1910.

NEW ZEALAND.

NEW ZEALAND GEOLOGICAL SURVEY

(FOURTH ANNUAL REPORT (NEW SERIES) OF THE).

Presented to both Houses of the General Assembly by Command of His Excellency.

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REPORT.

LETTER OF TRANSMITTAL.

SIR,— Geological Survey Office, Wellington, August, 1910.

I have the honour to forward you the fourth annual report (new series) of the New Zealand Geological Survey.

I have, &c.,
J. M. BELL,
Director Geological Survey.

Hon. R. McKenzie, Minister of Mines, Wellington.

INTRODUCTION.

The present report deals with the year commencing on the 1st June, 1908, and ending on the 31st May, 1910. During this period the work of the Geological Survey has been conducted on the same plan as in former years.

SUMMARY OF OPERATIONS.

During the past twelve months detailed geological surveys have been carried out in the Mount Radiant, Dun Mountain, Greymouth, New Plymouth, and Tairua-Waihi subdivisions. In addition to these investigations, visits of inspection were paid to Orepuki, Otaio, Annan, Waikakaho (Marlborough), New Plymouth, Mokau, and Retaruke.

The survey of the Mount Radiant Subdivision, commenced in the beginning of 1908 by Mr. E. J. H. Webb, was completed last June. Mr. Webb's detailed report, which will be ready for presentation to Parliament very shortly, contains a full and accurate account of the Mount Radiant copper prospects as at present developed.

The systematic investigation of the Dun Mountain Subdivision, which was begun in October, 1908, was completed in September, 1909. A full report upon the area, written by Dr. P. Marshall, Mr. E. de C. Clarke, and myself, is now being finally revised. Besides describing the copper and chrome deposits of Dun Mountain, this report gives attention to the Tertiary coal-measures of the Waimea Valley, where there is a likelihood of workable coal-seams occurring.

PUBLICATIONS.

During the past twelve months, besides the third annual report, containing an account of the operations of the survey during the season 1908–9, Bulletin No. 8 was issued. This bulletin, entitled "The Geology of the Whangaroa Subdivision, Hokianga Division," was written by Mr. E. de C. Clarke and myself. It describes the geology and mineral resources of an area of about four hundred square miles that contains several metalliferous deposits.

Geological surveys and scientific societies in many foreign countries continue to send us their publications. In this connection the reports of the United States Geological Survey may be mentioned as being especially valuable to students of economic geology.

FIELD AND OFFICE WORK OF THE DIRECTOR.

From the beginning of June, 1909, until the end of August I was engaged in office-work in Wellington. From the 1st to the 3rd September I was at Orepuki, Southland, examining the oil-shale deposits of that district. Some attention also was given to the ironsands. From the 7th to the 11th September coal-occurrences near the Otaio River, South Canterbury, and at Annan, North Canterbury, were investigated. On the 15th September a visit was paid to Waikakaho, Marlborough, in order to inspect Thomas's Quartz Reef, a new discovery which was stated to be of some potentiality, but proved to be of little value.* During the latter part of October I made an inspection of the New Plymouth oilfield. The results of this inspection have already been published.† From the 3rd to the 10th November a reconnaissance of the little-known Mokau Coalfield was made. After the Mokau inspection I proceeded to Tairua, on the east coast of the Hauraki Peninsula, in order to inaugurate a detailed geological survey of the Tairua-Waihi Subdivision. Early in December I made a hasty visit to the scene of the coal-discovery at Retaruke, near Waimarino. Again in February and March, 1910, somewhat more detailed examinations of the same locality were made.

Except during my visits to Retaruke and one or two minor inspections, I was continuously engaged in organizing and conducting field-work in the Tairua-Waihi Subdivision from November, 1909, as already mentioned, until the middle of May, 1910. In this work I was assisted throughout by Mr. Colin Fraser, who had joined me at the beginning of December, 1909. On the 17th May I returned to Wellington, where departmental business claimed attention for some days. I then left for Australia, where I attended the Mount Morgan meeting of the Australasian Institute of Mining Engineers.

WORK IN THE TAIRUA-WAIHI SUBDIVISION.

The Tairua-Waihi Subdivision comprises the survey districts of Whitianga, Tairua, Ohinemuri, and Waihi North. On account of the importance of the area as a mining-field it was necessary to add very considerably to the topographical information available, so that the geology could be mapped with sufficient accuracy and detail. As noted in last year's report, a topographical survey of the northern part of the area was begun by Mr. K. M. Graham in October, 1908. At the end of May, 1909,

* Assay: Gold, 3 dwt. 3 gr.; silver, 7 gr.; value, 12s. 6d., per ton.

† Parliamentary Paper C.–14, 1909.

Mr. Graham had almost finished the northern part of the area, and was preparing to enter upon work in the southern part, where are situated the principal mining districts. As a result of his labours, accurate topographical maps on which to base the geology are being prepared.

A small portion of the subdivision lying near the eastern boundary of the Thames Subdivision was surveyed in detail by Mr. Fraser during the season of 1908–9.

Accompanied by Mr. Fraser, I paid a visit to the Tairua district in May, 1907. The results of the reconnaissance then made were given in our second annual report (1908).

By the end of May, 1910, the whole of the Whitianga Survey District, the greater part of the Tairua Survey District, and a portion of the Ohinemuri Survey District had been geologically surveyed. It is intended to continue work in the area throughout the winter, and it is hoped that the survey will be completed by next February. Meantime a very brief *résumé* of the field-work will be presented. This may be considered purely preliminary in character, and, as a result of the laboratory work yet to be carried out, the final conclusions may, of necessity, be somewhat different from those tentatively stated here.

Physical Geography.—The Tairua-Waihi Subdivision is on the whole a hilly, almost mountainous country, the higher elevations being 2,500 ft. or more. Only in the lower portions of the stream-valleys and in the neighbourhood of Waihi are any notable areas of flat or gently undulating land to be found. The greater part of the subdivision lies to the eastward of the main divide of the Hauraki Peninsula, but in the Ohinemuri district the divide turns abruptly east, and almost reaches the coast, close to which it runs for a number of miles before again striking inland.

The coast-line of the Tairua and Whitianga survey districts has a number of inlets, the chief of which are Tairua and Whangamata harbours. Each of these is a typical sunken river-mouth. The same feature is seen farther north in Whitianga Estuary (which enters the north-western corner of the subdivision) and other inlets. To the south of the subdivision it is observable also in the numerous minor V-shaped bays of Tauranga Harbour.

Towards the coast-line, especially in the Whitianga Survey District, there are considerable areas of open fern-clad land. The so-called Waihi Plains are also open country, covered by a somewhat sparse growth of fern and stunted manuka. Elsewhere the area is in great part forested, and contains some valuable milling-timber. Chief among the forest-trees is the noble kauri, now unfortunately fast disappearing before the bushman's axe.

General Geology.—With the exception of the material forming the flood-plains of the larger streams, and the flats that in places border the various inlets, the visible rocks of the subdivision are wholly of igneous origin. The oldest of these rocks are andesites and dacites, with tuffs and agglomerates of similar petrological composition. These volcanics probably belong to at least two periods of eruptive activity. Following the andesitic and dacitic rocks comes a considerable development of acidic volcanics, consisting of rhyolitic lavas and tuffs. Finally, andesitic lavas of younger age than the rhyolites are in places developed to a small extent.

In many parts of the subdivision the volcanic rocks are highly altered both by meteoric and by hydrothermal agencies. More especially hydrothermal metamorphism is prominent in the vicinity of the auriferous veins of the various goldfields. In several places masses of siliceous sinter on the surface testify to the comparatively recent cessation of solfataric action.

Economic Geology.—During the past season detailed studies of the auriferous veins at Tairua and Whangamata have been made, whilst in other districts similar work is now being done. Only the briefest outline of the results obtained can here be given, as our maps are still uncompiled, and the laboratory work is yet to be done.

In the Tairua district several mines have reached the producing stage, whilst others are still being prospected. The principal concerns are the Tairua Broken Hills, Tairua Golden Hills, Tairua Monarch, Golden Belt, and Champion mines. It is important to note that several of the Tairua mines are in rhyolitic rocks, and not in altered andesites or dacites such as form the vein-bearing rocks in most parts of the Hauraki Goldfields.

The Ohui (Phœnix) Mine workings, south of Tairua, are not in an advanced state, but the prospects are considered promising.

At Wharekerauponga, in the inland Whangamata district, the workings of the now defunct Royal Standard Company are located on a series of parallel reefs, which, like many of the Tairua lodes, are in rhyolite. Apparently the development of the mine by the Royal Standard Company was not carried out satisfactorily, and it is thought that the mine is worthy of further prospecting, especially in depth.

In the well-known mining districts of Waihi, Waitekauri, and Karangahake the reefs traverse highly altered dacites and andesites. In these areas a detailed study of the veins and of the enclosing rocks, such as is now being made, may be expected to give results of considerable value to the mining community.

VISIT TO OREPUKI.

To those interested in New Zealand's mineral resources Orepuki has been known for some time as the site of a large plant erected to treat certain oil-shales existing in this locality for their hydrocarbon contents—paraffin, kerosene, &c. Recently much interest has been aroused at Orepuki by the supposed presence of native platinum in large quantities in the widespread black-sand-bearing alluvium of this neighbourhood. For many years this alluvium has been worked for its gold content, and precious metal to the value of £500,000 is said to have been derived from the locality.

The geology of the country around Orepuki is simple. Apparently the oldest rocks visible in the immediate neighbourhood are granites or allied plutonics, above which lie a series of sedimentary rocks —clays, sandstones, and conglomerates, with coaly and carbonaceous layers, the latter containing the oil-shales. The rocks of this series dip generally at gentle angles, and are followed by horizontally

disposed gravels, sands, and clays, with peaty lignite beds. The lowest beds of the horizontal series are formed by coarse conglomerates containing many norite and gabbro boulders. These conglomerates may be glacial in origin.

The oil-shales so far worked exist in a small basin surrounded by granite, which seemingly is a small embayment in the larger basin of coal-bearing rocks stretching inland from the bay on which Orepuki is situated. In this smaller basin there are now visible several outcrops of the oil-shales, which dip at gentle angles away from the surrounding granites, and another outcrop appears about three miles to the westward in the larger basin.

Boreholes have proved the continuity of the oil-shales within the smaller basin, and for a short distance from the entrance of that basin in the larger one; but it is not definitely known whether or not they exist beneath the widespread superincumbent later rocks of the larger basin, though this is thought to be the case.*

The oil-shale bed, which is generally about 4 ft. 6 in. in thickness, but is in places as much as 5 ft., occurs associated with beds of lignites, generally impure, which may overlie or underlie the shale.

The shale is high in paraffin, and contains a relatively low percentage of lubricating-oil, kerosene, and the more volatile oils. According to analyses made by Dr. J. G. Black, of Otago University, in 1873, Orepuki shale yielded 42 gallons of crude oil per ton, with a specific gravity of 0·897, equal to 16·8 per cent. of oil. An analysis made in the Colonial Laboratory in 1892 is as follows:—

Fixed carbon	13·82
Hydrocarbons	59·57
Water	6·20
Ash	20·41
	100·00

In 1906 extended tests of the shale were made at the Pumpherston Oil Company's works in Scotland.† Over 50 tons of material was treated, and the results show that the Orepuki shale yielded 38·41 gallons of crude oil per ton, whilst 19·12 lb. per ton of sulphate of ammonia was obtained. In addition, more than sufficient gas was produced for firing the retort. The crude oil, which had a specific gravity of 0·890, yielded 70·7 per cent. of finished commercial products, as follows:—

	Specific Gravity.	Yield per Cent. of Crude Oil.
Burning-oil	0·835	25·92
Gas-oil	0·849	3·07
Medium oil	0·868	4·05
Lubricating-oil	0·916	17·55
Hard paraffin, with melting-point of 119·5° Fahr., and containing 4 per cent. of oil		19·03
Soft paraffin, with melting-point of 86·5° Fahr.		1·08

About eight years ago a magnificent plant, costing £120,000, for the retorting and refining of the various hydrocarbon products of the oil-shales was completed. This, after about a year's operations, closed down, and has not since been reopened. Much of the plant is still in good repair, though in some parts crumbling brick walls, rusting ironwork, &c., testify to its decay. The plant is said to have been closed down for various reasons, the chief being,—

(1.) Because of the removal by the Government of the duty on kerosene, paraffin, &c.

(2.) Because of the expense of mining the shale. Before commencing the works it had been estimated that the shale would cost 3s. 6d. per ton to mine; but, instead, it is said to have cost no less than 18s. per ton. The very shattered nature of the shale and of the overlying rock rendered the drives, &c., difficult to keep open, and consequently greatly increased the cost of mining.

(3.) Because the supply of shale was found to be so small that it would have been soon exhausted had the works been kept open.

I think the difficulty in regard to mining might have been overcome had there been pursued a longwall method, starting at the boundary and working backwards towards the incline shaft, and abandoning the ground behind.

The supply of shale, as already mentioned, in the small basin is undoubtedly limited. However, it seems probable, since there is an outcrop three miles distant from the entrance of the small basin, that the shale-bed is continuous beneath the larger basin as well. If this is the case, there is a goodly supply available, though it is another question as to whether it could be profitably mined and treated in view of the economic conditions at present existing in the Dominion.

Within the horizontally lying beds that overlie the tilted strata enclosing the oil-shales are lenses or leads rich in black sand, and containing in places payable quantities of fine pure gold. On the sea-beach is a thick deposit of black sand, accumulated by wave concentration of the débris derived from the denudation of the horizontally bedded sands, gravels, &c., forming the cliffs bordering the sea. In the cliffs is exposed a bed of peaty lignite, varying in thickness from 2 ft. to 7 ft.

The black sands formerly contained a great deal of free gold, but are now mainly exhausted. Away from the sea-beach the richer leads have, apparently, for the most part been worked out, but a few small claims are still being profitably operated.

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* Recently, in a borehole put down by the Government drill 9 chains south-west of the shale-works, 4 ft. 9 in. of shale was located at a depth of 287 ft., underlying 3 ft. of coal (probably lignite). Some coal (thickness not stated) followed the shale.

† For some of the particulars see "New Zealand Mines Record," Vol. x, 1906–7, p. 268.

A small amount of platinum occurs in the black-sands leads. This is rarely of sufficient importance in itself to render the sands workable, but is in places a very valuable by-product with the gold.

Popular interest in the Orepuki black sands at the time of my visit centred around a heavy grey sand obtained in fairly large quantity in the concentrates. This was thought by many of the local miners to be platinum in a finely comminuted state; but it has been found on microscopic examination to consist in the main of rutile and ilmenite (titaniferous magnetite), with a minor amount of quartz, fragmentary garnets, and other rock-forming minerals. The disc-shaped grains of platinum which sometimes occur sparingly in such sands are easily recognizable under the microscope, but none was found in the sample of sand examined. It is possible that a grain or two of monazite may be present. In a similar sample of Orepuki sand analysed in the Dominion Laboratory, however, the total amount of rare earths (other than zirconia) was less than 0·02 per cent.

Rutile is a very hard mineral, and the crystals and grains in the sand are decidedly angular. If found in sufficient quantity, which in this case is rather unlikely, it would make a fairly good cutting and polishing material.

West of the Waiau River, which enters the sea about nine miles west of Orepuki, and northward to Lake Te Anau, lies an unknown wilderness which is thought by the Orepuki miners to contain much mineral wealth. Ores of tin, manganese, and copper, together with coal, asbestos, and garnets, have been reported from this mountainous area.

GEOLOGICAL RECONNAISSANCE OF THE MOKAU COUNTRY.

Introduction.

During the past few years much interest has been taken in the development of the petroleum industry throughout New Zealand. This has been chiefly due to the comparative success met with in the boreholes Nos. 1, 2, and 3 of the Taranaki Petroleum Company (Limited), operating at Moturoa, just out of New Plymouth. Among other parts of the country, men interested in the search for petroleum have turned their attention to the Mokau district. Here it was thought that, as suggested in former geological reports, the same strata as those carrying oil near Moturoa would lie much nearer the surface than in the neighbourhood of New Plymouth, and consequently drilling to pierce the supposed reservoirs of petroleum would not have to be carried to such great depths. It was with the intention of obtaining definite information as to the prospects of the Mokau country as a possible petroleum-field that a reconnaissance was made through this part of the Dominion by the writer. Owing to the very brief time available, the exploration was naturally a very hurried one, and was scarcely sufficient to settle the main question at stake. However, some interesting and valuable information on the locality was obtained.

The reconnaissance lasted from the 3rd November—the day on which Waitara was left—to the 10th November, when Te Kuiti was reached. During that period a rough examination was made of the shore-line between Ureti and Tongaporutu, in the vincinity of the White Cliffs; of the Mokau River to a point twenty-three miles, following the bends of the river, from the mouth; of the shore-line from Mokau to Petone Creek, two miles north of Awakino Heads; and of the main road between Awakino Heads and Te Kuiti, through Mahoenui, Paemako, and Piopio.

Situation and Topography.

The Mokau is a fine large stream which enters the sea about thirty-eight miles north-east of New Plymouth. It is navigable for small coastal steamers for twenty-two miles (by the river) from its mouth, and could, with some slight artificial excavation, be made available for boats still further up its course. The Awakino and Tongaporutu are smaller streams than the Mokau—the former entering the sea about three miles to the northward, and the latter about ten miles to the southward. Mahoenui, Paemako, and Piopio are unimportant post-offices in the heart of the King-country, and situated respectively twenty-three, fifteen, and twelve miles (air line) to the south-westward of Te Kuiti. The distance in a straight line from Te Kuiti to Awakino is about thirty-eight miles, but the route taken by the writer is much longer.

The whole country examined forms, physiographically considered, part of the Wanganui coastal plain—an area composed of marine strata but recently elevated (geologically speaking) above the sea. Thus the crests of the various ridges show, generally speaking, a gradually increasing elevation in going inland, and indicate the surface of the old plain. On the whole, the country—especially towards the coast or westward of the gorge of the Mangaotaki, a tributary of the Mokau—may be described as hilly, with narrow-crested ridges separating the numerous watercourses—the tributaries of the Awakino, Mokau, &c. Eastward of the Mangaotaki, particularly in the neighbourhood of Paemako and Piopio, the country is more rolling and undulating than hilly.

The principal streams, the Mokau, Awakino, and Tongaporutu, flow at gentle gradient, and, though inconsiderable rapids occur in their courses, waterfalls of magnitude exist only in their headwaters. The Wairere Falls, on the Mokau, are situated near Paemako, or about twenty-five miles in a direct line from the sea. Below these falls the Mokau flows in a narrow deep valley, with precipices in places coming to the water's edge. Above the falls its valley is more open for some miles, but in its headwaters its course is broken by gorges. The Awakino and Tongaporutu resemble the Mokau in general character.

The road from Awakino to Te Kuiti follows the low flood-plain of the Awakino for some three or four miles, and then rises and falls over hilly country as far as Mahoenui. Here it passes through a spacious flat carved by the Awakino and its tributary the Mangaorongo for about four or five miles; then follows hilly country as far as the railway, save in the vicinity of the rolling plains around Paemako and Piopio.

Terraces may be seen along the sea-shore in many places, marking old levels of the sea.

General Geology.

The geology of the portion of New Zealand between Waitara and Te Kuiti shows much variety. Briefly put, the geological column may be summarized as follows :—

Sedimentary	3. Argillites and grauwackes.
	2. Conglomerates, claystones, sandstones (with coal-seams), and limestones.
	1. Black-sand beds.
Igneous	3. Serpentines.
	2. Rhyolitic tufa and breccia.
	1. Andesitic tufa and breccia.

The oldest sedimentary rocks (No. 3 above) are seen on the Awakino – Te Kuiti Road a few miles east of Awakino, and again in many places underlying the later sedimentary rocks (No. 2 above) in the low rolling country around Paemako and Piopio. They are well exposed at the Wairere Falls, where they contain small stringers of quartz. From an economic standpoint the rocks of this series are unimportant in the locality under description. They are pre-Tertiary in age (possibly Triassic), and wherever exposed are much altered, and exhibit a complicated structure.

The sedimentary rocks of No. 2 series above cover by far the greater part of the area under description, and are of commercial interest, since they contain (1) extensive coal-seams ; (2) thick beds of limestone suitable for cement and lime manufacture, and clays suitable for brickmaking and for cement-manufacture ; (3) supposed reservoirs or pools of petroleum. These three headings will be discussed in a later part of this report.

The rocks of this series (No. 2 above), which are in general quite unaltered, have been classified by the earlier geologists, partly as Cretaceo-Tertiary and partly as Pliocene. The writer's visit was not of sufficient duration to make a definite decision on this question of age, but he is of the opinion that the whole series belongs to the Tertiary period, and is probably mainly Miocene.

The structure of the Tertiary rocks is of interest, since this feature has such a marked influence upon the presence or absence of petroleum. As far south as rocks of this series appear unshrouded by volcanic débris—near Waitara ; up the Mokau to and beyond the outcrop of coal at the rapids, twenty-three miles from the mouth ; up the coast as far north as Petone Creek ; and along the Awakino – Te Kuiti Road as far as Mr. A. J. Bignell's house (five miles and a half north-east of the mouth of the Awakino)—the Tertiary beds dip at very gentle angles, or are disposed almost horizontally. The structure seems in general to be that of a westerly- or south-westerly-dipping monocline. The smaller irregularities of structure in this monocline—gentle anticlinal and synclinal cross-swells—produce, however, slight changes in dip, sufficient, it is thought, to influence the location of the petroleum-pools, if these exist.

Along the coast in the neighbourhood of Petone Creek and northward the Tertiary rocks are greatly corrugated and faulted. On the Awakino – Te Kuiti Road, north-eastward from Bignell's, the strata also exhibit marked complications, being in places both folded and faulted. The various formations composing the series are apparently repeated several times between Bignell's and Te Kuiti. In this part of the area being described the series is known in places not to be of great thickness owing to the widespread exposure of the earlier sedimentaries. Thus, at the Wairere Falls, limestone, which forms one of the upper terrains of the series, immediately overlies the older sedimentaries, and over most of the rolling country around Piopio and Paemako Tertiary rocks occur only as outliers overlying the pre-Tertiaries.

The coal-seams interstratified with sandstones and claystones lie towards the base of the series. In the seaward and more southerly part of the area under description the limestones are overlain by many hundreds of feet of claystone (locally called " papa ") and sandstone ; but these upper rocks are less conspicuous inland. A splendid section of the upper measures is visible at the White Cliffs, overlain by later volcanics.

The black sands (No. 1 above) are seen in several places along the coast. Their black colouring is due to the presence of magnetite and ilmenite (titanic-iron oxide). The beds all contain more or less of these minerals, and in some places are of considerable thickness, but elsewhere they are much intermixed with quartz sand, titanite, and other materials. The beds of fairly pure black sand are generally thin and lensoid, being replaced both in horizontal and vertical extension by more barren sandy material.

Frequently the outcrop of these black-sand beds is rusty, owing to the further oxidation of the iron-bearing minerals they contain. The beds are generally soft and friable, excepting where held together by hydrous ferric oxide, and are usually disposed horizontally, but in places exhibit false bedding. They are thought to be Pleistocene in age, but probably their deposition extended from that period to the present.

Reassortment of the sands by the winds and the sea-waves is constantly proceeding, and thus are separated from the lighter material heaps of rich black sands containing hundreds of tons of high-grade material, which in the future, with exhaustion of other iron-ores more easily treated metallurgically, will be of great value. They are especially conspicuous in the neighbourhood of the sand-dunes just north of the mouth of the Awakino River.

The igneous rocks in this paper, which, owing to their economic importance, deals principally with the Tertiary sedimentaries, need be mentioned but briefly.

Serpentine rocks, which from a microscopic examination were found to be highly altered peridotites (apparently, in part at least, harzbergite), occur in a narrow band running N. 20° E., and outcropping beneath Tertiary limestones on Rangikohora Creek—a tributary of the Mokau, and about two miles south-east of the Wairere Falls. The serpentines are thought, from the doubtful analogy of similar rocks in the neighbourhood of the North Cape, to cut the supposed Triassic rocks,

but they may be more ancient. They are said to contain traces of copper, gold, and platinum. In the writer's opinion their economic value is of very equivocal nature. The discovery of fragments of rodingite in this locality is of interest as showing a petrological connection between the rocks of the Mokau serpentine area and those of the Dun Mountain Subdivision.

Rhyolitic rocks—in the main apparently tufa and agglomerate—are prominent on the Awakino – Te Kuiti Road, and near the Mokau River from nine to twelve miles south-west of Te Kuiti. They probably continue above the Tertiary rocks, at least in places, right through to Te Kuiti.

Tufaceous rocks lightly shroud the sedimentaries along the coast, and extend into the interior. No attempt was made to define exactly their petrological character. Towards the coast they are apparently mainly andesitic, but probably in the interior they may merge into rocks of more acid type. This volcanic coating is conspicuous because of the rusty soil which it affords on weathering.

Economic Geology.

As remarked in a previous paragraph, the economic geology of the area covered by the Mokau reconnaissance may be discussed under the headings (1) coal, (2) limestone and clay, (3) petroleum. The possibility of the occurrence of traces of copper, platinum, and gold in serpentine rocks near Wairere Falls has been mentioned; but this possibility is not worthy of further elaboration here. Similarly, too, the widespread ironsand mentioned before is not of immediate economic interest, and need not be discussed.

Coal.—Coal was seen by the writer on the Awakino – Te Kuiti Road at a point a few miles east of Bignell's house, and at several places on the Mokau River in the neighbourhood of Stubbs's Mine. It has been reported from several points in the Upper Mokau Valley in the neighbourhood of Piopio and Paemako, and is mentioned by Professor James Park* as occurring on the Mokauiti and another tributary of the Mokau entering on the left side.

The occurrence of coal to the east of Bignell's house is economically unimportant, the coal being merely a narrow seam a few inches thick in highly tilted sandy claystones.

Several parallel coal-seams are exposed on the Mokau near Stubbs's Mine. Professor Park* mentions a section on the Mangakawhia Creek in which four seams outcrop in a sandstone face, their thickness in descending order being 2½ ft., 7½ ft., 3 ft., and 8 ft. respectively. It is probably one of these seams which is now being worked at Stubbs's Mine, a short distance to the westward. This seam is altogether about 7 ft. 6 in. thick. A carbonaceous claystone band, however, occurs in it, decreasing the amount of marketable coal, and making mining somewhat expensive. The lower portion of the seam below the claystone band varies in thickness from 3 ft. to 4 ft., while the upper portion varies from 3 ft. 6 in. to 4 ft. 6 in. The parting varies from 6 in. to 16 in. in thickness generally, but in a few places it is almost a mere knife-edge. The coal is lignitic or sub-bituminous in character, non-caking, and in general is of very fair quality, the lower portion of the seam being superior to the upper. The coal is especially suitable for household purposes, but is also of some value for steaming. Its worst feature is its ready friability on exposure to the atmosphere, and the consequent loss through pulverization in shipping.

In Professor Park's report appear two analyses of the coal from Stubbs's Mine. No. 1 is from above the claystone parting, and No. 2 from below :—

	No. 1.	No. 2.
Fixed carbon	46·17	47·58
Hydrocarbon	34·15	36·05
Water	13·92	12·79
Ash	5·76	3·58
	100·00	100·00

The enclosing rocks consist of fine greenish argillaceous sandstones, with which are interbedded more or less sandy claystones. The roof stands remarkably well, and comparatively little timbering is required even in the open bords. The coal is mined on the pillar-and-stall principle, and up to the present none of the pillars has been removed. The dip of the seam is very slight—at an angle of about 6° generally in a direction S. 66° W., and, as the mining is conducted to the rise, drainage is good, and the coal readily run out from the mine. At about 200 yards from the mouth of the main drive it is stored in a shoot on the shores of the Mokau River, and from here it is shipped by small ocean-going steamers. When the Mokau River is low the seam of coal being worked can be seen in the river-bank, and is traceable for some distance up the stream.

At the rapid occurring some twenty-three miles from the mouth of the river a seam of coal some 4 ft. 6 in. thick, and underlain by about 1 ft. of carbonaceous shale, with coaly partings, appears on the left bank of the river a few feet above the water. The under- and over-lying rocks consist of argillaceous greensandstones. A few feet below the floor of the seam a coaly parting appears in the sandstones.

About a quarter of a mile lower down the Mokau (at about 22¾ miles from the mouth of the stream) are the workings of the old Stockman Mine. Here is exposed a fine seam of coal about 4 ft. in thickness.

On the Mangakawhia Creek a number of seams were examined, all of which exhibited coal of the same general quality as that seen elsewhere in the locality.

The coal being mined at Stubbs's Mine, the Mangakawhia seams, and Stockman's seam are all on the Mangapapa Block, which is the property of Mr. G. H. Stubbs, of Waitara. That on the left

* See reports of N.Z.G.S., Vol. xviii, 1887, pp. 44–47.

bank of the river is on the land formerly controlled by Mr. Joshua Jones, of Mokau ; but this property is now, the writer understands, in the hands of a Wellington syndicate. To the northward of the Mangapapa is a block of land held by the Cadman Estate, which is reputed to contain considerable coal.

To sum up, it may be said that the Mokau Valley in the neighbourhood of Stubbs's Mine contains an extensive coal-basin, which comprises several seams exhibiting considerable continuity and apparently not very markedly faulted. The coal is easy to mine, owing to the general good-standing quality of the strata in which the seams lie. Though the quality of the coal from the different seams varies somewhat, it is generally of fair grade, being most suitable for household purposes. Though resembling in places a bituminous coal, it is best described as a lignite, or perhaps more correctly a sub-bituminous coal. Its worst feature, as mentioned previously, is its ready decrepitation on exposure to the air.

Although Mokau coal is mined in proximity to a waterway navigable to the sea, the vessels which cross the bar at the mouth of the river are of such small size as to render the cost of landing the coal in the various centres of New Zealand high. Were the Mokau bar so much improved that fairly large vessels could enter the river, there would be a good field for coal-mining in this part of the Dominion.

Limestone and Clay.—Limestone is to be seen in many parts of the valley of the Mokau. It occurs at various points in the lower part of the river, being especially conspicuous about eighteen miles above the mouth. It is of widespread occurrence in the rolling country around Paemako and Piopio, where it is frequently very light-coloured, and crystalline in character. Though differing in quality in various parts of the area, and being in places coarse and gritty, it is apparently in certain localities entirely suitable for the manufacture of lime, and also for utilization in cement-manufacture. The limestone burnt on the Mokau River is said to have produced lime of very good quality. Clays suitable for brickmaking occur in almost every part of the area under description. The limestone and clay can for the present hardly be said to be of great value, but in the future, with the opening-up of the country, they will be of definite commercial importance.

Petroleum.—The observed indications of petroleum and allied products in the area under review are neither very great in number, nor are they definite or conclusive in character. They may be summarized as follows :—

(*a*.) Inflammable gas bubbles up fairly constantly through a pool of standing water with a boggy bottom on the right bank of the Awakino, at a point just below Papaurakohoe, and distant some seven miles and a half in a straight line from the mouth. This is apparently marsh-gas, and is probably only a surface phenomenon.

(*b*.) Springs of salt water are said to occur on the Mokau River near the locality of the gas-bubbles. These were not seen by the writer, and no very definite information could be obtained concerning them. As salt water not infrequently accompanies petroleum in nature, it may be considered an indication of that natural product.

(*c*.) From time to time chunks of a black viscous solid, thought to be asphaltum, are washed ashore in the neighbourhood of the mouth of Petone Creek. Judging from a sample of this material, the writer is of the opinion that it is indeed a solid bitumen.

(*d*.) A surface seepage of petroleum is said to have been discovered by some bushmen in the bush to the eastward of Tongaporutu. The information obtainable on this point is very scant, and it is understood that the seepage is not now visible.

The whole of the country covered by the Mokau reconnaissance is practically unexplored geologically, and we do not know what information a careful and detailed survey (such as has been conducted in portions of the Poverty Bay district) would bring to light. It might perhaps lead to an alteration of conclusions mentioned herein. However, in the light of existing knowledge it is considered improbable that the Tertiary rocks in the area contain petroleum or its allied product in payable quantities. The following are the principal reasons for this conclusion :—

(1.) No indication of the presence of petroleum was seen by the writer in the beds at the surface, although they are faulted and tilted, and in the interior highly so. Along the Mokau River the succession of beds is in general so well exposed that some of the oil could hardly fail to escape to the surface and leave a trace, if any existed. The information regarding the alleged oil-seepage near Tongaporutu is too uncertain to be considered, nor is the very doubtful occurrence of a fissure in the sea-floor from which issues the bitumen washed ashore near Petone Creek of much value in this connection. The other supposed indications of petroleum and its allied products shown to the writer consisted of films of hydrous iron-oxide on water or as stains in the claystones, or of manganese-oxide coatings or vegetable discolorations.

(2.) The source of the petroleum at Moturoa, near New Plymouth, is thought to be entirely within the Tertiary rocks, and the petroleum to be a product derived by the slow distillation, either by volcanic heat or by the general heat of the earth's interior, of the coal-seams and other carbonaceous layers which lie near the base of that series. On the Mokau the coal-bearing horizons are exposed, and could consequently not be also the source of the petroleum. Of course, these lie beneath the surface at the mouth of the river, but not, it is thought, sufficiently deep to be greatly influenced by the earth's interior heat, and volcanic rocks apparently are unimportant here.

In much of the upper part of the Mokau country (around Piopio and Paemako especially) the Tertiary rocks are now so very scant that it seems hardly possible any great pools of petroleum could have been derived from them. If any ever existed—as products derived from the rocks now removed by erosion—these, too, would have disappeared in the general wearing-down of the land.

The chances for the occurrence of pools of petroleum may in very general terms be said to increase southward from the mouth of the Mokau towards Tongaporutu and Waitara, as the distance below

the surface of the supposed source of the petroleum increases in that direction. Also, the possibility of the discovery of petroleum is perhaps more hopeful (than elsewhere in the interior) around Mahoenui, in the neighbourhood of the Awakino and Mangaorongo rivers, where the lower measures of the Tertiaries are brought, by down-folding, nearer the earth's heated interior.

From the above notes it will be seen that it would be, in the writer's opinion, distinctly unwise to commence boring for oil in the Mokau country, or, in fact, anywhere northward of Tongaporutu, unless more hopeful indications of petroleum than those already observed are discovered.

THE RETARUKE COALFIELD.

1. Introduction.

During the winter of 1909 information reached the Head Office of the Mines Department that coal had been found in the country adjoining the Main Trunk line to the westward of Waimarino and Erua stations. Soon afterwards instructions were given the writer to visit the locality, with a view to ascertaining whether or not the reported coal actually existed. Accordingly, early in December a brief visit of inspection was made; but on this occasion, as the guide, a settler living near Erua, was unable to point out any coal occurring *in situ*, and as the flooded state of the creeks prevented any detailed personal prospecting, it was impossible to ascertain more than the fact that coal-bearing measures were widely distributed in the neighbourhood, and that float coal occurred in numerous tributaries of the Retaruke, as well as in the main stream itself.

During February and the first three weeks of March, following the receipt of further instructions from the Under-Secretary of Mines, the area was somewhat carefully examined by the writer, assisted by Mr. H. S. Whitehorn, chainman of the staff of the Geological Survey. To Mr. Whitehorn was left all the topographical work, the prospecting for coal, and much of the detailed geological examination. However, the writer, under whose control the work was conducted, visited most of the principal coal-outcrops, of which some sixteen were located during the progress of the survey.

The locality had been recently surveyed for land-settlement purposes by the Lands and Survey Department; but, as these surveys did not include a traverse of the numerous streams, where alone the coal usually appears, it was necessary for Mr. Whitehorn to survey the creeks in order to accurately place the various coal-seams which were discovered. This proved by no means an easy task, owing to the extremely gorgy nature of the main Retaruke, and to the many steep waterfalls on its tributaries. The tracing kindly given by the Lands and Survey Department proved of great service, and to the fixed pegs placed thereon were tied the stream traverses. On the map accompanying this report it will be observed that the streams were surveyed only as far up their valleys as the coal-outcrops, whilst, above, their courses were merely sketched in.

In sampling the various coal-exposures some difficulty was experienced in getting a clean face, the coal naturally being much weathered and decomposed on the surface. In no case could a really fresh surface be obtained, and to fully prove the quality of the coal at the various outcrops a drive would have to be put in for a chain or more in each case. It will be readily understood that the quantity of ash in the coal must be higher at the surface than farther in, since much fine silt carried by the water ever percolating downward at the surface is deposited there in fine layers between the laminæ of coal. The amount of water in the decomposed coal is naturally, too, greater at the surface than away from it.

Samples were analysed from most of the coal-outcrops examined. These were taken from cuts made from roof to floor of the seams, and consequently included much of the impurity in the stony and shaly bands, which are present in greater or less degree in all exposures seen. Where the size and general quality of the coal-outcrops seemed to warrant it, samples were also taken for analysis, picked free from "stone." In these cases it is thought that the impurities can perhaps be readily separated from the good coal in actual mining, as has, unfortunately, to be done in so many mines.

In general terms the Retaruke coalfield may be said to extend westward from a meridional line lying about a mile westward from Erua Station, and possibly rather more from Waimarino Station. Its westward, northern, and southern confines are as yet not known, but it is thought that when geological investigations have been prosecuted further in these directions, extensive coal-beds will be found. The examinations so far conducted extended down the Retaruke from its headwaters as far as Mr. A. B. Tylee's whare, situated about ten miles west of Waimarino. It must be evident that in an area so densely forested and in many parts so highly inaccessible as the Retaruke coalfield, by no means all the outcrops of coal were discovered in the brief period covered by the Survey's investigations. However, it is thought that sufficient exposures have been located to indicate the presence of a coalfield of some promise.

2. Character of the Topography.

Physiographically considered, the Retaruke coalfield forms part of the Wanganui coastal plain. The plain is here elevated to a general height of over 2,000 ft., and, though almost flat-topped, it has a very gentle inclination towards the west. The densely forested nature of the surface of the plain, and of the numerous valleys incised therein, stands in marked contrast to the tussock-clad Waimarino Plains, which border the coastal feature to the east, and, surrounding the volcanoes of Ruapehu and Ngauruhoe, extend eastwards to the Kaimanawa Ranges.

In the area now being described, the Retaruke and its tributaries have deeply dissected the coastal plain. The narrow and V-shaped valleys are everywhere bordered by steep slopes descending from the level of the plain. Alluvial flats along the course of the Retaruke and its tributaries practically do not exist in the area under revision, though further down the Retaruke, towards the Wanganui, they are fairly extensive.

3. General Geology.

The coal, which is sub-bituminous in quality (generally known as "lignite" in New Zealand, but "sub-bituminous" according to recent approved classification), occurs in seams from 3 ft. to 8 ft. in thickness, interstratified with a great series of conglomerates, sandstones, claystones, and impure limestones. These rocks, which extend over a great portion of the west coast of the North Island, are Tertiary in age, and are generally considered to belong to the Miocene division of that era, or may possibly be earlier.

In the area now being described, these beds lie almost horizontally, or dip with very gentle inclinations in southerly or easterly directions. The beds have been apparently widely dislocated by earth-movements, but the faults thus caused are mainly of inconsiderable throw. Naturally, the coal-beds have been disrupted with the enclosing rocks. For this reason it is as yet impossible to say whether the several coal-outcrops examined belong to more than one seam, or to one seam only. From a consideration of the generally similar quality of the coal in the various outcrops, from the constancy of a bed of conglomerate closely overlying the coal-seams, and from actual faulting phenomena observed in the field, it is thought, however, that there is only one seam. The floor and roof of the coal-seam consist everywhere of claystone, which is sometimes separated from the coal proper by carbonaceous shale. The coal-bearing beds are overlain in many places by loosely consolidated tufa, whilst elsewhere recent gravel-beds occupy the floors of the narrow valleys.

4. Detailed Description of the Several Coal-seams.

(*a.*) Tylee's Seam.—Tylee's seam is situated on the property of Mr. A. B. Tylee, and is exposed on a small right-hand branch of Tylee's Creek, a tributary of the Retaruke. There are nearly 8 ft. of coal altogether, but a 3 ft. band of stone appears, which divides the seam into two parts, the upper 3 ft. thick and the lower 4 ft. 10 in. thick. The seam dips at an angle of 8° in a south-east direction. Measured from top to bottom, the upper part of the seam consists of 1 ft. of poor coal containing carbonaceous-sandstone layers, and 2 ft. of good coal, while the lower part is made up of 6 in. of carbonaceous shale with coaly partings, 1 ft. 2 in. of good coal, 2 in. of carbonaceous-sandstone parting, and 3 ft. of good coal.

It will thus be seen that there are only 6 ft. 2 in. of good coal. The general quality, including much carbonaceous shale and sandstone, of the upper portion (A) and the lower portion (B) is given below :—

	A.	B.
Fixed carbon	32·27	28·85
Volatile hydrocarbons	36·98	37·47
Water	12·20	14·21
Ash	18·55	19·47
	100·00	100·00
Sulphur	3·15	2·64

If the seams were picked free of all shaly or stony bands the amount of ash would be considerably less than that given in the analysis.

(*b.*) Inverarity's Creek.—The seam near the head of Inverarity's Creek, a fairly large tributary of the Retaruke, shows about 2 ft. thick at the outcrop. The coal is much weathered, but appears to be of fair quality. The seam is probably of much greater thickness than the 2 ft. showing, but is so covered with débris that it is impossible, without a great deal of work, to expose the whole width of it, nor was it possible at the time of examination to determine the strike and dip. The altitude is 2,304 ft.

(*c*) and (*d*). Longridge Nos. 1 and 2.—These two seams are on a high ridge above the heads of two small creeks which enter the Retaruke about 10 and 15 chains respectively above Inverarity Creek. The two outcrops are only about 7 chains apart, and are probably both exposures of the same seam. They are so covered with débris that it was not possible to arrive at their extent or dip. The approximate altitude is 1,946 ft.

(*e.*) Paddy's Creek.—A seam 7 ft. 8 in. in thickness is exposed in Paddy's Creek, a very small tributary on the right-hand side of the Retaruke. A good deal of work was done on this outcrop to free it from débris and to get a clean face for sampling; but even with this care the sample would undoubtedly contain many impurities in the silt deposited along the laminæ near the surface, which would not be shown further in. Measured from top to bottom, the seam is made up of 2 ft. 4 in. of fair coal containing two ¼ in. clayey selvages near the top, 3 in. of a highly carbonaceous shale with coaly partings, 11 in. of fair coal, 3 in. of a carbonaceous shale, 2 ft. 8 in. of good coal, 6 in. of shale containing a good deal of clayey material, 6 in. of good coal, 3 in. of a puggy seam, and shale to the claystone floor.

The seam, which is at an altitude of 1,955 ft., dips at a very slight angle in a south-easterly direction. Its general quality is as follows :—

Fixed carbon	34·48
Volatile hydrocarbons	37·00
Water	15·10
Ash	13·42
	100·00
Sulphur	2·40

Had the coal been picked free from stone, the quality would have been considerably better than shown by the above analysis.

(*f.*) Sandy Creek.—A seam of coal is exposed in Sandy Creek, which enters the Retaruke a few chains below Dandy Gully. The measurement showed only 4 ft. 8 in. of coal, but, owing to the position of the outcrop, and the amount of débris overlying it, it is quite possible than a greater thickness would be shown further inland, where the seam has not been disturbed. The measurement taken showed 1 ft. 1 in. of good coal, 4½ in. of highly carbonaceous shale with two 1 in. coaly partings, 3 in. of fair coal, 1 in. of clayey selvage, 2 ft. of a good coal, but becoming rather shaly in the lower few inches, then 10½ in. of shale, including a 2 in. clayey band, to the claystone floor.

The seam is at an altitude of 1,727 ft., and dips in a south-easterly direction at an angle of 5°.

The analysis of the sample taken gave the results shown below. A better result could have been obtained had the stone contained been removed.

Fixed carbon	36·25
Volatile hydrocarbon	37·70
Water	12·75
Ash	13·30
	100·00
Sulphur	2·60

(*g.*) Coal Creek No. 1.—In Coal Creek, a left-hand branch of the Retaruke, are two exposures of coal. The lower outcrop, No. 1, which is made up of 2 in. of fair coal, 1 in. of clayey selvage, 1 ft. 6 in. of good coal, 2½ in. of sandy carbonaceous shale, 1 ft. 1 in. of good coal, ½ in. of sandy selvage, 1½ in. of good coal, ½ in. of sandy selvage, 2 ft. 3 in. of good coal, and 11 in. of carbonaceous shale, is 6 ft. 2 in. in thickness.

The outcrop is very much weathered ; so the general sample taken would be likely to show a poorer analysis than one taken in a solid face at some distance from the surface.

The seam dips at an angle of 7° in a south-westerly direction, and has an altitude of 1,508 ft.

The general quality of the seam, including the stony bands, is as shown in (A) below, while the quality of the coal picked free from visible impurity is given in (B) :—

	A.	B.
Fixed carbon	35·98	38·68
Volatile hydrocarbons	36·89	41·49
Water	14·61	13·26
Ash	12·52	6·57
	100·00	100 00
Sulphur	2·70	3·01
Calories per gram	..	5,478
British thermal units per pound	..	9,860
Evaporative power per pound	..	10·20 lb.
Practical evaporative power (60 per cent. efficiency)	..	6·12 ,,

(*h.*) Coal Creek No. 2.—The upper seam (No. 2) exposed in Coal Creek is 5 ft. 9 in. in thickness. The coal seems to be of a good quality, and is of a hard, bright variety. Probably the whole of it could be mined with the exception of 1 ft. at the bottom, which is highly argillaceous. At distances of 1 ft. 5 in., 2 ft. 4 in., and 2 ft. 8 in. respectively from the top there are three selvages of clayey material, but none of them is more than ¼ in. in thickness.

The seam dips at an angle of only 2° in a south-easterly direction, and is at an altitude of 1,612 ft.

The analyses of (A), the sample containing the stony bands, which was taken from the upper 4 ft. 9 in., and of (B), a sample taken from the same part, but picked free of stony bands, are given below :—

	A.	B.
Fixed carbons	34·37	40·75
Volatile hydrocarbons	38·96	38·80
Water	12·07	12·98
Ash	14·60	7·47
	100·00	100·00
Sulphur	2·66	2·49
Calories per gram	..	5,359
British thermal units per pound	..	9,646
Evaporative power per pound	..	9·99 lb.
Practical evaporative power (60 per cent. efficiency)	..	5·99 ,,

(*i.*) Dandy Gully No. 1.—There are two exposures of coal at the foot of a bluff in Dandy Gully, one on either side of the stream at about 30 chains from its junction with the Retaruke. It is probable that these two exposures belong to one and the same seam, broken through by a fault, which roughly follows the course of the stream. The upper seam is about 60 ft. above the lower one.

Measurements of the lower seam (No. 1) in Dandy Gully gave the following section : 3 in. of fair coal, ½ in. of clayey selvage, 1½ in. of carbonaceous shale, 3 in. of fair coal, ¼ in. of clayey selvage, 2 ft. of good coal, ½ in. of carbonaceous sandstone, 2 ft. 3 in. of good coal, 8 in. of highly carbonaceous shale with some good coal mixed, 4 in. of a soft clayey band, 7 in. of good coal, and 3 in. of carbonaceous sandstone, making a total thickness of 7 ft. 10 in.

The seam dips in a south-easterly direction at an angle of 4°, and is at an altitude of 1,621 ft.

The general sample, including the stony bands, gave on analysis the result shown in (A), while the better-grade coal picked free from stone gave the results as shown in (B) :—

	A.	B.
Fixed carbon	23·03	37·78
Volatile hydrocarbons	38·05	45·48
Water	11·00	10·82
Ash	27·92	5·92
	100·00	100·00
Sulphur	3·05	3·38
Calories per gram	..	5,964
British thermal units per pound	..	10,735
Evaporative power per pound from calorimeter	..	11·12 lb.
Practical evaporative power (60 per cent. efficiency)	..	6·67 ,,

(*j.*) Dandy Gully No. 2.—The upper seam in Dandy Gully (No. 2) is 7 ft. 7 in. in thickness, and is made up as follows, measuring from the top to the bottom : 2 ft. 3 in. of excellent coal, ¼ in. of clayey selvage, 1 ft. 7 in. of fair coal, ¾ in. of sandy selvage, 1 ft. 11 in. of good coal, 1 ft. 9 in. of highly carbonaceous shale with some impure coal.

The dip of the seam is in a south-easterly direction, at an angle of 5°.

Analyses of the material taken from the whole seam gave the result (A) below, while that taken from the better layers only gave the result as shown in (B) below.

	A.	B.
Fixed carbon	32·08	39·85
Volatile hydrocarbons	39·13	42·89
Water	13·07	12·01
Ash	15·72	5·25
	100·00	100·00
Sulphur	2·82	3·25
Calories per gram	..	5,871
British thermal units per pound	..	10,568
Evaporative power per pound	..	10·95 lb.
Practical evaporative power (60 per cent. efficiency)	..	6·57 ,,

(*k.*) Lower Retaruke No. 1.—At station 7 (see map) on the Retaruke River a seam of coal is exposed on the left bank. It is about 6 ft. in thickness, and is made up from the roof to the floor as follows : 2 in. of good coal, ¼ in. of clayey selvage, 1 ft. 6 in. of good coal, 2 in. of sandy carbonaceous shale, 1 ft. 4 in. of fairly good coal greatly improving downwards, ¼ in. of sandy selvage, 1½ in. of good coal, ½ in. of sandy selvage, 2 ft. 3 in. of good coal, excellent at the top but somewhat inferior lower down, 1 in. of highly carbonaceous shale containing a little fairly good coal. Of this, all may be considered as good fuel excepting about 1 ft. 3 in. altogether. The 2 in. of sandy carbonaceous shale seems rather indefinite, and apparently passes into fairly good coal along the dip. The ¼ in. and ½ in. of sandy selvage are more constant breaks.

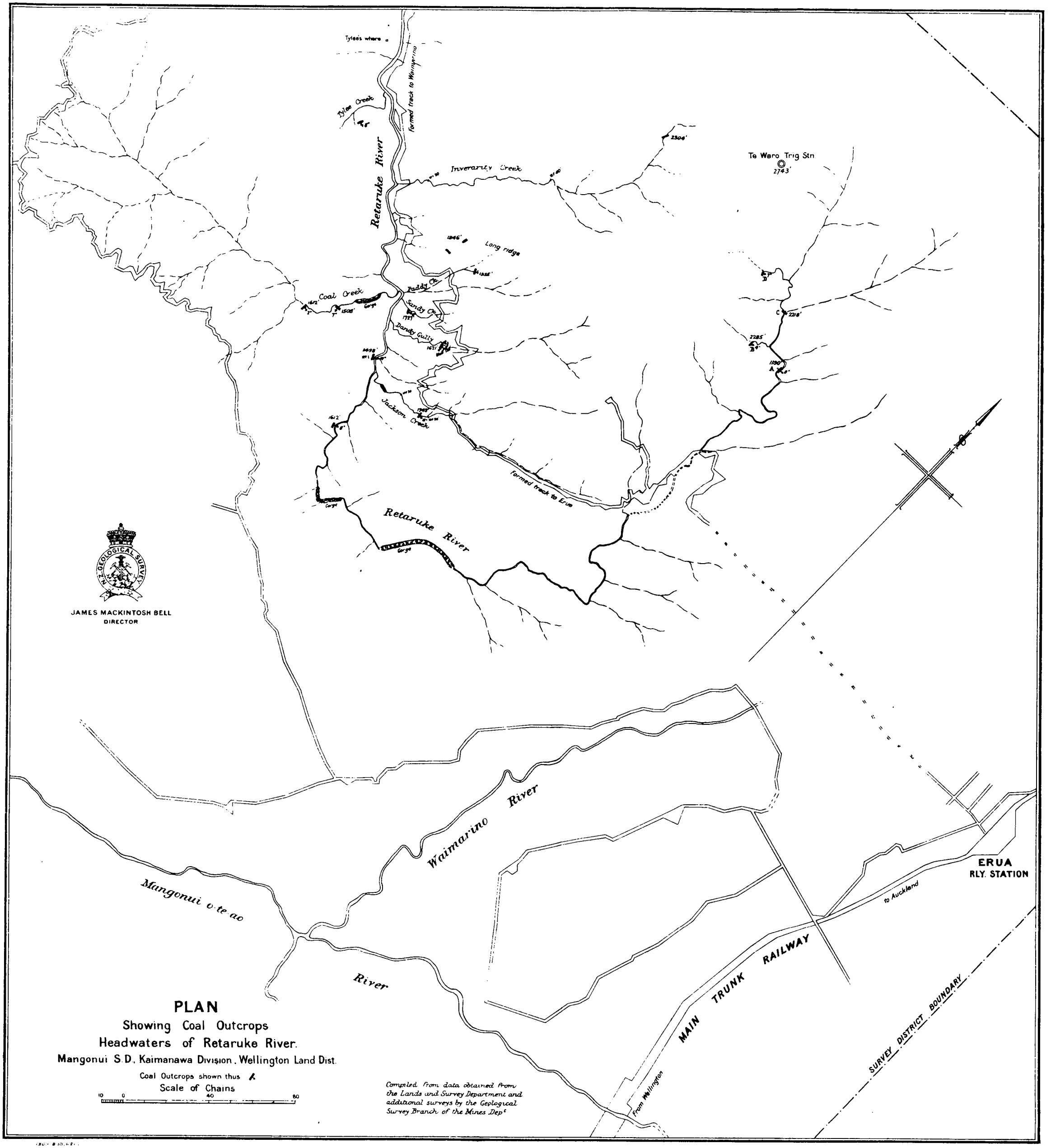
The dip is in a south-easterly direction, at an angle of 10°. The seam is highly friable, and not at all rusty at the outcrop. The altitude of the seam is 1,498 ft.

Appended are the analyses of the samples which were taken (A) from coal with stone in the higher part of the seam, (B) from coal with stone in the lower, and (C) from the better part of the coal, picked free from stone :—

	A.	B.	C.
Fixed carbon	29·48	30·32	41·15
Volatile hydrocarbons	40·14	37·93	41·06
Water	12·21	12·45	12·07
Ash	18·17	19·30	5·72
	100·00	100·00	100·00
Sulphur	3·67	2·57	3·01
Calories per gram	..	..	5,721
British thermal units per pound	..	..	10,298
Evaporative power per pound from calorimeter	..	..	10·67 lb.
Practical evaporative power (60 per cent. efficiency)	..	..	6·40 ,,

(*l.*) Jackson's Creek.—The seam exposed in Jackson's Creek, a right-hand branch of the Retaruke, is 7 ft. 7 in. in thickness. This seam, which is very much weathered, is so broken up into shaly, clayey, and sandy bands that it seems unnecessary to enumerate the nineteen variations in the section taken. Taking all the different laminæ of fair and good coal, the total thickness is about 3 ft. 6 in., of which only 1 ft. 10 in. is unbroken by stony bands. Possibly the seam would show improvement further away from the outcrop.

The dip is in a south-easterly direction, at an angle of 6°, and the seam is exposed at an altitude of 1,743 ft.


Tyldes where
Tyldes Creek
formed track to Waingarimo
Retaruke River
Inverarity Creek
2304'
Te Waro Trig Stn
2743'
1946'
Long ridge
1555'
Paddy Ck.
Coal Creek
1612'
1508'
Sandy Ck.
1777'
Dandy Gully
1671'
1438'
1590'
2285'
2218'
Jackson Creek
1612'
1908'
formed track to Erua
Retaruke River
Waimarino River
Mangonui o te ao
River
ERUA
RLY. STATION
to Auckland
MAIN TRUNK RAILWAY
from Wellington
SURVEY DISTRICT BOUNDARY
N.Z. GEOLOGICAL SURVEY
JAMES MACKINTOSH BELL
DIRECTOR
PLAN
Showing Coal Outcrops
Headwaters of Retaruke River.
Mangonui S.D., Kaimanawa Division, Wellington Land Dist.
Coal Outcrops shown thus
Scale of Chains
10 0 40 80
Compiled from data obtained from the Lands and Survey Department and additional surveys by the Geological Survey Branch of the Mines Dep.t

The general sample taken from this seam gave on analysis the following results :—

Fixed carbon	32·97
Volatile hydrocarbons	39·03
Water	13·15
Ash	14·85
	100·00
Sulphur	2·96

(*m.*) Lower Retaruke No. 2.—This seam, which is 6 ft. 2 in. thick, like the upper seam in Coal Creek, seems to have very few impure bands. The measurements from the top to the bottom show 1 ft. 3 in. of soft but fairly good coal, 3 ft. 2 in. of very hard bright coal, and 1 ft. 9 in. of clayey carbonaceous shale.

The seam dips at an angle of 8° in a south-easterly direction, and lies at an altitude of 1,612 ft.

The general sample from the seam, including stony bands, gave the following analysis :—

Fixed carbon	28·12
Volatile hydrocarbons	38·68
Water	9·60
Ash	23·60
	100·00
Sulphur	3·81

Undoubtedly, were the stony bands not analysed with the better-grade coal, the amount of ash would be much less than that given above.

(*n.*) Upper Retaruke A.—This seam dips in a south-easterly direction at an angle of 8°. Only about 1 ft. of the seam is exposed, consisting of coal of good quality. The seam outcrops for about 20 ft. right across the stream, but is overlain by débris on either side of the creek-bed. The outcrop is at an altitude of 1,190 ft.

The general sample, including stony bands, taken for analysis yielded the following results :—

Fixed carbon	32·53
Volatile hydrocarbons	41·39
Water	11·96
Ash	14·12
	100·00
Sulphur	3·48

(*o.*) Upper Retaruke B.—A coal-outcrop occurs on a very small right-hand branch of the upper Retaruke. The seam is 3 ft. 4 in. in thickness, and is of poor quality, being chiefly a highly carbonaceous shale with a few coaly partings. There is about 6 in. of fairly good coal near the bottom. The seam outcrops at an altitude of 2,285 ft., and dips in a south-easterly direction at an angle of 4°.

(*p.*) Upper Retaruke C.—At the junction of the two main branches of the upper Retaruke, at an altitude of 2,218 ft., is an outcrop of coal 3 ft. in thickness. The seam is nowhere of very good quality, and the lower part is distinctly shaly, the upper part being fair.

The sample for analysis was from the upper part only, and the result is as follows :—

Fixed carbon	31·10
Volatile hydrocarbons	42·36
Water	10·99
Ash	15·55
	100·00
Sulphur	3·15

(*q.*) Upper Retaruke D.—On a small right-hand branch near the head of the Retaruke is an exposure of coal 3 ft. 5 in. in thickness. The upper 1 ft. 10 in., though much weathered, appears to be of fair quality. Below this is 1 ft. of highly carbonaceous shale, with another 7 in. of fair coal to the floor. The seam dips at an angle of 7° in a south-east direction.

5. General Conclusions.

If all the analyses given under the detailed description of the various exposures of coal are examined, it will be found that the coal is in every case high in ash, high in sulphur, and high in water, which are all serious defects. For reasons stated above it is believed that the coal away from the surface will very probably contain less ash and less water, but it is very unlikely that the quantity of sulphur will diminish at all; in fact, it is more likely to increase, as, away from the influence of the air, the iron-pyrites which contains the sulphur will be less oxidized. In general, the quality of the Retaruke coal is more like that of Mokau coal than any other of the New Zealand coals. The best of the Retaruke coal, too, is not inferior to the Mokau coal. In the almost equal percentages of fixed carbon

and volatile hydrocarbons the Retaruke coal resembles that from Taupiri; but the quantity of ash and sulphur is higher in the Retaruke than in the Taupiri coal. However, a certain amount of ash—below 8 per cent.—is not really a serious matter, and in some cases prevents decrepitation of coal by holding it together. Like the Mokau and Taupiri coals, the Retaruke coal is non-caking, and is essentially a household coal. Below are inserted, for purposes of comparison with Retaruke coals, the analyses of coals from Mokau and Taupiri.*

(*a.*) Taupiri Coal-mine No. 1.
(*b.*) ,, No. 2.
(*c.*) ,, No. 3.
(*d.*) Mokau, Mangapapa.
(*e.*) No. 1 seam, Retaruke.
(*f.*) Lower seam, Coal Creek.
(*g.*) Upper seam, Coal Creek.
(*h.*) Lower seam, Dandy Gully.
(*i.*) Upper seam, Dandy Gully.

	(*a.*)	(*b.*)	(*c.*)	(*d.*)	(*e.*)	(*f.*)	(*g.*)	(*h.*)	(*i.*)
Fixed carbon	42·11	43·73	41·93	38·65	41·15	38·68	40·75	37·78	39·85
Volatile hydrocarbons ..	43·57	42·12	41·05	43·29	41·06	41·49	38·80	45·48	42·89
Water	12·24	11·72	14·22	11·34	12·07	13·26	12·98	10·82	12·01
Ash	2·08	2·43	2·80	6·72	5·72	6·57	7·47	5·92	5·25
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Sulphur..	0·26	0·32	0·31	2·71	3·01	3·01	2·49	3·38	3·25
Calories per gram ..	6,079	6,129	5,649	5,987	5,721	5,478	5,359	5,964	5,871
British thermal units per pound	10,942	11,032	10,168	10,777	10,298	9,860	9,646	10,735	10,568
Evaporative power per pound, from calorimeter..	11·34	11·44	10·54	11·22	10·67	10·20	9·99	11·12	10·95
Practical evaporative power (60 per cent. efficiency) ..	6·80	6·86	6·32	6·73	6·40	6·12	5·99	6·67	6·57

In the detailed descriptions given above of the various coal-outcrops, it may be noticed that the most promising exposures—those of highest quality, and sufficiently thick to be worth mining—are those in—

(1.) The Lower Retaruke,
(2.) Coal Creek,
(3.) Dandy Gully.

The thickness of the seams diminishes and the quality becomes inferior to the rise towards the north-west, in the direction of the Main Trunk line. From Erua Station the seams on Coal Creek are about nine miles distant to the westward in an air line, but a branch line to the railway would probably be at least fifteen miles in length. It is thought that if the coal were lifted from a point near the outcrop to the level of the plain above, an easy grade could be found to the south of the Retaruke to the railway.

The lower of the two outcrops on the lower Retaruke is some eight miles distant in a direct line from the railway; and the upper, some eight miles also. Apparently the best way to get the coal out from these exposures would be by means of a steep incline to the watershed to the south of the Retaruke, and thence by an easily graded line of about twelve miles to the railway. The outcrops of coal in Dandy Gully are the nearest to the Main Trunk line of any of the workable deposits, being only about six miles west of Erua. From them an incline could easily be made up to the top of the steep spur adjoining, to the level of Cuff's ridge, whence a relatively easy grade of about seven or eight miles could, it is thought, be found to the railway. There would be an up grade for the first two or three miles, and then a slight down grade into Erua.

Now that coal-seams of workable thickness and of a quality suitable for household use, though not of value for steaming purposes, have been proven to exist in the Returuke coalfield, it seems necessary, in the writer's opinion, that certain preliminary exploration should be carried out. Thus it would be desirable to put in prospecting drives on the outcrops in Coal Creek, Lower Retaruke, and in Dandy Gully, to ascertain the quality and the thickness of the seam or seams there exposed, away from the surface. The quality of the coal at the surface, picked free from stony bands, is in general fair, and, for reasons given before in section 1, it is thought it will be better, as far as ash and water are concerned, farther in. The thickness is not likely to alter greatly within short distances.

It is extremely difficult in the present very limited knowledge of the Retaruke coalfield to hazard even an opinion as to the amount of coal available. However, since a rough estimate of a portion of the field may be better than none, the following calculations are given: The area, which includes the seams in Coal Creek, the lower Retaruke, Paddy's Creek, Sandy Creek, Dandy Gully, and Jackson's Creek, covers an area of about 810 acres. Of this, in probably 80 acres the coal is denuded in the stream-valleys, leaving a balance of 730 acres, or 31,798,800 sq. ft. The coal-seams in the above-mentioned localities average at least 6 ft. in thickness, but, on the assumption that some of this material is too stony to mine, it will be well to allow for a thickness of only 3 ft. This third dimension will give 95,396,400 cub. ft. of coal. Supposing that a ton (2,240 lb.) of Retaruke coal occupies, roughly, some 28 cub. ft., then some 3,407,000 tons of coal are available within the area given.† This amount is not likely to be less, and may be more. It is thought that the grade of this amount of coal need not exceed the 8-per-cent. limit of ash, or the 3-per-cent. limit of sulphur.

* All analyses in this report are by Dr. J. S. Maclaurin, Dominion Analyst, and staff. Analyses *a*, *b*, *c*, and *d* quoted above are from "Report on Analyses of New Zealand Coals," 1906, p. 8.

† The specific gravity of Retaruke coal, even after allowing for porosity, &c., is probably higher than 1·25, as assumed in this calculation. A sample from Dandy Gully had a specific gravity of 1·358.

REPORTS OF FIELD OFFICERS.

Mr. P. G. MORGAN, GENERAL GEOLOGIST.

Mr. P. G. Morgan, General Geologist, who has been at work throughout the year in the Greymouth Subdivision, presents the following preliminary report on the results of his examinations. Since he is now preparing a detailed bulletin on the area, this report is in most respects of a general character.

General Narrative.

From the 1st to the 20th June, 1909, I was engaged in field-work in the Greymouth Subdivision. Mr. J. A. Bartrum, Assistant Geologist, who was then associated with me, continued field-work until the end of the month, when he left for Nelson. Leaving Greymouth on the 21st June, I arrived in Wellington next day, and from that date until the 15th October, with the exception of a fortnight's holiday leave, was occupied in general office-work. On the 16th October I left for Greymouth, and from the time of my arrival in Westland until the middle of April, 1910, field-work in the Greymouth Subdivision occupied the whole of my attention.

The necessary data for the preparation of a detailed report on the subdivision having then been accumulated, short visits to the Reefton and Westport districts were made, in order that the gold-bearing rocks and the coal-measures of those areas might be compared with the corresponding rocks of the Greymouth Subdivision.

On the 24th April I returned to Wellington, and from that date until the end of May was occupied chiefly in compiling a detailed report on the Greymouth Subdivision. This report, which will yet require some time for its completion, besides describing the general geology of the area, will deal exhaustively with the economic geology. More especially will the deposits of alluvial gold and coal, and the possibility of an oilfield being developed at Kotuku, be discussed.

Summary of Field-work in the Greymouth Subdivision.

During the past season field-work was almost entirely confined to the survey districts of Mawheranui and Cobden, which contain almost the whole of the Grey coalfield. The exploration of this area, well provided as it is with roads and tracks, presented few difficulties. The geology of the coalfield, however, is of an intricate character, owing to the severe and irregular folding of the strata and the complications introduced by numerous faults.

The plan of conducting field-work was in all essential respects the same as that employed in other areas that have been geologically surveyed during the last few years. For the coalfield a larger scale for the field maps than that employed—namely, 1 in. to 20 chains—would have been desirable had an accurately contoured topographical map been available. In the absence of such a map, field-work in the coal-bearing areas was executed with as much detail as possible.

A brief summary of the results of the season's work may be given under the headings of (I) Physiography, (II) General Geology, (III) Economic Geology, and (IV) Miscellaneous Resources.

I. *Physiography.*

The two most important physiographic features of the area to be described are the southern part of the Paparoa Range and the broad valley of the Grey River east of the Paparoa Range. They are also very important from an economic point of view. Had the Paparoa Range not undergone elevation, no outcrops of coal would have been seen, and the existence of workable coal-seams would probably be a matter of mere speculation. Again, a proper understanding of the tectonic movements that have been the deciding factor in the formation of the Grey Valley will be decidedly helpful in arriving at a conclusion as to the origin and probable distribution of the petroleum found in the Kotuku district.

The Rapahoe or Twelve Apostles Range, that runs northward for about five miles from Cobden to the neighbourhood of Point Elizabeth, is a comparatively low and narrow ridge that would be considered part of the Paparoa Range but for the somewhat broad, low valley that intervenes. This valley has been considered to represent an old channel of the Grey River.*

The drainage of the area under consideration is effected mainly by the Grey River and its tributaries, chief among which are the Ahaura and Arnold rivers, and Nelson, Moonlight, and Blackball creeks. The only other streams requiring reference are those entering the ocean north of Point Elizabeth—namely, the Seven-, Nine-, and Ten-mile creeks.

II. *General Geology.*

In the area examined during the past year the oldest rocks known are certain argillites and grauwackes that have been referred to the Greenland Series of Bulletin No. 6, which is equivalent to the Kanieri Series of Bulletin No. 1. These rocks, which are locally known as "slates," near the northern boundary of the subdivision form the main part of the Paparoa Range. They also form Montgomery Ridge, near Blackball; and a narrow belt of these rocks, probably not continuous on the surface, extends southward from near Roa to the head of Langdon Creek.

* McLeod, H. N.: "Some Caves and Water-passages in the Greymouth District," Trans. N.Z., Inst., Vol. xxxvi, 1903, p. 480.

A great unconformity follows the Greenland rocks, the next sedimentary formation represented being the coal-measures, which are by the writer thought to be of approximately Eocene-Oligocene age—that is, post-Cretaceous and pre-Miocene. The remarks made in last year's report concerning the coal-measures may be taken as, on the whole, holding good, but a very important addition has to be made. Abundant evidence has been obtained that below the horizon of the Brunner coal-seam there exists a great thickness of shales and sandstones, together with many seams of high-class coal, and finally a thick bed of conglomerate resting on Greenland rocks. The existence of these beds, to which the provisional name of Paparoa Beds has been given, has been ascertained mainly through the prospecting operations undertaken, first of all, by the original holders of the Paparoa Coal Company's lease, and at a later date by the management of the Point Elizabeth State Coal-mine. The geological survey of the past season has revealed the proper sequence of the Paparoa Beds, and their relation to the overlying measures containing the seams hitherto worked. The full discussion of these matters is reserved for the detailed report, but the following table, giving the order of succession and approximate thickness of the various divisions of the coal-measures, will be found useful.

GREYMOUTH COAL-MEASURES.

Main Divisions.	Subdivisions.	Estimated Thickness.	Remarks.
Kaiata Mudstone ..	..	2,000 ft. to 3,000 ft. ..	Contains one coal-seam locally workable.
Island Sandstone ..	..	About 500 ft. ..	Often calcareous.
Brunner Beds ..	(*a.*) Coarse sandstone, grits, and pebble-beds	300 ft. to 400 ft. ..	Horizon of Brunner, State Mine, and Blackball coal-seams.
	(*b.*) Pebble-beds and conglomerate	0 to 400 ft... ..	At Ten-mile Creek contain coal-seams.
Paparoa Beds ..	(*a.*) Upper sandstones and shales ..	700 ft. to 800 ft. ..	Contain one or two minor seams, workable in places.
	(*b.*) Middle sandstones with minor shales	500 ft. to 600 ft. ..	Contain many small seams, some workable in places.
	(*c.*) Lower sandstones and shales..	700 ft. to 800 ft. ..	Contain three to five workable seams.
	(*d.*) Basal conglomerate with minor sandstones	0 to 1,000 ft. ..	Lower layers very coarse.

From the figures given in the above table it would appear that the maximum thickness of the Greymouth coal-measures may be as much as 7,000 ft. Some proportion of this, however, may be due to thickening caused by compression during elevation and folding.

The land-surface on which deposition of the Greymouth coal-measures began was very irregular. It thus happens that all the members from the basal conglomerate to the upper Brunner Beds may be found resting, unconformably, of course, on Greenland rocks. Thus also, the thickness of the lower members in particular varies, and there are variations in character dependent on local conditions. The folding, which is erratic, and the tremendous faulting that took place during the uplift of the Paparoa Range—matters already alluded to in this report—are other features introducing great difficulties in the reading of sections.

Perhaps the best way for the local student to obtain a clear idea of the actual succession of the coal-measures is to trace the Brunner Beds from the Brunner Mine through the area held by the North Brunner Coal-mine to Mount Sewell, and thence along the crest of the Paparoa Range to Mount Davy. Then, by descending, until Greenland rocks are seen, the branch of Bray Creek that heads about half a mile to the south-east of Mount Davy, a fair idea of the Paparoa Beds may be obtained, and more particularly their underlying position with reference to the Brunner Beds will be made manifest. Fuller knowledge of the Paparoa Beds can now be obtained by visiting the various coal-outcrops prospected and being opened out by the Paparoa Company near Roa, and by the State Coal-mine management in the Seven-mile Creek district (No. 2 Point Elizabeth Colliery).

Reference may be made to a great north-and-south fault which forms the eastern boundary of the belt of Greenland rocks that runs southward from Roa. This fault has a downward throw to the east, which at Roa exceeds 3,000 ft., and thus brings the Blackball seam, which lies in the horizon of the Brunner Beds, not only far below the seams to the westward now being worked by the Paparoa Company, but also below the outcrops of Greenland rocks forming the belt just mentioned. In other words, whereas just to the eastward of Roa one would have to bore perhaps a thousand feet to reach the Blackball seam, to the west we have the geologically underlying Paparoa seams almost in the clouds.

A description of other important faults and of the complicated system of minor folds into which the coal-measures are thrown will be reserved for the detailed report.

The statements made in last year's report referring to the undoubtedly Miocene and younger beds of the Greymouth Subdivision do not require repetition here. It need only be mentioned that beds belonging to horizons below that of the Cobden Limestone have a considerable development on the eastern side of the Paparoa Range from Rocky Creek to Mount Kinsella, and again on the eastern side of the Rapahoe Range. The crest of the latter feature, and its western slopes, including Point Elizabeth, are composed of calcareous sandstones and impure limestones belonging to the Cobden Limestone horizon. In that portion of the Grey Valley which was examined the rocks are sandstones and claystones belonging to the Blue Bottom horizon, overlain by a greater or less thickness of younger gravels. The Blue Bottom Beds, except just at the foot of the Paparoa Range, where they are more or less fault-involved, are very gently inclined, or even horizontal. There can be no doubt but that they are underlain by beds corresponding in age to the Cobden Limestone and the Omotumotu mudstones, whilst below these probably come strata of coal-measure age. Coal-seams, however, if present, are at great depth.

III. *Economic Geology.*

The economic geology of the area examined during the last field season may be summarized under the following headings :—

(1.) Alluvial Gold.
(2.) Metalliferous Quartz Veins.
(3.) Coal.
(4.) Petroleum.

(1.) Alluvial Gold.—In bygone years a large amount of gold has been obtained by alluvial miners within the area examined during the past twelve months ; but at the present time alluvial mining, with the exception of the dredging branch, is in the same decadent condition as in most other parts of Westland. Ground or hydraulic sluicing is still being carried on at a number of places, notably Nelson Creek, Montgomery's Terrace, and Healy's Gully. Abandoned workings may be seen in the valley of Blackball Creek near Blackball Township, in Ford Creek Valley, between Blackball and Roa, in Soldiers Creek, and to the southward of these localities in several streams descending from the Paparoa Range to the Grey River. Near Nelson Creek Township (Hatters) a small party is successfully working the bed of Gow Creek by a paddocking process, a water-lift being employed for the raising of the washdirt to the sluice-boxes. At Darkies' Terrace (near Point Elizabeth), near the Nine-mile Creek, in the valley of the Ten-mile Creek, and further north, are diggings now almost or quite abandoned. Near the Seven-mile Creek a little gold is still being obtained. In the valley of the Ten-mile Creek, somewhat outside the subdivision, is King's Terrace, where some gold was obtained in past years. The bed of the Ten-mile Creek and the small adjoining flats are even yet being worked by Perry and party. There are also old alluvial gold-workings in Upper Blackball Creek beyond the subdivision boundary. One sluicing claim is still at work near Williams's old hotel.

In the Grey Valley dredging has met with some success. In the Nelson Creek district the Pactolus, Nelson Creek, and New Trafalgar companies, more particularly the first-named, have been profitable concerns. The Notown dredge, at work in the stream-valley of the same name, has also been successful in its operations. The North Beach dredge, operating on the narrow coastal plain north of Greymouth, is also stated to have paid its way. In the Grey River itself, in Red Jack's Creek, in Blackball Creek, near its mouth, and in the lower course of Moonlight Creek, the dredging operations undertaken a few years ago have not proved profitable.

(2.) Metalliferous-quartz Veins.—During the past season quartz veins were frequently observed in the Greenland rocks, but in no case was a vein containing values of any consequence identified. The gold-antimony vein at the head of Langdon's Creek mentioned in last year's report was not revisited. A little lower down the creek is the Victory Reef, worked by Curtis Brothers and others during the years 1894 to 1899 with profitable results. Northward, in Bray Creek, on the mountain-slopes north of Roa, near the head of Smoke-Ho Creek, in German Gully, and near Healy's Gully, are a number of quartz veins, most of which do not exceed 1 ft. or 18 in. in thickness. The only metallic constituents identified in any of these veins were oxides of iron, iron-pyrites, and zinc-blende. Several samples submitted for assay for gold and silver gave negative results. A sample obtained from a prospector, however, showed some free gold.

In Blackball Creek, just outside the subdivision, and a little above the junction with Smoke-Ho Creek, a quartz lode several feet in thickness outcrops in the stream. This is the Minerva lode, worked some years ago with almost payable results. The stone, it is said, contained on an average 7 dwt. of gold per ton, of which 5 dwt. was recovered in the battery treatment.

Some miles to the northward of where the Paparoa Range passes out of the subdivision is an area which twelve or thirteen years ago became the scene of considerable mining activity, and was by many thought likely to become a notable goldfield. A large quartz lode known as the Crœsus Reef can be traced across the crest of the range in this area. It is joined by small leaders, one of which at least is stated to have carried rich gold. The Crœsus Company built a battery in the valley of the west branch of Blackball Creek, and from it constructed a very fine aerial tram to the crest of the range. Their operations, however, resulted in failure. Of all the other claims pegged out in the vicinity of the Crœsus, only one, the Taffy, has survived to the present day. After a somewhat chequered career the Taffy claim passed into the hands of a small syndicate, which is now working it with some measure of success. The workings are situated about a mile south-west of the termination of the old Crœsus tram, and deep down in the Ten-mile Creek Valley. Access is given by a well-graded horse-track, which starts near Blackball, and, after reaching the Crœsus, is continued to a point above the Taffy workings. From the horse-track a foot-track leads to the mine itself. The present workings consist of an open cut on a peculiar formation, consisting of a belt of argillite and fine-grained grauwacke ("slate" of the miners) about 60 ft. in width, and intersected by numerous small quartz veins occupying joint-planes. The quartz is very rusty, and shows numerous colours of gold, mostly associated with the iron-oxide. The formation is thus a kind of stockwork. It strikes north-west and south-east, and dips as a whole steeply to the north-east. It is said to have been traced up the hillside for 800 ft., but downhill towards the Ten-mile Creek it cuts out in some unexplained way—perhaps through faulting. Drives also have been put into the formation for short distances, the longest being 130 ft. Some of the loose mullock resulting from the operations of former owners has been sluiced with good results. At present the material from the face, after being hand-picked, is lowered to a battery of five light stamps situated on the bank of the Ten-mile Creek, and worked by water-power. Here the gold content is saved by means of amalgamated copper plates.

The opinion may be expressed that the Taffy stockwork is worthy of being prospected with a view to its development on a large scale. With a 40- or 60-stamp battery worked by the water-power easily obtainable in the neighbourhood, ore of the tenor of that now being handled would prove very profitable.

3. Coal.—Within the last few years the development of the Paparoa coal-seams has added greatly to the amount of available coal in the Greymouth Subdivision. From the detailed investigation lately carried out it will be possible to make an approximate calculation of the amount of coal that may be mined from the coalfield. The coal of the Paparoa seams is bituminous to almost semi-anthracitic in grade. If dirt and stone bands be excluded to the same extent as is possible in ordinary mining, the percentage of ash is low, and that of sulphur very low. The coal cakes readily, forming, as a rule, a hard coke of excellent quality. A characteristic of the Paparoa coals is their wonderful resistance to weathering, the outcrops as a rule being fully equal in quality to the portions of the seams under cover. A defect is their somewhat general friability, so that in the processes of mining and transportation a large percentage of slack is produced. This feature, however, if proper grates are used, and the coal is skilfully fired, need not seriously impair the calorific value. On the whole, then, the Paparoa coals may be considered excellent for steam-raising. For automatic firing, for dust firing, and for use with suction-gas engines and ordinary producer-gas plant, the Paparoa coals are probably the best in New Zealand.

Owing to faulting and irregular folding, the economic mining of the Paparoa seams throughout the coalfield becomes difficult. The deep valleys formed by stream erosion on the flanks of the Paparoa Range afford numerous outcrops, thus enabling the structural relations to be more easily made out and perhaps permitting readier access, but have the disadvantage of cutting the workable portions into blocks that must be mined separately. The loss of much coal by denudation is also a serious matter. From all these factors it follows that the profitable extraction of the greatest possible amount of coal from the Paparoa Beds becomes a problem requiring the highest degree of mining and engineering skill.

With respect to the coal being mined from the Brunner Beds, it has been mentioned on a former page that the State Mine seams (Point Elizabeth), the Brunner Mine seams, and the Blackball Mine seams are in the one horizon. Whether any one of these seams can be correlated with any of the others is a disputed point, and it will therefore be best to leave the full discussion of this matter to the detailed report. However, it may be stated that the writer's provisional conclusion is that the two seams of the Blackball Mine are probably equivalent to the Brunner Main Seam and the Brunner Rider (a small seam found overlying the Brunner Main Seam), whilst the two seams being worked in the Point Elizabeth State Coal-mine belong to a somewhat lower position in the Brunner horizon (the term "horizon" being here used in a rather wide sense).

(4.) Petroleum.—No boring or other prospecting work having been undertaken at Kotuku during the past year, no new data dealing directly with the oil-occurrences have become available. The investigation of the coal-measures, however, has considerable indirect bearing on the subject. On a former page it was stated that probably the coal-measures of the Paparoa Range extend beneath the known Miocene beds of the Grey Valley. To prove the existence of the coal-measures in the Grey Valley by deep boring is important in connection with the oil-occurrences, for the following reasons :—

(1.) The coal-measures are probably the source of the oil.
(2.) The sandstones of the coal-measures would afford good reservoirs for oil.
(3.) A large and permanent oilfield can hardly be expected unless the known Miocene beds are underlain by other sedimentaries of younger age than the Greenland rocks, and any such sedimentaries must almost necessarily be of coal-measure age.

IV. *Miscellaneous Resources.*

In the Grey Valley milling-timber is still fairly abundant, but the more accessible portions of the bush will soon be cut out. The valleys and lower slopes of the Paparoa Ranges will afford a plentiful supply of mining-timber for, perhaps, the next ten or fifteen years.

Water-power for the present requirements of the neighbouring mines could be obtained from the Blackball and Roaring Meg creeks. At present, however, most of the water from these streams is taken up for alluvial-mining purposes.

When in the future it is found necessary to install coal-washing machinery, there will be no difficulty at any of the mines in obtaining abundant water-supplies for this purpose.

MR. E. de C. CLARKE, LATE ASSISTANT GEOLOGIST.

Following my preliminary investigations in the Taranaki oilfield, Mr. E. de C. Clarke commenced detailed examinations in the Waitara Survey District (the eastern part of the New Plymouth Subdivision) with the objects of locating suitable sites for boring in that area, and of obtaining certain information regarding the geological structure. This information was required in order to elucidate certain problems connected with the geology of the whole of the Taranaki oilfield. Mr. Clarke unfortunately did not complete these investigations, as he resigned his position in February in order to accept a demonstratorship in geology in Auckland University. Mr. Clarke reports as follows on the results of the work actually accomplished :—

Geological Survey of Part of New Plymouth Subdivision.

Introductory.

Introduction.—From the 22nd November, 1909, to the 18th February, 1910, the writer was occupied in making a geological survey of a portion of the New Plymouth Subdivision. The following report deals mainly with the eastern portion of the subdivision, the survey in this part having been practically completed. Reference, however, will sometimes be made to some of the salient features of the uncompleted portion of the area.

Area dealt with in Report.—The New Plymouth Subdivision of the Taranaki Division covers an area of about 220 square miles, and consists of the survey districts of Waitara and Paritutu. It is bounded on the north by the coast-line of the North Taranaki Bight from a point about three miles and a half south-west of the New Plymouth Breakwater to a point about one mile and a quarter north-east of the mouth of the Mimi Stream. On the east it is bounded by a zigzag line running southwards for a distance of about twelve miles from the last-mentioned point on the coast-line. The southern boundary is also a zigzag line that runs westward for a distance of about twenty-five miles, where it meets the zigzag western boundary-line that runs southward from the western termination of the northern coast-line.

The Waitara Survey District, with which this report mainly deals, covers an area of about 125 square miles, and makes up the western half of the subdivision, being separated from the Paritutu Survey District by a zigzag line running southward from the Town of Waitara.

Object of Survey, and Plan of Conducting Work.—The sole object of the survey being the ascertaining of the petroliferous possibilities of the area, great attention was given to any "indications" in the shape of oil-seepages or gas-vents, and at the same time every effort was made to determine the geological structure of the area with a view to locating the position of anticlines and synclines, which, according to one widely accepted theory of the origin of petroleum-reservoirs, exert a preponderating influence on the occurrence of oil.

As in the case of the other geological surveys carried out under the present direction, all streams, ridges, roads, and other natural or artificial features that seemed likely to afford outcrops were carefully examined. Owing to the abundance of data on the maps supplied by the Lands and Survey Department, it was not found necessary to make chained traverses of any part of the area, the positions of outcrops being located with sufficient accuracy from the existing maps. The results were plotted on plans reduced to a scale of 20 chains to the inch from the original maps in the Lands Office at New Plymouth.

In order to ascertain as exactly as possible the stratigraphical arrangement of the sedimentary rocks, strikes and dips were observed with great care; and with the same object a great number of barometric heights were recorded.

Numerous supposed gas-vents and oil-seepages, of which information was given locally, were visited, and their positions carefully noted.

Previous Investigations.—The occurrence of petroleum at Moturoa is said to have been known to the Maoris prior to the advent of Europeans to the district.* In 1839 Dr. E. Dieffenbach visited the Taranaki District, and made various observations of a geological character. He noted the character of the rocks composing the "Sugar Loaves" and the adjacent mainland, and recorded also the occurrence of "sulphuretted hydrogen" gas-escapes in the sea near Moturoa.† It is said that a member of Dieffenbach's exploring party found an exceedingly rich specimen of auriferous quartz, the value of which was not known for many years. The locality of this find is unknown, but is almost certainly east of the area at present under consideration.

In 1867 Dr. (Sir James) Hector reported on the Taranaki District.‡ In his report, which seems to form the basis of all subsequent papers, Hector distinguished four different formations, and emphasized the absence at the surface of the alternating beds of sand and clay that are found in the chief oil districts of the world.

In 1899 Mr. Alex. McKay, in a "Report on Petroleum at New Plymouth, Taranaki,"§ gave a history of the search for oil in the district. He concluded that, while some of the surface indications of oil may be due to the decomposition of carbonaceous material in the more superficial strata, the boring operations have proved the existence of oil-bearing strata at a greater depth. Whether or not these are the continuation of the Mokau coal-beds he considered to be impossible of proof.

Towards the end of 1909 Dr. J. M. Bell issued a "Preliminary Report on the Taranaki Oilfield."¶ This report, while dealing mainly with present boring operations near New Plymouth, also gives a brief summary of the geology and physiography of the whole subdivision.

Physiography and General Geology.

Physiography.—The New Plymouth Subdivision exhibits a subdued topography, which may be said to be expressed by two general types—one seen in the western part of the area, the other in the eastern part. The western type—that of the Paritutu Survey District—presents an undulating country traversed by rather shallow, fairly rectilinear valleys. The eastern type, as seen in the Waitara Survey District (with which this report chiefly deals) exhibits a series of steep-sided even-crested ridges separated by sinuous flat-bottomed valleys, through which flow sluggish streams.

In the Waitara type of topography the trend of the ridges is in general parallel to the intervening streams. A striking exception to this rule is the Tarata Ridge, which has a general west-south-west

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* McKay, Alex.: Mines Report, 1899, C.–9, p. 3. † "New Zealand," 1843, Vol. i, pp. 134–35.
‡ Abstract Report of the Progress of the Geological Survey of New Zealand during 1866–67. § Mines Report, 1899, C.–9, pp. 3–10. ¶ C.–14.

and east-north-east direction, and which is broken through by the lower part of the Waitara River. The crests of the ridges show a gradually increasing height as the country is traversed from west to east. The highest points in the subdivision are the trigonometrical stations of Tuahu (1,075 ft.), Taramouku (1,055 ft.), and Urenui (1,030 ft.). These elevations, however, are only slightly higher than many other points on the ridges to which they belong.

All but the very smallest streams flow at grade almost to their source, and in the eastern part of the subdivision, even where, near their head-waters, they enter narrow little gorges with precipitous walls cut in the soft "papa" (claystone, &c.), their course is still excessively sinuous, and but rarely interrupted by even the smallest waterfalls.

In the Waitara Survey District the sea-beach of black sand is generally bounded by vertical and in places overhanging cliffs, usually less than 100 ft. in height, though they show a slight increase in altitude to the north. The cliffs are interrupted by the alluvial plains at the mouths of the larger streams such as the Mimi, Urenui, Waitara, and Onairo. The smaller streams, which enter the sea directly, do so, as a rule, over waterfalls.

Outlying reefs and islets are markedly absent from the coast of the Waitara Survey District, but in a few places portions of the cliffs have become almost or quite separated from the mainland by narrow rifts fretted out by the waves.

A small lake not more than 20 ft. deep occurs in the south-western corner of the Waitara Survey District. It occupies what is probably an area of subsidence. Other subsided areas show the remains of similar ponds now converted into raupo swamps.

The present topography of the New Plymouth Subdivision may be understood when it is recognized that at the close of the period during which the great series of sediments generally regarded as of Miocene age accumulated, there ensued elevation which raised the sediments 1,000 ft. or more above sea-level. After a considerable period of dissection, the new land-surface was buried, except perhaps in the extreme east of the subdivision, under débris from the great volcano, or group of volcanoes, that for convenience will be referred to in this report as the Taranaki Volcano. Of this volcano the present Mount Egmont is but a remnant.

The formation of the Taranaki Volcano profoundly influenced the drainage of the country. Before the period of volcanic activity the rivers flowed in the main from east to west. The great mass of volcanic material formed a barrier diverting the westerly flowing streams to the north and the south, and produced also a number of new streams that flowed eastward off the flanks of the mountain. A glance at the map will show that such rivers as the Waitara in the north, and probably the Wanganui in the south, have been deflected in the manner just described.

The effusion of volcanic débris was either preceded or followed by an appreciable subsidence, though following this event there has probably been some elevation. The coast-line of the Waitara Survey District shows clearly the effects of this last elevation, followed by marine denudation. The uniform character of the rocks, which therefore entails a nearly uniform rate of erosion, explains the almost total absence of outlying reefs and islets already mentioned.

Summary of Geology.—The oldest rocks in the area under consideration are a succession of claystones and sandy claystones, with less frequent sandstones and conglomerates. These rocks, from palæontological evidence, appear to be Miocene in age, and will be spoken of as the Miocene Rocks in this report.

Lying in marked unconformity on the Miocene Rocks are rudely stratified layers of basic or semi-basic volcanic débris. These are probably to be assigned to the earlier phases of activity of the Taranaki Volcano.

Near the sea-coast a small development of marine sands overlies, apparently unconformably, the Miocene Rocks, and may be said to be Pleistocene in age, in order to distinguish it from the recent alluvial and marine accumulations of sand, mud, and gravel that occupy the sea-coast and the flood-plains of the streams.

The writer has not been able to recognize the unconformity near the mouth of the Onairo Stream that according to Hector marks the division of the Miocene rocks mentioned above into older and newer Tertiary.

Miocene Rocks.—*Distribution.*—Almost throughout the area under consideration the Miocene Rocks are covered by volcanic débris, but over about eighteen square miles in the south-east corner of the area this covering is so thin as to be negligible from a geological standpoint. In general it may be said that the Miocene Rocks are found outcropping in almost every gully as far west as the Waitara River. On the sea-coast the Miocene beds are not found west of a spot near a small stream about three-quarters of a mile east of trigonometrical station IX (Waihi), where they disappear beneath the Volcanic Débris.

Petrology.—The Miocene Rocks are in the main soft calcareous claystones, frequently rather sandy, and rarely passing into rather incoherent sandstones. These sandstones are often abundantly micaceous, and occasionally contain small coaly partings. This latter feature is especially noticeable near the quarry on the Okoke Road not far from its junction with the Mokau Road. The claystones and sandstones are frequently fossiliferous. In places bands of conglomerate varying in thickness from a few inches up to ten or twelve feet are found. Like the claystones and sandstones, the conglomerates are often fossiliferous. The pebbles of which they are composed are in the main of quartz, quartzite, and jasperoid rock, but fragments of grauwacke, and possibly diorite, are also rather common. The pebbles vary in size from small fragments to boulders 6 in. in diameter. All are well rounded and water-worn. The material of which the conglomerates are composed is evidently derived from the old sedimentaries and intrusives lying to the east of the area under review, which make up the structural axis of the North Island, and which were usually referred to the Maitai Series of supposed Carboniferous age by the staff of the former Geological Survey.

Structure.—As already noticed, the streams in the Waitara Survey District flow nearly to their head-waters through alluvial deposits, and therefore no outcrops of the Miocene Rocks are to be found in the actual watercourses except near their sources. It thus follows that the great majority of the strikes and dips recorded had to be obtained on the sides of spurs some distance from the streams, on faces exposed by landslips, in road-cuttings, quarries, and similar places. Though care was taken to record only those observations made in strata undisturbed by slipping, it seems probable that a certain amount of sagging would take place along exposed faces of such soft strata as those under consideration. When the prevailing low angle of dip is also remembered it becomes evident that, however much care may have been exercised in the field, the liability to error in recording the direction of strikes and dips is great.

A careful plotting of the most reliable strikes and dips has failed to reveal the existence of any persistent anticlines and synclines. The strata under consideration dip to all points of the compass, but on summarizing it will be found that the westerly dips outnumber the easterly in the proportion of three to one. The directions of the westerly dips are divided almost equally between south-west, west, and north-west, but in the south-east portion of the Waitara Survey District the dips show a slight preponderance to the south-west, whilst in the north-east portion the dip is more usually to the north-west.

The dips are always at low angles, usually less than 10°, while only ten or twelve instances of dips of 15° or more and about the same number of dips at angles between 10° and 15° were observed. Of these higher dips a few more are westerly than easterly.

It thus appears that the Miocene Rocks are arranged in gently undulating fashion, but are in general dipping in a westerly direction, and that there is some faint indication that they form the western end of a westerly pitching anticlinorium, the axis of which runs in a north-west and south-east direction.

No evidence of faulting was found in any of the exposures of the Miocene Rocks, but in six localities the topography seems to indicate that local subsidence of the Miocene Rocks has occurred. These localities are (1) in the acute angle formed by the junction of the Richmond and Ackworth roads, (2) on the west side of the Richmond Road about half a mile beyond its junction with York Road, (3) near the Mangohewa Road line about half a mile from its junction with the Otaraoa Road, (4) at the head-waters of the Maugaonga Stream, (5) near the head-waters of the Mangapoua Stream, and (6) just outside the eastern boundary of the Waitara Survey District about half a mile north of the Junction Road. It must be remarked that no outcrops of Miocene Rocks have been found near the first two of the six localities mentioned, and the depressions may be due to subsidences in the overlying volcanic débris alone. In the other four localities there can be little reasonable doubt that local basin-faulting of the Miocene Rocks has occurred. In each case basin-like areas bounded by more or less steep-sided edges have been produced. In the case of the two "graben" in the south-east portion of the area the ground is traversed by ditches and mounds which are probably the remains of minor fault-scarps. It must be added here that the possibility of the ditches and mounds being the remains of Maori fortifications was fully considered, and found untenable.

It was hoped that some connection between these graben, the main structural features of the Miocene Rocks, and the occurrence of oil-indications would be established; but the facts so far collected are not sufficient for the drawing of general conclusions.

Palæontology, Age, and Correlation.—Large numbers of fossils were collected from many outcrops of the Miocene Rocks. No more than field identifications are at present available, but there is little doubt that the rocks in question are more or less homotaxial with the Miocene (Oamaru and Jenkins Hill) rocks of Nelson.*

North-east of the area under review lie the coal-bearing rocks of the Mokau district, which are generally regarded as conformable to the Miocene Rocks of this report. To the south lie the rocks of the Wanganui Series, which are usually considered to be Pliocene. A careful study of critical sections in the field and of large collections of fossils from the Mokau, Waitara, and Wanganui rocks would be of interest both as throwing more light on the interrelationships of New Zealand Tertiaries and as indicating the probability or otherwise of the westerly continuation of the Mokau coal-bearing rocks towards New Plymouth and Wanganui.

VOLCANIC DÉBRIS.—*Distribution.*—As already explained, practically the whole of the Waitara Survey District is covered to a varying extent with débris derived from the ancient Taranaki Volcano. The thickness of the Volcanic Débris is of course very variable, since it was deposited on a previously dissected land-surface. Except in the western portion of the Waitara Survey District the thickness of the Volcanic Débris rarely exceeds 50 ft., but to the west, and almost throughout the Paritutu Survey District, the thickness increases to the entire exclusion at the surface of the Miocene Rocks.

Petrology.—No microscopic sections or chemical analyses of the rocks in question are yet available. It seems likely, however, that the Volcanic Débris will prove to be made up of andesites of various types. Hornblende-augite-andesites have already been described from Mount Egmont and the neighbourhood of New Plymouth.†

Structure.—In general, the boulders of the Volcanic Débris are loosely aggregated, and show little assorting as to size. In the Waitara River, however, about one mile and a half above the mouth of the Manganui River, the rocks under discussion are found in the form of slightly waterworn pebbles unconformably overlying the Miocene Rocks, and showing distinct, rather inclined bedding. These excep-

* See Bull. No. 3 (New Series) N.Z.G.S., p. 49, &c.; and Bull. No. 12 (in course of publication).

† Marshall, P.: "Distribution of the Igneous Rocks of New Zealand"; Rep. Aust. Ass. Adv. Sci., Vol. xi, 1908, p. 375. See also Hutton, F. W.: "Corrections in the Names of some New Zealand Rocks"; Trans. N.Z. Inst., Vol. xxxi, 1898, p. 484.

tional beds are probably the deposits of a large stream that existed in these parts during the early stages of activity of the Taranaki Volcano.

Buried Forest.—Well-sinkings in the country near, and especially to the north of, the old military settlement of Tikorangi (as well as in many parts of the Paritutu Survey District) usually pass at a depth of 20 ft. to 40 ft. through a notable layer of vegetable débris consisting of carbonized trees, creepers, &c., apparently identical with species at present growing in the forests of Taranaki. It could not be definitely ascertained whether this buried forest always lies on a surface of Miocene Rocks, but it seems probable that the deposits in question are the remains of the vegetation that grew on the land-surface of Miocene Rocks, and was buried under the ejecta of the Taranaki Volcano.

Lignitic Beds.—In the extreme south-west corner of the Waitara Survey District a rectangle measuring about two miles from east to west and one mile and a half from north to south contains post-Miocene deposits of a type differing from those just described. These deposits consist of 12 ft. to 20 ft. of alternating layers of sand and impure peaty lignite. The sand is made up of fragmentary crystals of ferro-magnesian minerals and of feldspar, the latter much decomposed. In the upper layers the bands of sand are thicker, whereas towards the base the lignite layers become predominant. These beds are most probably underlain by volcanic débris of the ordinary type; but direct proof of this has not been obtained.

The most plausible explanation of the origin of the lignitic beds is that during the period of activity of the Taranaki Volcano one or more lakes were formed in this part of the Waitara Survey District, and that in these lakes the deposits described above accumulated during alternate periods of volcanic activity and quiescence.

Bog-iron Ore.—Small beds of bog-iron ore resulting from the decomposition of the volcanic débris are found in various places, but appear to be of no consequence.

Pleistocene and Recent Deposits.—On the Mokau Road, in the cuttings on the north bank of the Mimi Stream, loosely consolidated sands containing a considerable proportion of "ironsand" are seen. The same sands are found on the Tupari Road about three-quarters of a mile beyond its junction with the Okoke Road, and, overlying the Miocene Rocks in apparent unconformity, on the sea-coast in the north-east corner of the Waitara Survey District. The relation of these sands to the Miocene Rocks is not quite certain, but may be elucidated in the future by the study of sections further to the north. It seems probable that the sands in question are unconformable to the Miocene Rocks, and since, if they are beach deposits, elevation must have intervened between their deposition and the laying-down of the recent deposits (to be described immediately), they may be temporarily classed as Pleistocene. It must here be mentioned, however, that they bear a strong resemblance to the so-called petrolaceous sands that, interbedded with Miocene Rocks, occur in one of the bores near New Plymouth.

Under the heading of "Recent Deposits" may be classed the marine sands of the sea-front, the fluvio-marine deposits of sand and silt at the mouths of the streams, and the silts deposited in the river-valleys. Sand-dunes, which have a small development in the Paritutu Survey District near the coast-line between Waitara and New Plymouth, are not found in the Waitara Survey District.

The beach-sands of the Waitara Survey District are the black "ironsands" for which Taranaki is well known. An examination of the sand during the summer of 1909 showed that the proportion of iron-ores in it was small. The iron-ore grains, being heavier than the other components of the sand, are dropped first by the waves of each falling tide, and form at low water a covering over the more heterogeneous material that has not been affected by that particular tide. This covering, however, is on an average only about ½ in. thick, and in places is absent altogether. It is thus evident that the iron-ores of the Waitara Survey District are of little importance, unless during certain weather-conditions much greater amounts of "ironsand" than were seen by the writer are brought up by the action of the waves.

The sand of the sea-beaches is derived mainly from the erosion of the volcanic débris described in the previous section, though smaller quantities of the more durable constituents of the Miocene Rocks may usually be detected. The most abundant constituents of the beach-sands will probably prove to be ferro-magnesian minerals.

The silts of the river-valleys in the Waitara Survey District are derived mainly from the Miocene Rocks, and contain a variable percentage of "ironsand" from the volcanics. The silts are of importance from an agricultural point of view, but call for no further description here.

Possibilities of Payable Oil in the Waitara Survey District.

Oil has been obtained in considerable quantities at Moturoa in the Paritutu Survey District, and near the Town of New Plymouth. Any explanation of the occurrence of oil at Moturoa may therefore reasonably be applied to the Waitara Survey District with the object of determining whether or not payable oil-wells may be located in that area. Unfortunately it is impossible at present to decide which of the several theories of oil origin and accumulation is most applicable to the New Plymouth oilfield. Whether, for example, the oil has originated from the decomposition of organic remains in the Miocene Rocks, or whether it has been formed by inorganic chemical processes (a theory little favoured at the present day) connected with the igneous rocks of the Taranaki Volcano, there is as yet little evidence to decide.

Again, if the oil had an organic origin, it might be supposed that the distillation by which it was formed was due to the intrusion of the igneous rocks of the Taranaki Volcano, in which case it would probably be useless to bore for oil except in the neighbourhood of these rocks. Further, the occurrence of payable oil-pools may have been determined either by folds in the Miocene Rocks, or by fissures caused by the igneous intrusions, or by some factor that at present is altogether obscure. In this preliminary report it is possible merely to summarize the facts obtained during the course of the present survey, and to draw tentative conclusions as to the probable future of the Waitara Survey District as an oilfield.

A large number of so-called oil-indications in the Waitara Survey District were visited by the writer, but, so far as surface features are of value, none seemed very important. In the majority of cases the "oil" proved to be a film of iron-oxide formed by the oxidation of ferrous carbonate. In other cases the scum appeared to be organic in origin, and due either to abundant fresh-water algæ or to the decomposition of buried organic matter.

Several wells the water of which had proved unfit for use were examined, especially those belonging to the farmers on Bristol Road near its junction with Everett Road, and on the southern part of York Road. Investigation showed that, although in some cases petroleum was said to have formed a scum on the surface of the water in the wells, and to have distinctly flavoured it, the water was usually unpotable owing to the presence of an excess of iron-compounds, and in a less degree owing to organic impurities, all of quite superficial origin. It may be noted, however, that on the left bank of the Manganui River, just above the Bristol Road crossing, very abundant seepages of iron-oxide, which possibly contain some petroleum, occur.

Three reported occurrences of petroleum may be mentioned in more detail. Close to the farm-house at the junction of Kelly and Ackworth roads petroleum is said to be frequently found as a scum on the surface of spring-water, especially after heavy rains. The writer was assured that this scum has been collected and burnt by means of a small wick. The scum seen by the writer on the occasion of a visit during a prolonged spell of dry weather was collected, but proved to be only iron-oxide.

Thirty-five years ago strong traces of oil are said to have been found by Messrs. Vickery and Hicks when digging a sheep-dip near the old military settlement of Tikorangi. Almost the exact location of this sheep-dip was indicated to the writer by Mr. Hicks, and two holes were dug to what he considered the depth at which the oil had oozed out in former days; but no trace of oil was found.

In early days large patches of oil are said to have been noticed floating on the sea at the mouth of the Waitara River. This was long before the erection of the freezing-works or the initiation of other commercial enterprises that by their operations might have given rise to the oily matter. It is just possible, however, that the oil had drifted from the "Sugar Loaves" near New Plymouth, where large patches of petroleum are frequently seen floating on the surface of the sea.

Gas-vents.—Gas-vents are of comparatively rare occurrence in the Waitara Survey District, and, so far as the writer has observed, are confined to an area of about three and three-quarter square miles, extending one mile and a half northwards from the southern boundary of the survey district, and bounded on the east and west by the Waitara and Manganui rivers respectively. Escaping bubbles of gas may be seen in most of the swamps and sluggish streams throughout the survey district, but may usually be ascribed to the decomposition of recently entombed organic matter. In the area defined above several escapes, more especially those in the Waitara River, appear to be too strong and constant to have such an origin.

There are two localities in which gas is escaping in fairly large quantity and is almost certainly of deep-seated origin. The first is at the junction of Bristol and Junction roads south of the boundary of the Waitara Survey District, and outside the area defined above, and the second is on Mr. Bishop's property, beside the Mangaone Stream, nearly two miles above its junction with the Waitara River. In both these places gas is escaping with some force. No analyses of the gases have yet been made.

Conclusion.

From what has already been said concerning the structure and arrangement of the Miocene Rocks it is evident that in all probabilty strata of the same horizon as those that are reached only by deep borings near New Plymouth will be found nearer the surface in the Waitara Survey District and still nearer the surface further to the east. It is evident also that the impossibility of locating well-defined anticlines and synclines in the Waitara Survey District, or, rather, the entire absence of such, prevents any definite indication of the most promising sites for bores in that area. It is, however, quite possible that further research in the Taranaki oilfield will show that the "anticlinal theory," which is not always a guide to the finding of oil, must be disregarded in this area, and that some other principle should be followed in choosing sites for bores. There is some reason to expect that explorations to the south and east of the area at present under review will prove that the anticlinal structure will there become more definite, and possibly the "oil-indications" more promising. It must be noted, however, that, unless some definite conclusion as to the mode of origin of the oil at Moturoa can be arrived at by further geological studies in that neighbourhood, boring for oil in the Waitara Survey District will be of a rather speculative character.

In connection with the possibilities of the country further to the east it may be noted that there are many well-authenticated reports of gas-vents in that direction. Moreover, lumps of bituminous matter have several times been picked up on the coast-line near the Petone Creek in the Mokau district. The largest of these weighed about 43 lb.

A sample recently submitted to analysis in the Dominion Laboratory gave the following results:—

Fixed carbon	26·00
Hydrocarbons	70·94
Loss at 100° C	2·81
Ash	0·25
	100·00
Specific gravity	1·037

Dr. Maclaurin remarks that the sample closely resembles Syrian asphalt.

Mr. A. Watkins, of New Plymouth, to whom the writer is indebted for many courtesies, remarks in a letter that the bitumen of the Mokau district has been known to the Maoris for many centuries, and that it formed a valuable article for trading purposes.

It seems probable that the asphaltum is derived from seams of the mineral occurring either along the sea-beach or in one or more of the streams that enter the sea in the neighbourhood of Petone Creek.

The writer has been informed that pieces of "soft coal," which were used for making candles, were found in the country east of the Waitara Survey District some years ago.

These occurrences of asphalt point to the probable existence of hydrocarbon-deposits in the more easterly areas of the Miocene Rocks.

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