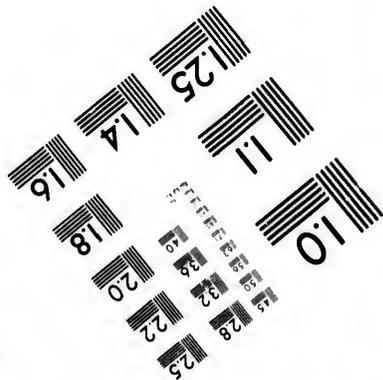
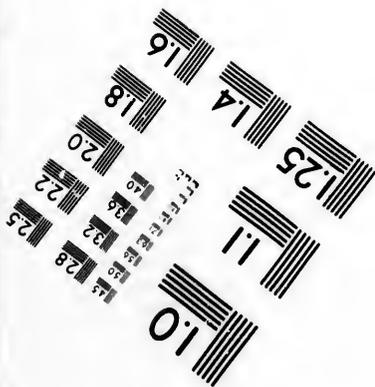
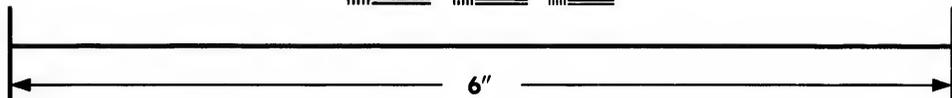
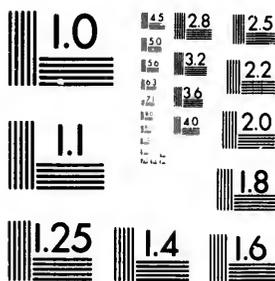


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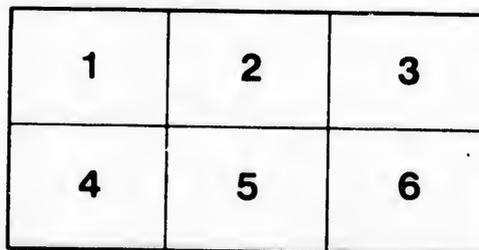
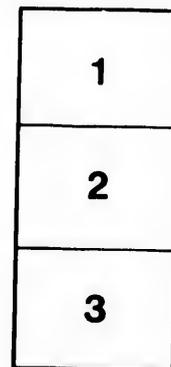
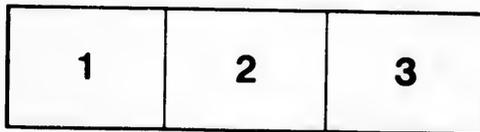
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ON THE

GEOGRAPHICAL DISTRIBUTION AND PHYSICAL
CHARACTERISTICS

OF THE

COAL-FIELDS OF THE NORTH PACIFIC COAST.

BY

ROBERT BROWN, F.R.G.S.,

COMMANDER AND GOVERNMENT AGENT OF THE FIRST VANCOUVER EXPLORING EXPEDITION,
BOTANIST OF THE BRITISH COLUMBIA EXPEDITION, ETC..

From the Transactions of the Edinburgh Geological Society, 1868-69.

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THE
COAL-FIELDS OF THE NORTH PACIFIC COAST.

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I. INTRODUCTION.—The north-west shores of America having been only visited by geologists within a comparatively recent period, our knowledge of its coal deposits dates from a period comprehended within a few years. The early explorers were either fur traders, soldiers, or botanists, who, while reaping harvests of discoveries in their own peculiar branch of science, added nothing to our knowledge of the mineral deposits. Almost the earliest information we possess regarding the geology of California is afforded us by the official report of Dr J. B. Trask,* and the various geologists attached to the splendid surveys for the Pacific railroad, and the U.S. North-West Boundary Commission. Mr H. Bauerman, while attached to the British North American Boundary Commission, made some observations on the geology, which he has published in a short paper, "On the Geology of the South-eastern part of Vancouver Island."† Subsequently, Dr Hector, while attached as geologist to the Rocky Mountain Expedition, under the command of Captain Palliser, visited Vancouver Island, and communicated his observations to the Geological Society of London in an elaborate and valuable paper.‡ The author of this communication, while engaged in other duties, made many notes on the geology, between the years 1863 and 1866, a portion of which are here given. They are merely as

* Report on the Geology of Northern and Southern California. Washington, 1856.

† Quarterly Journal of the Geological Society, 1860, vol. xvi. p. 198.

‡ Ibid. 1861, vol. xvii. p. 388.

the title expresses—notes on the limits of the coal deposits, and on the physical characteristics of the coal. His collection of fossils, now in the British Museum, will be described in another memoir.

II. COAL-FIELDS OF THE NORTH PACIFIC.—Extending from California to the borders of Alaska are three coal-fields, belonging respectively to the Tertiary, Secondary, and Palæozoic ages, the latter being situated, as far as yet known, only in the Queen Charlotte Islands, off the northern coast of British Columbia, the exact age being as yet undetermined, though the coal is anthracitic, and is in all probability palæozoic. The other two coal-fields are situated, as regards each other, from south to north, in the order of their age. The Tertiary extends from California Northward, and through Oregon and Washington Territory, impinging the southern end of Vancouver Island and British Columbia, and extending, with some interruptions, right across the Rocky Mountains, the Miocene coals of Missouri being apparently only a continuation of these same beds. The Secondary beds, on the other hand, on the North Pacific coast, are confined to the island of Vancouver, though in all probability they are also a continuation of the cretaceous strata of Missouri.

III. TERTIARY COALS OF THE NORTH PACIFIC—The general extent of this coal-field I have already given. The lignitic beds are associated with shales and sandstones alternately, and the contained fossils shew it to be of Miocene age throughout. The coal from it is of a very uniform character, burning freely, but leaving behind much slag and ash, and in many cases, though giving out a strong heat, unsuitable for domestic purposes, on account of its sulphurous character. It has, however, been wrought at various places throughout its extent, and is at present being mined for commercial purposes at several localities. These are as follows:—

1. *Monte Diablo, California*.—This coal is extensively mined, for use in San Francisco. The stratum of coal is about from 3 to 4 feet in thickness, and is overlaid by a sandstone containing marine shells. This shell is chiefly a gasteropod—the *Schizopya Californica* of Conrad.* The whole coal-field is much broken up by faults. I have not visited this locality myself, but I have seen many cargoes of the coal in San Francisco. A railroad is now in completion in connection with the mines; and from its nearness to San Francisco, the mine has proved profitable, the coal bringing \$8 per ton in that market. An analysis of the best specimens of this coal gave the following results:—

Carbon,	50.00
Volatile bituminous matter,	46.00
Ash,	4.00
	<hr/>
	100.00

* Pacific Railroad Reports, vi. Geology 68, pl. ii. fig. 1.

2. *Coose Bay, Oregon*.—This coal is interstratified with sandstones and shales, to a thickness of several hundred feet, but the bedding is everywhere much disturbed from intrusive traps. The greatest thickness the coal-seam has yet obtained is 9 feet, but this though considerable is not uniform throughout. The coal-field extends over a considerable space, and has been traced inland. The coal is bright black, and with an appearance resembling the best bituminous coal; but its appearance belies it, for it has been found to be a very inferior quality of lignite, the structure of the wood being perfectly apparent. Like most of the western lignites, when exposed to the air it cracks in numerous cubical fragments. It burns freely, with considerable heating power. The following is an approximate analysis:—

Fixed Carbon,	.	.	.	46.54
Volatile matter,	.	.	.	50.27
Ashes,	.	.	.	3.19
				100.00

The percentage of coke is 49.73, but it is dark, friable, and of little value. The amount of gas is large, but of low illuminating power. The coal apparently contains a little bisulphate of iron. It is used to some extent in San Francisco, 7759 tons having been imported into that town from January to August of last year. The fossils hitherto discovered connected with this coal have been fossil plants, dicotyledonous leaves, with various species of *Nautilus*, *Arca*, *Cardium*, *Tellina*, *Nucula Natica*, *Fusus*, *Cerithium*, &c.*

3. *Clallam Bay*.—This locality is situated about twenty miles inside Cape Flattery, in De Fucas Straits, opposite Vancouver Island. The coal is associated with similar shales and sandstones to that of Coose Bay. In the sandstones are found numerous fossil shells and crustacea, a number of which are recent species, though, as far as have yet been examined, the preponderance of them are extinct species, so that I see no reason for classing this coal as being of a newer date than Coose Bay or Monte Diabalo. Though the bay is only an open roadstead, yet from its proximity to Victoria, and being situated in American territory, and the coal therefore not liable to import duties if carried into San Francisco or other American ports, this locality has been frequently attempted to be wrought as a coal-producing station, but hitherto with but poor success. In 1863 and 1864 a Victoria company spent considerable labour and money on this project, and employed a most competent Scottish mining engineer, Mr John J. Landale, to report upon it. From his information I am enabled to furnish some further data regard-

* Newberry Pacific Railroad Reports, vi. Geol. p. 64.

ing the locality. At this locality there has been found cropping out in the face of a cliff of sandstone two seams of coal, respectively two and eight inches thick. The hill or cliff in which this coal is found extends from Clallam Bay to Pillar Point (eight or nine miles), and is several hundred feet in thickness. It rises abruptly, and nearly perpendicularly, from a bold shore, and, with scarcely any breadth of summit, descends as suddenly on the landward side, so that it is actually nothing more than a ledge of rock, thrown up by the faults which permeate the whole district. Behind this hill, however, stretching for several miles eastward and southward from Clallam Bay, the surface of the country is almost level. The company I have spoken of have driven a mine into coal cropping out about four miles west of Pillar Point, and after crossing two faults, got into clean coal 21½ inches thick, that had been thrown up by a great penine fault, traceable for at least nine miles from Pillar Point westward. On the other side of this range or bluff, on the west end, the land is nearly vertical, gradually flattening out as you proceed eastward, presenting a fine, gentle, undulating face. On the side of several small ridges in different parts of the valley, a soft yellow sandstone is exposed, but it is difficult to obtain any indication of the inclination or thickness of the strata, though this sandstone gives one some idea of continuity, and the probability is that a series of small detached coal-basins extend south, one after another, for a great distance inland. The beds appear to thicken and thin off at intervals. On sinking a shaft on the other side of the cliff, about a mile from Clallam Bay, the 22-inch seam was again reached at a depth of twenty-eight fathoms, and it is expected that, on boring still deeper, thicker seams will be found alternating with shales and sandstones. It has been estimated that the 22-inch seam will yield about 2250 tons per acre, and that about 15,000 acres in the immediate vicinity of this locality will be coal-bearing.

Regarding the quality of the coal, it is difficult to form an estimate from the often very partial reports of interested parties. It is, however, said that the clean picked coal gives very little ash, burns with a clear bright flame, and gives out considerable heat. Some of the large lumps which I have seen contained veins of sandstone varying from half-an-inch to one and a half inch, and to this possibly may be attributed the great amount of "clinker" which it forms on the furnace bars. It is only just to say, that all hitherto tried for steaming purposes has been merely surface coal, and therefore of inferior quality. The coal itself is hard, giving a brown lignite-like appearance on being scratched, shining equal to the appearance of anthracite, and breaking in small cubical fragments. Already a wharf has been built, and considerable works commenced, but I fear, whatever be the

quality of the coal, that it can never become of any importance on account of the want of a harbour. Almost every piece of shale is full of carbonaceous vegetable matter, but it is in the sandstone that the great amount of the fossils are found. These are chiefly marine shells with some fucoid remains. All of the shells which I obtained (now in the British Museum) were from these sandstones, and mostly collected from the nodules which had fallen from the cliffs on to the beach. They will be described at a future period, when the necessary examinations shall have been completed. The casual examination which they have already received is, however, quite sufficient to establish the age of the coal which is associated with them.

An analysis of some average specimens of the coal gives:—

Fixed carbon,	46.40
Volatile matter,	50.97
Ashes,	2.63
	<hr/>
	100.00

4. *Bellingham Bay*.—At intervals along the whole coast of Puget Sound, these carboniferous sandstones appear. It is also evident that they are continued through to the Columbia River, and in all likelihood crop out on the sides of the wild unexplored Olympian range. The valley between Olympia and the Columbia River, generally known as the Cowlitz Portage, appears to be a coal basin to some extent. Coal has been found not far from the celebrated Mound Prairie, about half-way over, and on the Monticello and Columbia rivers, but in such small quantities as hitherto to have rendered it unworthy of being wrought. If coal could be found in proximity to the splendid but undeveloped iron mines of the Columbia, the result would be of great commercial importance. Near the Squak Prairie, twenty-five miles from the village of Seattle, coal is seen to crop out on the side of the mountain in seams of two or three feet in thickness, but as its position would render its transportation expensive, it creates but little interest. On the Stoluchwanish River, north-east of Seattle, a thin seam of coal has been found, but is not wrought. It is only when we arrive at Bellingham Bay, situated a few miles south of the British boundary line (lat. 49° N.) that we find the coal of sufficient thickness and proximity to the sea to render it of sufficient importance to be mined. Here a company have been at work for a number of years, and export a considerable amount of coal to the San Francisco market. It is of the same quality as the other tertiary coals of the coast, and is generally mixed with a better class of coals before being used. The mines are very full of fire-damp, while the various mines of cretaceous age are entirely free from this. From January to August 1868, 5680 tons of this coal were imported into San Francisco. The strata

consist of the usual alternations of sandstone, shale, and coal, and are of immense thickness. The chief fossils found are species of *Platanus*, *Alnus*, *Acer*, *Taxus*, *Taxodium*, and *Juniperus*. The coal is better and harder than that of either Coose Bay, or, I think, De Fucas Strait (Clallam Bay); and owing to the action of eruptive traps and metamorphic rocks, approaches nearer to true coal than any other tertiary lignite on the coast. The following is the analysis as given by Professor W. P. Blake, one of our Foreign Corresponding Fellows:—*

Fixed carbon,	47·63
Bitumen,	50·22
Ash,	2·15
	<hr/>
	100·00

5. *Other localities for Tertiary Coal.*—Northward of Bellingham Bay the same coal crops out. On Fraser River, opposite Fort Langely; at Burrard Inlet; on various of the more southerly islands in the Haro Archipelago (Oreas, &c.); on Saanich Peninsula, Vancouver Island; and on the Vancouver shore of De Fucas Strait, near Sherringham Point, some few miles to the east of the Jordan River, it is seen in the cliffs in seams of some two feet to a few inches. In none of these localities has it, however, been wrought, either on account of the want of capital, ignorance of its value, or the inferior character of the out-crop. At Burrard Inlet, however, the Hudson Bay Company did many years ago intend opening mines, but the project was abandoned, on the better coal-seams of Nanaimo being discovered. Since then, the not overthiving town of New Westminster having been founded as the capital of the colony of British Columbia, in proximity to the Inlet, a new company attempted to open out the mines, but I cannot learn that they succeeded. At Saanich, the discovery of coal is of importance on account of its proximity to the town of Victoria, and various attempts have been made to render it available. The last account I had from that quarter informs me that a seam four feet in thickness has been found, and that the proprietors are sanguine as to their ultimate prospects of success. The general ignorance, not only among the colonists, but also among mining engineers on the coast, of the different qualities of the coal-fields, even of the existence of more than one on the island, renders it difficult to arrive at a true estimate of the value of any particular discovery. I believe, however, that the coals here enumerated, and all found south of the Chemainos River, are of tertiary age—the cretaceous series commencing north of that locality. In 1864, we found coal cropping out in a stream, falling into the Sooke River, not far from where we subsequently discovered the gold mines of Leech River, on the

* Pac. Railroad, Rep. v.; and Newberry, Id. lib. iv. 64.

Kokeseilah River, where gold in small quantities has also been discovered,* as well as on a stream falling into the Cowichan River. All of these coals, however, I believe to belong to the tertiary epoch, and almost, without doubt, to the same period as those already described, namely, the Miocene period.

6. *Newer Tertiary Lignites*.—Though the only lignites on the North Pacific coast, capable of being utilised as fuel, are of Miocene age, yet there are other lignites of a much more recent date, probably Pleistocene. The cliff at Useless Bay, Whidby's Island, shows the following section:—

- | | |
|---|-------------|
| 1. Alluvial Soil. | 5. Lignite. |
| 2. Boulder Clay. | 6. Sand. |
| 3. Lignite in thin horizontal stratum of the same thickness (3 or 4 inches) throughout. | 7. Lignite. |
| | 8. Sand. |
| 4. Sand. | 9. Lignite. |

This lignite is scarcely yet much changed from its former woody structure, and is quite useless for fuel. In this and other neighbouring localities, in the clays, are found abundant remains of the mastodon, and traditions of the existence of that animal still exist among the Indian tribes of the vicinity.†

IV. SECONDARY COALS.—The whole coast of Vancouver Island, on the east coast, north of Chemainos, and round to Koskeemo Sound, on the westward, and for some distance into the interior, is bounded by a belt of carboniferous strata—composed of sandstones, shales, and coarse gravel-stone conglomerates, interstratified with which are beds of coal of much superior character to any hitherto described. These beds, from the fossils they contain, appear to be cretaceous. Everywhere the strata named form a characteristic accompaniment of the coal, especially this coarse conglomerate just named; and nearly everywhere it is underlaid by one or more seams of coal. Hitherto we have only found it cropping out at some points of the circuit named, though it may reasonably be supposed yet to be found on the opposite shores of British Columbia. The wall of the deep fjords indenting this part of the coast everywhere are, however, in most cases composed of trap and other igneous rocks, and whatever sedimentary rocks may at one time have reposed on their flanks, have now been washed off by the action of denudation.

These localities are in order going north.

1. *In Chemainos district, near the river of the same name*.—Here the characteristic conglomerates prevail, and the Indians told me a very circumstantial story of an out-crop of coal in the mountain. I was however unable to find it, but have, neverthe-

* See my official "Explorations in Vancouver Island" (Victoria, 1864), and "Das Innere der Vancouver Insel," *Petermann's Geographische Mittheilungen*, 1869.

† See a letter by the writer of this paper to Professor Rupert Jones in *Reliquie Aquitanica* (Lartet and Christy), part vi.

less, no doubt but that such exists. North of this point the sandstones associated with the coal strata show along the coast, and in some places are fretted and worn into grottoes and caverns. Coal has been bored for here; but I am not aware that, so far as the sinkings have progressed, that the seams have been passed through.

2. *De Courcy Islands*.—On one of these islands we discovered coal, two feet in thickness, in the cliffs, almost concealed by the foliage, and accompanied, as elsewhere, by shales, sandstone, and conglomerates.

3. *Nanaimo*.—It is, however, at Nanaimo that these coals, of cretaceous age, have attained their greatest development. Some fifteen years ago this coal was discovered by the Indians, and by them communicated to the Hudson Bay Company, who commenced to work it, and continued to do so until 1861, when they sold out to an English Company, who have ever since continued to prosecute their works with considerable vigour. This year they have declared a dividend of fifteen per cent. They are the only coal-producing company in the island, and have now a town of some 500 inhabitants around the mines, with a railway and locomotive conveying the coal to the "shoots," under which the ships load. At present they only work one pit on the mainland, though on the off-lying islands (such as Newcastle Island) the same coal-measures prevail. On this island the Hudson Bay Company wrought coal for some years. The dip of the strata is acute, and the strike seaward, so that in any borings a considerable depth must be sought before the upper seams can be found. A section of the pit at present wrought will give a key to the whole subject of the nature of the lithology of the coal-seams. It will be noticed that in it the conglomerate does not appear; but again on the island, and nearer the shore, it shows itself. Dr Hector has furnished a problematical section of this coal,* and though some of its details are erroneous, it may be received as a fair diagrammatic view of the strata here. The strata in the pit in descending order are—

- | | |
|--|--------------------------------------|
| 1. Alluvial soil, gravels, sand. | 5. Eighteen feet blue shales. |
| 2. Five feet hard sandstone. | 6. Twenty inches sandstone (gritty). |
| 3. Nine feet shale. | 7. Six feet coal. |
| 4. Two feet four inches finesandstone. | 8. Finer gritty sandstone. |

This forms the floor of the pit, which is 121 feet in depth, but it is expected that under this will be found other seams of coal. There are eight inclines in the dip of the length of 400 yards. The bearing of the level is 24° E. of S., and the dip from 1 to 3½°. At present there are forty-seven men employed on the works, and some eighteen supernumeraries. About 120 tons of coal were raised per diem at the time of my last visit. This

* Quart. Journ. Geol. Soc. 1861, vol. xvii. pl. xiii. p. 388.

coal is sold at \$7 per ton to vessels calling, and to those loading for San Francisco, when import duties are chargeable on it, at \$6 per ton. In San Francisco it brings \$13 per ton; and at Victoria, only ninety miles south, where it is chiefly used, being brought down by small schooners, it is sold retail at \$11 per ton.* The following tables show the particulars of the export for last year:—

Table showing the Coal Exported from Nanaimo, for the year ending 31st December 1868.

	Tons.	Cwt.
January,	3,815	05
February,	4,536	05
March,	5,453	15
April,	4,876	15
May,	4,169	10
June,	3,355	05
July,	4,615	15
August,	4,141	15
September,	1,206	00
October,	2,630	10
November,	2,621	15
December,	2,355	10
Total shipments in 1868,	43,778	00
Total shipments in 1867,	31,239	05
Increase in favour of 1868,	12,538	15

Of the above shipments in 1868 there were shipped to

	Tons.	Cwt.
San Francisco,	23,799	00
Victoria, V.I.,	7,967	00
Portland, Oregon,	3,124	00
Sitka, Alaska,	2,295	00
Acapulco, Mexico,	1,305	00
Use of Her Majesty's ships, and other steamers calling,	5,288	00
	43,778	00

3a. Character of the Nanaimo Coal.—The coal itself is bright, tolerably hard, and not unlike some of the best qualities of English or Welsh coal in appearance. It burns freely with a good heat, but produces a great amount of ash. It is universally used by all Her Majesty's ships on the coast, and by all of the Colonial and other steamers plying on the coast. It is highly valued as fuel for domestic purposes, both in Victoria, San Francisco, and other towns. Gas is manufactured from it at Victoria of good illuminating quality. No fire-damp has hitherto been found in the mine. The coal is easily wrought; a miner being able, under

* The following note with which I am favoured by Mr S. M. Robins, the Secy. of the "Vancouver Coal Company," shows the export for the last six years:—1863, 21,394 tons; 1864, 28,632 tons; 1865, 32,819 tons; 1866, 25,115 tons; 1867, 31,239 tons; 1868, 43,778.

favourable circumstances, to take out about $2\frac{1}{2}$ tons in his working time, which at the rate of 5s. per ton for his clear dressed coal, will net him about 11s. per diem. Most of the miners are from Scotland or Lancashire, and generally employ an Indian to clean their coal for them. They rarely work a full day, preferring to earn a constant moderate wage, rather than run the chance of getting the price lowered, by their producing the coal in greater quantities. An analysis of the coal by Dr Newberry gives:—

Fixed Carbon,	.	.	.	51·81
Volatile Matter,	.	.	.	44·30
Ash,	.	.	.	3·89
				<hr/>
				100·00

A second (which I have adopted) made from better specimens gives:—

Carbon,	.	.	.	66·93
Hydrogen,	.	.	.	5·32
Nitrogen,	.	.	.	1·02
Sulphur,	.	.	.	2·20
Oxygen,	.	.	.	8·70
Ashes,	.	.	.	15·83
				<hr/>
				100·00

The specific gravity was 1·24.

3b. *Fossil Remains*.—In the sandstones are found various species of *Inoceramus*, *Baculites*, *Ammonites* (commonly), *Pecten*, *Natica*, *Mactra*, *Tellina*, *Trigonia*, *Emori*, *Cythera leonensis* (very common), *Arca*, *Exogyra*, *Ostrea*, *Rostellaria*, *Psammobia*, &c.; and in the shales various specimens of dicotylodonous and monocotylodonous plants, the leaves of which are perfectly preserved. The plant remains are wholly confined to the shales, and the animal almost entirely to the sandstones. Further north, fossils are found in nodules of sandstone which have fallen from the cliff, and got worn round by the action of the waves. Out of the shales here flows a salt spring, which produces salt of good quality.*

Behind, and out of the limits of the present Coal Company's grant, the beds of coal crop out again, showing in one place a clear face of 11 feet of pure coal. This has been taken up by the "Harewood Company"—an English concern, but as yet nothing has been done to develop the mines. The whole of this coal-field is, however, much broken up by faults and other disturbing influences.

4. *Bayne's Sound, Brown's River, &c.*—North of Nanaino the coal strata disappear for some distance, but on the shores of Bayne's Sound coal has been found in considerable quantity, and

* The spring is capable of supplying about a gallon a minute. The brine has a specific gravity of 10·60, and yields, on analysis, 3·446 grains of salt to the imperial gallon. Another spring on Salt Spring Island yields 4·994 grains per imperial gallon.

it is only the want of a suitable harbour which prevents this being an excellent place for mining. Already a coal company is in course of "prospecting it." In Valdez Inlet coal has been found, and some nine miles into the interior, on the banks of a river which bears my name, immense beds of coal were discovered by the expedition under my command. Again, on the shores on the lake whence the Puntledge (of which Brown's River is a tributary) rises, I saw pieces of coal, and though unable to find the seam where they had fallen out of, yet I observed the same sandstone strata associated with the coal on the river there. There are two seams on Brown's River—a thinner, and a thicker one of eight feet—and from the dip and general inclination, I believe that the coal which crops out in Valdez Inlet is the continuation of the upper seam at Brown's River. The coal here is of a better quality than that of Nanaimo, and produces excellent coke. We mined out huge blocks of it for our camp fire, alarming all the bears and other wild animals in the neighbourhood by the unwonted brilliancy with which we lit up the gloomy pine forest. On Salmon River, according to Indian report, coal crops out.

5. *Sukwash*.—North of this locality the trap rocks only appear until we come to a stream called Sukwash by the Indians, two miles south of Fort Rupert, when it again makes its appearance under the same conditions as before. Here the Hudson Bay Company mined it for some time, but have long ago discontinued the works, which have again begun to be tried by another company, who propose to carry it to Fort Rupert Harbour as their port of shipment; but independently of other considerations, the usual financial troubles inherent in colonial companies will prevent this scheme being realised for some time at least. From Sukwash is a valley which goes right through to Koskeemo Sound on the other side of the island. This basin is, I believe, one of coal deposit, and the coal at Sukwash is of the same nature, and continuous with the extensive coal seams of Koskeemo Sound on the other side.

6. *Koskeemo Coal Seams*.—The sounds of Quatseeno and Koskeemo are situated on the north-west coast of Vancouver Island,* about 240 miles seaward from Victoria. The sound is one vast harbour, entered from the Pacific, and ramifying into a south-east arm, an east arm, and a west arm. The land in the vicinity of this inlet was acquired by an English company some years ago, who expended a considerable amount of money in causing a proper survey to be made of their mineral riches. These surveys were chiefly confided to Mr J. J. Landale, who has been already mentioned as an able mining engineer. In 1866, just before my return to Europe, I had the good fortune also to visit these

* See the Admiralty Chart, No. 1719, in 9 sheets, and a map by the Author in Petermann's Geog., Mittheilungen, Tafel, i. 1869.

sounds, travelling over the island with some Indians who had visited Fort Rupert of the Hudson Bay Company, where I was then staying. The Indians I found to be the mildest and most amiable of the class I have yet encountered, and during my examination of the shores (chiefly for botanical purposes), they showed me every attention and kindness. At the period of my visit there were no whites then living there, and accordingly my sole companions were the Indians, in whose company I remained for upwards of a week, travelling from the head of the East or Rupert Arm to the Pacific in their canoes, subsisting almost entirely by my rifle, having taken very little provision from the fort. Previous to my visit, Mr Landale was good enough to favour me with a perusal of his MS. notes, which formed a useful guide to my geological examination of the coal seams. I found them exceedingly accurate, his examination having, from the length of time he resided in the locality, been much more minute than mine. What follows is derived almost entirely from his memoranda. However, without the use of sections and coloured geological maps, some portion will not be so intelligible as I should have desired.*

The coal-fields are situated on the north-western side of Rupert Arm, and are contained within an area of 5000 acres. The coal strata lie on a bed of calciferous sandstone many hundreds of feet in thickness—the last deposit being probably equivalent to the mountain limestone of older series. This coal-field has several peculiar stratigraphical features. While there are several beds of conglomerate through it, still two of them require particular attention, and form distinctive features in the basin. The one is of an aggregate thickness of 70 feet, overlying and in contact with the calciferous sandstone, and the other entirely above the coal; the former containing finer stones and pebbles, and having a dull reddish colour, owing to the presence of peroxide of iron; while the latter is coarser in its material, and not so firmly cohesive, and is, according to Mr Landale, at least 100 feet in thickness. These two deposits may be classed as the (α) upper, and (β) lower conglomerate of the series. By attending to the peculiarities described, it is easy to see what you are above or below the coal strata. Through the whole formation, consisting of coarse and fine conglomerates, sandstones, shales, fire-clays, and coal, are found fossiliferous beds. The contained fossils leave no doubt that the age of the beds are cretaceous, probably belonging to the same horizon as the Nanaimo strata. Dicotylodonus plants form the principal vegetable impressions, and calamite-like stems are common. Among other animal remains are *Be-*

* I have to thank my friends Mr J. Robertson Stewart of Victoria (Foreign Corresp. Fellow, Edin. Geol. Soc.), and Mr T. W. Lockwood Mackean, Chairman of the Bank of British Columbia, for much assistance in obtaining the material for these notes.

lemnites, Ammonites, Plagiostoma, Inocerami, Hippurites, various *Chama*-like shells, *Trigonia*, and some still more recent types as *Pectunculus sublevis, Astarte, Natica*, and *Paludina* (several species), all these overlying the coal-beds. Most of the shales are more or less bituminous, and the different seams of coal are characterised by a shining cubical fracture, by a regular lamination, and an almost complete exemption from sulphur in the "cutters" or vertical divisions. A large penine fault cuts off the whole basin by throwing it southwards, on which side of it are to be seen, at the surface, the calciferous sandstone whereon the basin lies, and also the underlying metamorphic rocks. The trap does not cross the great fault.

The seams of this basin are five in number, and have been found in outcroppings on various parts of the field, and in sundry small shafts sunk by Mr Landale. The dip is southwards, with an average indentation of 1°, 3½°, or 4°. The first seam is seen cropping out about two miles up the stream, called by the Indians *Natsenuchtum*. It varies in thickness from 2 feet 8 inches to 2 feet 11 inches, and consists of different varieties of coal. It is an excellent household coal; Mr Landale informs me, in his opinion—the best on the coast. It contains an unusually high percentage of carbon—fully as high as the Queen Charlotte Island anthracite, to be hereafter described—so that it seems scarcely a secondary lignite. I presume the analyses to be correct. It is as follows:—

	1st Analysis.	2d Analysis.
	In 100 parts not dried.	
Carbon,	70·00	71·00
Hydrogen,	5·30	5·35
Nitrogen,	1·28	1·10
Oxygen,	10·01	11·55
Sulphur,	0·41	0·60
Ash,	13·00	10·40
	<hr/>	<hr/>
	100·00	100·00
Specific gravity,	. 1·360	1·320

It evolves a strong, continuous heat, leaving a small bulk of pure white ash, easily fusible. The coke from it does not swell much. Mineralogically it has a cubical fracture, horizontal laminæ, and vertical cleavage planes, with thin films of carbonate of lime. The basin is calculated to contain about 4000 acres of this coal, and to be capable of yielding 2100 tons per acre. Immediately above the next seam lies a fine building stone. The thickness of this coal seam is from 1 foot 10 inches to 2 feet thick. The coal is of a denser quality than the former, is well fitted for coke making, swells considerably while burning in an open fire, and leaves a good deal of cinder. It is well adapted for smelting and smiths' purposes. There are about 3500 acres

of this coal, computed by Mr Landale to yield 2500 tons to the acre. Its mineralogical characteristics are cubical fracture, laminae filled with lignitic matter, lustre small. On analysis, it gives in 100 parts—

	1st Analysis.	2d Analysis. Not dried.
Carbon,	67.50	67.00
Hydrogen,	5.15	5.10
Nitrogen,	1.75	1.50
Oxygen,	12.00	13.17
Sulphur,	0.90	0.84
Ash,	12.70	12.39
	<hr/>	<hr/>
	100.00	100.00

Of the next seam it is difficult to speak, as it is only seen in a vitrified condition, at one point, lying close on the fault to the west of a point known as "Adamson's Hut." It appears to be a hard coal, and, in its natural condition, probably of the cannel kind. The next seam is 2 feet 6 inches in thickness, highly impregnated with gas, and closely resembling the Torbanehill or Boghead Gas Coal. It would probably yield paraffin by distillation. The bowl of a common tobacco-pipe filled with this shale, powdered, gave a jet of gas for two minutes and a half, though the luting round the bowl was very imperfect. This seam resembles the Torbanehill in another particular, viz., in burning it looses immensely in weight, though but little in bulk. Mr Landale computes that there are at least 4000 acres of this coal, capable of yielding 2250 tons to the acre. On analysis, it gave in 100 parts—

Carbon,	60.436
Hydrogen,	8.820
Nitrogen,	1.235
Sulphur,	0.300
Oxygen,	4.551
Ash,	25.168
	<hr/>
	100.510

In appearance it is dullish black, with very little lustre.

The fifth, or main seam was found in a shaft close to Adamson's Hut, in the West Arm. It is 4 feet 6 inches in thickness. There is some resemblance between this coal and that mined at Nanaimo. There is, however, this important difference, that the Nanaimo coal has its laminae and cleavage joints filled with a crust of earthy matter, consisting of carbonate of lime and iron, and often iron pyrites, to an extent which frequently renders the coal useless, while the only impurities in this seam are little laminae of shale of a dark colour, which burns nearly as well as the coal itself, the cleavage joints showing scarcely any sulphur, being very thin, and containing only a little lime. For steaming purposes an analysis of this seam shows it to be excellently adapted—

	1st Analysis.	2d Analysis.
Carbon,	66·15	68·15
Hydrogen,	4·70	4·50
Nitrogen,	1·25	1·10
Sulphur,	0·80	0·70
Oxygen,	13·50	11·50
Ash,	13·60	14·05
	100·00	100·00
Specific gravity,	100·00	1·320.

The whole of the Koskeemo coal-basin is broken up by four faults into three great divisions. The quantity of coal contained in the basin (of nearly 8 square miles) would, according to the calculations already given, be about 41,350,000 tons; deducting, however, one-fifth for the action of the faults—a large estimate—there yet remains 3,360,000 tons, or 600,000 tons for a period of fifty-five years! Even this calculation does not embrace all, for the study of the Vancouver coal-fields shows that the lower conglomerate is rarely found nearer than 120 feet to the top of the series, and is generally much further off; so that, in going down beyond 120 feet, other seams of coal may be discovered of great extent and excellence. Many copper seams being found in this vicinity, as well as in many other parts of Vancouver and Queen Charlotte Islands, smelting works might be conveniently established here. An exuberant supply of the finest timber is everywhere found over the North Pacific coast. My opinion is decided that the Koskeemo coal-field is the best yet discovered in Vancouver Island, though unopened out, not only on account of the superior quality of the coal, but the ready accessibility of the miners from the Pacific, without the tedious inland navigation requisite for reaching the mines on the eastern seaboard of the island.

7. *Other localities.*—The accompanying lithological characteristics of the coal strata do not disappear, except at intervals, down the whole west coast of Vancouver Island, until the cretaceous beds are again overlapped by the tertiary on the north shore of the De Fucas Straits. However, no coal has been found there; and in some places the rocks are highly metamorphosed, and for long tracts nothing but gneissose rocks, crystalline limestones, or traps are seen. The Indians told me of coal in Ouckucklesit Harbour, off the Alberni coast; but I could never get any specimens of it. At Alberni the coal shales appear, but no boring has been made for coal, so that whether coal underlies them or not is difficult to say. The little layers of coal which crop out here and there on the northern (Vancouver) shores of De Fucas Straits are, I am convinced, in every case of tertiary age, and continuous with the seams on the opposite shore at Clallam Bay.

V. GEOLOGY OF VANCOUVER ISLAND.—The dense forest which

almost everywhere covers Vancouver Island has prevented the island being so well explored as it ought to be; and the great mass of undergrowth and spongy decayed vegetation which overlies the whole surface, concealing any sections, except in rare cases, prevents the geologist from arriving at any extended deductions. The woods even come down in many places so close to the shore as to be laved by the tide; and the river banks are equally clothed with a mantle of the most luxuriant growth of timber and shrubbery. We have seen enough of the country, however, to allow us to express in a few sentences our ideas of the general structure of the island.

Gold in Connection with Coal Deposits.—A great portion of the island is occupied by igneous rocks—chiefly traps—and metamorphic sandstones—seen in the southern and south-eastern sections, as well described in Mr Bauerman's paper, already mentioned. About twenty-five miles from Victoria the expedition under my command discovered considerable deposits of gold on a tributary of the Sooke River, which I named "The Leech," in honour of my lieutenant. Within three months it was calculated that more than \$100,000 worth of gold was extracted from the stream. Nuggets of forty, fifty, sixty, and even seventy and eighty dollars were not uncommonly found; and though the great portion of the gold is now washed out of the bed of the stream, still, I read in the colonial newspapers, men occasionally arrive in the town of Victoria with a few hundreds of dollars worth of nuggetty dust. "Drifting" in the banks has yielded fair prospects; but the gold is what the miners call, "spotted," *i.e.*, unequally distributed, so that while one pan of gravel will yield \$2½, another will not wash out two cents. Leech River seems to take its course along the valley formed by the junction of two distinct classes of rocks. On the right bank of the river is seen the bold and abrupt bluffs of trap, and on the left the sharper outline of the metamorphic slates. This slate, in conjunction with quartz, is essentially a gold-bearing rock. The slate forms the bed of the river, though in many places it changes into micaceous sandstone or shale. There are also numerous veins of quartz running in the same direction as the cleavage of the slate, which, for the most part, runs with the river. The bed of the river is strewn with large boulders of trap and quartz, which have been polished smooth by the action of water and moving rocks and gravel. From the manner in which these boulders have been thrown about, and in which drift wood is piled up on the rocky banks, the force of water that comes down when the snow melts must be something fearful. The hard slate is in many places scooped out like waves; holes are cut or scoured out by whirlpools holding gravel and small boulders in suspension, and large trees are thrown up nearly 20

feet above the bed of the stream. That the gold of Leech River comes from the mountains of the left bank is certain, from the fact that no creek running down the right bank has been found to yield gold, whereas, on the left bank, heavy gold has been found in Wolf Creek, Martin Gulch, &c. Nearly all the gold in Sooke River (of which The Leech is a tributary), below the junction, comes, there is little doubt, from the Leech. Gold has since been found in small quantities all over the island, wherever similar formations prevail, but nowhere in paying quantity except in the first locality discovered. We must, however, guard against the idea that these slates must *necessarily* be Silurian or, at least, of Palæozoic age. In California there is no rock older than the Jurassic, as has been abundantly proved by Professor Blake, and Professor J. D. Whitney and his associates.* Mr Whitney is, however, in error when he states† that the boulder drift is not found in Vancouver Island. It prevails everywhere. Indeed, one of the banks in Victoria, and various stores, are built of syenitic blocks from the vicinity, which have been drifted hither by ice action. This was long ago demonstrated by Dr Forbes, R.N.,‡ and I have more fully described it elsewhere. The distribution of the tertiary and secondary strata has been already described.

VI. ANTHRACITE OF NORTH-WEST AMERICA—QUEEN CHARLOTTE ISLANDS.—North of Vancouver Island, at a distance of from twenty to forty miles from land, lie the Queen Charlotte Islands, consisting of a group of three main islands with a number of lesser islets lying off the shore. These islands are, in general, densely covered with forest, and permeated by inlets of the sea; but their interior is entirely unexplored. They are, however, rich in copper and other minerals; and gold quartz, of a surprisingly rich description, was discovered in one spot here about fifteen years ago. A hot spring is found at the southern end of the most southerly island; but there is no volcano here, as Mr Mallet erroneously places on his map of Earthquake Phenomena and Volcanoes.¶ The island, though so near the mainland, differs remarkably in having no deer, wolves, or racoons—animals extremely abundant on the opposite shores of British Columbia. The coasts are inhabited by several tribes of a very fine-looking, stalwart, and warlike race, generally known under the name of Hydahs. There are no white settlements on these islands, but they are occasionally visited by well-armed traders, for the natives bear the reputation of being anything but a remarkably docile

* "Geological Survey of California," 1866.

† "Proceedings of the California Academy of Sciences," vol. iii. (1866), p. 272.

‡ "Prize Essay on Vancouver Island (Victoria, 1862)."—*Petermann's Mittheilungen*, 1869, pp. 5 and 94.

¶ Reports Brit. Assoc. Adv. Sc. for 1850, 1851, 1854, 1855, and 1858.

race, a reputation earned by many lawless and cruel acts.* Of late years coal has been discovered on these islands of a very superior quality. Accordingly, in the spring of 1866 I took advantage of a party of miners going up to "prospect" this coal, to pay a visit to the islands. I saw no appearance of coal—or, indeed, of any sedimentary rock—along the whole coast of British Columbia until we arrived at these islands. Here the coal crops out in various places on the islands; but its chief development is at Skidegate Bay, where I passed some weeks. The whole of the beds seem to have been thrown out of position by erupted masses of felspathic trap, on the flanks of which the beds reposed, and by which the strata (sandstone, &c.), have been much metamorphosed and the coal altered. Two rival parties of miners were there prospecting, and one of them had driven an adit into the hillside some two or three hundred feet above the sea-level. Here they had gone through a great bed of coarse conglomerate—a fine hard slate when the coal was reached. This conglomerate was in every respect similar to that associated with the Nanaimo coal-fields; but the slate was peculiar. It is a close-grained, lustreless material, breaking in cuboidal fragments, and easily wrought. The Indians have long been in the habit of carving out of it pipes, models, &c., some of which are now in almost every European museum. Hitherto its geological position was unknown. Here there was no sandstone, but the section continued to the opposite shore showed sandstone immediately reposing on the igneous rock, and so highly metamorphosed as almost to have lost its original structure. The coal itself was apparently of the nature of a true anthracite, with a bright lustre, hard, and giving out an intense heat. When I visited the mine it was only commencing, and the results were far from satisfactory. At one minute a block of good anthracite would be mined, and the next minute the pick would drop into a material not unlike wet or dampgunpowder. However, I am informed that since I left the coast they have been more successful; but still the working of this coal will always be difficult, on account of numerous dykes, faults, and other disturbances. My impression at the time indicated that the company was working on a mere landslip, and not on the main seam. At that time there was no mining engineer on the spot; but since then this defect has been remedied, and we may hope for the success of an experiment which cannot fail but to be of the highest interest and importance, not only to the projectors, but to the whole country. An analysis, made by Mr Claudet, at the Government Assay Office, New Westminster, showed the following composition, which brings it up close to the Pennsylvania anthracite:—

* *Vide* the author's "Geography of Queen Charlotte Islands," in "Proceedings of Royal Geographical Society," vol. xvi. No. v.

Carbon,	71.20
Moisture,	5.10
Volatile combustible matter,	17.27
Ash,	6.43
	<hr/>
	100.00
Specific gravity,	1.46

At one time I was inclined to believe that this was only altered bituminous coal of cretaceous age, rendered anthracitic by the action of heat; but I am now in doubt as to the correctness of this opinion. I only found the cast of one shell in the metamorphosed slates; but since then other species have been found; and if they are correctly described to me (for the specimens have not yet reached this county), they would put this coal into some of the Palæozoic formations—perhaps Silurian.* This point, it is, however, impossible to settle without an appeal being made to the fossils themselves. The fossils lately found, have, I am informed, been discovered in the shale or slate wall, and were described to be *enerinites*, *orthoceras*, &c., though the alleged presence of dicotylodonus leaves allows of some hesitation regarding the correctness of the specific determination of those remains.

VII. THE COAL TRADE OF SAN FRANCISCO AND THE NORTH PACIFIC.—San Francisco is at present the chief market for the coal trade, and this trade must be immensely increased when the Pacific Railroad is completed, as well as increasing with the growth and prosperity of the coast, and other settlements.

The following tables show the coal imports for 1861 and a portion of 1868, and the sources whence this coal was derived:—

1. *Coal Imports of San Francisco, 1861.*

Jan. 1 to Dec. 16.		Jan. 1 to Dec. 16.	
English,	24,895 tons.	Japan,	25 tons.
Cumberland,	2,662 "	Coose and Bellingham Bay,	16,183 "
Chili,	12,254 "	Anthracite,	26,291 "
Sydney,	12,304 "	Nanaimo,	5,204 "

The great importation of the inferior tertiary coals of Coose and Bellingham Bay into San Francisco is evidently due to their being entered duty free, the high import duty on foreign coals rendering the use of the Vancouver coal limited, as no reciprocity treaty exists at present between the British and the American possessions on the Pacific.

2. *Coal Imports of San Francisco, from 1st Jan. to 16th Aug. 1868.*

Anthracite,	18,823 tons.	Coose Bay,	7,759 tons.
Australian,	13,348 "	English,	9,967 "
Bellingham Bay,	5,680 "	Lehig,	5,130 "
Cumberland,	2,597 casks.	Monte Diabalo,	59,524 "
Chili (Lota mine),	4,191 tons.	Nanaimo,	17,508 "

* A rich gold reef was found some years ago, penetrating metamorphic slates, in "Gold Harbour," on the western coasts of these islands (*vide* my Paper in "Proc. Roy. Geog. Soc." vol. xvi. No. v.)

3. Table of Analyses of Native and Imported Coals of the North Pacific (100 parts.)

Locality or name of Coal.	Specific Gravity.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Percentage of Coke.	Ash.	Remarks.
Welsh (Craigoey, Newcastle) (Cans Hartley),	1.25	84.87	3.84	0.41	0.45	7.19	85.5	3.24	S. and N. 2.45. Averages specimens. Bitumen, 50.22. Vol. matter, 50.97. Vol. matter, 50.27. Vol. bit. matter, 46. Moisture, 5.10. Vol. comb. matter, 7.27.
Scotch (Fordel Splint),	1.25	79.83	5.11	1.17	0.82	7.86	60.63	5.2	
Borneo (Labuan),	1.28	79.58	5.50	1.13	1.46	8.33	52.03	4.00	
Chili (Conception Bay),	1.29	64.52	5.74	0.80	1.45	20.75	...	7.74	
Sydney,	...	70.55	5.76	0.95	1.98	13.24	43.63	7.52	
Pennsylvania Anthracite,	...	82.39	5.32	1.23	0.70	8.32	...	2.04	
Nanaimo (V. I.),	1.24	90.45	2.43	...	...	...	...	4.67
Koskeemo (V. I.),	1.320	66.93	5.32	1.02	2.20	8.70	...	15.83	
Bellingham Bay (W.T.),	...	66.15	4.70	1.25	0.80	13.50	...	13.60	
Clallam Bay (W.T.),	...	47.63	...	...	...	...	...	2.15
Coose Bay (Ogn.),	...	46.40	...	...	...	...	...	2.63
Monte Diabalo Cal.	...	46.54	...	...	...	...	49.73	3.19
Queen Charlotte Islands,	1.46	50.00	...	...	...	...	...	4.00
		71.20	...	...	...	...	...	6.43

Imported Coals.

Native Coals
Tertiary.
Anthracite.

VIII. CONCLUSION.—It is apparent, from what I have said, that there are abundant supplies of coal on the North Pacific, sufficient, if properly developed, for the supply of the railroads and steamers, which are yearly on the increase; but that the only coal fitted for steaming purposes is found in the British possessions, all others being of tertiary age, and very inferior in quality. In these coal-fields British Columbia has within itself the elements of lasting prosperity, which, if properly managed, might be the means of raising the colony from its present state of commercial depression to a condition the reverse of this. The high rates of labour will, however, long act as a deterrent to the full development of the mineral riches of the coast, but this obstacle is gradually lessening in magnitude. It is not the province of this paper to enter upon the discussion of what expense would be incurred in opening up these mines,—even did its limits admit of such a dipression.

