte Islands is in great measure sheltered from the rain-bearing winds, and constitutes, in fact, the only extensive area of land which appears to be suitable for agriculture on the northern part of the coast. Mr. Duncan, of Metla-Katla, who kept a meteorological register for some time after his first arrival in the country,estimated that there were on an average about seven fine days in a month in that place. The behavior of the winds and barometer in both Vancouver and the Queen Charlotte Islands, appear to indicate that the centres of most storms, travelling from west to east, pass to the northward of the coast of British Columbia. This being so, it is probable that the force of the gales is somewhat greater on the northern part of the coast of the province than on the southern.

I have elsewhere stated that fogs do not seem to occur with such frequency in the vicinity of the Queen Charlotte Islands as in the southern part of the Strait of Georgia. It may be interesting to quote, in this connection, the following statement by the great but unfortunate navigator, La Péroure, bearing on the northern part of the west coast. † He writes: "I first thought these seas more foggy than those which separate Europe and America, but I should have been greatly mistaken to have irrevocably embraced this opinion. The fogs of Nova Scotia, Newfoundland, and Hudson's Bay have an incontestable claim to pre-eminence from their constant density."

The cause of the exceptional mildness of the climate of this region is to be found not alone in the fact of the proximity of the sea, but in the abnormal warmth of the water, due to the Kuro-Siwo or Japanese Current. The average temperature of the surface of the sea, during the summer months, in the vicinity of the Queen Charlotte Islands, as deduced from a number of observations taken by myself in 1878, is 53·8°. Between Victoria and Milbank Sound, by the inner channels, from May 28th to June 9th, the average temperature of the sea surface was 54·1°. In the inner

* Pacific Coast Pilot, Appendix 1, *loc. cit.*
† Quoted by G. Davidson in Alaska Coast Pilot.

channels between Port Simpson and Milbank Sound, between August 29th and September 12th, 54·5°, and from the last mentioned date to October 18th, about the north end of Vancouver Island, and thence to Victoria by the inner channels, 50·7°. Observations by the United States' Coast Survey, in 1867,* gave a mean temperature for the surface of the sea between Victoria and Port Simpson and outside the Prince of Wales Archipelago, from Fort Simpson to Sitka, in the latter part of July and early in August, of 52·1°. In the narrower inlets of the coast, the temperature of the sea falls, owing to the quantity of cold water mingled with it by the entering rivers. These observations serve to show the existence, off the coast, of a great body of warm water, and the temperatures closely correspond with those found in similar latitudes, and due to the Gulf Stream and North Atlantic surface drift, on the west coast of Britain. The annual average temperature of the sea surface off the west coast of Britain is stated as 49°, while that of the eastern North Atlantic, influenced by the Gulf Stream, varies from 44° to 54°.†

It will be observed that the summer temperature of this body of warm water appears to be somewhat lower than the mean summer temperature of Sitka. Its influence on the climate is not, however, a direct one, but is chiefly exercised in the following way.—The prevailing south-westerly winds, sweeping over the warm surface of the sea are raised to its temperature, and become saturated with moisture, abstracting from it, as they do so, and rendering latent in conformity with well known physical laws, a still greater quantity of heat. When, on reaching the mountainous coast, this moisture is again condensed and discharged, the latent heat becomes again apparent, and greatly raises the temperature of the atmosphere in which the reaction occurs.

According to Dove's tables, the mean annual temperature of a place situated in the latitude of Glasgow, derived from the temperature of the whole northern hemisphere, should be 35°. Owing to the Gulf Stream and south-westerly winds, the actual mean annual temperature of Glasgow is about 50°, or exceeds the normal by 15°. The mean temperature of the greater part of the North American continent in the same latitude is 5° to 12° below Dove's normal temperature, but that of the regions on the west coast of America—which is related to the course of the Japanese Current in a manner similar to that of the west coast of Europe and the Gulf Stream—as represented by the above detailed observations at Sitka, exceeds the general mean by eight degrees. The mean annual temperature of Sitka being, in fact, nearly the same as that of Montreal, ten degrees of latitude further south.

Many of the islands lying off the northern coast of British Columbia, and forming the great archipelago which fringes it, are low; but, though covered with luxurient forest, possess very little soil, and are in many cases composed of almost solid rock. About Metla-Katla and Port Simpson, small patches of ground are cultivated by the Indians as potato gardens, and good crops secured; but the total area of arable land existing on this part of the coast, with the exception of the portion of the Queen Charlotte Islands before referred to, is so inconsiderable as to be scarcely worth mention.

The coast about Port Simpson and the mouth of the Skeena is very imperfectly sheltered from the rain-bearing winds by the Queen Charlotte Islands, while the islands of the coast archipelago, being for the most part of moderate elevation in this region, abstract little moisture. Where these winds first impinge on the monuntainous mainland the heaviest precipitation occurs, in exact correspondence with the height to which the moist air is forced up into the higher regions of the atmosphere, and cooled there by its expansion and loss of heat by radiation. As the mountains attain a considerable elevation at the coast, and the increase in elevation of the peaks

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* Alaska Coast Pilot, 1869, p. 20.

† "That portion of the Kuro-Siwo having a temperature of 55° F., or more, approaches the coast of North-west America in the vicinity of Vancouver Island. The precipitation is greater, and sudden meteorological disturbences are more common between latitude 48° and 55° N. than on any other part of the coast, so far as we know. But the water near the coast is less than 55° in temperature, and may average not more than 50°."—Pacific Coast Pilot, Appendix 1, p. 21.

towards the axis of the range is comparatively gradual, the heavy rainfall of the coast is not found to be maintained in travelling eastward by the Skeena River. At forty-five or fifty miles above Port Essington, evidence of decreasing moisture is found, and is still more clearly apparent when Kitsalas Canyon, about half way from Port Essington to the Forks of Skeena, is reached. The devil's club and skunk cabbage (*Echinopanax horrida* and *Lysichiton Kamtschatsense*) luxuriant in the lower reaches of the river and indicative of a humid climate, no longer abound.

At Quatsalix Canyon, ninety-five miles from the coast, the highest summit of the Coast Range having been passed, the vegetation characteristic of the northern interior of British Columbia may be said to set in; the western scrub pine and aspen (*Pinus contorta and Populus tremuloides*) growing abundantly on the flats and slopes. The change is so gradual, however, and the blending of the coast and interior floras on the Skeena so complete that it is difficult to assign the precise position of the line.

With regard to the snowfall on the Skeena, Mr. H. J. Cambie during his survey here in 1877, gathered that from Port Essington to near the month of the Lakelse (56 miles), it was exceedingly heavy, reaching a depth of ten feet or more. From this place to Kitsalas Canyon it reaches, at least occasionally, a depth of six feet; while about Kitwungah,—sixteen miles below the Forks—it averages three feet. So far as information can be obtained from the Indians it appears to confirm these estimates. The depth on the benches about the Forks is not over one foot, but owing to local circumstances the snowfall is here considerably less than in any neighboring locality, the average for this part of the Skeena Valley being probably a little under two feet.

At about twenty miles below the Forks, the higher benches at the sides of the river and a few hundred feet above its level, extend several miles back from it, and show soil of fair quality, composed of sandy loam with more or less vegetable matter. It is reported that the Skeena valley continues to present the same appearance further up, and it is certainly wide and low for some distance above the Forks, while a considerable width of land suited for agriculture is also found in the valley of the Kispyox to the north-westward.

The summer temperature of the region about the Forks or Hazelton is often high, and the rainfall by no means excessive. According to Mr. Hankin, a trader who has resided many years here, snow generally first falls in October, but melts again, the winter snow not coming till about the middle of December. The winter is in general steadily cold, though there is almost always a thaw in February. The thermometer has been known to reach 48° below zero and to remain for days at a time below—30°.

The winter is in fact about the same as that of Stuart Lake, but the spring is said to open much earlier. Grass begins to grow green and some trees to bud out about the first week in April. Some cultivation is carried on. Potatoes are occasionally nipped by frost in the spring and on two occasions have been effected by summer frosts. They are generally harvested in the end of September, but are ripe before that time, and can be obtained large enough for use about the first of July. Indian corn does not ripen, and wheat, Mr. Hankin believes would be an uncertain crop. The season of 1878 was exceptionally long, and two successive crops of oats ripened before the frost; the second being a 'volunteer crop.' In favorable seasons, squashes, cucumber and other tender vegetables come to perfection. A few cattle and horses have been wintered here, the former requiring to be fed for five months, the latter have been kept by clearing away the snow to a certain depth in strips to allow them to scrape for grass.

The Skeena usually opens during the last week in April or first week of May. Ice begins to run in the river early in November, but the river does not generally freeze till the end of December. The river being very rapid, the occasion of its freezing is usually the occurance of a thaw. This sets free great quantities of anchor ice, sometimes very suddenly, blocking the river and causing it to freeze over. In 1867 the river closed on the 13th of November, which was exceptionally early. The river is generally highest in July, deriving most of its water from the melting snow on the mountains. It is lowest immediately after the ice goes.

Without entering into details as to the natural vegetation of the region, it may be said that it appears to indicate that the rainfall is nearly the same as about Quesnel, on the Fraser, while the climate is in general much like that of Quebec or Montreal, with the exception of the winter, which, according to the statements above given, though rather shorter, is more severe.

I am induced to think that Mr. Hankin is wrong in supposing that wheat would not succeed well about the Forks, but this must remain a matter for future experiment.

Meteorological observations kept by myself while on the Skeena, from June 7th to 23rd, being taken *en route* from Port Essington to the Forks, are necessarily imperfect, and as we were engaged in travelling during the day it was impossible to ascertain the maximum temperature. The mean minimum temperature read on a good thermometer carefully placed on nine nights; between Port Essington and Kitsalas Canyon is 43·4° F, the actual lowest reading being 39°. The mean of seven nights from the Canyon to the Forks, 43·6°, the actual lowest being 37·5°. The mean of observations taken about 6 a.m. and 6 p.m.; every day, on the first mentioned part of the river is 50·8°; on the upper part part of the river, 52·8°. The mean of morning readings taken below Kitsalas Canyon is 45° of evening reading, 56·4°. These reduced for the hour and time of the year by Dove's table of corrections, derived from observations at Sitka, indicate actual mean temperature of 49·1° and 53·1°, respectively. The mean doubtless lies between these figures, but their discord shows that we have already a considerably greater range and a climate more continental in character than that of Sitka. Morning observations above the Canyon indicate a mean of 46·6°. Evening observations 58·9°, which, corrected in the same way, yield 50·58° and 55·6° as approximations to the true mean temperature.

Of the Watsonquah River, which joins the Skeena from the south-eastward at the Forks, Mr. Cambie reports that the valley throughout its entire length is in part prairie and sustains a magnificent growth of grass, but is subject to frequent summer frosts and unsuited to agriculture. * The Sus-kwa valley which joins the Watsonquah, and up which the trail from the Forks toward Babine Lake runs, contains no agricultural land worth mention, but its northern side has been in many places very completely burnt over, and is covered with exceedingly luxurient grass and pea-vine, forming an excellent summer range for cattle or horses.

Babine and Stuart Lakes occupy portions of a single great valley, which is bounded by mountainous country on either side, and communicates northward with the flat country of the Lower Nechacco. The upper end of the lake rarely freezes completely across, but this is due, not to the mildness of the winter, but to the great depth of the water. A similar circumstance has already been reported for François Lake. † A terrace at a height of about 200 feet is specially prominent round the lake, and after reaching this height the land frequently runs back several miles as a level or gently undulating plain. In other places it slopes gradually up, reaching an elevation of 500, 600, or 800 feet above the lake at from two to five miles from it. The valley is not even then shut in by high mountains in its central part, but appears to continue at nearly the same, or a lower level in some places for many miles. The woods are generally light, aspen and poplar frequently preponderating over spruce, and considerable tracts with a southern exposure, from which fire has removed the forest, are covered with luxurient grass, pea-vine, epilobium, &c. The portage between Babine and Stuart Lakes is low, across wide spreading benches, and from half to one third of the surface appears fit for cultivation. Considerable areas of low land also border Stuart Lake.

The aggregate area of land below the 3,000 feet contour line, with light slopes or nearly level, and which may be supposed to have some prospective value, is great; but it is impossible to form even an approximately correct estimate of it till the maps are further advanced. That in sight from the lakes must exceed 500 square

* Canadian Pacific Railway Report, 1878, p. 70.
† Report of Progress, Geol. Survey of Canada, 1876-77 p 47.

miles. The soil is generally good, and the only remaining question is in regard to the character of the climate.

The northern or lower extremity of Babine Lake being more closely hemmed in by snow-clad mountains, is evidently less favorably situated than the remainder of this lake and Stuart Lake, and vegetation was found to be decidedly behind that of the Sus-kwa Valley. Mr. Sanpere, who is in charge of two Hudson Bay posts, one at the north end, the other at the middle of Babine Lake, states that at the latter he can grow potatoes and many kind of vegetables, and that his predecessor grew barley, which ripened well. An Indian living on the portage between the two lakes cultivates a little patch of land, and, though very poorly attended to, he had a fine looking crop of potatoes and a little field of barley, the latter about three feet high and with the ear just appearing at the date of our visit (July 4th). He also keeps some cattle here, cutting hay for them in swamps around Stuart Lake. At Fort St. James we found potatoes flourishing, but rather late, having been cut down by a frost in June. Barley was doing well, and has been grown as a regular crop for many years. * In the garden were peas, lettuce, beets, carrots, onions, garlic, turnips, cabbages and cauliflowers, doing well enough, but not carefully cultivated. Wheat has been sown this year as an experiment, and had not suffered from frost at the date of our visit (July 7th).

Temperature observations kept while on Babine and Stuart Lakes, June 27th to July 8th, gave a mean minimum temperature of 40·2°. The mean of the early morning and evening observations is 51·5°. The temperature is here subject to greater and more rapid changes than in the Skeena Valley, and on the night of June 29th we experienced a frost, the thermometer registering 26°, near the northern end of Babine Lake, and in the vicinity of the snow-clad mountains already referred to.

In the valley of Babine and Stuart Lakes the summer season seems to be sufficiently long, and the absolute amount of heat great enough to bring all ordinary crops, including wheat, to maturity, but the question remains to what extent the liability to summer frosts may interfere with the cultivation of some plants, more especially wheat. Though this valley may be regarded as a continuation of the country of the Lower Nechacco, its vicinity to mountains appears to render it somewhat inferior to that district in climate, and places it in this regard, in my opinion, nearly in the same position with the country bordering on François Lake. In previous reports † I have described the flat country of the Lower Nechacco basin as constituting the greatest connected region susceptible of cultivation in the Province of British Columbia. Its area has been estimated at 1,000 square miles. It is based on fine white silty deposits of the later portion of the Glacial period, constituting a soil almost uniformly fertile, and is remote from high snow-clad ranges. In the absence of further information, I can merely repeat what was said of this region on a former occasion, viz., that while it is not probable that wheat can be grown over all parts of its area, it can scarcely be doubted that barley may be ripened almost everywhere in it, while wheat would succeed in chosen spots. This region will, doubtless, at some time support a considerable population, but it is to be remarked that the passage of a railway through it would do little at present toward settling it; for in the first instance, the country to the east of the Rocky Mountains, in the Peace River or Saskatchewan Valleys, would offer superior inducements to farmers and stock raisers.

The country lying in the vicinity of the trail between Fort St. James, on Stuart Lake, and Fort McLeod has already been described by Mr. Selwyn and by Mr. Hunter. ‡ The elevation of the watershed which is characterized by wide sandy

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* Report of Progress, Geol. Survey of Canada, 1876-77, p 51.

† Report of Progress Geol. Survey of Canada, 1876-77, p 45. Canadian Pacific Railway Report, 1877, p. 252.

‡ Report of Progress, Geol. Survey of Canada, 1875-76, p. 34. Canadian Pacific Ry. Report, 1878, p. 73.

flats is about 2,816 feet, taking the height of Stuart Lake at 2,200 feet. With the exception of a belt a few miles wide near Stuart Lake, and rising in places about 400 feet above it, this region is scarcely to be considered as of any agricultural value. It lies to the north of the Nechacco basin previously mentioned. Its surface is considerably broken and the soil generally light, sandy or gravelly. It is at present covered for the most part with burnt woods. A considerable area would doubtless be available for pasture land if the forest were completely removed by fire, and there are numerous swamps and meadows along streams yielding good natural hay. A frost was experienced on the night of July 13th, my thermometer going down to 27°, on Iroquois Creek. No frost occurred at Fort McLeod, nine miles off, and between 400 and 500 feet lower.

At Fort McLeod the potatoes had been cut down by frost in June, but had recovered completely and were growing well in July. The soil is, however, rather poor, and the area of cultivable land not extensive.

D. W. Harmon, in his "Voyages and Travels" published at Andover, Mass., in 1820, states that the snow fall at Fort McLeod is sometimes as much as five feet, and this is confirmed by those now acquainted with the region. At Fort St. James the snow reaches a depth of about three feet. A difference remarkably great for two places so close together.

From Fort McLeod to the Middle Forks of Pine River, seventy-two miles distant, may be treated together as representing the Rocky Mountains, including the foot hills of both slopes and the higher plateau attaching to these on the north-eastward. From July 17th to August 5th, the mean of the observed minima on this part of the route is 39·7°. The mean of the early morning and evening readings of the thermometer, 49·4°. This must be much below the actual mean temperature, for the thermometer had seldom risen much above its minimum when observed at 6 a.m. The heat was sometimes great in the middle of the day, but as we were then always travelling, could not be registered. Three frosts were experienced, on the nights of the 2nd, 3rd and 4th of August, the thermometer reading 30·5°, 28° and 30°5 on these nights. Strong westerly winds, falling calm at sundown, with a clear sky were the conditions causing the frosts. The quantity of arable land in this mountainous zone is quite inconsiderable, being confined, on the route followed, to the actual valley of Pine River for a few miles above the Middle Forks.

The portion of the Peace River country, for which the exploration of last season enables pretty accurate general information to be given, may be considered as extending eastward from the Middle Forks of Pine River. West of this point, as already stated, the areas of fertile land are small, being confined to certain river valleys which penetrate the foot hills of the Rocky Mountains and high plateau attached to them. With this western limit, the region now to be described may be considered as bounded to the north by the 57th parallel, to its intersection eastward with the Peace River. Thence the boundary may be assumed to follow the Peace River southward to the mouth of Heart Brook, near the confluence of the Smoky River. Thence to run south-eastward to the extremity of Lesser Slave Lake, to follow the western border of the hilly region lying to the south of the lake to the Athabaska River; thence to follow the Athabaska westward to the foot hills, and skirting the foot-hills to run north-westward to the first mentioned point on Pine River.*

The tract included within the limits above given has an area of about 31,550 square miles, and by far the larger part of this area may be classed as fertile. Its

* In addition to the area above defined, my explorations and those of my assistant, Mr McConnell, during the past season, included an examination of the upper part of the Athabasca to Athabasca Landing, of the north shore of Lesser Slave Lake and Lesser Slave Lake River, of a route from the east end of Lesser Slave Lake to old Fort Assineboine and thence to Edmonton, and of the road from Athabasca Landing to Edmonton. Also of the Athabasca from the Landing to the mouth of the Rivière la Bèche, by the valley of the latter to Lac la Bèche and thence to Victoria and Egg Lake. The country examined on these lines is not included in the present report, as being less homogenous in character than the great region above defined, it requires to be treated at greater length and in more detail. It may suffice for the present to state that considerable areas of fertile land are found throughout, but more particularly in the region south of the line of the Athabasca River.

average elevation may be stated as little over 2,000 feet, and this is maintained with considerable uniformity, for though the general surface slopes slightly from the north and south toward Peace River, the region as a whole may be considered as a plateau through which the great gorge-like valley of the Peace has been excavated. This valley has in general a depth of 600 to 800 feet below that part of the plateau bordering it, with a width of two to three miles from rim to rim. Its tributary streams at first nearly on the plateau level, flow in valleys of continually increasing depth as they approach that of the Peace River. Those from the south-eastern portion of the region rise either in the Rocky Mountains, or near the Athabaska, the tributaries received by the latter stream from the north and north-west being—with the exception of the Batiste—quite inconsiderable in this part of its course.

The ridges and hills by which this region is occasionally diversified, appear in all cases to be composed either of the generally soft rocks of the Cretaceous and Tertiary or of arenaceous clays containing erratics and representing the boulder clays of the glacial period. These elevations are generally slight, and with exceedingly light and gradual slopes, the scarped banks of the streams constituting much more important irregularities. These ridges, however, often resemble detached portions of a higher plateau and spread widely enough to occupy in the aggregate a considerable area, of which the soil is not so uniform in character as elsewhere. With these exceptions, the soil of the district may be described as a fine silt, resembling the white silts of the Nechacco basin previously referred to, and not dissimilar from the loess-like material constituting the subsoil of the Red River Valley in Manitoba. This silt, at a short distance below the surface, is greyish or brownish in color, but becomes mixed superficially with a proportion of vegetable matter to a varying depth. It has evidently been deposited by a comparatively tranquil body of water not loaded with ice, probably toward the close of the glacial period, and has either never been laid down on the ridges and undulations above referred to, or has been since removed from them by natural processes of waste. As evidenced by the natural vegetation its fertility is great.

West of the Smoky River, both to the south and north of Peace River, there are extensive areas of prairie country, either perfectly open and covered with a more or less luxuriant growth of grass, or dotted with patches of coppice and trees.

The northern banks of the Peace River Valley are also very generally open and grassed, and parts of the valley of the Smoky and other rivers have a similar character. The total area of prairie land west of the Smoky River, may be about 3,000 square miles. The remainder of the surface is generally occupied by second-growth forest, occasionally dense, but more often open and composed of aspen, birch, and cottonwood, with a greater or less proportion of coniferous trees. Some patches of the original forest, however, remain, particularly in the river valleys, and are composed of much larger trees, chiefly coniferous, among which the black spruce is most abundant. Handsome groves of old and large cottonwoods are also to be found in some of the valleys. Where the soil becomes locally sandy and poor, and more particularly in some of the more elevated parts of the ridges before described, a thick growth of scrub pine and black spruce, in which the individual trees are small, is found; and in swampy regions the tamarac is not wanting, and grows generally intermixed with the black spruce.

East of the Smoky River, and southward toward the Athabaska, the prairie country is quite insignificant in extent, the region being characterized by second-growth woods of the character just described, which, on approaching the Athabaska, are replaced by extensive and well nigh impassible tracts of brulé and wind-fall, in which second growth forest is only beginning to struggle up.

Though the prairies are most immediately available, from an agricultural point of view, the regions now covered with second-growth and forest, where the soil itself is not inferior, will eventually be equally valuable. The largest tract of poor land is that bordering the valley of the Athabaska on the north. This rises to an elevation considerably greater than most of the region to the north and west, and appears during the submergence to which the superficial deposits are due, to have been exposed to

stronger currents which have prevented the deposition of the fine silt, causing it to be replaced by a coarser silt which passes in places with actual sand, and alternates with ridges of boulder clay. This region is also often very swampy, and for a width of twenty to twenty-five miles on the trail from Sturgeon Lake to the Athabaska is quite unsuited to agriculture, though still in many places capable of yielding good summer grazing when the forest has been completely removed by fire. To the northward, more particularly to the east of Smoky River, peaty and mossy swamps occupy part of the surface, and these may be regarded as permanently unsuited to agriculture.

There is also a sandy tract, though of small width, along the lower part of the Elk River near its junction with the Smoky. Deducting, as far as possible, all the areas known to be inferior or useless, with about twenty per cent. for the portions of the region under consideration of which less is known, the total area of land, with soil suited to agriculture, may be estimated as at least 23,500 square miles. In the absence of complete maps, such an estimate cannot be otherwise than very rough, but may serve to give some idea of the fact.

Whatever theory be adopted, and may have been advanced, to account for the wide prairies of the western portion of America further to the south, the origin of the prairies of the Peace River is sufficiently obvious. There can be no doubt that they have been produced and are maintained by fires. The country is naturally a wooded one, and where fires have not run for a few years, young trees begin rapidly to spring up. The fires are, of course, ultimately attributable to human agency, and it is probable that before the country was inhabited by the Indians it was everywhere densely forest-clad. That the date of origin of the chief prairie tracts now found is remote, is clearly evidenced by their present appearance, and more particularly by the fact that they are everywhere scored and rutted with old buffalo tracks, while every suitable locality is pitted with the saucer-shaped 'buffalo wallows.' It is reported that a few buffaloes were seen last year near Pine River, but the animal has now become in the Peace River county practically extinct; an event which, according to the Indians, happened at a date not very remote, owing to a winter of exceptional severity, during which the snow "reached to the buffaloes backs."

The luxuriance of the natural vegetation in these prairies is truly wonderful, and indicates, not alone the fertility of the soil, but the occurence of a sufficient rainfall. The service berry, or amalanchier, and the choke-cherry are very abundant in some places, particularly on the so-called Grande Prairie, which constitutes the great berry gathering ground of the Indians.

With regard to the climate of the Peace River country, we are without such accurate information as might be obtained from a careful meteorological record, embracing even a single year, and its character can at present be ascertained merely from notes and observations of a general character and the appearance of the natural vegetation.

It may be stated at once that the ascertained facts leave no doubt on the subject of the sufficient length and warmth of the season, to ripen wheat, oats and barley, with all the ordinary root crops and vegetables, the only point which may admit of question being to what extent the occurence of late and early frosts may interfere with growth. This remark is intended to apply to the whole district previously defined, though it must be remembered, in considering the subject, that the conditions of places situated in the bottom of the trough-like river valley, and 600 to 800 feet below the plateau, may be considerably different from those of its surface.

The summer season of 1879 was an unusual one, characterized by excessively heavy rain-fall, with cold raw weather in the early summer months. These conditions did not extend to the west of the Rocky Mountains, but appear to have been felt over the entire area of the plains to the Red River Valley. As a result of this, the crops generally throughout the North-west were later than usual, and the mean temperature of even the latter part of the summer appears to have been rather abnormally low. Notwithstanding this, on my arrival at Dunvegan, on the 16th of August, small patches of wheat and barley in the garden of the fort presented a remarkably fine appearance and were beginning to turn yellow. On my return to

the fort on August 31st these were being harvested, their complete ripening having been delayed by overcast and chilly weather which prevailed between these dates. At the first-mentioned date potatoes were quite ripe, with the balls formed on the stalk, and the garden contained also fine cabbages, cauliflowers, beets, carrots, onions, lettuce and turnips. Dwarf beans, cucumbers and squashes were also flourishing, and though these plants are particularly tender, showed no sign of frost. The two last named having been sown in the open ground did not appear likely to perfect their fruit. A few stalks of Indian corn were also growing, though it is improbable that this plant would ripen its seed in this district.

When this garden was again visited, on the last day of August, the beans, cucumbers and squashes had been cut down by a frost, but not completely killed. The potato tops were also slightly nipped.

Rev. M. Tessier, who has been at Dunvegan as a missionary for some years, has always been able to ripen small, black butter-beans, but in some seasons not without difficulty owing to frosts. He has also tried a few grains of oats which he procured accidentally, and obtained a return of astonishing abundance. About the date just referred to the potatoe plants at Smoky River post (The Forks) were badly cut down by frost, the tubers being, however, quite ripe, fine and large.

On the 15th September, Mr. R. McConnell, my assistant, found the potatoes in the garden of the fort at the west end of Lesser Slave Lake, and on the level of the plateau, little affected by frost, with tubers large and ripe. Mr. H. J. Cambie also ascertained that wheat thrives at this place. We found some rude attempt at cultivation also at the 'Cree Settlement,' which consists of a few log houses built by Indians on the border of Sturgeon Lake, about 70 miles south-west of the west end of Lesser Slave Lake, and is at the average level of the country, with an elevation of about 2,100 feet. Here, on September 14th, the potatoe plants were slightly affected by frost, but not more so than observed with those at Dunvegan two weeks before. The tubers were quite ripe, but the Indians did not intend to dig them for about ten days. Turnips were very fine, and carrots, beets and onions were good, though evidently cultivated with very little care. Two or three very small patches of barley had been almost completely destroyed by mice, but a few stalks remaining were quite ripe and with fine heads. The Indians here were very anxious to have a supply of garden seeds, which I have since been able to forward to them by the kindness of Messrs. Stobart, Eden & Co., of Winnipeg.

At Fort St. John, 95 miles west of Dunvegan, and so much nearer the mountains, on July 26th, 1875, Professor Macoun states that potatoes, oats, barley and many varieties of vegetables were in a very flourishing state in 'Nigger Dan's' garden. The oats stood nearly five feet high and the barley had made nearly an equal growth.* The barley and oats were both ripe about the 12th of August. Prof. Macoun was informed by Charlette at Hudson's Hope, thirty miles still further west, that in 1874 there was no frost from the 1st of May until the 15th of September. In 1875 sowing commenced the last week in April. There appears to have been a frost on June 28th, but the first autumn frost occurred on the 8th of September, and Mr. Selwyn found the potato tops still green in the middle of the month. Mr H. J. Cambie saw wheat flourishing here in July last, but on his return in September it had been cut down by frost.

Such are the notes that can be obtained on the growth of cereals and vegetables in the district in question. From information obtained at Dunvegan, it seems that the snow disappears about the middle of April, westerly winds sweeping it away fast. The river opens at about the same time. Cultivation begins at about the end of April or first of May. The river generally begins to freeze in November. The depth of snow, I was told, averages about two feet, an estimate which agrees with Mr. Horetzky's statement.† Mr. Horetzky was also told that the plains were often nearly bare up to the month of December, though the winter usually sets in with the month of

* Report of Progress, Geol. Survey of Canada, 1875-6, p. 154.

† Canada on the Pacific Coast, p. 205.

November. Sir Alexander Mackenzie remarked the same absence of snow in the early winter months of 1792. It was entirely gone on April 5th, 1793, and gnats and mosquitoes were troublesome on April 20.* Horses almost invariably winter out well without requiring to be fed. Hay should be provided for cattle, to ensure perfect safety, for a period of three or four months, though in some seasons it is necessary to feed the animals for a few weeks only. The Indians of the 'Cree Settlement' on Sturgeon Lake, previously referred to, winter their horses without any difficulty round the borders of a neighboring lake, the shores of which are partly open. From Hudson's Hope, the horses are sent southward to Moberly's Lake to winter, and according to Mr. Selwyn, do well there. Lesser Slave Lake, with its wonderful natural meadows, has long been known as an excellent place for wintering stock, and is referred to as such by Sir J. Richardson.

Some general idea of the length and character of the seasons at Fort St. John may be gained by an examination of the extracts from the journals from 1866 to 1875, published by Mr. Selwyn.† The dates of opening and closing of Peace River, being an important clue to the mean temperature of the region, may be quoted as summarized by Prof. Macoun in the same report (p. 156).

	Ice breaking		Ice drifting, first time
1866	April	19	Nov. 7.
1867	"	21	" 8.
1868	"	20	" 7.
1869	"	23	" 8.
1870	"	26	no record.
1871	"	18	" 10.
1872	"	19	" 8.
1873	"	23	" 4.
1874	"	19	Oct. 31.
1875	"	16	

The average date of the breaking up of the ice may thus be stated to be April 21st; that on which ice is running on the river for the first time, November 7th. In 1792 and, 93, when wintering at the mouth of Smoky River, Sir Alexander Mackenzie observed the ice to be running for the first time on November 6th, while the river was clear of ice on the 25th April. I have been unable to find any precise records of the dates of closing and opening of the Saskatchewan, but Dr. Hector states these are usually the second week of November and the second week of April respectively. The Saskatchewan is a more rapid stream than the Peace.

With regard to the probable difference between the actual valley of the Peace and the plateau forming the general surface of the country, Prof. Macoun observes,‡ speaking of the vicinity of Fort St. John, that notwithstanding the difference in altitude the berries on the plateau ripened only about a week later than those near the river, while he was informed that there was about the same difference in the time of disappearance of the snow in spring. While at Dunvegan, I ascertained that a similar difference was observed there, but it was added that this obtained chiefly with the wooded parts of the plateau, the snow disappearing on the prairies much about the same time as in the valley. In my diary, under date September 5th, I find the following entry:— "Aspens and berry bushes about the Peace River Valley now looking quite autumnal. On the plateau 800 or 900 feet higher, not nearly so much so. Slight tinge of yellow only on some aspen groves." This difference, through not altogether constant and depending much on diversity of soil, appears to be actual. In October, 1872,

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* Voyages, p. 131-132.

† Report of Progress, Geol. Survey of Canada, 1875-76 p. 84.

‡ *Op. Cit.*, p. 155.

Mr. Horetzky writes: * "We observed that, curiously enough, the vegetation upon these uplands did not appear to have suffered so much from the effects of frost, this being probably due to the fact of the air in these upper regions being constantly in motion, while in the deep and capacious valley of the river the winds have often no effect"

The difference between the valley and the plateau being thus very small, I have not treated separately the observations for temperature taken by myself in the different situations. Most of the observations, however, refer to the plateau, and including the whole time spent in the country, from the Middle Forks of Pine River to the bank of the Athabaska, cover a period of nearly two months. The mean minimum temperature for the month of August, deduced from observations extending from the 6th to the 31st of the month is 39·9°. The mean of observations at 6 a. m. during the same period is 42·3°. That of the observations at 6 p. m. 59·5°. In September the mean minimum temperature was 28·1°. The mean of morning observations 34·3°, of evening observations 51·5°. I have endeavored to deduce from these observations means temperatures for the months in question, by correcting them by the tables of hourly variations in temperature given by C. A. Schott in the Smithsonian Contributions to Knowledge (No. 277), but find it impossible to do so, as the daily range is here so much greater than that of any of the places represented by the tables, which refer chiefly to the eastern portion of the continent. It would appear that while in most places the mean temperature of the day is reached about 8 p. m., it is found in the Peace River country not far from 6 p. m., by reason of the increased rapidity of loss of heat by radiation due to greater elevation and dryer atmosphere. The maximum temperature was seldom observed, but the daily range is very great, and the maximum probably several times reached 80° in August, and often surpassed 70° in September.

From the 6th to the 31st of August I registered two nights of frost, on the 13th and 20th of the month when the thermometer showed 32° and 26° respectively. Both of these were observed on the plateau, but one at least of them (that of the 20th) must have occured also in the valley, from the effects produced Dunvegan on tender vegetation. These frosts occured in very fine weather, following a day of strong westerly wind, the result of which is to remove from the surface of the earth the whole of the lower heated layer of the atmosphere. This, succeeded by a calm and cloudless night with transparent sky, causes the thermometer to sink below the freezing-point before morning. When not preceeded by strong wind, mere transparency of the atmosphere seems seldom or never to lead to frost in August, in this district, as many beautifully starlight nights without an approach of the mercury to be freezing-point were observed.

Though in some cases such frosts as these may be general, and extend over a wide district of country, it is more usually found that they are quite local in character. A few floating clouds, or light wreaths of mist, may arrest radiation so far as to prevent frost over the greater part of the country, while some spot accidentally exposed during the whole night under a clear sky experiences a temperature below 32°. The contour, and character of vegetation of the country also have much to do with the occurrence of frosts, and it is very frequently the case that river valleys are more subject to frosts than the upland districts. During the month of September, in a region for the most part wooded, and often above the average altitude, between Dunvegan and the Athabaska, nineteen frosts were registered, the actually lowest temperature being 20° on Septem'ber 18th.

Through the kindness of Colonel Jarvis, of the North-west Mounted Police, I have been able to secure a copy of records kept by Dr. Herkomer, of Fort Saskatchewan, on the Saskatchewan River, about twenty miles north-east of Edmonton. For comparison with the observed temperatures in the portion of the Peace River country now discussed, they are invaluable; for in the whole district surrounding Fort Saskatchewan and Edmonton we now know from actual and repeated experiment that

* Canada on the Pacific p. 44.

wheat and all other ordinary cereals and vegetables thrive, and yield most abundant crops. The climate in its great diurnal and annual range corresponds exactly with that of the Peace River country. Fort Saskatchewan is situated on the brow of the Saskatchewan Valley, about seventy feet above the river, and therefore probably less liable to frosts than either the bottom of the river valley, or extensive flat tracts of plain where there is little circulation of air. This, with the position of the thermometers in regard to the buildings, leads to the belief that if at all in error, as representing the climate of the region generally, the indicated temperatures are slightly too great. The thermometer appears to have been read in all cases to the nearest degree only.

A comparison may be made between the temperature observed in the Peace River country during August and September, with those at Fort Saskatchewan, as follows.—

Peace River Country, mean of minima during	August	39· 9°
" " "	September	28· 1°
" Frosts experienced during	August	3
" " "	September	19
For Saskatchewan, mean of minima during	August	39· 3°
" " "	September	31· 1°
" Frosts experienced during	August	0
" " "	September	15
Fort Saskatchewan, mean of maxima during	August	77· 8°
" " "	September	68· 1°
Fort Saskatchewan, deduced mean temperature of	August	58· 6°
" " "	September	49· 6°

The mean of maxima and actual mean temperature for the months cannot be stated for the Peace River country. The actual mean for Fort Saskatchewan is obtained by adding the minima and maxima for each month together, and is probably very nearly correct.

While regretting that the data at disposal for the determination of the agricultural value of the Peace River country are not more ample, we may I believe, arrive with considerable certainty at the general fact that it is great. From such comparison as can be made, it would be premature to allow that the climate of the Peace River is inferior to that of the region about Edmonton or the Saskatchewan. It is true that in both the Saskatchewan and Peace River districts the season is none too long for the cultivation of wheat, but if the crop can be counted on as a sure one,—and experience seems to indicate that it may—the occurrence of early and late frosts may be regarded with comparative indifference. The season is at least equally short throughout the whole fertile belt from the Peace River to Manitoba, though early and late frosts are not so common in the low valley of the Red River. The almost simultaneous advance of spring along the whole line of this fertile belt, is indicated by the dates of the flowering of the various plants, a point referred to by me in some detail elsewhere.* It is further unquestionable that the winter is less severe, and not subject to the same extremes in the Peace River and Upper Saskatchewan regions as in Manitoba.

We have already found reason to believe that the early and late frosts, and not the absence of a sufficient aggregate amount of heat, constitutes the limiting condition of wheat culture in the North-west; but that neither the Saskatchewan nor the Peace River countries lie upon the actual verge of the profitable cultivation of wheat appears to be proved by the fact that oats succeed on the Saskatchewan, and also —in so far as one or two seasons can be accepted as evidence—on the Peace River; while it is well known that this cereal is less tolerant of summer frost than wheat. This is further proved by the fact that at Fort Vermilion and Athabaska Lake, 180 and 300 miles respectively north-east of Dunvegan, Prof. Macoun found wheat and barley ripening well; but in this instance the fact is complicated by the circumstance

* Geology and Resources of the 49th Parallel 1875, p. 279.

of the decreasing altitude of the country, which introduces a new condition. As no knowledge has been gained of this country on the Lower Peace in addition to that collected by Prof. Macoun in 1875,* it is not included in the above discussion, though from it additional great areas might doubtless be added to the fertile tract.

Referring to the journals kept at Fort St. John, Mr. Selwyn, in the report already several times referred to, comes to the conclusion that the climate of the Peace River compares favorably with that of the Saskatchewan country, or Montreal.

It has often been stated in a general way that the cause of the exceptionally favorable climate of the Saskatchewan and Peace River countries, as compared with those of the eastern portion of the American continent, is to be found in the prevalence of warm westerly winds from the Pacific. Sir Alexander Mackenzie speaks of these westerly winds in winter, writing :—"I had already observed at Athabaska, that this wind never failed to bring us clear mild weather, whereas, when it blew from the opposite quarter, it produced snow. Here it is much more perceptible, for if it blows hard south-west for four hours a thaw is the consequence, and if the wind is at north-east it brings sleet and snow. To this cause it may be attributed that there is so little snow in this part of the world. These warm winds come off the Pacific Ocean, which cannot, in a direct line, be very far from us, the distance being so short that, though they pass over mountains covered with snow, there is not time for them to cool." †

Further south these south-westerly currents are known as 'Chinook winds,' and similar consequences are observed to accompany their occurrence. Sir Alexander Mackenzie, however, in the summer of 1793, found the distance to the Pacific coast from his wintering-place, at the mouth of Smoky River, greater than he appears to have imagined at the time he penned the above quoted remarks, and it is difficult indeed, to understand how currents of air, blowing for at least 350 miles across a country which is for the most part mountainous, should retain enough warmth to temper effectually, the climate of the plains to the east. This difficulty would appear to be particularly great in summer, when the mountains are largely snow-clad and the mean temperature of the Peace and Saskatchewan Valleys, is probably considerably in excess of that of the region intervening between them and the sea.

The complete explanation is to be found in the great quantity of heat rendered latent when moisture is evaporated or air expanded in volume, but which becomes sensible again on condensation of the moisture or compression of the air.

The pressure in the upper regions of the atmosphere being so much less than in the lower, a body of air rising from the sea-level to the summit of the coast mountains must expand, which implying molecular work, results in an absorption of heat and consequent cooling. The amount of this coling has been estimated at about 1° Centigrade for 100 metres of ascent when the air is dry, but becomes reduced to ½ degree when the temperature has fallen to the dew-point of the atmosphere and precipitation of moisture as cloud, rain or snow begins; the heat resulting from this condensation retarding to a certain degree the cooling due to the expansion of the air. When the air descends again on the further side of the mountain range, its condensation leads to an increase of sensible heat equal to 1° C. for each 100 metres. ‡ It is owing to this circumstance that places in the south of Greenland, on the west coast, during the prevalence of south-easterly winds which flow over the high interior of the country, have been found, in winter, to experience for a time a temperature higher than that of North Italy, or the south of France, though the north Atlantic Ocean from which the winds come can have been little above the freezing-point at this season. The wind well known in the Alps as the foehn, is another example of the same phenomenon.

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* Report of Progress of Geol. Survey, Canada, 1875-76.

† Voyages, p. 138.

‡ The figures are Dr. Hann's, quoted by Hoffmeyer in the Danish Geographical Society's Journal, and reproduced in Nature, August, 1877.

The data are wanting for an accurate investigation of the circumstances of our west coast in this regard, but a general idea of the fact may be gained. We may assume that the air at the sea level is practically saturated with moisture, or already at its dew-point, that in crossing the mountainous region the average height to which the air is carried is about 2,000 metres (6,560 feet), and that it descends to a level of about 700 metres (2,296 feet) in the Peace River country. The loss of sensible heat on elevation would, in this case, amount to 10° C. (18° F.), the gain on descent to the level of 700 metres to 13° C. (23·4° F.). The amount of heat lost by the air during its passage across the mountainous region, by radiation and contact with the snowy peaks, cannot be determined. It is of course much greater in winter than in summer, and depends, also on the speed with which the current of air travels. Taking the mean summer temperature of the coast at about 12° C., (54° F.) and allowing several degrees for loss of radiation, it becomes easy to understand how the western prairies may be flooded with air nearly as warm as that of the coast, though it has travelled to them over a region comparatively cold.

Owing to the great width of the mountain barrier, the main result is complicated by local details, regions of considerable precipitation occurring at each important mountain range, with subsidiary drier regions in the lee. The last of these regions of precipitation is that of the Rocky Mountain range, properly so-called. By this a further addition of heat is made to the air, which then flows down as a dry and warm current to the east.

In addition to the favorable climatic conditions indicated by the thermometer, the length of the day in summer in the higher northern latitudes favours the rapid and vigorous growth of vegetation, and takes the place, to a certain extent, of heat in this respect. This has been supposed to be the case from the luxuriant vegetation of some northern region, but Alfonse de Candolle has put the matter beyond doubt by subjecting it to direct experiment. In latitude 56° which may be taken as representing that of much of the Peace River country, sunrise on 21st June, occurs at 3h. 12m., sunset at 8h. 50m.; while six degrees further south, in latitude 50°, which may be assumed to represent Manitoba, sunrise occurs on the same day at 3h. 49m., sunset at 8h. 13m. The duration of sunlight, in the first case, is 17h. 38m.; in the second, 16h. 24 m., or one hour and a quarter in excess in the northern locality. This excess of course decreases to zero at the spring and autumn equinoxes, and the difference is reversed in the winter.

A further circumstance giving to the Peace River country and that on the upper part of the Saskatchewan, other things being equal, a value as farming land acre for acre considerably greater than that of most parts of the North-west, is the immunity of this region from the visits of the devastating locust or grasshopper (*Caloptenus spretus*). I have elsewhere discussed the question of locust invasions, in several papers,* and it has since been taken up by the United States Entomological Commission.† It must suffice to state here, that while long series of years may pass without the occurrence of serious invasions, these must continue always, or at least for a very long time, to constitute a drawback to the whole territory lying south of a line drawn about sixty miles south of Edmonton, and thence nearly following the border of the wooded country eastward and southward to Manitoba.

(2) *General Geological features, and Minerals of Economic Importance.*

The rocks of the coast of the northern part of British Columbia and its adjacent islands, resemble those of the southern part of the coast, in the same line of strike, and the Victoria series of Vancouver Island. The age of these rocks I believe to be not greater than Palaeozoic, though their crystalline and highly altered appearance might, at first sight, suggest a comparison with still older series. They may be

* Canadian Naturalist, Vol. VIII., pp. 119, 207, 411.

† First Annual Report, United States Entomological Commission, 1878.

described, generally, as consisting of gneisses, diorites, mica and hornblende-schists, with occasional limestones and great masses of granite or diorite of intrusive origin. About Port Simpson and Metla-Katla these rocks are predominantly schistose and dark in colour. Mica-schist, generally rather fine grained and often glossy, very dark and containing some graphite, is the most abundant material.

The dip of the beds is generally north-eastward at high angles. The resemblance of some of these schists to the auriferous rocks of Cariboo and Leech River, Vancouver Island, is close, but I cannot learn that gold in paying quantity has been found in connection with them on this part of the coast. Limestone is found in association with them in some places. Copper ores appear to occur pretty frequently in these or the associated gneissic rocks of the Coast Ranges, but though much prospecting has been done no permanent mines have been established. A rather promising cupriferous vein has been discovered by Mr. J. W. McKay on the slope of the hill immediately behind the Hudson Bay Company's buildings at Port Simpson.

In Work Channel the rocks appear to be chiefly schistose, like those of Port Simpson, but massive granites or granitoid gneisses occur on the eastern shore and probably constitute the range of mountains which follow it. At Port Essington, at the mouth of the Skeena, the rock is a grey hornblendic granite, traversed by dykes similar in composition but coarser in texture. For about sixty mile up the Skeena from this point, gneissic and schistose rocks, micaceous or hornblendic, and belonging to the metamorphic series of the Coast Ranges, continue to prevail, and are shown often in great bare mountain sides, on which vegetation is prevented by the occurence of snow-slides. There is no doubt that if required, building stone of fair quality could be obtained in many places from the rocks of this series.

Above the point just indicated, the rocks bordering the Skeena change their character, being of much newer appearance, chiefly felspathic in composition, and, in fact, representing with little doubt the Porphyrite group of my reports of 1875 and 1876. The rocks are greenish, purplish or gray, frequently fragmental, forming agglomerates, or passing over into conglomerates. The boulders and gravel of the river-bed at the same time change their character, being now almost entirely composed of these porphyrites while Mr. Cambie informs me that the stones in the Zymoetz are also similar, proving that the porphyritic rocks have here a wide extension. At Ksipkeeagh Rapid, where a short portage is necessary, the rock over which the canoe is dragged is a rather coarse-grained grey granite, probably intrusive. It appears capable of being quarried into blocks of fair size, breaking along planes of jointage which are nearly vertical, and run S. 50° E., N. 50° W., magnetic. The range of high mountains abutting on the river above Ksipkeeagh appear from a distance to be composed of granite, or some similar massive rock. At Kitsalas Canyon the rocks seem to belong to the porphyritic series, but are much confused and fractured. They are hard, greenish, and felspathic, with no apparent bedding.

The Chimdemash River of the map, four miles above Kitsalas, appears to be that known also as Sebastipool Creek, and if so, is the locality from which a specimen of quartz yielding $42.18 of gold, $13.29 of silver to the ton was brought. The vein yielding this ore has, I believe, been explored to a small extent, but never systematically worked.

Between this place and Quatsalix Canyon, rocks of the porphyritic series are probably most abundantly represented among the mountains generally, but become associated with a considerable and increasing proportion of ordinary sedimentary sandstones not showing evidence of volcanic action.

Fossils also occur in altered ash rocks, like those of the Iltasyouco River,* including belemnites, trigonias, and a coral. These rocks are probably of the same age with those of the Iltasyouco, which, though stated in a previous report to be Jurassic, Mr. Whiteaves is now inclined to regard as probably Cretaceous. In this part of the river extensive exposures of granite also occur, the material being without doubt

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

intrusive. At Quatsalix Canyon the rocks are grey hard sandstone or quartzites, with blackish argillies, often arenaceous, and generally well bedded, and resembling those of the Nechacco series of my report of 1876.

Rocks of the kind last mentioned continue to prevail to the mouth of the Kitseguecla River, where carbonaceous shales were observed to be included in the series for the first time. These are so homogeneous and dark in color that they resemble coals, and on close examination small fragments deserving to be called coal, and probably representing portions of individual stems which have been imbedded in the formation, may be found. The carbonaceous shales are generally more or less lenticular, and the rocks at this place are very much disturbed. Ironstone in nodules, and irregular sheets is abundant in some parts of the formation.

In the rugged mountainous country between the Forks of the Skeena and the lower or north end of Babine Lake, the rocks seen in the vicinity of the trail are probably entirely of Mesozoic age, and resemble those found on the Skeena from Kwatsalix to the Forks. They are generally sandstones of fine or coarse grain, occasionally felspathic or replaced by porphyrite-like and sometimes brecciated rocks. Carbonaceous shales and imbedded fragments of plants were occasionally found, and in one place a few molluscs. The strike is generally nearly true north and south, but subject to great local irregularity. In the bed of the Tzes-a-tza-kwa River, near the point at which the trail from the Forks reaches Babine Lake, fragments resembling coal were found, but contain too much earthy matter to be useful as a fuel. From the appearance of the mountains visible from different points in this region it seems probable that Mesozoic rocks of the kind described are very widely spread in this part of the province, a belief confirmed by a number of small specimens collected by Mr. Horetzky in neighbouring regions, during the expedition of last summer.

Precisely what horizon these rocks represent it is, as present, impossible to tell, or as yet to enter into any details as to their arrangement or thickness. From their relation to the Porphyrite series above referred to, it appears, however, that they must represent, at least in part, the coal-bearing series of the Queen Charlotte Islands and Quatsino Sound, while they may even extend upward to include rocks of the horizon of those of Comox and Nanaimo.

The mere existence of rocks of this age, is not necessarily in itself, to be regarded as establishing a probability of the occurence of coal seams of economic value, but the general dissemination over the district of coaly shales containing impure coal, points to the occurrence of conditions such as those required for the deposition of true coals, and indicates the possibility, if not the probability, of the occurrence of coal beds of economic value in some part of the region. Specimens of some of these coaly materials collected by myself have not yet been subjected to examination, but wo collected by Mr. Horetzky, and analysed at his request in the laboratory of the survey, are reported on as follows by Mr. C. Hoffmann.

Specimen labelled Skeena, Station 37, nine miles above the Forks.

Colour, black; lustre, for the greater part, bright, but contains occasional dull layers, consisting apparently of carbonaceous shale. It is rather brittle, does not soil the fingers; takes fire in a lamp flame, burning with a bright somewhat smoky flame, and evolving an empyrumatic odour; in the closed tube yields water and tarry matter. Colour of powder, black, with a faint brownish tinge; the sample communicated no coloration to a boiling solution of caustic potash.

By slow and fast coking the following results were obtained :—

	Slow Coking.	Fast Coking.
Hygroscopic water	1·05	1·05
Volatile combustible matter	15·35	19·09
Fixed carbon	42 70	38·96
Ash	40·90	40·90
	100 00	100·00
Ratio of volatile combustible matter to fixed carbon	1—2·78	1—2·04

By slow coking the under portion of the powder alone was sintered, the middle and upper portions remaining pulverulent. Fast coking gave a firmer coke. Ash, pale cream colour.

Specimen labelled Skeena, Station 65, twenty miles above the Forks.

The specimen was made up of alternate dull layers of what appeared to be carbonaceous shale, and a bright black coal. Occasionally these latter exhibited a conchoidal fracture; but generally showed a very distinct columnar structure, at right angles to the plane of bedding. It does not soil the fingers. In the closed tube yields water, but scarcely any tarry matter; evolves however, a faint empyrumatic odour. Colour of the powder, black; communicates no color to a boiling solution of caustic potash.

Analysis by slow and fast coking give the following results:—

	Slow Coking.	Fast Coking.
Hygroscopic water	1 52	1·52
Volatile combustible matter	7·63	7·20
Fixed carbon	45·61	46·04
Ash	45·24	45·24
	100·00	100·00
Ratio of volatile combustible matter to fixed carbon	1—6 39	1—5·97

Both slow and fast coking gave a pulverulent coke. Color of ash almost white.

In addition to these, I received from Mr. Hankin, when at the Forks of the Skeena, a small specimen of true coal, apparent of excellent quality. This material came from a point in the Watsonquah River, about eighteen miles from the Forks, and it is reported by the Indians to occur in quantity. I was unable to visit the locality, but it lies nearly on the strike of the carbonaceous beds seen near the mouth of the Kitseguecla, on the Skeena, and may therefore occur in a horizon nearly the same. Arrangements were made to procure a larger specimen, but this has not yet arrived.

Mr. Hoffmann has examined a fragment of this coal, on which he reports as follows.—

Very compact, homogeneous, hard and brittle. Does not soil the fingers. Color black, but with a just perceptible brownish tinge. Lustre dull resinous. Fracture conchoidal. Takes fire in a lamp flame, burning with a bright flame (which however soon dies out on removal from the source of heat), with emission of smoke and a slight empyrumatic odour. Heated in a covered crucible it produces a large amount of flame. In the closed tube yields a considerable quantity of tarry product. Its powder did not impart the slightest coloration to a broiling solution of caustic potash.

An analysis by fast coking gave the following results:—

Volatile matter	40·52
Fixed carbon	57·51
Ash	1·97
	100·00

A determination of the water gave 0·85 per cent., as however, owing to lack of material, no control was made, the amount of this constituent is included in the number indicating volatile matter. Rapid heating gave a firm coke. The ash, which was somewhat bulky, had a slight reddish brown color and agglutinated slightly at a bright red heat. This is an excellent fuel and closely resembles a coal of the true coal measures.

In the present isolated position of the northern interior of British Columbia, the possible existence of workable deposits of coal is a matter of indifference, but in the event of the opening of any route through it, it would be exceedingly desirable to have all parts of the extensive Mesozoic area subjected to a geological examination as close as possible.

Gold has not been found extensively, or in such quantity, as to give rise to permanent mining on the Skeena or the Nasse.

The hills behind the Hudson Bay post, on the east side of the north or lower end of Babine Lake, are of sandstones and fine-grained conglomerates with a strike of N. 15° E. (mag.) and high north-westerly dips. Some beds might form good building material if opened below the frost-shattered surface. For some distance southward on the lake, similar rocks prevail, but from Na-tal-kuz Mountain and the second Hudson Bay post to the head of the lake, rocks which may be referred to the Cache Creek group of the interior of British Columbia, and are probably Carboniferous in age, appear to form the sub-structure of the country; while Tertiary volcanic materials lie upon them, and characterize long stretches of the lake shore. Banded limestones and marbles occur on the north bank, near the great bend of the lake. The rocks of the portage, for some miles from Babine Lake, appear to be Tertiary, while near the head of Stuart Lake massive grey hornblendic granite occurs. In travelling down Stuart Lake, in haste and with bad weather, very little chance occurred for the examination of the rocks. The granite above referred to is soon, however, replaced by a schistose greenish and greyish series, and in the hills north of the Pinchi River, massive limestone beds were first made out. These run southeastward forming the range along the north-east side of the lake, and culminating in Na-katl, or Pope's Cradle, 4,800 feet in height, a few miles from Fort St. James. These limestones have already been described* and are known to be of Carboniferous age.

Between Fort St. James, on Stuart Lake, and Fort McLeod, the surface is almost everywhere covered with drift deposits, and consequently, though travelling nearly at right angles to the general strike of the rocks of this part of the province, little can be ascertained as to their character. Neither the Tertiary basin, previously outlined on the Lower Nechacco River, nor that of the vicinity of Fort George, appears to extend as far north as the line of route just referred to. There appear, however, to be outlying patches of Tertiary volcanic rocks, which rest upon the older formations. These, as indicated chiefly by the debris and drift of the surface, and stones found in brooks, seem to include rocks both of the Cache Creek and Mesozoic series. On Long Lake River, near Iroquois Creek, rocks with little doubt belonging to the first mentioned series occur and include felspathic materials and bands of limestone. In the vicinity of Fort McLeod, rocks similar to these, but with thicker beds of limestone, are found. North of Fort McLeod, on the Parsnip, Mr. Selwyn believes an area of Tertiary lignite-bearing rocks to extend as far as the mouth of the Nation River. Lignite was observed in places near the junction of the Pack, or McLeod's Lake River, with the Parsnip, and loose blocks of a quality likely to be serviceable as fuel, were found scattered further down.†

In continuing eastward from the Parsnip River by the Misinchinca, the country, to Azouzetta Lake at the summit of the Pine River Pass, is characterized by schistose and slaty rocks, with occasional bands of quartzite. The schists are generally micaceous and often very bright, with lustrous surfaces which are not unfrequently minutely wrinkled. These together form a well marked series, and as they occupy a belt of country about twenty miles in width, and are generally at high angles, are doubtless many times repeated by folding. These rocks appear to overlie the massive limestones of the central range of the Rocky Mountains, which appear to be of Carboniferous or Devonian age. From their lithological identity there can be little doubt that they represent the auriferous series of Cariboo, but they have not here been extensively prospected, and no paying deposits of gold have been found in this part of the country.

* Report of Progress, Geol. Survey of Canada, 1876-77, page 55.

† Report of Progress, Geol. Survey of Canada, 1875-76, p. 71.

On the uppor part of the Misinchinca, numerous 'colors' may be obtained on the bars of the river, and while it is possible that rich auriferous deposits may yet be found here, it should be mentioned that the rocks are not so extensively traversed by quartz veins as in the Cariboo region.

It is apparently on the north-western extension of this belt of schistose rocks, that the Omineca gold district is situated. The known auriferous localities here lie about fifty miles north of a line passing westward from the Pine Pass by Forts McLeod and St. James. There are three routes by which Omenica may be reached. First from the coast by the Skeena River, Babine Portage and Firepan Pass. This route is travelled by canoe and on foot. Second by trail from Fort St. James, practicable for pack animals; and third by canoe or boat from the eastward by the Peace and Finlay Rivers. Without entering into details, a glance at the map will show how completely isolated this district is, and account for the scarcity and high price of provisions, which has prevented the working of any but good paying claims and hindered the thorough examination of the country.

Some facts in connection with this district have been given by me in a previous report,* but it has never been visited by any member of the Geological Survey. The main points which seem to bear on the possible future of the district are as follows :— The existence of rich deposits of gold, and the possibility that with greater facility of access the known area covered by these would be increased, and that it would become possible to work those of a lower grade. The occurrence of pellets of native silver or amalgam in association with the gold. It may not be found possible to trace this material to veins of workable dimensions, but its presence seems in some degree to show the general argentiferous character of the district. The chief promise of future importance as a mining centre seems to lie, however, in the fact that highly argentiferous galena occur in some abundance, and, it is reported, in well-defined and wide veins. These it is at present impossible to utilize, owing to the cost of labor and carriage, but the subjoined particulars may serve to give some idea of the character of the deposits.

According to Mr. Woodcock, of Victoria, some of the most important veins are in the vicinity of a stream called Boulder Creek.

That known as the "Arctic Circle" is said to be about twenty feet wide, and to show about four feet of highly metalliferous ore. It is exposed by the brook in a face about thirty feet high. The claim adjoining this is called the "Black Warrior," and shows a vein eight feet wide of nearly pure galena. Other specimens have been obtained from places within a radius of eight miles from this locality.

Near Lost Creek a vein known as the "Champion Ledge" is found, and runs nearly parallel with the stream. Particulars as to its size are wanting. Another vein in the creek is reported to be twenty feet wide.

Mr. Woodcock has favored me with copies of the following analyses of two specimens of the ores from this district, by Messrs. Johnston, Matthy & Co., London, England.

Arctic Circle Vein.

Lead	26·80
Iron	2·50
Silver	0·13
Sulphur	6 35
Silica	61·60
Alumina	1·40
Combined water	0·95
Oxygen and loss	0·27

Silver equal to 44·2 oz. per ton of 20 cwt.

* Report of Progress, Geol. Survey of Canada, 1876-77, p. 116.

A second analysis of the Arctic Circle ore, is by G. W. Hopkins, San Francisco, and gives the following result :—

Silver, per ton, 40·81 oz. or $52.76.

Gold, trace.

Pig lead would contain about 50 oz. to the ton.

Black Warrior Vein.

Lead	20·25
Iron	2·15
Silver	0·09
Sulphur	4·80
Silica	69·80
Alumina	1·50
Combined water	1·00
Oxygen and loss	1·41
	100·00

Silver equal to 29·8 oz. per ton of 20 cwt.

A second assay of the "Black Warrior," by Messrs. Riehn, Hemme & Co., San Francisco, showed the sample to contain 98 oz. or $126.70 of silver to the ton, equal to $187.10 per ton of pig lead.

Two assays of specimens of ore from a deposit known as the "Mammoth Ledge," gave the following results. Assay by Thos. Price, San Francisco :—

Gold, per ton, $\frac{1}{10}$ oz	$ 2.06
Silver do $32\frac{4}{10}$ oz	41.89
	$43.95

Clean galena would assay, $131.85.

Assay by Messrs. Riehn, Hemme & Co., San Francisco :—

Gold, per ton	$ 6·28
Silver do	91·13
	$97·41

Pig lead would contain 207 ounces to the ton.

A specimen of quartz with galena, from a stream near Mansen Creek in the same district, was examined by Mr. Hoffmann some years ago * and found to contain 8·971 oz. of silver to the ton, with traces of gold, but, as Mr. Hoffmann remarks, the silver is confined to the galena, of which only a small quantity occurs in the vein-stone, and which must consequently be highly argentiferous. An analysis of a sample of galena from the Arctic Circle vein, separated as far as possible from the gangue, in the laboratory of the Survey, gave 128 oz. of silver to the ton. A specimen of ore from the Champion Ledge, including galena and gangue, showed 20 oz. of silver to the ton and a trace of gold.

It would thus appear that a considerable percentage of silver occurs in all the galena ores examined from this district, and that if the veins are sufficiently large and constant in character, the region must be of importance when sufficient means of access to it are provided.

All these ores might, by ordinary process of dressing and washing, be raised nearly to the grade which they show when the precious metals are calculated to the proportion of galena contained.

During the summer of 1879, there were, as I have been informed, about sixty white men engaged in mining at Omineca, with twenty Chinamen, and sixty to seventy Indians, the latter receiving wages as laborers of $3 a day. I am inclined to believe, however, that these figures may be rather above the mark than below it.

* Report of Progress, 1875-76, p. 430, 1876-77, p. 116.

To the north-east of the schistose rocks, and apparently underlying them, are the massive limestones which form the axial mountains of the Rocky Mountain range. These, in their direction of strike, are parallel to the general north-westerly and south-easterly trend of the range. From the line of the summit, or Azouzetta Lake Valley, the width of the limestones and other old rocks measured transversely is about five or six miles only. On the north-eastward side of the range, the limestones become associated with quartzites which may be of greater age, and with blackish shales and slaty rocks holding *Monotis subcircularis*, and therefore to be assigned to the Triassic period. These rocks of the axis of the mountains are not known to be of any economic importance, though in some places capable of yielding building stone of fair quality. 'Colors' of gold may be obtained in the upper part of the Pine River, as on the Misinchinca.

From the point on the upper Pine River last described, rocks probably for the most part of Cretaceous age, but possibly passing up into Tertiary in some places, extend over the whole upper part of the basin of the Peace River. A line drawn from this point north-north-westward to near the confluence of the Otter Tail River with the Peace—a distance of about forty-five miles—probably marks with approximate accuracy, for a portion of its length, the junction of these newer rocks with the main mass of the older rocks of the axis of the mountains. There is evidence that this line is nearly that of the shore at the time of the deposit of the Cretaceous rocks, and that the present axial elevations of the Rocky Mountains have stood as an island or islands above the Cretaceous sea. Cherty fragments, like those associated with the limestones of the mountains, are found abundantly in the conglomerates and sandstones of the newer series. The existence of the remains of plants, and of seams, of coal in different parts of the newer rocks, show that the sea must have been a shallow one, and by occasional elevations, patches at least of its bed were, from time to time, converted into land areas.

It is in these rocks, forming a zone to the east of the Rocky Mountains, that the most promising coal-fields of the North-west lie, and they are now known to be characterized by the presence of coal from the Peace River to the 49th parallel. Their study is consequently attended with interest, and much additional light has been thrown upon it by the examination of sections in the Peace River region, last summer. Till maps are complete, and the whole of the observations properly discussed, it would be unwise to attempt to enter into detail, but some points bearing on the carboniferous character of the formation may be given.

In the vicinity of the mountains, the rocks are much flexed, but the undulations gradually lessen as the mountains are left behind, and the beds become at length horizontal, or so nearly so that no inclination of a fixed character can be detected by ordinary methods. Near the mountains the rocks are almost entirely sandstones, and often quite coarse and associated with conglomerates. Further off, shaly intercalations appear, and eventually two well marked and thick zones of dark colored shales are found, separated by a zone of sandstone and shales, and capped above by a second sandstone and shale formation, which may possibly belong to the lower part of the Tertiary.

In both the horizons characterized by sandstones coal is found, and while as above stated the upper may represent a portion of the Tertiary, the lower is certainly well down in the Cretaceous formation. This in itself is a point of considerable importance, showing that the carboniferous character of the rocks is not confined to a single series of beds, but recurs at two stages. It also, probably confirms the view advanced by Dr. Hector and supported by Mr. Selwyn, for the Saskatchewan country, as to the existence of a coal-bearing horizon in the Cretaceous of that region in addition to that of the Tertiary or Laramie age.

The localities in which coal is known to occur in the lower or certainly Cretaceous zone are:—Table Mountain, Coal Brook and vicinity, Portage Mountain and the lower part of Smoky River.

Table Mountain is situated on the south bank of Pine River between the Lower and Middle Forks. It was examined by Mr. Selwyn in 1875, who describes the coal as

occurring in four seams, in descending order, six inches, eight inches, two feet and six inches thick respectively.

The coal is stated to be of good quality, but has not been analyzed.

Coal Brook joins the south branch of Pine River a few miles from the Lower Forks, and though a comparatively small stream, has formed numerous fine sections in the soft Cretaceous rocks. Coal was discovered here by Mr. J. Hunter in 1877, and is mentioned by him in the Canadian Pacific Railway Report for 1878 (p. 79). Mr. Hunter favored me with specimens collected by him at this time, and I have since personally examined the locality. The rocks are probably nearly on the same horizon as those of Table Mountain. The coal is of good quality and occurs in several beds, which are however, so far as observed, all very thin, the thickest measuring about six inches. Coal also occurs on the south branch of Pine River above the mouth of Coal Creek, and there is much ground to hope for the ultimate discovery of coal seams of workable thickness in this region.

Portage Mountain is cut through by the canyon of the Peace River above Hudson's Hope. The thickest seam observed by Mr. Selwyn in this place, was again but six inches,* but in July last Mr. H. J. Cambie noticed one about two feet in thickness.

The following analysis of a specimen of coal from this place is published by Dr. Harrington.†

	Slow coking.	Fast coking.
Water	2·10	2.10
Volatile combustible matter	21·54	25.09
Fixed carbon	71·63	68·08
Ash	4·73	4·73
	100·00	100·00

Ratio of volatile to fixed combustible by slow coking 1–3·32, by fast coking 1–2·71. By rapid heating the coal yielded a fine coke, and it may be regarded in all respects as a fuel of excellent quality, only requiring to be found in sufficient quantity to claim importance.

The coal referred to as occurring on this horizon on the lower Smoky River is in itself of no importance whatever, being but 2½ inches thick. With the fact of the abundance of impressions of roots and branches in the sandstone is shows merely the carboniferous character of the formation to this point. It appears at the very summit of the series of sandstones forming the lower group, at their junction with the overlying bluish shales.

On Rivière Brulé, near its mouth, about fourteen miles from Dunvegan, my assistant, Mr. McConnell, examined a reported coal seam, which proved to be a lignite coal of inferior quality, and about twelve inches only in thickness. Coal or lignite is also reported to occur on Rat River ten or fifteen miles above Dunvegan, but the locality was not visited. It is probable that in both these places it is the lower or distinctively Cretaceous series of sandstone and slates which hold the coal.

Of localities showing coal or lignite in the upper series of sandstones and slates, which may, so far as present information goes, represent the uppermost part of the Cretaceous, or the overlying Laramie group; the first discovered is Mountain Creek, joining Elk River, about fifty-eight miles in a direction nearly due south from Dunvegan. The beds found here were again quite thin, but the bars in the stream are strewn with large blocks which appear to be of bituminous coal rather than lignite, and are of good quality as a fuel. These must be derived from thicker beds than those examined, but which may be below the water-level.

The banks of the Elk River, above the mouth of Mountain Creek, show similar fragments of coal more or less rounded, and on the Smoky River, below the mouth

*Report of Progress, Geol. Survey of Canada, 1875-76, p. 63.

†Report of Progress, Geol. Survey of Canada, 1876-77, table facing p 470.

of the Elk, near the base of the upper sandstone series, a seam of good coal five inches in thickness was seen. Drift coal found on the upper part of the main Smoky probably also belongs to this upper sandstone series.

Sandstones and shales, which might represent either the upper or lower series above referred to, occur on the Athabasca River, and were observed in many places above Old Fort Assineboine to hold coal seams. Two of these were noticed to be of remarkable persistency, and though generally thin, the upper seam was found in one place to measure ten feet in thickness, including however a few shaly partings which would reduce the thickness of good coal or lignite to nine feet two inches. This is separated by about twenty feet of soft sandstone from the lower seam, which is compact and of good appearance and about three feet in thickness.

On a stream entering Lesser Slave Lake from the north, near its eastern end, Mr. McConnell observed numerous fragments of lignite of good quality, but all considerably rounded, showing that they had been brought from some distance.

It would thus appear that while in the region lying between the Athabasca and the Peace rivers, no coal seams sufficiently thick to be of great economic value have yet been discovered, that coal and lignite of good quality occur in two distinct series of beds. Wherever natural sections of these occur in the valleys of rivers and streams, coal in greater or less quantity is found, and the persistently carboniferous character of the beds thus abundantly proven. There can be little doubt that beds of a workable character occur in different parts of this region and will be found by further search.

On the extension of these formations to the south-eastward, a bed of coal, reported to be eight feet in thickness, occurs near the projected railway crossing of the North Pembina River, while between Fort Edmonton and the mouth of the Brazeau River, on the Saskatchewan, a seam of coal fifteen to twenty feet in thickness was discovered by Mr. Selwyn in 1873;* other thick seams are reported on the upper part of the Brazeau.

An analysis of the fuel from the North Pembina River made in 1874 by Prof. Haanel, gives the following composition:—

Water	11·88
Volatile combustible matter	28·66
Fixed carbon	57·25
Ash	2·21
	100·00

The coal collected by Mr. Selwyn at the place above referred to on the Saskatchewan yielded to Dr. Harrington the following result on analysis by slow coking:—

Water	10·09
Volatile combustible matter	28·69
Fixed carbon	54·96
Ash	5·45
	100·00

While neither of these can be classed as true bituminous coals, they are fuels of great value, and compare closely with those brown coals used extensively on the line of the Union Pacific Railway in the Rocky Mountain region.

In many localities on the Peace River, and between that stream and the Athabasca, clay ironstone in nodules and nodular sheets is abundant; but generally not in such quantity as to justify a belief in its economic importance. On the lower part of Smoky River, however, great quantities of ironstone apparently of excellent quality might be collected from the bars and beaches, while in few places in the banks, zones largely composed of ironstone and of considerable thickness occur.

* Report of Progress, Geol. Survey of Canada, 1873-74, p. 49.

As already stated, gold in small quantity may be found in both the Misinchinca and upper part of Pine River, while as stated by Mr. Selwyn it has been found from time to time, in various places and in paying quantities both along the Parsnip and the Peace Rivers. Mr. Selwyn remarks that there are no gold-bearing rocks on the Peace below Finlay Branch, and suggests that the fine gold of the lower part of the river may have been originally derived from rocks on the western slope of the mountains, or may have been carried from the belt of Laurentian and other crystalline rocks forming the north-eastern boundary of the interior basin, and stretching from Lake Superior to the Arctic Ocean. For the gold of the Parsnip and upper part of the Peace, the former appears to me to be the most probable explanation, while to that found in the Misinchinca, the Pine and other streams in the vicinity of the mountains a local origin must also be granted.

In all this region, below a certain contour line and to the east of it, drift from the Laurentian axis, above referred to is, in great abundance. The height of this contour line may for the present be roughly stated at 2,000 feet. It is in this tract to the east, characterized by Laurentian *débris* that the paying gold-washings of the Saskatchewan are situated, while in the direction of the mountains the 'pay' appears to run out where the Laurentian drift ceases. Gold has also been found in paying quantities in the parts of the Athabasca and McLeod Rivers which traverse this drift-covered region, and the evidence seems to be strongly indicative in all these cases of an eastern or north-eastern source for the precious metal. It would thus appear, that with the exception of the regions of the Parsnip and Upper Peace, the Rocky Mountain zone in this part of its length has not so far been proved to yield gold in paying quantity, but that remunerative placer deposits supplied from the opposite direction, occur at a greater or less distance from the mountains on several rivers.

GEORGE M. DAWSON.

Bundle 51 #46

APPENDIX No. 7.

REPORT ON THE CLIMATE AND AGRICULTURAL VALUE, GENERAL GEOLOGICAL FEATURES AND MINERALS OF ECONOMIC IMPORTANCE OF PART OF THE NORTHERN PORTION OF BRITISH COLUMBIA, AND OF THE PEACE RIVER COUNTRY, BY GEORGE M. DAWSON D.S., A.R.S.M. F.G.S., ASSISTANT DIRECTOR GEOLOGICAL SURVEY OF CANADA *

(1.) *Climate and Agriculture.*

The climate of the coast of the northern part of British Columbia, while not subject to great extremes of temperature, is excessively humid, with much rain at all seasons of the year and occasional heavy falls of snow in winter. Neither Esquimalt nor New Westminster, which are the only regular meteorological stations maintained near the coast of the Province, give any criterion by which to arrive at a knowledge of the climatic conditions of other districts; for both these places—but especially Esquimalt—are sheltered from the excessive precipitation which occurs where the moisture-bearing winds first strike the high coast line. Observations maintained by myself while engaged in a geological examination of the Queen Charlotte Islands, during the summer of 1878 (published as an Appendix to the Report of Progress of the Geological Survey, 1878–9), fairly represent the climate of that region during a few months. Observations kept up during many years at Sitka, two and a-half degrees north of Port Simpson, and considerably further west, doubtless represent a climate considerably worse than that of the northern part of the coast of British Columbia. It may, however, be useful to extract from these the following facts. The latitude of Sitka is 57° 3', or about one degree north of Glasgow (Scotland). Temperature observations extend over a period of forty-five years with little interruption. "The mean temperature of spring is 41·2°; for summer, 54·6°; for autumn, 44·9°; for winter, 32·5°, and for the entire year, 43·3, F°. The extremes of temperature for 45 years are 87·8° and –4·0°. However, the mercury has fallen below zero of Farenheit in only four years out of the 45, and has risen about 80° during but seven years of that period. The coldest month is January, the warmest August; June is slightly warmer than September." The mean of the minima for seven years of the above period is 38·6°, and of the maxima for seven years, 43·9°, shewing a remarkably equible climate. The average annual amount of rain, melted snow and hail from 1847 to 1864 (with the exception of the year 1855) was 82·66 inches, or within a fraction of seven feet; and the average annual number of days on which rain, snow or hail fell, or heavy fogs prevailed, was two hundred and forty-five, or two days out of three, while it does not follow that the other days have a clear sky. Tables by Lütke, from observations in 1828 and 1829, show that on an average each year there were 170 days calm, 132 days moderate winds, and 63 days with strong winds.†

The average annual precipitation of moisture at the mouth of the Columbia River, eleven degrees of latitude further south, is stated to be five inches greater than at Sitka, and it is therefore probable *a priori* that in the vicinity of Port Simpson and about the mouth of the Skeena, on that part of the coast of the mainland

* Transmitted for publication in advance of the forthcoming detailed Report on the Explorations of 1879, by permission of A. R. C. Selwyn, F.R.S., F,G.S., Director Geological Survey of Canada.

† Alaska Coast Pilot, 1869, and Pacific Coast Pilot, Appendix 1, 1879, p. 30.

lying open to the westerly winds between Queen Charlotte and Vancouver Island, and on the west coasts of these islands, that the precipitation is at least equally great, and amounts to between 80 and 90 inches per annum. This amount of precipitation, though small in comparison with that of a few exceptional places on the earth's surface, is greater than that characterizing even the western coasts of the British Islands, with the exception of a few peculiarly situated mountainous localities, where it is exceeded, and little less than the heaviest rainfall on the Norwegian coast (90 inches).

Recently published observations for Fort Tongass, though covering a period of but little over two years, must represent the climate of the region in the vicinity of Port Simpson and of the Queen Charlotte Islands pretty closely, as Tongass is situated on the north side of Dixon Entrance, little over fifty miles from Port Simpson in a direct line. The mean temperature is here 46·5°, or considerably warmer than Sitka. "This may be due," Mr. W. H. Dall writes "to the reception in the open throat of Dixon Entrance of the warm waters of the Alaska Current, fresh from the great north Pacific Gulf Stream."Fort Tongass is the locality of greatest known precipitation in Alaska, the rainfall averaging during the years of observation 118·3 inches, on which Mr. Dall remarks, that observations point to the Queen Charlotte Islands, and the region about Dixon Entrance as the most rainy part of the north-west coast. At Tongass about 200 days a year are either rainy or snowy, a proportion agreeing nearly with that observed at Sitka.*

The excessive rainfall, considered in conjunction with the fact that the sky throughout the year is essentially cloudy, preventing rapid evaporation and keeping the dew point near the actual temperature of the air, accounts for the peculiar character of the vegetation, and the fact that ordinary cereals cannot be grown in the districts exposed to these conditions. At Fort Simpson, on the west coast of the Queen Charlotte Islands, and elsewhere, many of the hills are but partially covered with forest, the remainder of the surface being occupied by sphagneous moss several feet in depth, and saturated with water even on steep slopes. The low north-eastern part of the Queen Charlotte Islands is in great measure sheltered from the rain-bearing winds, and constitutes, in fact, the only extensive area of land which appears to be suitable for agriculture on the northern part of the coast. Mr. Duncan, of Metla-Katla, who kept a meteorological register for some time after his first arrival in the country,estimated that there were on an average about seven fine days in a month in that place. The behavior of the winds and barometer in both Vancouver and the Queen Charlotte Islands, appear to indicate that the centres of most storms, travelling from west to east, pass to the northward of the coast of British Columbia. This being so, it is probable that the force of the gales is somewhat greater on the northern part of the coast of the province than on the southern.

I have elsewhere stated that fogs do not seem to occur with such frequency in the vicinity of the Queen Charlotte Islands as in the southern part of the Strait of Georgia. It may be interesting to quote, in this connection, the following statement by the great but unfortunate navigator, La Péroure, bearing on the northern part of the west coast. †He writes: "I first thought these seas more foggy than those which separate Europe and America, but I should have been greatly mistaken to have irrevocably embraced this opinion. The fogs of Nova Scotia, Newfoundland, and Hudson's Bay have an incontestable claim to pre-eminence from their constant density."

The cause of the exceptional mildness of the climate of this region is to be found not alone in the fact of the proximity of the sea, but in the abnormal warmth of the water, due to the Kuro-Siwo or Japanese Current. The average temperature of the surface of the sea, during the summer months, in the vicinity of the Queen Charlotte Islands, as deduced from a number of observations taken by myself in 1878, is 53·8°. Between Victoria and Milbank Sound, by the inner channels, from May 28th to June 9th, the average temperature of the sea surface was 54·1°. In the inner

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* Pacific Coast Pilot, Appendix 1, *loc. cit.*
† Quoted by G. Davidson in Alaska Coast Pilot.

channels between Port Simpson and Milbank Sound, between August 29th and September 12th, 54·5°, and from the last mentioned date to October 18th, about the north end of Vancouver Island, and thence to Victoria by the inner channels, 50·7°. Observations by the United States' Coast Survey, in 1867,* gave a mean temperature for the surface of the sea between Victoria and Port Simpson and outside the Prince of Wales Archipelago, from Fort Simpson to Sitka, in the latter part of July and early in August, of 52·1°. In the narrower inlets of the coast, the temperature of the sea falls, owing to the quantity of cold water mingled with it by the entering rivers. These observations serve to show the existence, off the coast, of a great body of warm water, and the temperatures closely correspond with those found in similar latitudes, and due to the Gulf Stream and North Atlantic surface drift, on the west coast of Britain. The annual average temperature of the sea surface off the west coast of Britain is stated as 49°, while that of the eastern North Atlantic, influenced by the Gulf Stream, varies from 44° to 54°.†

It will be observed that the summer temperature of this body of warm water appears to be somewhat lower than the mean summer temperature of Sitka. Its influence on the climate is not, however, a direct one, but is chiefly exercised in the following way.—The prevailing south-westerly winds, sweeping over the warm surface of the sea are raised to its temperature, and become saturated with moisture, abstracting from it, as they do so, and rendering latent in conformity with well known physical laws, a still greater quantity of heat. When, on reaching the mountainous coast, this moisture is again condensed and discharged, the latent heat becomes again apparent, and greatly raises the temperature of the atmosphere in which the reaction occurs.

According to Dove's tables, the mean annual temperature of a place situated in the latitude of Glasgow, derived from the temperature of the whole northern hemisphere, should be 35°. Owing to the Gulf Stream and south-westerly winds, the actual mean annual temperature of Glasgow is about 50°, or exceeds the normal by 15°. The mean temperature of the greater part of the North American continent in the same latitude is 5° to 12° below Dove's normal temperature, but that of the regions on the west coast of America—which is related to the course of the Japanese Current in a manner similar to that of the west coast of Europe and the Gulf Stream—as represented by the above detailed observations at Sitka, exceeds the general mean by eight degrees. The mean annual temperature of Sitka being, in fact, nearly the same as that of Montreal, ten degrees of latitude further south.

Many of the islands lying off the northern coast of British Columbia, and forming the great archipelago which fringes it, are low; but, though covered with luxurient forest, possess very little soil, and are in many cases composed of almost solid rock. About Metla-Katla and Port Simpson, small patches of ground are cultivated by the Indians as potato gardens, and good crops secured; but the total area of arable land existing on this part of the coast, with the exception of the portion of the Queen Charlotte Islands before referred to, is so inconsiderable as to be scarcely worth mention.

The coast about Port Simpson and the mouth of the Skeena is very imperfectly sheltered from the rain-bearing winds by the Queen Charlotte Islands, while the islands of the coast archipelago, being for the most part of moderate elevation in this region, abstract little moisture. Where these winds first impinge on the monuntainous mainland the heaviest precipitation occurs, in exact correspondence with the height to which the moist air is forced up into the higher regions of the atmosphere, and cooled there by its expansion and loss of heat by radiation. As the mountains attain a considerable elevation at the coast, and the increase in elevation of the peaks

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* Alaska Coast Pilot, 1869, p. 20.

† "That portion of the Kuro-Siwo having a temperature of 55° F., or more, approaches the coast of North-west America in the vicinity of Vancouver Island. The precipitation is greater, and sudden meteorological disturbences are more common between latitude 48° and 55° N. than on any other part of the coast, so far as we know. But the water near the coast is less than 55° in temperature, and may average not more than 50°."—Pacific Coast Pilot, Appendix I, p. 21.

towards the axis of the range is comparatively gradual, the heavy rainfall of the coast is not found to be maintained in travelling eastward by the Skeena River. At forty-five or fifty miles above Port Essington, evidence of decreasing moisture is found, and is still more clearly apparent when Kitsalas Canyon, about half way from Port Essington to the Forks of Skeena, is reached. The devil's club and skunk cabbage (*Echinopanax horrida* and *Lysichiton Kamtschatsense*) luxuriant in the lower reaches of the river and indicative of a humid climate, no longer abound.

At Quatsalix Canyon, ninety-five miles from the coast, the highest summit of the Coast Range having been passed, the vegetation characteristic of the northern interior of British Columbia may be said to set in; the western scrub pine and aspen (*Pinus contorta and Populus tremuloides*) growing abundantly on the flats and slopes. The change is so gradual, however, and the blending of the coast and interior floras on the Skeena so complete that it is difficult to assign the precise position of the line.

With regard to the snowfall on the Skeena, Mr. H. J. Cambie during his survey here in 1877, gathered that from Port Essington to near the month of the Lakelse (56 miles), it was exceedingly heavy, reaching a depth of ten feet or more. From this place to Kitsalas Canyon it reaches, at least occasionally, a depth of six feet; while about Kitwungah,—sixteen miles below the Forks—it averages three feet. So far as information can be obtained from the Indians it appears to confirm these estimates. The depth on the benches about the Forks is not over one foot, but owing to local circumstances the snowfall is here considerably less than in any neighboring locality, the average for this part of the Skeena Valley being probably a little under two feet.

At about twenty miles below the Forks, the higher benches at the sides of the river and a few hundred feet above its level, extend several miles back from it, and show soil of fair quality, composed of sandy loam with more or less vegetable matter. It is reported that the Skeena valley continues to present the same appearance further up, and it is certainly wide and low for some distance above the Forks, while a considerable width of land suited for agriculture is also found in the valley of the Kispyox to the north-westward.

The summer temperature of the region about the Forks or Hazelton is often high, and the rainfall by no means excessive. According to Mr. Hankin, a trader who has resided many years here, snow generally first falls in October, but melts again, the winter snow not coming till about the middle of December. The winter is in general steadily cold, though there is almost always a thaw in February. The thermometer has been known to reach 48° below zero and to remain for days at a time below—30°.

The winter is in fact about the same as that of Stuart Lake, but the spring is said to open much earlier. Grass begins to grow green and some trees to bud out about the first week in April. Some cultivation is carried on. Potatoes are occasionally nipped by frost in the spring and on two occasions have been effected by summer frosts. They are generally harvested in the end of September, but are ripe before that time, and can be obtained large enough for use about the first of July. Indian corn does not ripen, and wheat, Mr. Hankin believes would be an uncertain crop. The season of 1878 was exceptionally long, and two successive crops of oats ripened before the frost; the second being a 'volunteer crop.' In favorable seasons, squashes, cucumber and other tender vegetables come to perfection. A few cattle and horses have been wintered here, the former requiring to be fed for five months, the latter have been kept by clearing away the snow to a certain depth in strips to allow them to scrape for grass.

The Skeena usually opens during the last week in April or first week of May. Ice begins to run in the river early in November, but the river does not generally freeze till the end of December. The river being very rapid, the occasion of its freezing is usually the occurance of a thaw. This sets free great quantities of anchor ice, sometimes very suddenly, blocking the river and causing it to freeze over. In 1867 the river closed on the 13th of November, which was exceptionally early. The river is generally highest in July, deriving most of its water from the melting snow on the mountains. It is lowest immediately after the ice goes.

Without entering into details as to the natural vegetation of the region, it may be said that it appears to indicate that the rainfall is nearly the same as about Quesnel, on the Fraser, while the climate is in general much like that of Quebec or Montreal, with the exception of the winter, which, according to the statements above given, though rather shorter, is more severe.

I am induced to think that Mr. Hankin is wrong in supposing that wheat would not succeed well about the Forks, but this must remain a matter for future experiment.

Meteorological observations kept by myself while on the Skeena, from June 7th to 23rd, being taken *en route* from Port Essington to the Forks, are necessarily imperfect, and as we were engaged in travelling during the day it was impossible to ascertain the maximum temperature. The mean minimum temperature read on a good thermometer carefully placed on nine nights; between Port Essington and Kitsalas Canyon is 43·4° F, the actual lowest reading being 39°. The mean of seven nights from the Canyon to the Forks, 43·6°, the actual lowest being 37·5°. The mean of observations taken about 6 a.m. and 6 p.m.; every day, on the first mentioned part of the river is 50·8°; on the upper part part of the river, 52·8°. The mean of morning readings taken below Kitsalas Canyon is 45° of evening reading, 56·4°. These reduced for the hour and time of the year by Dove's table of corrections, derived from observations at Sitka, indicate actual mean temperature of 49·1° and 53·1°, respectively. The mean doubtless lies between these figures, but their discord shows that we have already a considerably greater range and a climate more continental in character than that of Sitka. Morning observations above the Canyon indicate a mean of 46·6°. Evening observations 58·9°, which, corrected in the same way, yield 50·58° and 55·6° as approximations to the true mean temperature.

Of the Watsonquah River, which joins the Skeena from the south-eastward at the Forks, Mr. Cambie reports that the valley throughout its entire length is in part prairie and sustains a magnificent growth of grass, but is subject to frequent summer frosts and unsuited to agriculture.* The Sus-kwa valley which joins the Watsonquah, and up which the trail from the Forks toward Babine Lake runs, contains no agricultural land worth mention, but its northern side has been in many places very completely burnt over, and is covered with exceedingly luxurient grass and pea-vine, forming an excellent summer range for cattle or horses.

Babine and Stuart Lakes occupy portions of a single great valley, which is bounded by mountainous country on either side, and communicates northward with the flat country of the Lower Nechacco. The upper end of the lake rarely freezes completely across, but this is due, not to the mildness of the winter, but to the great depth of the water. A similar circumstance has already been reported for François Lake.† A terrace at a height of about 200 feet is specially prominent round the lake, and after reaching this height the land frequently runs back several miles as a level or gently undulating plain. In other places it slopes gradually up, reaching an elevation of 500, 600, or 800 feet above the lake at from two to five miles from it. The valley is not even then shut in by high mountains in its central part, but appears to continue at nearly the same, or a lower level in some places for many miles. The woods are generally light, aspen and poplar frequently preponderating over spruce, and considerable tracts with a southern exposure, from which fire has removed the forest, are covered with luxurient grass, pea-vine, epilobium, &c. The portage between Babine and Stuart Lakes is low, across wide spreading benches, and from half to one third of the surface appears fit for cultivation. Considerable areas of low land also border Stuart Lake.

The aggregate area of land below the 3,000 feet contour line, with light slopes or nearly level, and which may be supposed to have some prospective value, is great; but it is impossible to form even an approximately correct estimate of it till the maps are further advanced. That in sight from the lakes must exceed 500 square

* Canadian Pacific Railway Report, 1878, p. 70.
† Report of Progress, Geol. Survey of Canada, 1876-77 p 47.

miles. The soil is generally good, and the only remaining question is in regard to the character of the climate.

The northern or lower extremity of Babine Lake being more closely hemmed in by snow-clad mountains, is evidently less favorably situated than the remainder of this lake and Stuart Lake, and vegetation was found to be decidedly behind that of the Sus-kwa Valley. Mr. Sanpere, who is in charge of two Hudson Bay posts, one at the north end, the other at the middle of Babine Lake, states that at the latter he can grow potatoes and many kind of vegetables, and that his predecessor grew barley, which ripened well. An Indian living on the portage between the two lakes cultivates a little patch of land, and, though very poorly attended to, he had a fine looking crop of potatoes and a little field of barley, the latter about three feet high and with the ear just appearing at the date of our visit (July 4th). He also keeps some cattle here, cutting hay for them in swamps around Stuart Lake. At Fort St. James we found potatoes flourishing, but rather late, having been cut down by a frost in June. Barley was doing well, and has been grown as a regular crop for many years. * In the garden were peas, lettuce, beets, carrots, onions, garlic, turnips, cabbages and cauliflowers, doing well enough, but not carefully cultivated. Wheat has been sown this year as an experiment, and had not suffered from frost at the date of our visit (July 7th).

Temperature observations kept while on Babine and Stuart Lakes, June 27th to July 8th, gave a mean minimum temperature of 40·2°. The mean of the early morning and evening observations is 51·5°. The temperature is here subject to greater and more rapid changes than in the Skeena Valley, and on the night of June 29th we experienced a frost, the thermometer registering 26°, near the northern end of Babine Lake, and in the vicinity of the snow-clad mountains already referred to.

In the valley of Babine and Stuart Lakes the summer season seems to be sufficiently long, and the absolute amount of heat great enough to bring all ordinary crops, including wheat, to maturity, but the question remains to what extent the liability to summer frosts may interfere with the cultivation of some plants, more especially wheat. Though this valley may be regarded as a continuation of the country of the Lower Nechacco, its vicinity to mountains appears to render it somewhat inferior to that district in climate, and places it in this regard, in my opinion, nearly in the same position with the country bordering on François Lake. In previous reports † I have described the flat country of the Lower Nechacco basin as constituting the greatest connected region susceptible of cultivation in the Province of British Columbia. Its area has been estimated at 1,000 square miles. It is based on fine white silty deposits of the later portion of the Glacial period, constituting a soil almost uniformly fertile, and is remote from high snow-clad ranges. In the absence of further information, I can merely repeat what was said of this region on a former occasion, viz., that while it is not probable that wheat can be grown over all parts of its area, it can scarcely be doubted that barley may be ripened almost everywhere in it, while wheat would succeed in chosen spots. This region will, doubtless, at some time support a considerable population, but it is to be remarked that the passage of a railway through it would do little at present toward settling it; for in the first instance, the country to the east of the Rocky Mountains, in the Peace River or Saskatchewan Valleys, would offer superior inducements to farmers and stock raisers.

The country lying in the vicinity of the trail between Fort St. James, on Stuart Lake, and Fort McLeod has already been described by Mr. Selwyn and by Mr. Hunter. ‡ The elevation of the watershed which is characterized by wide sandy

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* Report of Progress, Geol. Survey of Canada, 1876-77, p 51.

† Report of Progress Geol. Survey of Canada, 1876-77, p 45. Canadian Pacific Railway Report, 1877, p. 252.

‡ Report of Progress, Geol. Survey of Canada, 1875-76, p. 34. Canadian Pacific Ry. Report, 1878, p. 73.

flats is about 2,816 feet, taking the height of Stuart Lake at 2,200 feet. With the exception of a belt a few miles wide near Stuart Lake, and rising in places about 400 feet above it, this region is scarcely to be considered as of any agricultural value. It lies to the north of the Nechacco basin previously mentioned. Its surface is considerably broken and the soil generally light, sandy or gravelly. It is at present covered for the most part with burnt woods. A considerable area would doubtless be available for pasture land if the forest were completely removed by fire, and there are numerous swamps and meadows along streams yielding good natural hay. A frost was experienced on the night of July 13th, my thermometer going down to 27°, on Iroquois Creek. No frost occurred at Fort McLeod, nine miles off, and between 400 and 500 feet lower.

At Fort McLeod the potatoes had been cut down by frost in June, but had recovered completely and were growing well in July. The soil is, however, rather poor, and the area of cultivable land not extensive.

D. W. Harmon, in his "Voyages and Travels" published at Andover, Mass., in 1820, states that the snow fall at Fort McLeod is sometimes as much as five feet, and this is confirmed by those now acquainted with the region. At Fort St. James the snow reaches a depth of about three feet. A difference remarkably great for two places so close together.

From Fort McLeod to the Middle Forks of Pine River, seventy-two miles distant, may be treated together as representing the Rocky Mountains, including the foot hills of both slopes and the higher plateau attaching to these on the north-eastward. From July 17th to August 5th, the mean of the observed minima on this part of the route is 39·7°. The mean of the early morning and evening readings of the thermometer, 49·4°. This must be much below the actual mean temperature, for the thermometer had seldom risen much above its minimum when observed at 6 a.m. The heat was sometimes great in the middle of the day, but as we were then always travelling, could not be registered. Three frosts were experienced, on the nights of the 2nd, 3rd and 4th of August, the thermometer reading 30·5°, 28° and 30°5 on these nights. Strong westerly winds, falling calm at sundown, with a clear sky were the conditions causing the frosts. The quantity of arable land in this mountainous zone is quite inconsiderable, being confined, on the route followed, to the actual valley of Pine River for a few miles above the Middle Forks.

The portion of the Peace River country, for which the exploration of last season enables pretty accurate general information to be given, may be considered as extending eastward from the Middle Forks of Pine River. West of this point, as already stated, the areas of fertile land are small, being confined to certain river valleys which penetrate the foot hills of the Rocky Mountains and high plateau attached to them. With this western limit, the region now to be described may be considered as bounded to the north by the 57th parallel, to its intersection eastward with the Peace River. Thence the boundary may be assumed to follow the Peace River southward to the mouth of Heart Brook, near the confluence of the Smoky River. Thence to run south-eastward to the extremity of Lesser Slave Lake, to follow the western border of the hilly region lying to the south of the lake to the Athabaska River; thence to follow the Athabaska westward to the foot hills, and skirting the foot-hills to run north-westward to the first mentioned point on Pine River.*

The tract included within the limits above given has an area of about 31,550 square miles, and by far the larger part of this area may be classed as fertile. Its

* In addition to the area above defined, my explorations and those of my assistant, Mr McConnell, during the past season, included an examination of the upper part of the Athabasca to Athabasca Landing, of the north shore of Lesser Slave Lake and Lesser Slave Lake River, of a route from the east end of Lesser Slave Lake to old Fort Assineboine and thence to Edmonton, and of the road from Athabasca Landing to Edmonton. Also of the Athabasca from the Landing to the mouth of the Rivière la Bèche, by the valley of the latter to Lac la Bèche and thence to Victoria and Egg Lake. The country examined on these lines is not included in the present report, as being less homogenous in character than the great region above defined, it requires to be treated at greater length and in more detail. It may suffice for the present to state that considerable areas of fertile land are found throughout, but more particularly in the region south of the line of the Athabasca River.

average elevation may be stated as little over 2,000 feet, and this is maintained with considerable uniformity, for though the general surface slopes slightly from the north and south toward Peace River, the region as a whole may be considered as a plateau through which the great gorge-like valley of the Peace has been excavated. This valley has in general a depth of 600 to 800 feet below that part of the plateau bordering it, with a width of two to three miles from rim to rim. Its tributary streams at first nearly on the plateau level, flow in valleys of continually increasing depth as they approach that of the Peace River. Those from the south-eastern portion of the region rise either in the Rocky Mountains, or near the Athabaska, the tributaries received by the latter stream from the north and north-west being—with the exception of the Batiste—quite inconsiderable in this part of its course.

The ridges and hills by which this region is occasionally diversified, appear in all cases to be composed either of the generally soft rocks of the Cretaceous and Tertiary or of arenaceous clays containing erratics and representing the boulder clays of the glacial period. These elevations are generally slight, and with exceedingly light and gradual slopes, the scarped banks of the streams constituting much more important irregularities. These ridges, however, often resemble detached portions of a higher plateau and spread widely enough to occupy in the aggregate a considerable area, of which the soil is not so uniform in character as elsewhere. With these exceptions, the soil of the district may be described as a fine silt, resembling the white silts of the Nechacco basin previously referred to, and not dissimilar from the loess-like material constituting the subsoil of the Red River Valley in Manitoba. This silt, at a short distance below the surface, is greyish or brownish in color, but becomes mixed superficially with a proportion of vegetable matter to a varying depth. It has evidently been deposited by a comparatively tranquil body of water not loaded with ice, probably toward the close of the glacial period, and has either never been laid down on the ridges and undulations above referred to, or has been since removed from them by natural processes of waste. As evidenced by the natural vegetation its fertility is great.

West of the Smoky River, both to the south and north of Peace River, there are extensive areas of prairie country, either perfectly open and covered with a more or less luxuriant growth of grass, or dotted with patches of coppice and trees.

The northern banks of the Peace River Valley are also very generally open and grassed, and parts of the valley of the Smoky and other rivers have a similar character. The total area of prairie land west of the Smoky River, may be about 3,000 square miles. The remainder of the surface is generally occupied by second-growth forest, occasionally dense, but more often open and composed of aspen, birch, and cottonwood, with a greater or less proportion of coniferous trees. Some patches of the original forest, however, remain, particularly in the river valleys, and are composed of much larger trees, chiefly coniferous, among which the black spruce is most abundant. Handsome groves of old and large cottonwoods are also to be found in some of the valleys. Where the soil becomes locally sandy and poor, and more particularly in some of the more elevated parts of the ridges before described, a thick growth of scrub pine and black spruce, in which the individual trees are small, is found; and in swampy regions the tamarac is not wanting, and grows generally intermixed with the black spruce.

East of the Smoky River, and southward toward the Athabaska, the prairie country is quite insignificant in extent, the region being characterized by second-growth woods of the character just described, which, on approaching the Athabaska, are replaced by extensive and well nigh impassible tracts of brulé and wind-fall, in which second growth forest is only beginning to struggle up.

Though the prairies are most immediately available, from an agricultural point of view, the regions now covered with second-growth and forest, where the soil itself is not inferior, will eventually be equally valuable. The largest tract of poor land is that bordering the valley of the Athabaska on the north. This rises to an elevation considerably greater than most of the region to the north and west, and appears during the submergence to which the superficial deposits are due, to have been exposed to

stronger currents which have prevented the deposition of the fine silt, causing it to be replaced by a coarser silt which passes in places with actual sand, and alternates with ridges of boulder clay. This region is also often very swampy, and for a width of twenty to twenty-five miles on the trail from Sturgeon Lake to the Athabaska is quite unsuited to agriculture, though still in many places capable of yielding good summer grazing when the forest has been completely removed by fire. To the northward, more particularly to the east of Smoky River, peaty and mossy swamps occupy part of the surface, and these may be regarded as permanently unsuited to agriculture.

There is also a sandy tract, though of small width, along the lower part of the Elk River near its junction with the Smoky. Deducting, as far as possible, all the areas known to be inferior or useless, with about twenty per cent. for the portions of the region under consideration of which less is known, the total area of land, with soil suited to agriculture, may be estimated as at least 23,500 square miles. In the absence of complete maps, such an estimate cannot be otherwise than very rough, but may serve to give some idea of the fact.

Whatever theory be adopted, and may have been advanced, to account for the wide prairies of the western portion of America further to the south, the origin of the prairies of the Peace River is sufficiently obvious. There can be no doubt that they have been produced and are maintained by fires. The country is naturally a wooded one, and where fires have not run for a few years, young trees begin rapidly to spring up. The fires are, of course, ultimately attributable to human agency, and it is probable that before the country was inhabited by the Indians it was everywhere densely forest-clad. That the date of origin of the chief prairie tracts now found is remote, is clearly evidenced by their present appearance, and more particularly by the fact that they are everywhere scored and rutted with old buffalo tracks, while every suitable locality is pitted with the saucer-shaped 'buffalo wallows.' It is reported that a few buffaloes were seen last year near Pine River, but the animal has now become in the Peace River county practically extinct; an event which, according to the Indians, happened at a date not very remote, owing to a winter of exceptional severity, during which the snow "reached to the buffaloes backs."

The luxuriance of the natural vegetation in these prairies is truly wonderful, and indicates, not alone the fertility of the soil, but the occurence of a sufficient rainfall. The service berry, or amalanchier, and the choke-cherry are very abundant in some places, particularly on the so-called Grande Prairie, which constitutes the great berry gathering ground of the Indians.

With regard to the climate of the Peace River country, we are without such accurate information as might be obtained from a careful meteorological record, embracing even a single year, and its character can at present be ascertained merely from notes and observations of a general character and the appearance of the natural vegetation.

It may be stated at once that the ascertained facts leave no doubt on the subject of the sufficient length and warmth of the season, to ripen wheat, oats and barley, with all the ordinary root crops and vegetables, the only point which may admit of question being to what extent the occurence of late and early frosts may interfere with growth. This remark is intended to apply to the whole district previously defined, though it must be remembered, in considering the subject, that the conditions of places situated in the bottom of the trough-like river valley, and 600 to 800 feet below the plateau, may be considerably different from those of its surface.

The summer season of 1879 was an unusual one, characterized by excessively heavy rain-fall, with cold raw weather in the early summer months. These conditions did not extend to the west of the Rocky Mountains, but appear to have been felt over the entire area of the plains to the Red River Valley. As a result of this, the crops generally throughout the North-west were later than usual, and the mean temperature of even the latter part of the summer appears to have been rather abnormally low. Notwithstanding this, on my arrival at Dunvegan, on the 16th of August, small patches of wheat and barley in the garden of the fort presented a remarkably fine appearance and were beginning to turn yellow. On my return to

the fort on August 31st these were being harvested, their complete ripening having been delayed by overcast and chilly weather which prevailed between these dates. At the first-mentioned date potatoes were quite ripe, with the balls formed on the stalk, and the garden contained also fine cabbages, cauliflowers, beets, carrots, onions, lettuce and turnips. Dwarf beans, cucumbers and squashes were also flourishing, and though these plants are particularly tender, showed no sign of frost. The two last named having been sown in the open ground did not appear likely to perfect their fruit. A few stalks of Indian corn were also growing, though it is improbable that this plant would ripen its seed in this district.

When this garden was again visited, on the last day of August, the beans, cucumbers and squashes had been cut down by a frost, but not completely killed. The potato tops were also slightly nipped.

Rev. M. Tessier, who has been at Dunvegan as a missionary for some years, has always been able to ripen small, black butter-beans, but in some seasons not without difficulty owing to frosts. He has also tried a few grains of oats which he procured accidentally, and obtained a return of astonishing abundance. About the date just referred to the potatoe plants at Smoky River post (The Forks) were badly cut down by frost, the tubers being, however, quite ripe, fine and large.

On the 15th September, Mr. R. McConnell, my assistant, found the potatoes in the garden of the fort at the west end of Lesser Slave Lake, and on the level of the plateau, little affected by frost, with tubers large and ripe. Mr. H. J. Cambie also ascertained that wheat thrives at this place. We found some rude attempt at cultivation also at the 'Cree Settlement,' which consists of a few log houses built by Indians on the border of Sturgeon Lake, about 70 miles south-west of the west end of Lesser Slave Lake, and is at the average level of the country, with an elevation of about 2,100 feet. Here, on September 14th, the potatoe plants were slightly affected by frost, but not more so than observed with those at Dunvegan two weeks before. The tubers were quite ripe, but the Indians did not intend to dig them for about ten days. Turnips were very fine, and carrots, beets and onions were good, though evidently cultivated with very little care. Two or three very small patches of barley had been almost completely destroyed by mice, but a few stalks remaining were quite ripe and with fine heads. The Indians here were very anxious to have a supply of garden seeds, which I have since been able to forward to them by the kindness of Messrs. Stobart, Eden & Co., of Winnipeg.

At Fort St. John, 95 miles west of Dunvegan, and so much nearer the mountains, on July 26th, 1875, Professor Macoun states that potatoes, oats, barley and many varieties of vegetables were in a very flourishing state in 'Nigger Dan's' garden. The oats stood nearly five feet high and the barley had made nearly an equal growth.* The barley and oats were both ripe about the 12th of August. Prof. Macoun was informed by Charlette at Hudson's Hope, thirty miles still further west, that in 1874 there was no frost from the 1st of May until the 15th of September. In 1875 sowing commenced the last week in April. There appears to have been a frost on June 28th, but the first autumn frost occurred on the 8th of September, and Mr. Selwyn found the potato tops still green in the middle of the month. Mr H. J. Cambie saw wheat flourishing here in July last, but on his return in September it had been cut down by frost.

Such are the notes that can be obtained on the growth of cereals and vegetables in the district in question. From information obtained at Dunvegan, it seems that the snow disappears about the middle of April, westerly winds sweeping it away fast. The river opens at about the same time. Cultivation begins at about the end of April or first of May. The river generally begins to freeze in November. The depth of snow, I was told, averages about two feet, an estimate which agrees with Mr. Horetzky's statement.† Mr. Horetzky was also told that the plains were often nearly bare up to the month of December, though the winter usually sets in with the month of

* Report of Progress, Geol. Survey of Canada, 1875-6, p. 154.

† Canada on the Pacific Coast, p. 205.

November. Sir Alexander Mackenzie remarked the same absence of snow in the early winter months of 1792. It was entirely gone on April 5th, 1793, and gnats and mosquitoes were troublesome on April 20.* Horses almost invariably winter out well without requiring to be fed. Hay should be provided for cattle, to ensure perfect safety, for a period of three or four months, though in some seasons it is necessary to feed the animals for a few weeks only. The Indians of the 'Cree Settlement' on Sturgeon Lake, previously referred to, winter their horses without any difficulty round the borders of a neighboring lake, the shores of which are partly open. From Hudson's Hope, the horses are sent southward to Moberly's Lake to winter, and according to Mr. Selwyn, do well there. Lesser Slave Lake, with its wonderful natural meadows, has long been known as an excellent place for wintering stock, and is referred to as such by Sir J. Richardson.

Some general idea of the length and character of the seasons at Fort St. John may be gained by an examination of the extracts from the journals from 1866 to 1875, published by Mr. Selwyn.† The dates of opening and closing of Peace River, being an important clue to the mean temperature of the region, may be quoted as summarized by Prof. Macoun in the same report (p. 156).

	Ice breaking	Ice drifting, first time
1866	April 19	Nov. 7.
1867	" 21	" 8.
1868	" 20	" 7.
1869	" 23	" 8.
1870	" 26	no record.
1871	" 18	" 10.
1872	" 19	" 8.
1873	" 23	" 4.
1874	" 19	Oct. 31.
1875	" 16	

The average date of the breaking up of the ice may thus be stated to be April 21st; that on which ice is running on the river for the first time, November 7th. In 1792 and, 93, when wintering at the mouth of Smoky River, Sir Alexander Mackenzie observed the ice to be running for the first time on November 6th, while the river was clear of ice on the 25th April. I have been unable to find any precise records of the dates of closing and opening of the Saskatchewan, but Dr. Hector states these are usually the second week of November and the second week of April respectively. The Saskatchewan is a more rapid stream than the Peace.

With regard to the probable difference between the actual valley of the Peace and the plateau forming the general surface of the country, Prof. Macoun observes,‡ speaking of the vicinity of Fort St. John, that notwithstanding the difference in altitude the berries on the plateau ripened only about a week later than those near the river, while he was informed that there was about the same difference in the time of disappearance of the snow in spring. While at Dunvegan, I ascertained that a similar difference was observed there, but it was added that this obtained chiefly with the wooded parts of the plateau, the snow disappearing on the prairies much about the same time as in the valley. In my diary, under date September 5th, I find the following entry:— "Aspens and berry bushes about the Peace River Valley now looking quite autumnal. On the plateau 800 or 900 feet higher, not nearly so much so. Slight tinge of yellow only on some aspen groves." This difference, through not altogether constant and depending much on diversity of soil, appears to be actual. In October, 1872,

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* Voyages, p. 131-132.

† Report of Progress, Geol. Survey of Canada, 1875-76 p. 84.

‡ *Op. Cit.*, p. 155.

Mr. Horetzky writes: * "We observed that, curiously enough, the vegetation upon these uplands did not appear to have suffered so much from the effects of frost, this being probably due to the fact of the air in these upper regions being constantly in motion, while in the deep and capacious valley of the river the winds have often no effect"

The difference between the valley and the plateau being thus very small, I have not treated separately the observations for temperature taken by myself in the different situations. Most of the observations, however, refer to the plateau, and including the whole time spent in the country, from the Middle Forks of Pine River to the bank of the Athabaska, cover a period of nearly two months. The mean minimum temperature for the month of August, deduced from observations extending from the 6th to the 31st of the month is 39·9°. The mean of observations at 6 a. m. during the same period is 42·3°. That of the observations at 6 p. m. 59·5°. In September the mean minimum temperature was 28·1°. The mean of morning observations 34·3°, of evening observations 51·5°. I have endeavored to deduce from these observations means temperatures for the months in question, by correcting them by the tables of hourly variations in temperature given by C. A. Schott in the Smithsonian Contributions to Knowledge (No. 277), but find it impossible to do so, as the daily range is here so much greater than that of any of the places represented by the tables, which refer chiefly to the eastern portion of the continent. It would appear that while in most places the mean temperature of the day is reached about 8 p. m., it is found in the Peace River country not far from 6 p. m., by reason of the increased rapidity of loss of heat by radiation due to greater elevation and dryer atmosphere. The maximum temperature was seldom observed, but the daily range is very great, and the maximum probably several times reached 80° in August, and often surpassed 70° in September.

From the 6th to the 31st of August I registered two nights of frost, on the 13th and 20th of the month when the thermometer showed 32° and 26° respectively. Both of these were observed on the plateau, but one at least of them (that of the 20th) must have occured also in the valley, from the effects produced at Dunvegan on tender vegetation. These frosts occured in very fine weather, following a day of strong westerly wind, the result of which is to remove from the surface of the earth the whole of the lower heated layer of the atmosphere. This, succeeded by a calm and cloudless night with transparent sky, causes the thermometer to sink below the freezing-point before morning. When not preceeded by strong wind, mere transparency of the atmosphere seems seldom or never to lead to frost in August, in this district, as many beautifully starlight nights without an approach of the mercury to be freezing-point were observed.

Though in some cases such frosts as these may be general, and extend over a wide district of country, it is more usually found that they are quite local in character. A few floating clouds, or light wreaths of mist, may arrest radiation so far as to prevent frost over the greater part of the country, while some spot accidentally exposed during the whole night under a clear sky experiences a temperature below 32°. The contour, and character of vegetation of the country also have much to do with the occurrence of frosts, and it is very frequently the case that river valleys are more subject to frosts than the upland districts. During the month of September, in a region for the most part wooded, and often above the average altitude, between Dunvegan and the Athabaska, nineteen frosts were registered, the actually lowest temperature being 20° on September 18th.

Through the kindness of Colonel Jarvis, of the North-west Mounted Police, I have been able to secure a copy of records kept by Dr. Herkomer, of Fort Saskatchewan, on the Saskatchewan River, about twenty miles north-east of Edmonton. For comparison with the observed temperatures in the portion of the Peace River country now discussed, they are invaluable; for in the whole district surrounding Fort Saskatchewan and Edmonton we now know from actual and repeated experiment that

* Canada on the Pacific p. 44.

wheat and all other ordinary cereals and vegetables thrive, and yield most abundant crops. The climate in its great diurnal and annual range corresponds exactly with that of the Peace River country. Fort Saskatchewan is situated on the brow of the Saskatchewan Valley, about seventy feet above the river, and therefore probably less liable to frosts than either the bottom of the river valley, or extensive flat tracts of plain where there is little circulation of air. This, with the position of the thermometers in regard to the buildings, leads to the belief that if at all in error, as representing the climate of the region generally, the indicated temperatures are slightly too great. The thermometer appears to have been read in all cases to the nearest degree only.

A comparison may be made between the temperature observed in the Peace River country during August and September, with those at Fort Saskatchewan, as follows.—

Peace River Country, mean of minima during August	39· 9°
" " " September	28· 1°
" Frosts experienced during August	3
" " " September	19
For Saskatchewan, mean of minima during August	39· 3°
" " " September	31· 1°
" Frosts experienced during August	0
" " " September	15
Fort Saskatchewan, mean of maxima during August	77· 8°
" " " September	68· 1°
Fort Saskatchewan, deduced mean temperature of August	58· 6°
" " " September	49· 6°

The mean of maxima and actual mean temperature for the months cannot be stated for the Peace River country. The actual mean for Fort Saskatchewan is obtained by adding the minima and maxima for each month together, and is probably very nearly correct.

While regretting that the data at disposal for the determination of the agricultural value of the Peace River country are not more ample, we may I believe, arrive with considerable certainty at the general fact that it is great. From such comparison as can be made, it would be premature to allow that the climate of the Peace River is inferior to that of the region about Edmonton or the Saskatchewan. It is true that in both the Saskatchewan and Peace River districts the season is none too long for the cultivation of wheat, but if the crop can be counted on as a sure one,—and experience seems to indicate that it may—the occurrence of early and late frosts may be regarded with comparative indifference. The season is at least equally short throughout the whole fertile belt from the Peace River to Manitoba, though early and late frosts are not so common in the low valley of the Red River. The almost simultaneous advance of spring along the whole line of this fertile belt, is indicated by the dates of the flowering of the various plants, a point referred to by me in some detail elsewhere.* It is further unquestionable that the winter is less severe, and not subject to the same extremes in the Peace River and Upper Saskatchewan regions as in Manitoba.

We have already found reason to believe that the early and late frosts, and not the absence of a sufficient aggregate amount of heat, constitutes the limiting condition of wheat culture in the North-west; but that neither the Saskatchewan nor the Peace River countries lie upon the actual verge of the profitable cultivation of wheat appears to be proved by the fact that oats succeed on the Saskatchewan, and also —in so far as one or two seasons can be accepted as evidence—on the Peace River; while it is well known that this cereal is less tolerant of summer frost than wheat. This is further proved by the fact that at Fort Vermilion and Athabaska Lake, 180 and 300 miles respectively north-east of Dunvegan, Prof. Macoun found wheat and barley ripening well; but in this instance the fact is complicated by the circumstance

* Geology and Resources of the 49th Parallel 1875, p. 279.

of the decreasing altitude of the country, which introduces a new condition. As no knowledge has been gained of this country on the Lower Peace in addition to that collected by Prof. Macoun in 1875,* it is not included in the above discussion, though from it additional great areas might doubtless be added to the fertile tract.

Referring to the journals kept at Fort St. John, Mr. Selwyn, in the report already several times referred to, comes to the conclusion that the climate of the Peace River compares favorably with that of the Saskatchewan country, or Montreal.

It has often been stated in a general way that the cause of the exceptionally favorable climate of the Saskatchewan and Peace River countries, as compared with those of the eastern portion of the American continent, is to be found in the prevalence of warm westerly winds from the Pacific. Sir Alexander Mackenzie speaks of these westerly winds in winter, writing:—"I had already observed at Athabaska, that this wind never failed to bring us clear mild weather, whereas, when it blew from the opposite quarter, it produced snow. Here it is much more perceptible, for if it blows hard south-west for four hours a thaw is the consequence, and if the wind is at north-east it brings sleet and snow. To this cause it may be attributed that there is so little snow in this part of the world. These warm winds come off the Pacific Ocean, which cannot, in a direct line, be very far from us, the distance being so short that, though they pass over mountains covered with snow, there is not time for them to cool." †

Further south these south-westerly currents are known as 'Chinook winds,' and similar consequences are observed to accompany their occurrence. Sir Alexander Mackenzie, however, in the summer of 1793, found the distance to the Pacific coast from his wintering-place, at the mouth of Smoky River, greater than he appears to have imagined at the time he penned the above quoted remarks, and it is difficult indeed, to understand how currents of air, blowing for at least 350 miles across a country which is for the most part mountainous, should retain enough warmth to temper effectually, the climate of the plains to the east. This difficulty would appear to be particularly great in summer, when the mountains are largely snow-clad and the mean temperature of the Peace and Saskatchewan Valleys, is probably considerably in excess of that of the region intervening between them and the sea.

The complete explanation is to be found in the great quantity of heat rendered latent when moisture is evaporated or air expanded in volume, but which becomes sensible again on condensation of the moisture or compression of the air.

The pressure in the upper regions of the atmosphere being so much less than in the lower, a body of air rising from the sea-level to the summit of the coast mountains must expand, which implying molecular work, results in an absorption of heat and consequent cooling. The amount of this coling has been estimated at about 1° Centigrade for 100 metres of ascent when the air is dry, but becomes reduced to $\frac{1}{2}$ degree when the temperature has fallen to the dew-point of the atmosphere and precipitation of moisture as cloud, rain or snow begins; the heat resulting from this condensation retarding to a certain degree the cooling due to the expansion of the air. When the air descends again on the further side of the mountain range, its condensation leads to an increase of sensible heat equal to 1° C. for each 100 metres. ‡ It is owing to this circumstance that places in the south of Greenland, on the west coast, during the prevalence of south-easterly winds which flow over the high interior of the country, have been found, in winter, to experience for a time a temperature higher than that of North Italy, or the south of France, though the north Atlantic Ocean from which the winds come can have been little above the freezing-point at this season. The wind well known in the Alps as the foehn, is another example of the same phenomenon.

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* Report of Progress of Geol. Survey, Canada, 1875-76.

† Voyages, p. 138.

‡ The figures are Dr. Hann's, quoted by Hoffmeyer in the Danish Geographical Society's Journal, and reproduced in Nature, August, 1877.

The data are wanting for an accurate investigation of the circumstances of our west coast in this regard, but a general idea of the fact may be gained. We may assume that the air at the sea level is practically saturated with moisture, or already at its dew-point, that in crossing the mountainous region the average height to which the air is carried is about 2,000 metres (6,560 feet), and that it descends to a level of about 700 metres (2,296 feet) in the Peace River country. The loss of sensible heat on elevation would, in this case, amount to 10° C. (18° F.), the gain on descent to the level of 700 metres to 13° C. (23·4° F.). The amount of heat lost by the air during its passage across the mountainous region, by radiation and contact with the snowy peaks, cannot be determined. It is of course much greater in winter than in summer, and depends, also on the speed with which the current of air travels. Taking the mean summer temperature of the coast at about 12° C., (54° F.) and allowing several degrees for loss of radiation, it becomes easy to understand how the western prairies may be flooded with air nearly as warm as that of the coast, though it has travelled to them over a region comparatively cold.

Owing to the great width of the mountain barrier, the main result is complicated by local details, regions of considerable precipitation occurring at each important mountain range, with subsidiary drier regions in the lee. The last of these regions of precipitation is that of the Rocky Mountain range, properly so-called. By this a further addition of heat is made to the air, which then flows down as a dry and warm current to the east.

In addition to the favorable climatic conditions indicated by the thermometer, the length of the day in summer in the higher northern latitudes favours the rapid and vigorous growth of vegetation, and takes the place, to a certain extent, of heat in this respect. This has been supposed to be the case from the luxuriant vegetation of some northern region, but Alfonse de Candolle has put the matter beyond doubt by subjecting it to direct experiment. In latitude 56° which may be taken as representing that of much of the Peace River country, sunrise on 21st June, occurs at 3h. 12m., sunset at 8h. 50m.; while six degrees further south, in latitude 50°, which may be assumed to represent Manitoba, sunrise occurs on the same day at 3h. 49m., sunset at 8h. 13m. The duration of sunlight, in the first case, is 17h. 38m.; in the second, 16h. 24 m., or one hour and a quarter in excess in the northern locality. This excess of course decreases to zero at the spring and autumn equinoxes, and the difference is reversed in the winter.

A further circumstance giving to the Peace River country and that on the upper part of the Saskatchewan, other things being equal, a value as farming land acre for acre considerably greater than that of most parts of the North-west, is the immunity of this region from the visits of the devastating locust or grasshopper (*Caloptenus spretus*). I have elsewhere discussed the question of locust invasions, in several papers,* and it has since been taken up by the United States Entomological Commission.† It must suffice to state here, that while long series of years may pass without the occurrence of serious invasions, these must continue always, or at least for a very long time, to constitute a drawback to the whole territory lying south of a line drawn about sixty miles south of Edmonton, and thence nearly following the border of the wooded country eastward and southward to Manitoba.

(2) *General Geological features, and Minerals of Economic Importance.*

The rocks of the coast of the northern part of British Columbia and its adjacent islands, resemble those of the southern part of the coast, in the same line of strike, and the Victoria series of Vancouver Island. The age of these rocks I believe to be not greater than Palaeozoic, though their crystalline and highly altered appearance might, at first sight, suggest a comparison with still older series. They may be

* Canadian Naturalist, Vol. VIII., pp. 119, 207, 411.

† First Annual Report, United States Entomological Commission, 1878.

described, generally, as consisting of gneisses, diorites, mica and hornblende-schists, with occasional limestones and great masses of granite or diorite of intrusive origin. About Port Simpson and Metla-Katla these rocks are predominantly schistose and dark in colour. Mica-schist, generally rather fine grained and often glossy, very dark and containing some graphite, is the most abundant material.

The dip of the beds is generally north-eastward at high angles. The resemblance of some of these schists to the auriferous rocks of Cariboo and Leech River, Vancouver Island, is close, but I cannot learn that gold in paying quantity has been found in connection with them on this part of the coast. Limestone is found in association with them in some places. Copper ores appear to occur pretty frequently in these or the associated gneissic rocks of the Coast Ranges, but though much prospecting has been done no permanent mines have been established. A rather promising cupriferous vein has been discovered by Mr. J. W. McKay on the slope of the hill immediately behind the Hudson Bay Company's buildings at Port Simpson.

In Work Channel the rocks appear to be chiefly schistose, like those of Port Simpson, but massive granites or granitoid gneisses occur on the eastern shore and probably constitute the range of mountains which follow it. At Port Essington, at the mouth of the Skeena, the rock is a grey hornblendic granite, traversed by dykes similar in composition but coarser in texture. For about sixty mile up the Skeena from this point, gneissic and schistose rocks, micaceous or hornblendic, and belonging to the metamorphic series of the Coast Ranges, continue to prevail, and are shown often in great bare mountain sides, on which vegetation is prevented by the occurence of snow-slides. There is no doubt that if required, building stone of fair quality could be obtained in many places from the rocks of this series.

Above the point just indicated, the rocks bordering the Skeena change their character, being of much newer appearance, chiefly felspathic in composition, and, in fact, representing with little doubt the Porphyrite group of my reports of 1875 and 1876. The rocks are greenish, purplish or gray, frequently fragmental, forming agglomerates, or passing over into conglomerates. The boulders and gravel of the river-bed at the same time change their character, being now almost entirely composed of these porphyrites while Mr. Cambie informs me that the stones in the Zymoetz are also similar, proving that the porphyritic rocks have here a wide extension. At Ksipkeeagh Rapid, where a short portage is necessary, the rock over which the canoe is dragged is a rather coarse-grained grey granite, probably intrusive. It appears capable of being quarried into blocks of fair size, breaking along planes of jointage which are nearly vertical, and run S. 50° E., N. 50° W., magnetic. The range of high mountains abutting on the river above Ksipkeeagh appear from a distance to be composed of granite, or some similar massive rock. At Kitsalas Canyon the rocks seem to belong to the porphyritic series, but are much confused and fractured. They are hard, greenish, and felspathic, with no apparent bedding.

The Chimdemash River of the map, four miles above Kitsalas, appears to be that known also as Sebastipool Creek, and if so, is the locality from which a specimen of quartz yielding $42.18 of gold, $13.29 of silver to the ton was brought. The vein yielding this ore has, I believe, been explored to a small extent, but never systematically worked.

Between this place and Quatsalix Canyon, rocks of the porphyritic series are probably most abundantly represented among the mountains generally, but become associated with a considerable and increasing proportion of ordinary sedimentary sandstones not showing evidence of volcanic action.

Fossils also occur in altered ash rocks, like those of the Iltasyouco River,* including belemnites, trigonias, and a coral. These rocks are probably of the same age with those of the Iltasyouco, which, though stated in a previous report to be Jurassic, Mr. Whiteaves is now inclined to regard as probably Cretaceous. In this part of the river extensive exposures of granite also occur, the material being without doubt

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

intrusive. At Quatsalix Canyon the rocks are grey hard sandstone or quartzites, with blackish argillies, often arenaceous, and generally well bedded, and resembling those of the Nechacco series of my report of 1876.

Rocks of the kind last mentioned continue to prevail to the mouth of the Kitseguecla River, where carbonaceous shales were observed to be included in the series for the first time. These are so homogeneous and dark in color that they resemble coals, and on close examination small fragments deserving to be called coal, and probably representing portions of individual stems which have been imbedded in the formation, may be found. The carbonaceous shales are generally more or less lenticular, and the rocks at this place are very much disturbed. Ironstone in nodules, and irregular sheets is abundant in some parts of the formation.

In the rugged mountainous country between the Forks of the Skeena and the lower or north end of Babine Lake, the rocks seen in the vicinity of the trail are probably entirely of Mesozoic age, and resemble those found on the Skeena from Kwatsalix to the Forks. They are generally sandstones of fine or coarse grain, occasionally felspathic or replaced by porphyrite-like and sometimes brecciated rocks. Carbonaceous shales and imbedded fragments of plants were occasionally found, and in one place a few molluscs. The strike is generally nearly true north and south, but subject to great local irregularity. In the bed of the Tzes-a-tza-kwa River, near the point at which the trail from the Forks reaches Babine Lake, fragments resembling coal were found, but contain too much earthy matter to be useful as a fuel. From the appearance of the mountains visible from different points in this region it seems probable that Mesozoic rocks of the kind described are very widely spread in this part of the province, a belief confirmed by a number of small specimens collected by Mr. Horetzky in neighbouring regions, during the expedition of last summer.

Precisely what horizon these rocks represent it is, as present, impossible to tell, or as yet to enter into any details as to their arrangement or thickness. From their relation to the Porphyrite series above referred to, it appears, however, that they must represent, at least in part, the coal-bearing series of the Queen Charlotte Islands and Quatsino Sound, while they may even extend upward to include rocks of the horizon of those of Comox and Nanaimo.

The mere existence of rocks of this age, is not necessarily in itself, to be regarded as establishing a probability of the occurence of coal seams of economic value, but the general dissemination over the district of coaly shales containing impure coal, points to the occurrence of conditions such as those required for the deposition of true coals, and indicates the possibility, if not the probability, of the occurrence of coal beds of economic value in some part of the region. Specimens of some of these coaly materials collected by myself have not yet been subjected to examination, but wo collected by Mr. Horetzky, and analysed at his request in the laboratory of the survey, are reported on as follows by Mr. C. Hoffmann.

Specimen labelled Skeena, Station 37, nine miles above the Forks.

Colour, black; lustre, for the greater part, bright, but contains occasional dull layers, consisting apparently of carbonaceous shale. It is rather brittle, does not soil the fingers; takes fire in a lamp flame, burning with a bright somewhat smoky flame, and evolving an empyrumatic odour; in the closed tube yields water and tarry matter. Colour of powder, black, with a faint brownish tinge; the sample communicated no coloration to a boiling solution of caustic potash.

By slow and fast coking the following results were obtained :—

	Slow Coking.	Fast Coking.
Hygroscopic water	1·05	1·05
Volatile combustible matter	15·35	19·09
Fixed carbon	42 70	38·96
Ash	40·90	40·90
	100 00	100·00
Ratio of volatile combustible matter to fixed carbon	1—2·78	1—2·04

By slow coking the under portion of the powder alone was sintered, the middle and upper portions remaining pulverulent. Fast coking gave a firmer coke. Ash, pale cream colour.

Specimen labelled Skeena, Station 65, twenty miles above the Forks.

The specimen was made up of alternate dull layers of what appeared to be carbonaceous shale, and a bright black coal. Occasionally these latter exhibited a conchoidal fracture; but generally showed a very distinct columnar structure, at right angles to the plane of bedding. It does not soil the fingers. In the closed tube yields water, but scarcely any tarry matter; evolves however, a faint empyrumatic odour. Colour of the powder, black; communicates no color to a boiling solution of caustic potash.

Analysis by slow and fast coking give the following results:—

	Slow Coking.	Fast Coking.
Hygroscopic water	1·52	1·52
Volatile combustible matter	7·63	7·20
Fixed carbon	45·61	46·04
Ash	45·24	45·24
	100·00	100·00
Ratio of volatile combustible matter to fixed carbon	1—6·39	1—5·97

Both slow and fast coking gave a pulverulent coke. Color of ash almost white.

In addition to these, I received from Mr. Hankin, when at the Forks of the Skeena, a small specimen of true coal, apparent of excellent quality. This material came from a point in the Watsonquah River, about eighteen miles from the Forks, and it is reported by the Indians to occur in quantity. I was unable to visit the locality, but it lies nearly on the strike of the carbonaceous beds seen near the mouth of the Kitseguecla, on the Skeena, and may therefore occur in a horizon nearly the same. Arrangements were made to procure a larger specimen, but this has not yet arrived.

Mr. Hoffmann has examined a fragment of this coal, on which he reports as follows.—

Very compact, homogeneous, hard and brittle. Does not soil the fingers. Color black, but with a just perceptible brownish tinge. Lustre dull resinous. Fracture conchoidal. Takes fire in a lamp flame, burning with a bright flame (which however soon dies out on removal from the source of heat), with emission of smoke and a slight empyrumatic odour. Heated in a covered crucible it produces a large amount of flame. In the closed tube yields a considerable quantity of tarry product. Its powder did not impart the slightest coloration to a broiling solution of caustic potash.

An analysis by fast coking gave the following results:—

Volatile matter	40·52
Fixed carbon	57·51
Ash	1·97
	100·00

A determination of the water gave 0·85 per cent., as however, owing to lack of material, no control was made, the amount of this constituent is included in the number indicating volatile matter. Rapid heating gave a firm coke. The ash, which was somewhat bulky, had a slight reddish brown color and agglutinated slightly at a bright red heat. This is an excellent fuel and closely resembles a coal of the true coal measures.

In the present isolated position of the northern interior of British Columbia, the possible existence of workable deposits of coal is a matter of indifference, but in the event of the opening of any route through it, it would be exceedingly desirable to have all parts of the extensive Mesozoic area subjected to a geological examination as close as possible.

Gold has not been found extensively, or in such quantity, as to give rise to permanent mining on the Skeena or the Nasse.

The hills behind the Hudson Bay post, on the east side of the north or lower end of Babine Lake, are of sandstones and fine-grained conglomerates with a strike of N. 15° E. (mag.) and high north-westerly dips. Some beds might form good building material if opened below the frost-shattered surface. For some distance southward on the lake, similar rocks prevail, but from Na-tal-kuz Mountain and the second Hudson Bay post to the head of the lake, rocks which may be referred to the Cache Creek group of the interior of British Columbia, and are probably Carboniferous in age, appear to form the sub-structure of the country; while Tertiary volcanic materials lie upon them, and characterize long stretches of the lake shore. Banded limestones and marbles occur on the north bank, near the great bend of the lake. The rocks of the portage, for some miles from Babine Lake, appear to be Tertiary, while near the head of Stuart Lake massive grey hornblendic granite occurs. In travelling down Stuart Lake, in haste and with bad weather, very little chance occurred for the examination of the rocks. The granite above referred to is soon, however, replaced by a schistose greenish and greyish series, and in the hills north of the Pinchi River, massive limestone beds were first made out. These run southeastward forming the range along the north-east side of the lake, and culminating in Na-katl, or Pope's Cradle, 4,800 feet in height, a few miles from Fort St. James. These limestones have already been described* and are known to be of Carboniferous age.

Between Fort St. James, on Stuart Lake, and Fort McLeod, the surface is almost everywhere covered with drift deposits, and consequently, though travelling nearly at right angles to the general strike of the rocks of this part of the province, little can be ascertained as to their character. Neither the Tertiary basin, previously outlined on the Lower Nechacco River, nor that of the vicinity of Fort George, appears to extend as far north as the line of route just referred to. There appear, however, to be outlying patches of Tertiary volcanic rocks, which rest upon the older formations. These, as indicated chiefly by the debris and drift of the surface, and stones found in brooks, seem to include rocks both of the Cache Creek and Mesozoic series. On Long Lake River, near Iroquois Creek, rocks with little doubt belonging to the first mentioned series occur and include felspathic materials and bands of limestone. In the vicinity of Fort McLeod, rocks similar to these, but with thicker beds of limestone, are found. North of Fort McLeod, on the Parsnip, Mr. Selwyn believes an area of Tertiary lignite-bearing rocks to extend as far as the mouth of the Nation River. Lignite was observed in places near the junction of the Pack, or McLeod's Lake River, with the Parsnip, and loose blocks of a quality likely to be serviceable as fuel, were found scattered further down.†

In continuing eastward from the Parsnip River by the Misinchinca, the country, to Azouzetta Lake at the summit of the Pine River Pass, is characterized by schistose and slaty rocks, with occasional bands of quartzite. The schists are generally micaceous and often very bright, with lustrous surfaces which are not unfrequently minutely wrinkled. These together form a well marked series, and as they occupy a belt of country about twenty miles in width, and are generally at high angles, are doubtless many times repeated by folding. These rocks appear to overlie the massive limestones of the central range of the Rocky Mountains, which appear to be of Carboniferous or Devonian age. From their lithological identity there can be little doubt that they represent the auriferous series of Cariboo, but they have not here been extensively prospected, and no paying deposits of gold have been found in this part of the country.

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* Report of Progress, Geol. Survey of Canada, 1876-77, page 55.

† Report of Progress, Geol. Survey of Canada, 1875-76, p. 71.

On the uppor part of the Misinchinca, numerous 'colors' may be obtained on the bars of the river, and while it is possible that rich auriferous deposits may yet be found here, it should be mentioned that the rocks are not so extensively traversed by quartz veins as in the Cariboo region.

It is apparently on the north-western extension of this belt of schistose rocks, that the Omineca gold district is situated. The known auriferous localities here lie about fifty miles north of a line passing westward from the Pine Pass by Forts McLeod and St. James. There are three routes by which Omenica may be reached. First from the coast by the Skeena River, Babine Portage and Firepan Pass. This route is travelled by canoe and on foot. Second by trail from Fort St. James, practicable for pack animals; and third by canoe or boat from the eastward by the Peace and Finlay Rivers. Without entering into details, a glance at the map will show how completely isolated this district is, and account for the scarcity and high price of provisions, which has prevented the working of any but good paying claims and hindered the thorough examination of the country.

Some facts in connection with this district have been given by me in a previous report,* but it has never been visited by any member of the Geological Survey. The main points which seem to bear on the possible future of the district are as follows :— The existence of rich deposits of gold, and the possibility that with greater facility of access the known area covered by these would be increased, and that it would become possible to work those of a lower grade. The occurrence of pellets of native silver or amalgam in association with the gold. It may not be found possible to trace this material to veins of workable dimensions, but its presence seems in some degree to show the general argentiferous character of the district. The chief promise of future importance as a mining centre seems to lie, however, in the fact that highly argentiferous galena occur in some abundance, and, it is reported, in well-defined and wide veins. These it is at present impossible to utilize, owing to the cost of labor and carriage, but the subjoined particulars may serve to give some idea of the character of the deposits.

According to Mr. Woodcock, of Victoria, some of the most important veins are in the vicinity of a stream called Boulder Creek.

That known as the "Arctic Circle" is said to be about twenty feet wide, and to show about four feet of highly metalliferous ore. It is exposed by the brook in a face about thirty feet high. The claim adjoining this is called the "Black Warrior," and shows a vein eight feet wide of nearly pure galena. Other specimens have been obtained from places within a radius of eight miles from this locality.

Near Lost Creek a vein known as the "Champion Ledge" is found, and runs nearly parallel with the stream. Particulars as to its size are wanting. Another vein in the creek is reported to be twenty feet wide.

Mr. Woodcock has favored me with copies of the following analyses of two specimens of the ores from this district, by Messrs. Johnston, Matthy & Co., London, England.

Arctic Circle Vein.

Lead	26·80
Iron	2·50
Silver	0·13
Sulphur	6 35
Silica	61·60
Alumina	1·40
Combined water	0·95
Oxygen and loss	0·27

Silver equal to 44·2 oz. per ton of 20 cwt.

* Report of Progress, Geol. Survey of Canada, 1876-77, p. 116.

A second analysis of the Arctic Circle ore, is by G. W. Hopkins, San Francisco, and gives the following result :—

Silver, per ton, 40·81 oz. or $52.76.

Gold, trace.

Pig lead would contain about 50 oz. to the ton.

Black Warrior Vein.

Lead	20·25
Iron	2·15
Silver	0·09
Sulphur	4·80
Silica	69·80
Alumina	1·50
Combined water	1·00
Oxygen and loss	1·41
	100·00

Silver equal to 29·8 oz. per ton of 20 cwt.

A second assay of the "Black Warrior," by Messrs. Riehn, Hemme & Co., San Francisco, showed the sample to contain 98 oz. or $126.70 of silver to the ton, equal to $187.10 per ton of pig lead.

Two assays of specimens of ore from a deposit known as the "Mammoth Ledge," gave the following results. Assay by Thos. Price, San Francisco :—

Gold, per ton, $\frac{1}{10}$ oz	$ 2.06
Silver do $32\frac{4}{10}$ oz	41.89
	$43.95

Clean galena would assay, $131.85.

Assay by Messrs. Riehn, Hemme & Co., San Francisco :—

Gold, per ton	$ 6·28
Silver do	91·13
	$97·41

Pig lead would contain 207 ounces to the ton.

A specimen of quartz with galena, from a stream near Mansen Creek in the same district, was examined by Mr. Hoffmann some years ago * and found to contain 8·971 oz. of silver to the ton, with traces of gold, but, as Mr. Hoffmann remarks, the silver is confined to the galena, of which only a small quantity occurs in the vein-stone, and which must consequently be highly argentiferous. An analysis of a sample of galena from the Arctic Circle vein, separated as far as possible from the gangue, in the laboratory of the Survey, gave 128 oz. of silver to the ton. A specimen of ore from the Champion Ledge, including galena and gangue, showed 20 oz. of silver to the ton and a trace of gold.

It would thus appear that a considerable percentage of silver occurs in all the galena ores examined from this district, and that if the veins are sufficiently large and constant in character, the region must be of importance when sufficient means of access to it are provided.

All these ores might, by ordinary process of dressing and washing, be raised nearly to the grade which they show when the precious metals are calculated to the proportion of galena contained.

During the summer of 1879, there were, as I have been informed, about sixty white men engaged in mining at Omineca, with twenty Chinamen, and sixty to seventy Indians, the latter receiving wages as laborers of $3 a day. I am inclined to believe, however, that these figures may be rather above the mark than below it.

* Report of Progress, 1875-76, p. 430, 1876-77, p. 116.

To the north-east of the schistose rocks, and apparently underlying them, are the massive limestones which form the axial mountains of the Rocky Mountain range. These, in their direction of strike, are parallel to the general north-westerly and south-easterly trend of the range. From the line of the summit, or Azouzetta Lake Valley, the width of the limestones and other old rocks measured transversely is about five or six miles only. On the north-eastward side of the range, the limestones become associated with quartzites which may be of greater age, and with blackish shales and slaty rocks holding *Monotis subcircularis*, and therefore to be assigned to the Triassic period. These rocks of the axis of the mountains are not known to be of any economic importance, though in some places capable of yielding building stone of fair quality. 'Colors' of gold may be obtained in the upper part of the Pine River, as on the Misinchinca.

From the point on the upper Pine River last described, rocks probably for the most part of Cretaceous age, but possibly passing up into Tertiary in some places, extend over the whole upper part of the basin of the Peace River. A line drawn from this point north-north-westward to near the confluence of the Otter Tail River with the Peace—a distance of about forty-five miles—probably marks with approximate accuracy, for a portion of its length, the junction of these newer rocks with the main mass of the older rocks of the axis of the mountains. There is evidence that this line is nearly that of the shore at the time of the deposit of the Cretaceous rocks, and that the present axial elevations of the Rocky Mountains have stood as an island or islands above the Cretaceous sea. Cherty fragments, like those associated with the limestones of the mountains, are found abundantly in the conglomerates and sandstones of the newer series. The existence of the remains of plants, and of seams, of coal in different parts of the newer rocks, show that the sea must have been a shallow one, and by occasional elevations, patches at least of its bed were, from time to time, converted into land areas.

It is in these rocks, forming a zone to the east of the Rocky Mountains, that the most promising coal-fields of the North-west lie, and they are now known to be characterized by the presence of coal from the Peace River to the 49th parallel. Their study is consequently attended with interest, and much additional light has been thrown upon it by the examination of sections in the Peace River region, last summer. Till maps are complete, and the whole of the observations properly discussed, it would be unwise to attempt to enter into detail, but some points bearing on the carboniferous character of the formation may be given.

In the vicinity of the mountains, the rocks are much flexed, but the undulations gradually lessen as the mountains are left behind, and the beds become at length horizontal, or so nearly so that no inclination of a fixed character can be detected by ordinary methods. Near the mountains the rocks are almost entirely sandstones, and often quite coarse and associated with conglomerates. Further off, shaly intercalations appear, and eventually two well marked and thick zones of dark colored shales are found, separated by a zone of sandstone and shales, and capped above by a second sandstone and shale formation, which may possibly belong to the lower part of the Tertiary.

In both the horizons characterized by sandstones coal is found, and while as above stated the upper may represent a portion of the Tertiary, the lower is certainly well down in the Cretaceous formation. This in itself is a point of considerable importance, showing that the carboniferous character of the rocks is not confined to a single series of beds, but recurs at two stages. It also, probably confirms the view advanced by Dr. Hector and supported by Mr. Selwyn, for the Saskatchewan country, as to the existence of a coal-bearing horizon in the Cretaceous of that region in addition to that of the Tertiary or Laramie age.

The localities in which coal is known to occur in the lower or certainly Cretaceous zone are:—Table Mountain, Coal Brook and vicinity, Portage Mountain and the lower part of Smoky River.

Table Mountain is situated on the south bank of Pine River between the Lower and Middle Forks. It was examined by Mr. Selwyn in 1875, who describes the coal as

occurring in four seams, in descending order, six inches, eight inches, two feet and six inches thick respectively.

The coal is stated to be of good quality, but has not been analyzed.

Coal Brook joins the south branch of Pine River a few miles from the Lower Forks, and though a comparatively small stream, has formed numerous fine sections in the soft Cretaceous rocks. Coal was discovered here by Mr. J. Hunter in 1877, and is mentioned by him in the Canadian Pacific Railway Report for 1878 (p. 79). Mr. Hunter favored me with specimens collected by him at this time, and I have since personally examined the locality. The rocks are probably nearly on the same horizon as those of Table Mountain. The coal is of good quality and occurs in several beds, which are however, so far as observed, all very thin, the thickest measuring about six inches. Coal also occurs on the south branch of Pine River above the mouth of Coal Creek, and there is much ground to hope for the ultimate discovery of coal seams of workable thickness in this region.

Portage Mountain is cut through by the canyon of the Peace River above Hudson's Hope. The thickest seam observed by Mr. Selwyn in this place, was again but six inches,* but in July last Mr. H. J. Cambie noticed one about two feet in thickness.

The following analysis of a specimen of coal from this place is published by Dr. Harrington.†

	Slow coking.	Fast coking.
Water	2·10	2.10
Volatile combustible matter	21·54	25.09
Fixed carbon	71·63	68·08
Ash	4·73	4·73
	100·00	100·00

Ratio of volatile to fixed combustible by slow coking 1–3·32, by fast coking 1–2·71. By rapid heating the coal yielded a fine coke, and it may be regarded in all respects as a fuel of excellent quality, only requiring to be found in sufficient quantity to claim importance.

The coal referred to as occurring on this horizon on the lower Smoky River is in itself of no importance whatever, being but $2\frac{1}{2}$ inches thick. With the fact of the abundance of impressions of roots and branches in the sandstone is shows merely the carboniferous character of the formation to this point. It appears at the very summit of the series of sandstones forming the lower group, at their junction with the overlying bluish shales.

On Rivière Brulé, near its mouth, about fourteen miles from Dunvegan, my assistant, Mr. McConnell, examined a reported coal seam, which proved to be a lignite coal of inferior quality, and about twelve inches only in thickness. Coal or lignite is also reported to occur on Rat River ten or fifteen miles above Dunvegan, but the locality was not visited. It is probable that in both these places it is the lower or distinctively Cretaceous series of sandstone and slates which hold the coal.

Of localities showing coal or lignite in the upper series of sandstones and slates, which may, so far as present information goes, represent the uppermost part of the Cretaceous, or the overlying Laramie group ; the first discovered is Mountain Creek, joining Elk River, about fifty-eight miles in a direction nearly due south from Dunvegan. The beds found here were again quite thin, but the bars in the stream are strewn with large blocks which appear to be of bituminous coal rather than lignite, and are of good quality as a fuel. These must be derived from thicker beds than those examined, but which may be below the water-level.

The banks of the Elk River, above the mouth of Mountain Creek, show similar fragments of coal more or less rounded, and on the Smoky River, below the mouth

*Report of Progress, Geol. Survey of Canada, 1875-76, p. 63.

†Report of Progress, Geol. Survey of Canada, 1876-77, table facing p 470.

of the Elk, near the base of the upper sandstone series, a seam of good coal five inches in thickness was seen. Drift coal found on the upper part of the main Smoky probably also belongs to this upper sandstone series.

Sandstones and shales, which might represent either the upper or lower series above referred to, occur on the Athabasca River, and were observed in many places above Old Fort Assineboine to hold coal seams. Two of these were noticed to be of remarkable persistency, and though generally thin, the upper seam was found in one place to measure ten feet in thickness, including however a few shaly partings which would reduce the thickness of good coal or lignite to nine feet two inches. This is separated by about twenty feet of soft sandstone from the lower seam, which is compact and of good appearance and about three feet in thickness.

On a stream entering Lesser Slave Lake from the north, near its eastern end, Mr. McConnell observed numerous fragments of lignite of good quality, but all considerably rounded, showing that they had been brought from some distance.

It would thus appear that while in the region lying between the Athabasca and the Peace rivers, no coal seams sufficiently thick to be of great economic value have yet been discovered, that coal and lignite of good quality occur in two distinct series of beds. Wherever natural sections of these occur in the valleys of rivers and streams, coal in greater or less quantity is found, and the persistently carboniferous character of the beds thus abundantly proven. There can be little doubt that beds of a workable character occur in different parts of this region and will be found by further search.

On the extension of these formations to the south-eastward, a bed of coal, reported to be eight feet in thickness, occurs near the projected railway crossing of the North Pembina River, while between Fort Edmonton and the mouth of the Brazeau River, on the Saskatchewan, a seam of coal fifteen to twenty feet in thickness was discovered by Mr. Selwyn in 1873;* other thick seams are reported on the upper part of the Brazeau.

An analysis of the fuel from the North Pembina River made in 1874 by Prof. Haanel, gives the following composition:—

Water	11·88
Volatile combustible matter	28·66
Fixed carbon	57·25
Ash	2·21
	100·00

The coal collected by Mr. Selwyn at the place above referred to on the Saskatchewan yielded to Dr. Harrington the following result on analysis by slow coking:—

Water	10·09
Volatile combustible matter	28·69
Fixed carbon	54·96
Ash	5·45
	100·00

While neither of these can be classed as true bituminous coals, they are fuels of great value, and compare closely with those brown coals used extensively on the line of the Union Pacific Railway in the Rocky Mountain region.

In many localities on the Peace River, and between that stream and the Athabasca, clay ironstone in nodules and nodular sheets is abundant; but generally not in such quantity as to justify a belief in its economic importance. On the lower part of Smoky River, however, great quantities of ironstone apparently of excellent quality might be collected from the bars and beaches, while in few places in the banks, zones largely composed of ironstone and of considerable thickness occur.

* Report of Progress, Geol. Survey of Canada, 1873-74, p. 49.

As already stated, gold in small quantity may be found in both the Misinchinca and upper part of Pine River, while as stated by Mr. Selwyn it has been found from time to time, in various places and in paying quantities both along the Parsnip and the Peace Rivers. Mr. Selwyn remarks that there are no gold-bearing rocks on the Peace below Finlay Branch, and suggests that the fine gold of the lower part of the river may have been originally derived from rocks on the western slope of the mountains, or may have been carried from the belt of Laurentian and other crystalline rocks forming the north-eastern boundary of the interior basin, and stretching from Lake Superior to the Arctic Ocean. For the gold of the Parsnip and upper part of the Peace, the former appears to me to be the most probable explanation, while to that found in the Misinchinca, the Pine and other streams in the vicinity of the mountains a local origin must also be granted.

In all this region, below a certain contour line and to the east of it, drift from the Laurentian axis, above referred to is, in great abundance. The height of this contour line may for the present be roughly stated at 2,000 feet. It is in this tract to the east, characterized by Laurentian *débris* that the paying gold-washings of the Saskatchewan are situated, while in the direction of the mountains the 'pay' appears to run out where the Laurentian drift ceases. Gold has also been found in paying quantities in the parts of the Athabasca and McLeod Rivers which traverse this drift-covered region, and the evidence seems to be strongly indicative in all these cases of an eastern or north-eastern source for the precious metal. It would thus appear, that with the exception of the regions of the Parsnip and Upper Peace, the Rocky Mountain zone in this part of its length has not so far been proved to yield gold in paying quantity, but that remunerative placer deposits supplied from the opposite direction, occur at a greater or less distance from the mountains on several rivers.

GEORGE M. DAWSON.