1909.

NEW ZEALAND.

NEW ZEALAND GEOLOGICAL SURVEY

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

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

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REPORT.

SIR,— Geological Survey Office, Wellington, 28th July, 1909.

I have the honour to present to you the third 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.

DURING the season 1908–9 the Geological Survey has conducted surveys, both topographical and geological, in many parts of New Zealand.

The present report deals with the year commencing on the 1st June, 1908, and ending on the 31st May, 1909.

SUMMARY OF OPERATIONS.

During the season just closed work has been conducted by the Geological Survey in several parts of the North and South Islands.

The survey of the Whangaroa Subdivision in North Auckland, commenced in July, 1907, was finished in November, 1908. A detailed bulletin on this interesting area, which contains deposits of copper, mercury, and iron, and other features of economic interest, is now in the printer's hands.

A comprehensive investigation of the Thames Goldfield and of the adjoining survey districts of Hastings, Thames, and Waihou, known as the Thames Subdivision, was commenced in November, 1907. The work was continued throughout the past season, and has just been completed. The exhaustive examinations revealed many features of great economic interest in connection with this interesting and formely highly remunerative goldfield. Mr. Fraser, under whose direction the work has been conducted, will prepare a report thereon during the present winter.

In October last Mr. K. M. Graham commenced the topographical survey of the Waihi Subdivision—lying just east of the Thames Subdivision. Perhaps no one area in New Zealand requires more careful investigation. The area, which comprises the survey districts of Whitianga, Tairua, and Ohinemuri, contains the mining-fields of Tairua, Waihi, and Karangahake.

The survey of the Whatatutu Subdivision—a portion of the Poverty Bay Oilfield—started in January, 1908, is also just finished. The detailed bulletin by Mr. J. H. Adams on this area will contain much of value to those interested in the geology and technology of petroleum-fields in New Zealand.

A systematic investigation of the Dun Mountain Subdivision, which includes the City of Nelson, and comprises the survey districts of Waimea and Maungatapu, was commenced in October last, and the work thereon is now nearing completion. The area contains the chrome and copper deposits of Dun Mountain and the Aniseed Valley, and the widespread Tertiary strata with coal-seams that lie along the north-western base of the Aniseed Hills.

In Karamea, topographical surveys have been continued throughout the year; but, though the work has been considerably advanced, much still remains to be done. Very little geological work has as yet been accomplished; but, as will be seen by a perusal of Mr. Richardson's brief report in this statement, an extensive coalfield with several seams of an excellent sub-bituminous coal has been located.

The Geological Survey party under Mr. E. J. H. Webb, which has been operating in the Mount Radiant copper-molybdenite field since the beginning of 1908, has almost completed its examinations.

The survey of the Greymouth Coalfield and of the Kotuku Oilfield—both in the Greymouth Subdivision—was commenced by Mr. P. G. Morgan in November last, and has been prosecuted continuously ever since. The work has advanced rapidly, but it will take at least another field season to complete.

Investigations were conducted by myself at the Franz Josef Glacier during the month of February, my object being to add some necessary geological data to the topographical work carried out at this remarkable glacier during the previous season by Mr. R. P. Greville.

Professor P. Marshall was again employed on the staff of the Geological Survey. His examinations during the past season lay in the Dun Mountain Subdivision, where he worked during the months of December, January, February, and part of March.

In addition to the detailed investigations above mentioned, a reconnaissance was made by myself and Mr. E. de C. Clarke to the North Cape, and somewhat cursory examinations were also made of coal-bearing strata near Belgrove, and near Tadmor, Nelson.

PUBLICATIONS.

Last year the second annual report of the Geological Survey was issued. This publication contained an account of the operations of the survey during the season 1907–8. In addition, Bulletins Nos. 6 and 7 were issued.

Bulletin No. 6, written by Mr. P. G. Morgan, describes topographically and geologically a portion of South Westland known as the Mikonui Subdivision.

Bulletin No. 7, entitled "The Geology of the Queenstown Subdivision, Western Otago," was written by Professor James Park as the result of field-work done during the season of 1907–8.

In all, approximately 2,100 copies of the bulletins were distributed, and about 800 copies of the second annual report.

FIELD AND OFFICE WORK OF THE DIRECTOR.

With the exception of a few brief visits to Wellington on departmental business, I was constantly engaged in field-work from the beginning of August till the end of May. The short period from the 5th to the 10th August was occupied in a casual examination of coal-bearing strata in the neighbourhood of Tiraumea Sheep-station, south east of Eketahuna. From the 14th to the 20th August I was absent in Nelson, where a preliminary inspection was made of the copper-deposits of the Aniseed Valley, with a view to more elaborate investigation at a later date.

On the 22nd August I left Wellington for the Bay of Islands to undertake the mining geological work in connection with the survey of the Whangaroa Subdivision, which was then being prosecuted under Mr. E. de C. Clarke's direction. My time was spent in North Auckland from the 25th August till the 9th October. Of this period some ten days were occupied in a reconnaissance expedition to the North Cape and Cape Maria van Diemen.

The period from the 12th October to the 21st October was utilised in a brief investigation of the geological and mining explorations being conducted in the Thames Subdivision by Mr. Colin Fraser, and in the organization of the topographical survey under Mr. K. M. Graham in the Waihi Subdivision.

On the 30th October, after a brief stay in Wellington, I left for Nelson, where the systematic survey of the Dun Mountain Subdivision was commenced. The work in this important mineral area claimed my attention until the 13th January, and again from the 12th April to the 27th May.

From the 15th to the 19th January I conducted some rather hurried investigations of the coal-seams at West Wanganui, Pakawau, and Otemataura, and then continued up the Aorere Valley and across the Gouland Downs to the Valley of the Heaphy, where I remained till the 7th February. Most of the remainder of the month and the first week in March were occupied in a hurried inspection of the work being conducted in the Greymouth Subdivision under the direction of Mr. P. G. Morgan, and in a geological examination of the Franz Josef Glacier and immediate neighbourhood.

Investigations at Tiraumea.

The Tiraumea Stream, near the headwaters of which lies the station of the same name, is a tributary of the Manawatu. The area has been examined geologically in the past by McKay and others, and this report may be considered in the main a recapitulation.

On the Tiraumea Estate two series of rocks are exposed — a lower Tertiary series and a pre-Tertiary series (probably early Mesozoic), called by McKay the Rimutaka Series. The latter consist of shattered and often shaly argillites and grauwackes. The argillites are in places reddish and purplish, and frequently contain quartz in small and very irregular lenses. The Tertiary rocks have been classified as Eocene by McKay. The series in the locality under discussion is made up of fine conglomerates, sandstones, and limestones. The beds dip generally at very low angles, though in places very pronounced variation from horizontality is observable. False bedding is conspicuous in the sandstones, which are usually of a yellowish colour, and to a less extent in the conglomerates.

Thin and very inconsistent seams of low-grade coal (apparently sub-bituminous or lignitic in quality) appear in several places on the Tiraumea Estate, notably in Spring Hill Creek, a small tributary of the Ngarangikopo, which again is a tributary of the Tiraumea; and, again, close to the Ngarangikopo, just below the falls on that stream; and, further, near the Tiraumea Falls themselves. The seams are only a few inches thick, and, though they may contain a little fine lustrous coal, in general the material is very impure.

While it is notable that the coal is always seen in practically the same horizon, namely, in the conglomerates and sandstones just above the Rimutaka Series — a fact which suggests a definite stratum—the thinness and great irregularity of the seams and the general impurity of the coal appear unfavourable to the discovery of any definite continuous deposit.

The limestones apparently are generally impure, being either sandy or clayey. Generally, too, the thin beds of a foot or less in thickness are interstratified with beds of claystone, as seen at the Tiraumea Falls. It is proposed to use the limestone as road-metal, for which purpose it will prove of great value. Some of it might later be utilised for cements.

Typical specimens of the limestone from Maire Creek and that from Tiraumea Falls on analysis gave the following results:—

	(1.)	(2.)
Silica (SiO_2)	28·20	33·20
Alumina (Al_2O_3)	5·16	4·97
Iron-oxide (Fe_2O_3)	1·64	1·88
Lime (CaO)	35·25	30·12
Magnesia (MgO)	0·74	0·76
Carbonic anhydride (CO_2)	28·20	24·10
Moisture and organic matter	0·32	3·72
Alkalis and undetermined	0·49	1·25
	100·00	100·00

Work in Whangaroa Subdivision.

The general geological examinations in the Whangaroa Subdivision were almost completed by the time of my arrival in the area. There remained, however, to be done much careful scrutiny of the economic mineral wealth, as well as some physiographic and hydrographic investigation. As the bulletin on the Whangaroa Subdivision is now in press, it is unnecessary here to describe the area in any great detail. However, a few general remarks about this interesting subdivision may be of interest.

The oldest rocks, which have been tentatively called the Waipapa series, are probably early Mesozoic in age. They consist of quartzites, phyllites, argillites, and grauwackes, with interbanded flows

and accumulations of agglomerate. The Waipapa rocks are much folded. Above them lie the Kaeo Series of argillites, claystones, sandstones, and limestones. These rocks, which are greatly disturbed and faulted, but are not actually much folded, seem to vary in age from late Cretaceous to early Tertiary. Above the Kaeo rocks lie two great series of volcanics—the first andesitic in character, the second doleritic. Each consists of pyroclastics and lava flows, but in the earlier series (known as the Wairakau Series) fragmental rocks predominate, while in the latter series (Kerikeri) the lavas are more conspicuous. With the Wairakau Series occur in a few places thin beds of water-laid sediments. Since the Wairakau Series was deposited, acidic volcanics have reached the surface, and still more recently basic volcanics have built up several cones and formed a number of lava flows.

From a physiographic standpoint the most salient feature of the Whangaroa Subdivision is a broad faulted table-land (from 700 ft. to 1,400 ft. high), the individual blocks of which are almost intact near the centre of the area, but are deeply dissected towards the sea to the north, east, and west by the various streams.

The shore-line is interesting, as it displays to a remarkable degree the effect of a relatively recent advance of the sea over a well-dissected land.

From an economic mineral point of view there is little of any great importance, if we except kaurigum, which is still dug in considerable quantity, though in annually diminishing amounts. Ores of copper, mercury, iron, and manganese occur in the area, but none apparently in very great quantity. Deposits of oil-shales are also found in the neighbourhood of Pungaere.

The copper deposits consist of irregular and much-faulted lenses in shaly argillites, and occur in the slopes of Maungaemiemi Mountain. The ore is mainly cupriferous marcasite (in places pyrite), with some chalcopyrite and a very little chalcocite, bornite, and covellite. The gangue-material is mainly calcite and country rock, but there is generally a little quartz. A number of claims have been staked in the cupriferous area, and on several—notably the Hare-Ratjen Claim, the Whangaroa Amalgamated Claim, and the Ferguson Company's Claim—considerable exploration has been conducted, though so far not with very marked success. On the Hare-Ratjen Claim occur the most definite veins, but these never exceed 5 ft. in thickness, and are rarely as much. Moreover, their greatest longitudinal extension so far discovered amounts only to 24 ft. However, there is no doubt that further prospecting of the claim is warranted.

The Whangaroa Amalgamated Claim exhibits some very handsome ore, containing a large percentage of chalcopyrite with the marcasite and pyrite; but as yet no continuous seam of ore has been located.

The mercury deposits are located at the Ohaeawai Hot Springs, about four miles south-west of the township of the same name. The deposits are of great scientific and possibly of some economic value. The ore, which is mainly cinnabar, though with some native mercury, occurs as impregnations with marcasite and native sulphur in shattered and sintered claystone and sandstone of probably late Tertiary date. There is still marked hydrothermal activity in the vicinity, with numerous warm pools from which steam issues. Hydrogen-sulphide is also expelled from the surface in many places, and petroleum is being naturally distilled in at least one locality. It seems probable that mercury is still being deposited by the heated waters, as traces were found in some of the waters analysed.

It is very difficult to state how great is the quantity of mercury-ores available. The quality in general seems to be low, the material as a rule assaying less than 1 per cent. in the metal. Mining operations are said to have been difficult owing to the great heat of the ground, while in the plant the condensation of the mercury was not effective. In the opinion of the writer, the quantity of mercuriferous sinter sufficiently rich in the metal to be called ore is not great, but the exact amount can be ascertained only by very careful prospecting. This exploration seems distinctly warrantable at the localities known as Shaft Springs (Area No. 1 of Bulletin No. 8), and the Maori Reserve (Area No. 5). The difficulty formerly experienced with the great heat of the ground could be overcome by mining in wide, open pits. It may be mentioned *en passant* that the waters of the Ohaeawai Hot Springs are of marked therapeutic value in connection with certain skin-diseases.

Though the iron-ores of the Whangaroa Subdivision are of widespread occurrence and of very great purity, they never occur in very large quantity. The ore is limonite, and generally contains about 50 per cent. of metallic iron. The largest deposit occurs on the Okaihau–Kerikeri Road, about three miles from Okaihau. A careful estimate gave about 100,000 long tons at this locality. Another small deposit is situated near Pungaere, and a still smaller deposit on the ridge between the Pungaere and Kohatu Whakangaongao creeks.

The manganese veins in Waipapa rocks are of no economic importance, being merely narrow seams of very impure material. The manganese minerals are psilomelane and pyrolusite.

The oil-shales mentioned above as occurring at Pungaere are found outcropping for 3 or 4 chains along the right bank of the Waiarewau Stream. The oil content is not high, as will be seen by the subjoined analyses, and the amount varies in the different beds; but it is possible that more improved methods of refining than those now in use may make the beds of value in the future. Paraffin-oil is obtained in Scotland from rocks yielding only a slightly higher percentage of volatile hydrocarbons than those at Pungaere.

Of the following two analyses, No. 1 is from a representative specimen of the poorer material, and No. 2 is from that of better quality:—

	(1.)	(2.)
Fixed carbon	7·47	4·75
Volatile hydrocarbons	18·12	26·95
Water	1·11	1·50
Ash	73·30	66·80
	100·00	100·00

Reconnaissance of North Cape Peninsula.

Introduction.—The object of my journey to the North Cape was to get a general idea of the geology of that comparatively little-known part of New Zealand, and, more especially, for the purpose of correlating the strata occuring in the limited area of the Whangaroa Subdivision with the more extensive area farther north, in which similar rocks outcrop.

General Geology.—The geology of the North Cape Peninsula is distinctly complicated. The oldest rocks apparently are highly corrugated argillites and grauwackes, with which occur widespread flows of amygdaloid and allied volcanics. The age of the rocks is uncertain, though they are probably Mesozoic. It is possible they may belong to two series as indicated by McKay, though, judging from the limited section seen by us, no definite reason for any such separation seems to exist.

The argillites are greyish, greenish, or purplish in colour. The amygdaloids in many places show a curious pseudo-agglomeratic structure, with rounded areas enclosed in a matrix of the same material, showing, however, a faint alignment, and containing much chloritic and calciferous material.

Rocks of this oldest series outcrop at Scott's Point, and are practically continuous from Cape Maria van Diemen to Tom Bowline Bay. They also appear around Parengarenga Inlet.

The rocks of Mount Camel are thought to be of the same age as the ones just described further north, though it is possible they may be older.

Cutting these rocks between the North Cape and Tom Bowline Bay is a great mass of igneous rocks —all of ultra-basic type, and comprising gabbros, norites, lherzolites, and harzburgites. It is probable that smaller masses or dykes of similar ultra-basics cut the older sedimentaries and flows at several points west of Tom Bowline Bay.

Unconformably above the earlier sedimentaries and igneous rocks are fossiliferous sandstones and shales, with coal-seams. The sandstones are practically reassorted volcanic tufa, and they represent merely the lower beds of volcanic breccia which are of widespread outcrop on the hills to the south-east and north of Parengarenga Harbour and towards Tom Bowline Bay. These breccias are generally conceded to be of Miocene age—a fact to which fossiliferous beds at their base testify. They are apparently similar in age to the Manukau breccias and to the Wairakau breccias of the Whangaroa Subdivision.

The fossiliferous sediments at the base of the breccias of the area now being described occur to the north of Parengarenga Inlet, and again just south of the North Cape. These rocks, as well as the overlying breccias, generally lie horizontally or at least at angles departing but slightly therefrom.

Above the breccias are a series of but slightly coherent sands, grits, fine conglomerates, and peat-beds. McKay classifies these as Pliocene, but it is probable that they extend from that period into the Pleistocene. These beds are conspicuous just south of Cape Maria van Diemen, north of Parengarenga Harbour, and southward therefrom almost as far as Hohoura. In many places, however, they, with older rocks, are almost completely shrouded by the widespread and all-invading sand-dunes which cover practically the whole of the North Cape Peninsula from Ahipara to within a mile of Parengarenga Inlet on the east and as far as Rocky Point on the west.

Economic Geology.—From an economic standpoint there is comparatively little interest in the geology of the North Cape Peninsula. The mineral wealth may be discussed under the following sections: (1) Quartz veins, (2) copper-ore, (3) iron-ore, (4) coal and peat, (5) glass-sand.

(1.) *Quartz Veins.*—Quartz veins occur at Mount Camel, and on the ridge to the north thereof; to the east of Hohoura Inlet; and also near Cape Kerr. An inspection was made of a vein near Hohoura Inlet on which a little prospecting work had been done. The quartz is opaque and cherty in appearance and of a greyish-blue colour. The enclosing rock is argillite, which forms very indefinite walls to the narrow vein (about 2 ft. wide). Analyses of the quartz showed neither gold nor silver to be present. The veins of Mount Camel are said to be much wider than the one near Hohoura, and to be well mineralised.

A tiny stringer of quartz a few inches wide was noted in pinkish and rusty argillites just west of Cape Kerr. The quartz resembled that seen near Hohoura Inlet, but was much more ferruginous. An analysis of a sample of quartz from this locality gave,—

	Per Ton. dwt.	gr.
Gold	1	21
Silver	0	15

Value, 7s. 7d. per ton.

(2.) *Copper-ore.*—While in the North, samples of copper-ore were given to me which on reliable authority were said to come from near the North Cape. The specimens of ore seen consist of iron-sulphide with some chalcopyrite and a little green copper-carbonate. From the description given, the deposit is apparently very small. An analysis of what was said to be a typical specimen gave the following result:—

Gold	Nil.
Silver	7 dwt. 13 gr. per ton.
Copper	6·24 per cent.
Cobalt and nickel	Nil.

Copper-ores have also been reported from near Cape Karikari.

(3.) *Iron-ore.*—On the elevated table-land between Cape Kerr and the North Cape thousands of tons of high-grade limonite lie scattered in large boulders, small fragments, and even dust, on a surface of softish yellow clay formed by the weathering of the ultra-basic igneous rocks of this locality. The iron-ore also is a product of the decay of these highly ferruginous rocks.

An analysis of a typical sample of the ore is as follows :

Silica (SiO_2)	2·89
Alumina (Al_2O_3)	7·69
Ferric oxide (Fe_2O_3)	69·07
Manganous oxide (MnO)	0·10
Lime (CaO)	Nil
Magnesia (MgO)	0·60
Chromic oxide (Cr_2O_3)	3·25
Loss on ignition	16·01
Undetermined	0·39
	100·00

Equivalent to metallic iron 48·35 per cent.

On heating, the sample of ore gave a colour similar to that of Parapara iron-ore when burnt, and, therefore, should be suitable as paint. It scarcely occurs in sufficiently large quantity to be utilised for the manufacture of pig iron.

(4.) *Coal and Peat.*—Small seams of lignite occur in Miocene rocks at the northern head of Parengarenga entrance, and have in a very small way been utilised for fuel ; but they are of very limited extent.

Peat is fairly widespread in the North Cape area, but is especially conspicuous in the uppermost measures of the Pliocene-Pleistocene rocks just south of Cape Maria van Diemen. Here, by the marine erosion of the sandstone cliffs, the peat is undercut, and falls to the beach below in huge chunks. A small stream which enters the sea at this point exhibits good sections on either bank. The peat-beds are in places fully 3 ft. in thickness. In general, the finer part of the peat, which comprises much the greater portion, is highly carbonised, but the larger chunks of wood contained are relatively but little changed. It was in the swamps of which the peat-beds now bear witness that great kauri forests formerly flourished, and fragments of kauri-gum are commonly found in the beds.

(5.) *Glass-sand.*—In the immense deposits of very pure, fine, white sand on the sea-coast just south of Parengarenga Harbour entrance the northern part of New Zealand has a real asset. The sand is formed of tiny grains of pure-white quartz, and forms hillocks of dazzling whiteness.

The sand seems particularly suitable for glassmaking, and, I understand, is used in Auckland to a very limited extent for this purpose. It also could be used to advantage for many other purposes, such as forming silica linings for furnaces, making silica bricks, &c.

Work in the Dun Mountain Subdivision.

The Dun Mountain Subdivision comprises the survey districts of Maungatapu and Waimea. The area encloses the City of Nelson, and lies just to the south of Golden Bay.

General Geology.—Perhaps no single area of the same size in the Dominion presents such a variety of geological features as does the Dun Mountain Subdivision.

The oldest rocks in the area are a series of conglomerates, agglomerates, and argillites, which have been called Te Anau by the members of the old Geological Survey, and have been classified by them as Devonian. For these rocks we have adopted the provisional name of Pelorus Series, as there seems to be no satisfactory proof of unconformity between them and the Maitai Series which follows. It is possible and even probable that the two series belong to one more or less continuous period of sedimentation. The great series of grauwackes, argillites (red and grey), and limestones which overlies the Pelorus Series and constitutes the Maitai Series is now generally conceded to be Carboniferous in age. Both Maitai and Pelorus rocks have been greatly folded and faulted.

In unconformity with the Palæozoic rocks are conglomerates, sandstones, and shales, with coal-seams and limestones. This series was considered to be Cretaceo-Tertiary by the old Survey. As yet the writer can assign no definite age to these rocks, but it is probable that they are early Tertiary. Though the coal-bearing rocks, which generally dip gently, are in places steeply inclined, this position is due to tilting and faulting rather than to folding.

Above the coal-bearing strata lie the Moutere Gravels, which apparently are the deposit of a great Pliocene or Pleistocene river which flowed northward from Westland to enter Golden Bay. The Moutere Gravels rarely show stratification, and, apparently, are practically undisturbed. The most recent beds consist of the gravels, sands, &c., of the Waimea Plain and the lesser flood-plains, the muds of the tidal flats, &c., &c.

Igneous rocks occupy a prominent part of the mountainous country. These are in the main ultra-basic in type, and consist of dunites and various other peridotites, which are all more or less serpentinised together, with diorites, diabases, and gabbros. A remarkable dyke rock, which we have called nelsonite—a combination of grossularite and diallage—cuts the other ultra-basics. Granitic rocks appear *in situ* just to the east of the area under description, and the pebbles and cobbles shed therefrom are conspicuous in the conglomerates at the base of the coal series and in the Boulder Bank. An amygdaloid melaphyre is interstratified with the rocks of the Maitai Series, and may be seen on the tributaries of the Brook and elsewhere.

Economic Geology.—From an economic standpoint the Dun Mountain Subdivision contains much of interest. The mineral wealth may be discussed under the following headings : (1) Gold, (2) Copper, (3) Chromite, (4) Coal, (5) Cement-materials and Building-stone.

(1.) *Gold.*—Though alluvial gold is of widespread occurrence in the Moutere Gravels, and occurs in almost every stream draining these rocks, it has never yet been discovered in payable quantities. We have obtained prospects in several branches of Eve's Valley Stream, and in one of the streams entering the sea near Bronte Point. Gold is said to have been found in some of the quartz stringers

in argillites in the north-western slopes of Mount Starveall, but the quartz veins seen by our Survey in this locality were exceedingly barren.

As shown in the next section, some of the copper-ores carry small quantities of gold and silver.

(2.) *Copper.*—Mining for ores of copper has been carried on at intervals in the Dun Mountain Subdivision since the early sixties, and even before; but the results have never been really successful. The principal deposits are near Dun Mountain and in the watershed of the Roding Stream, or what is popularly known as the Aniseed Valley. Near Dun Mountain at least fourteen small deposits of copper-ores occur in serpentinised pyroxenites, and frequently with nelsonite, with which the copper-deposits seem to have some genetic relation. More or less desultory prospecting work was done on most of these deposits—shafts sunk, tunnels driven, &c.,—and some ore was shipped to Australia. However, operations for the main part ceased long ago, and the workings have in many places collapsed. From the surface inspection and from an examination of such of the underground workings as are open, none of the prospects appears worthy of further exploration. The original ore seems in every case to have consisted of pyrrhotite and chalcopyrite. At the surface, the oxidation products—native copper, cuprite, tenorite, malachite, and chrysocolla—occurred, and formed the rich ore which was found worth shipping. In the Aniseed Valley a great number of prospects have been found along the continuation of the so-called mineral belt—a name applied in Nelson to the serpentine rocks stretching south-westward from D'Urville Island through and beyond the Dun Mountain. The principal deposits, named from the northward, are the Duckpond lode, the Saddle lode, the Jackson lode, the Imperial lode, the Mount Claude lode, the Monster lode, the United lodes, the Champion lode, the deposit between the Serpentine and Hacket Streams, and, lastly, the Johnston Mine, on the Serpentine. The Duckpond, Saddle, Jackson, Imperial, and Mount Claude lodes are all very small deposits, which closely resemble each other, and which are on the Hill, known as Mount Claude, between Jackson's Stream and the Roding. On every one of them a little prospecting-work has been done; but in every case the writer was told the deposits looked more promising on the surface than in depth. The deposits all consist of short, narrow lenses, showing at the surface a ferruginous gossan, with stains of malachite, chrysocolla, a little cuprite, and generally magnetite. Where development on the prospects extends any distance below the surface their oxidation products are replaced by pyrrhotite and chalcopyrite. In the writer's opinion, the only one of the small deposits in Mount Claude that might warrant a little further prospecting is the Jackson lode, and even that seems a rather unpromising speculation. The Monster lode, or, more correctly, lodes, consist of several disconnected lenses of very low-grade copper-ore occurring in serpentine close to the border of an inclusion of argillite, and in intimate relation with some irregular dykes of nelsonite. As elsewhere, the lenses show a ferruginous gossan at the surface, with rare malachite stains, but, just below, pyrrhotite, containing a very little chalcopyrite, appears. On two lenses extensive exploration has been conducted, tunnels driven, shafts sunk, &c., but both deposits were found to diminish in size and to show no improvement in quality in depth. The more easterly of the two lenses has an average width of about 10 ft. 8 in., and a length of about 16 ft. 6 in. The ore exposed in the open cut consists of pinkish pyrrhotite. A carefully collected sample obtained from a cut in this deposit assayed :—

Gold	7·5 gr. per ton.
Silver	15 gr. ,,
Copper	0·53 per cent.

The more westerly of the two lenses, which runs in a general direction of about 20° west of north for some 53 ft., has a maximum width of 5 ft. 6 in. The ore away from the immediate surface consists of pinkish pyrrhotite with a little chalcopyrite. A representative analysis of the ore on the surface at its widest exposure is as follows :—

Gold	3 dwt. 10 gr. per ton.
Silver	2 dwt. 4 gr. ,,
Copper	0·95 per cent.

In the shaft sunk at this point the lens can be traced downwards for at least 50 ft., and it is said that traces of ore were found even lower during excavation, but no ore-body could be discovered in the drive below (some 112 ft. below the mouth of the shaft). Though from a casual surface examination the relatively wide lenses of the Monster lode seem promising, their very low grade and the fact that they show no continuity in depth scarcely warrant further exploration in this locality.

The United Mine has been worked more or less intermittently for years, and under various auspices. Until the beginning of the year it was controlled by the Maoriland Copper Company, but this has now given place to a company bearing the name of the Copper Development Company.

On the whole, the mine may be said to be well developed by seven levels, which are connected with each other by winzes and rises. The levels are numbered from top to bottom from 1 to 7. The uppermost level, No. 1, is partially collapsed, and No. 6 entirely so. The others are all free of access.

The ore now visible consists almost entirely of cupriferous sulphide, though there is said to have been some rich gossan, bearing malachite and native copper, and in several of the levels, notably No. 4, a very little malachite with native copper has been discovered. The sulphide consists mainly of pyrrhotite, containing small amounts of copper, nickel, cobalt, gold, and silver, and with this is more or less chalcopyrite. In the upper levels the latter mineral may even predominate in places, but there is a marked depreciation in quality with depth.

As elsewhere, the ore is in shattered serpentine cut by nelsonite dykes, and occurs in very irregular narrow lenses, which soon die out both along the dip and strike, to be replaced by others. The lenses run in general a little east of north, but there are many variations from regularity. The dip is always at a high angle, and both to easterly and westerly.

The maximum width of any lens was found to be just under 5 ft., a dimension obtained in the winze between No. 2 and No. 3 levels. While the most continuous shoots are those extending from No. 1 to below No. 2, and from about No. 5 to below that level, the lenses of ore in No. 7 are narrow, irregular, and of poor quality. The following table shows the quality of the ore at the various levels :—

	Per Cent. Copper.
(1.) Average of four assays from No. 2 level	2·88
(2.) Average of seven assays from winze and stopes between No. 2 and No. 3 levels..	4·58
(3.) Average of four assays from No. 4 level	1·91
(4.) Average of five assays from No. 5 level	4·91
(5.) Average of ten assays from No. 7 level	0·42

By far the greatest amount of the ore has already been removed from the United Mine, and, in the writer's opinion, further exploration seems unwarranted, as the discovery of ore appears to be entirely fortuitous. Quantity as well as quality seems to diminish in depth. In November last, a rough estimate of the amount of ore developing in the mine gave about 400 long tons (2,240 lb.); while, in addition, there were about 270 tons of mined ore, apparently for the most part of good quality, lying at grass outside the various levels.

The Champion Mine, which is now worked under the same management as the United Mine, and, in fact, has been so controlled for some years, was formerly worked separately. The mine has been well developed by numerous shafts and levels. The most important workings are the Champion level (about 30 ft. above the level of the Champion Creek), the Champion 150 ft. level, and the winze descending therefrom for 78 ft., and the Doctor's level. The Champion level and the Doctor's level are at the same elevation on the south bank of the stream. A shaft descends from the surface on the north bank of the stream to the 150 ft. level, and a winze also descends thereto from the Champion level. The Champion level and the Doctor's level approach each other at a very acute angle, and in one place almost join. In addition to the workings named, there are a number of levels, prospecting shafts, surface holes, &c. Like the other mines, the Champion is located in a series of narrow and very irregular lenses in serpentinised peridotite cut by nelsonite. This mine, like the United, lies close to the contact of these rocks with argillites and crystalline limestone. The mineral association in the ore of the Champion presents a marked variation from the other mines of the district. Above the water-level there is, or was, a relatively thick capping (some feet) of oxidized ore, consisting mainly of malachite, cuprite, native copper, and possibly a little chrysocolla. Below the water-level this gradually gives place to unoxidized material (except, of course, where recent alteration has taken place along the workings), consisting of very low-grade cupriferous pyrrhotite and native copper. Both occur in irregular zones of a highly shaly shattered serpentine. The lenses of native copper and pyrrhotite (often, though not always, joined together) are generally very small, being merely stringers, but several of them may occur along the length and width of the zones. Chunks of a hundredweight or more of native copper have been excavated in the upper levels.

In every way the Champion seems much the more promising of the two mines, and, in my opinion, there are fair chances of opening up some small though payable patches in the old mine. Several places in the workings which, I think, would repay further prospecting may be enumerated below :—

(*a.*) At the end of the Champion level. Here a small seam of native copper with a little pyrrhotite was discovered recently in a shallow cubby-hole in the west wall of the drive, and at the extreme southern end of the present working : a former company carried this level a little further. The ore in the seam is rich, and the shattered country is mineralised with shot copper. Only about 4 ft. of the seam is exposed. It should be prospected to north and south where visible, and, if this work warranted further exploration, a winze should then be sunk on the seam.

(*b.*) In the 150 ft. level a seam of rich native copper and pyrrhotite was discovered, and traced for about 15 ft. An inclined winze sunk on this seam followed the ore for about 75 ft., on the steep incline of about 75°, with native copper and pyrrhotite appearing at frequent intervals in that distance. At 60 ft. below the level short drives proved the ore-seam to be at least 30 ft. in length. Undoubtedly some further exploration should be done : the winze ought to be sunk further, and the two short drives above mentioned should be further driven to test the full extent of the ore-body

(*c.*) Signs of copper are visible at various places on the hanging-walls of the winze descending from the Champion level to the 150 ft. level, and it seems possible that the winze may have been sunk not actually on an ore-body, but on one wall ; consequently, further prospecting might here be done to advantage.

Some very small deposits of copper-ore—on which a little prospecting has been done—occur at the head of a branch of the Hacket, known as Chromite Creek, and near the divide between the Hacket and the Serpentine. The most conspicuous of these deposits consists of a thin lens of ore about 12 ft. long by a few inches thick underlying a narrow dyke of nelsonite. The ore is in serpentine, but partly impregnates as well the nelsonite. On the surface it consists of shot native copper, freely disseminated, together with malachite. The quality of the ore is good, but the quantity is very doubtful. Traces of copper-ore were found in Miner Creek in several places.

The Johnston Mine, in Serpentine Creek, has been fairly well prospected—an adit level has been driven at the creek, from which a shaft descends some 30 ft. ; another adit about 65 ft. higher up the hillside ; and an incline shaft still further up. Very little ore is now visible in the workings, but a small amount of ore is scattered over the surface and on the tip-heads.

The country rocks consist of serpentinised peridotite of varying degrees of hardness, cut by irregular dykes and stringers of nelsonite. The ore seems to resemble exactly that from the various small deposits on Mount Claude.

An interesting discovery was recently made in the quarry at "The Wood," Nelson, where a small gougy seam in altered igneous rocks was found to contain both native copper and malachite. A little prospecting has been done thereon, and the seam shows signs of developing into a definite lens of possibly payable ore. Its great accessibility is distinctly in its favour, and renders careful prospecting advisable.

(3.) *Chromite.*—Small deposits of chromite are of widespread occurrence in the mineral belt of the Dun Mountain Subdivision, and the mineral has been mined in the past in many localities — in the neighbourhood of Dun Mountain, on the saddle at the head of Jackson Creek, at the head of Chromite Creek, and on the Serpentine. The deposits consist of segregations (apparently magmatic) in the chromite-bearing peridotites. Both the peridotites and the chromite deposits are cut by nelsonite. From the experience gained by actual mining it may be gathered that the chromite deposits of the Dun Mountain Subdivision differed in no way from the generality of deposits of this nature in being very inconstant and irregular in their boundaries. Much of the richest ore was mined in the sixties, and shipped to England when the price of chromite was high. There are still, however, some small deposits, which might repay mining were there an improved price for the mineral. Notable among these may be mentioned some of the small patches at the south-east of the Dun Mountain and the one on Jackson's Saddle.

(4.) *Coal.*—Coal-bearing rocks fringe the base of the mountains skirting the Waimea Plains on the south-east side, running diagonally across the subdivision from the Brook to Brightwater. It is quite probable, too, that they underlie the Moutere and Recent gravels to the north-westward on the low country.

Coal has actually been discovered at many points, notably in the Brook Street Mine, at the old Enner Glynn Mine, and back of Richmond. In Brook Street mining was carried out about ten years ago in a seam of coal apparently sub-bituminous (lignitic) in quality. The seam dipped everywhere at a high angle, and in places was vertical. The thickness showed remarkable variations. In a prospecting shaft sunk on the outcrop the following thicknesses were noted :—

	Thickness. Ft.
At 130 ft.	8
,, 170 ft.	10
,, 260 ft.	11
,, 329 ft.	5

Mining was just beginning to meet with some success when a fire occurred—the mine had to be flooded, and, as a result, no further mining was done.

The old coal-mine in Enner Glynn Creek was worked as far back as the early days of the Nelson settlement, and was examined by Dr. Von Hochstetter at the time of his visit. The seams are said to have in places lain horizontally, but elsewhere at steeper angles, and were, it is understood, much broken and disturbed. It is the writer's opinion that both the Enner Glynn seam and the Brook Street seam have been profoundly influenced by the great fault that runs along the base of the mountains forming the south-eastern boundary of the Waimea graben mentioned before. This accounts for the great irregularity in the dip of the seams and for the shattered nature of the coal. On the Brook the coal-beds have been tilted at very high angles along the base of the fault-line, and have in Enner Glynn Creek actually been overturned. Away from the fault on the low country to the north-west it is thought, from exposures seen near Belgrove, that the coal-bearing rocks will assume either a horizontal attitude or, at least, a very moderate inclination, and it is in this undisturbed locality where it may be suggested that boring for coal should be conducted.

When the careful survey now being done along the base of the mountains is completed sites for drill-holes will be suggested in the completed report of the Dun Mountain Subdivision. The quality of the Enner Glynn and Brook Street coal make it very suitable for household purposes. Though the known coal is not of a high grade for steaming and export purposes, there can be no doubt that the discovery of definite and persistent seams of coal so near Nelson would be of very great commercial value.

(5.) *Cement-materials and Building-stone.*—The limestones of the Maitai Series are widely exposed in the Dun Mountain Subdivision, notably on the Maitai Stream, on the Dun Mountain Tramway, on the Roding, United, Champion, Miner, and Wairoa streams. The limestone, though in places argillaceous or siliceous, is elsewhere of great purity, and suitable for the manufacture of lime. The travertine formed from the limestone on the Miner Stream is especially pure. Its utilisation for cement-manufacture in connection with the adjoining argillites seems quite a possibility, but not an immediate one. Possibly suitable for cement manufacture, though scarcely occurring in sufficient quantity for this purpose, are the limestone and clays on Enner Glynn Creek. The harder peridotites might be utilised with success as building-stones, but their occurrence remote from centres of communication greatly detracts from their commercial value.

The Pakawau Coalfield.

Coal-bearing strata occupy most of the northern part of the Cape Farewell Peninsula. Coal-seams occur at many places, those at Pakawau, Puponga, Ferntown, and West Wanganui being the best-known. The whole area covered by coal-bearing strata may be known as the Pakawau Coalfield. Early in January a hasty examination was made of the seams exposed in the Otemataura Creek, at the Pakawau Coal Mine itself, and on the Bassett property at West Wanganui.

On the Otemataura Stream, at an altitude of about 1,200 ft., a number of coal-seams are exposed. The lowest visible seam, which is about 3 ft. 6 in. thick, consists of fine lustrous coal rather high in ash. It is overlain by conglomerate, and underlain by shale. Some 8 ft. above is a 1 ft. seam of fair

coal; 7 ft. higher up is a 3 ft. seam of fair coal, which is, however, quite rusty at the outcrop. Just above this 3 ft. seam are two thin seams 6 in. and 4 in. thick respectively. The coal is usually bituminous in quality, and is for the most part apparently of fair grade. The seams lie with a very gradual inclination to the west. Analyses of representative specimens of the lower 3 ft. 6 in. seam (No. 1), and of the upper 3 ft. seam (No. 2), are as follows:—

	No. 1 Seam.	No. 2 Seam.
Fixed carbon	35·88	50·29
Volatile hydrocarbons	34·70	39·96
Water	1·32	2·61
Ash	28·10	7·14
	100·00	100·00
Total sulphur	0·31 per cent.	0·64 per cent.

Each of these coals gives a dense hard coke.

On the hillside forming the slope descending to the left bank of the Otemataura, coal is exposed in a number of places. The lower outcrops are apparently the same as those seen in the creek-bed, but the uppermost is a distinct seam. This seam—which is some 5 ft. 6 in. thick, though not all coal—was traced for about 250 ft.

The coal at present being mined in the Pakawau Mine is from a seam about 3 ft. 3 in. thick, which dips at about 1 in 6. The coal is of good quality, bituminous in grade, and distinctly coking. In many places the whole thickness of the seam consists of good coal, but elsewhere some stone is intermixed, especially, so the miners say, when a gritty sandstone intervenes between the coal and the overlying conglomerate. A representative section of the coal-seam is as follows:—

	Ft.	in.
Coal	1	0
Stone	0	1
Coal	1	9
Stone	0	5
Coal	0	6

The seam of coal which outcrops at West Wanganui Inlet, on the Bassett property, dips at about 10° to the north-west, and is under- and over-lain by sandy shale. The seam is only 22 in. thick: the upper 6 in. is a compact coal high in ash, while the lower 16 in. forms a soft friable coal.

Work at the Franz Josef Glacier.

For the last two seasons the Geological Survey has been conducting work of a somewhat special character at the Franz Josef Glacier and in the immediate neighbourhood. It has been our object to make an accurate topographical survey of this great ice feature, and to this end accurate measurement was made of the great snowfields, of the height of the peaks, of the position of the frontal face, &c., &c. All this topographical detail was obtained by Mr. R. P. Greville—then Topographer on the Geological Survey—during the summer of 1908, while such geological data as were necessary for the preparation of a report on the glacier were collected by the writer in the course of a brief visit during the season just passed.

From the camp at the frontal face expeditions were made in the ranges on either side, and to the great snowfields at the head of the glacier. The Franz Josef Glacier forms at once one of the most magnificent and one of the most interesting sights in this land of scenic wonders. Its source lies in the numerous fields of *névé* formed by the union of the rivers from the main Alpine divide, and from the subsidiary ranges which border the Franz Josef to east and west. From this source it descends now gradually, now in great ice cataracts, to the frontal face at about 692 ft. above sea-level. As Dr. Von Hochstetter remarked many years ago, one would have to travel as far north as northern Norway to get a glacier so near to the sea-level as the frontal face of the Franz Josef. That frontal face has steadily advanced within the last few years, and is now farther forward than at any other time in the memory of the oldest inhabitant. However, formerly the glacier deployed on the plain and stretched seaward, uniting with many other glaciers to the north and south to form the great piedmont glacier of Westland. Within the last year the glacier has made a maximum advance of 162 ft., smashing down a gallery on the eastern side at the frontal face, and pushing itself up on to the smooth rock beyond. Glacial striæ and ice gouging are splendidly shown at the Franz Josef, being especially observable on the several *roches moutonnées* at the frontal face and on the eastern side of the glacier near Pipe Creek.

The stratigraphical side of the geology of the neighbourhood of the Franz Josef Glacier presents little of interest. The rocks bordering the upper part of the glacier consist of argillites and grauwackes which have been complexly folded. Underlying these, towards the lower part of the glacier, are much-corrugated biotite and chlorite-quartz schists of a general light greenish colour and with lenses of calcite. The latter are often rusty, owing to the oxidation of contained iron pyrites. All these rocks are considerably faulted. Below the frontal face these old rocks are shrouded in morainic débris. Both the schists and the less metamorphic argillites and grauwackes contain quartz stringers, though these are more common in the argillites and grauwackes than in the schists. Some rusty quartz containing pyrite from a stringer above the Unser Fritz Fall gave an assay,—

	Dwt.	gr.
Gold	5	1
Silver	3	18

It is interesting in this connection to note that sparse colours of gold can be washed from the débris now issuing from beneath the frontal face of the Franz Josef Glacier, and that there is much coarse gold in the Callery Stream, which joins the Waiho River about two miles below the Franz Josef ice-front. The gravel terraces, too, below the Callery, on either side of the Waiho, contain much fine gold, and doubtless they could be sluiced with success were it not for the difficulty of removing the many huge ice-carried boulders which the gravels contain. It is quite possible that much gold could be obtained from the narrow V-shaped bottom of the Callery River were the water taken by tunnel to the Totara Stream on the north—an expensive undertaking, but one which local miners consider warrantable by the amount of gold which is obtained on the bars of the Callery every successive year, when for a short period in the winter cold the water sinks low enough to lay them bare. In all some 20,000 pounds' worth of gold has been obtained from the river, notwithstanding the difficulty of access to the principal bars, two of which—the Little Beach and the Buster—occur three and eight miles respectively up the stream, and are reached by a rough track through the wild gorges of the river.

The scenery of the Franz Josef is wonderfully fine. From a point of vantage on the ridge in the western side of the glacier one may look down at the much-crevassed blue and green ice, almost free from moraine, and bordered by steep slopes gay with an almost tropical vegetation, and bright in summer with the crimson flowers of the rata. Ever beyond is the background of a maze of lofty snow-peaks girt by great but almost unexplored snowfields.

Coal-bearing Strata in the Wai-iti and Wangapeka Valleys.

The hasty reconnaissance of the coal-bearing country between Belgrove and the junction of the Sherry and Wangapeka was intended merely as a preliminary examination of an area which it is hoped later to investigate in detail. Coal-bearing strata outcrop in the foot of the hills back of Belgrove, and in the past at a number of places coal of fair quality has been taken out in small quantity. However, as all mining so far conducted has been carried out along the base of the hills, where the strata are very highly tilted and faulted, and not on the flat, where they lie almost horizontal, the utility of the coal-seams can hardly be said to have been properly tested.

Near Tadmor I inspected a seam of coal 2 ft. 8 in. thick in a small tributary of the Wangapeka, which enters on the right bank just below the mouth of the Sherry. There are, I understand, numerous outcroppings of coal on the Sherry, Wangapeka, Baton, and other streams in the locality. The coal is generally sub-bituminous to bituminous in quality. The following analysis shows the quality of the coal of the Sherry River—the sample having been sent some years ago to the Geological Survey Office by Mr. T. McCarthy :—

	Per Cent.
Fixed carbon	44·10
Volatile hydrocarbons	48·60
Water	1·60
Ash	5·70
	100·00

Total sulphur, 3·13 per cent.

The whole area from Brightwater to and beyond Tadmor, in the survey districts of Waimea, Wai-iti, Wangapeka, Tadmor, and Gordon, contains an extensive coalfield of considerable promise, but its potentialities can be correctly gauged only after a careful survey.

REPORTS OF FIELD OFFICERS.

Mr. P. G. MORGAN, GENERAL GEOLOGIST.

Office-work.

From the 1st June, 1908, until the middle of October I was engaged principally in writing and seeing through the Press Bulletin No. 6, on " The Geology of the Mikonui Subdivision," North Westland. Among other work, I prepared manuscript indexes to Von Haast's " Geology of Canterbury and Westland," and to Park's " Geology and Veins of the Hauraki Goldfield."

Field-work in Greymouth Subdivision.

On the 3rd November I left Wellington for North Westland, and from the time of my arrival in Westland until the end of May, 1909, was continuously employed in field-work in the Greymouth Subdivision. In this work I was assisted throughout by Mr. J. A. Bartrum, M.Sc., Assistant Geologist, who had begun operations in the Greymouth Subdivision about three weeks previous to my arrival. On the whole, a good season was experienced, and by the end of May field-work in the survey districts of Waimea, Hohonu, Brunner, and Arnold was completed. In the other survey districts comprising the subdivision—namely, Greymouth, Cobden, and Mawheranui—a considerable amount of field-work was done, so that at the close of the season not more than one-fourth of the subdivision remained to be surveyed. The remainder, however, contains the greater part of the Grey Coalfield, and it will be necessary to bestow more than ordinary care and attention upon its survey.

Now and again, as opportunity offered, a number of stream-measurements were made. During the dry spell in February and March, 1909, all the streams of the subdivision were very low, and the measurements then made may be considered to indicate almost the minimum flows.

The results obtained during the past season's work may be stated under the headings of (1) Physiography, (2) General Geology, (3) Economic Geology, (4) Miscellaneous Economic Resources.

Physiography.

The Greymouth Subdivision possesses a varied physiography closely connected with its geological structure and history. It may be said that unequal elevation of the land since the beginning of the Tertiary periods, the advance and retreat of the glaciers during Pliocene and later times, the diversion of drainage caused by ice damming and changes beneath the surface of the piedmont ice-sheet that once covered much of the low country, the abundant supply of débris afforded by the Southern Alps, and varying but always excessive rainfall and snowfall, are factors that have given rise to a complicated set of natural features that cannot be adequately described in a brief report. The description of the physiography will therefore be reserved for the detailed report on the area.

General Geology.

The geology of the Greymouth Subdivision is of an interesting character. The oldest rocks known are late Palæozoic or early Mesozoic grauwackes and slates, that may be correlated with the Greenland Series of Bulletin No. 6, and the Maitai Series of Hector and McKay. The granites of the Hohonu Range and Mount Te Kinga are probably next in order of age. These rocks are seamed by numerous basic dykes that, it is thought, are but slightly younger than the granites themselves. The Tertiary formations of New Zealand are represented by an immense thickness of strata ranging in age from probable Eocene to the present day.

The following table shows the geological formations represented in the Greymouth Subdivision, together with their provisional ages and estimated maximum thicknesses :—

Provisional Age.	Provisional Name.	Estimated Maximum Thickness.
		Ft.
Recent, Pleistocene, and Pliocene	Marine gravels	200
	Younger fluviatile gravels	200
	Morainic and fluvio-glacial gravels	100
	Other fluviatile gravels	200
	Unconformity.	
Miocene	Blue Bottom	1,000
	Cobden Beds	750
	Blue mudstones	750
	Mudstones with grit and pebble bands; sandstones and grits with fragments of coal; Kotuku conglomerate	1,100
	Moderate Unconformity.—Coal-measures.	
Pre-Miocene (Eocene-Oligocene)	Dark-coloured mudstones (with minor sandstones)	3,080
	Island sandstone	500
	Grits and sandstones with coal-seams	800
	Conglomerate	500
	Strong Unconformity.	
Late Palæozoic or Early Mesozoic	Greenland Series	..
	Igneous Rocks.	
Post-Greenland, Post-Tuhua	Tuhua (Granite) formation	..
	Basic dykes	..

Greenland Series.—The rocks included under this heading may from their lithological character and mode of occurrence be considered as the equivalents of the Kanieri Series of Bulletin No. 1 and the Greenland Series of Bulletin No. 6. In the Grey Subdivision outcrops of Greenland rocks occur on the western flanks of the Hohonu Range, near Brunnerton, on the slopes of Mount Buckley, and as a narrow band along the eastern slope of the Paparoa Range northward from Battery Creek. This last area, which has not yet been fully investigated, extends beyond the boundaries of the subdivision, and, there widening out, occupies a large extent of country that contains numerous quartz reefs.

Coal-measures.—The beds belonging to the coal-measures outcrop principally on the slopes of the Paparoa Range, but there is also a small area exposed on the south side of the Grey River. The estimated thickness of 4,880 ft. is probably under, rather than over the truth. The strike of the coal-measures is on the whole nearly north and south; but, in places owing to faults and "rolls" in the strata, may be almost east and west. The beds are arranged in a distinct anticline, having its axis roughly coincident with the crest of the Paparoa Range. The anticlinal axis is not level, but from Mount Davy to Brunnerton has a notable inclination or pitch to the south. Immediately south of Brunnerton

the anticlinal axis has an upward pitch, but from the summit of Mount Buckley the downward pitch to the south is resumed, so that the coal-measures speedily disappear beneath younger rocks. The western limb of the anticline dips on the average about 16°. The eastern side has a much steeper dip, in places approaching 90°.

The coal-measures of the Grey district are traversed by numerous faults. Some of these are of considerable magnitude, and add much to the difficulty and expense of opening out and working the coal-mines.

Age of Coal-measures.—The facts mentioned on a later page indicate that the coal-measures are separated by an unconformity from overlying beds of known Miocene age, and, on this account, they are considered to be of pre-Miocene age. The palæontological evidence has not yet been fully worked out, but so far as it has been determined is consistent with the view that a moderate time-break intervenes between the coal-bearing strata and the unquestionably Miocene beds.

Conglomerate.—The basal conglomerate of the coal-measures has been observed in a small creek on the south side of the Grey east of Brunnerton, and on the Paparoa Range near Mount Sewell. Other localities in which it is known to occur have not yet been visited. The constituent pebbles are grauwackes, occasional argillite or slate, and a little quartz. They are of large size towards the base of the conglomerate, but become smaller in the upper layers. Their derivation from the Greenland rocks on which the conglomerate unconformably rests is sufficiently obvious.

Grits and Sandstones with Coal-seams.—Grits and sandstones of probable fresh-water origin conformably succeed the conglomerate just described, which indeed to some extent is interbedded with them. The rocks under consideration are seen on the slopes of Mount Buckley, in the Brunner Gorge, and on the higher slopes of the Paparoa Range. The sandstones consist almost entirely of quartz grains, with a little mica. They graduate into grits, which again are often coarse enough to be more correctly termed fine conglomerates. The coal-seams associated with the beds just mentioned will be described under the heading of *Economic Geology*.

Island Sandstone.—Above the coal horizon comes a thick band of slightly calcareous yellowish-grey sandstone, well seen in the high cliff-faces near Brunnerton and Dobson. Owing to its forming a low rocky island in the Grey River opposite the Dobson Quarry, Sir James Hector gave this bed the name of Island Sandstone. The marine origin of the Island Sandstone is shown by its containing remains of echinoderms and molluscs, together with numerous imperfect casts of fucoid stems.

Dark-coloured Mudstones (with Minor Sandstones).—The mudstones of the coal-measures are usually dark bluish-grey rocks that weather to a dark-brown, buff, or purplish colour. They are often of a sandy character, and in places pass into a dark impure sandstone. They seldom exhibit distinctive strike or dip. As developed on the eastern side of the Paparoa Range, the mudstones have a great thickness, probably well over 3,000 ft.

Miocene Beds. — The unquestionably Miocene strata of the Greymouth Subdivision have an estimated thickness of 3,600 ft. They are decidedly folded, and exhibit fairly well-marked anticlines and synclines with a general north and south trend. In the case of the anticline running southwards from Mount Buckley (a continuation of the Paparoa anticline previously mentioned), a quick downward pitch to the south has a considerable influence on the strike, and in other localities notable irregularities may be observed. The dip is usually gentle, but occasionally reaches 50° and 60°, and may even approach 90°. From the horizon of the Cobden Beds downward the Miocene strata may be correlated with the Oamaru Series of Hutton. The upper or Blue Bottom horizon is probably equivalent to Von Haast's Pareora Series.

So far as can be judged, there is no marked structural unconformity between the coal-measures and the Miocene strata, but the presence in the lower beds of the latter of numerous waterworn fragments of coal almost certainly derived from the known coal-measures indicates a marked break between the two sets of strata. It is therefore evident that in order to allow of the denudation of the coal-measures there must have been very decided elevation of some part of the land immediately preceding Oamaru times. Probably a certain measure of folding took place also, but proof of this is lacking.

Mudstones with Grit and Pebble Bands; Sandstones and Grits with Fragments of Coal.—In Rocky Creek (on the east side of the Paparoa Range) the almost uniform mudstones of the coal-measures are succeeded by another class of mudstones with grit and pebble bands. Of these beds there appears to be a thickness of not less than 1,100 ft. From their nature and on stratigraphical grounds they are thought to correspond in age with the beds next to be mentioned.

On the south side of the Grey, in the valleys of Kaiata, Racecourse, and Omotumotu Creeks, there are sandstones, grits, and mudstones that contain in many places numerous fragments and even bands of water-worn coal, a feature commented on above. The occurrence of waterworn pieces of coal in the Miocene rocks of this locality was noted by Mr. Alexander McKay as far back as 1873.*

Kotuku Conglomerate.—Two of the Lake Brunner Oil Company's bores at Kotuku, after passing through Miocene mudstones and limestone, entered conglomerate. In one of their bores (No. 9) this rock was penetrated for 256 ft. without being passed through. The diamond-drill cores obtained show that the conglomerate consists of pebbles of grauwacke, argillite, or slate, and granite. It is in general fairly fine, but towards the bottom of No. 9 bore boulders of some size were encountered. The Kotuku conglomerate may be correlated with a fault-involved bed of grit and conglomerate seen at the base of the Hohonu Range near the Teremakau Settlement.

Blue Mudstones.—Above the horizon of the beds last described comes a thick band of bluish mudstones, that often closely resemble typical Blue Bottom. They are well exposed on the west side of the Omotumotu Valley, and are seen also along the main road from Omotumotu to Greymouth. In the

* Geo. Survey Reports for 1873–74, Vol. viii, 1877, pp. 78, 79. See also "Report on Supposed Coal-seams in Kaiata Range, Greymouth," C.–10, 1901, p. 7; and *New Zealand Mines Record*, December, 1900, p. 203.

upper horizon the mudstones contain calcareous bands. These become more and more frequent, and finally predominate. Hence there is no distinct division-line between the mudstones and the beds of the next division.

Cobden Beds.—The strata comprising the Cobden Beds (often called the Cobden Limestone) are well seen in the quarries at Greymouth and Cobden. Here they consist of a succession of argillaceous and arenaceous layers, with a varying proportion of carbonate of lime. Inland the beds seem to thin out and become more calcareous, so that they form a limestone of fair quality. The bores at Kotuku have proved the presence in that district of a bed of good limestone 110 ft. to 120 ft. thick. This probably is to be correlated with the Cobden Beds.

Blue Bottom.—The beds classed as belonging to the Blue Bottom have a maximum thickness certainly exceeding 1,000 ft. They are well exposed in the southern part of the Grey Subdivision, where, as is shown by the outcrops, Blue Bottom underlies the whole area from the Hohonu Range to the coast. Northward, beds of Blue Bottom age underlie the morainic débris near Lake Brunner, and probably the lake itself, as well as the Kotuku district and much of the Grey Valley. In general, the Blue Bottom beds consist of the tough blue clay or mudstone that has given it its name, but towards the base of the Hohonu Range, and in the Kotuku and Notown districts, the visible outcrops show a bluish or yellowish-brown sandstone, containing in its upper portions interbedded layers of gravel or conglomerate. Much of the material penetrated by the oil-prospecting bores at Kotuku is arenaceous mudstone rather than sandstone. In the same district layers of impure lignite were seen in a shallow shaft, and again in sandstone some distance above Deep Creek Gorge.

Pliocene, Pleistocene, and Recent.—After the deposition of the Blue Bottom there was considerable elevation of the land, accompanied by marked folding of the pre-existing Tertiary strata. The Southern Alps now rose to great heights, and gave rise to permanent snowfields, from which glaciers ultimately descended into the lowlands. Denudation of the higher lands was intense, and, in consequence, an abundance of débris was carried first by the rivers and at a later date by the glaciers into the lowland country. When the ice rivers finally retreated to the mountains the greater part of Westland was covered by a thick deposit of morainic and fluvio-glacial gravels. Portions of these have since been reassorted by the modern streams, and, with fresh material brought down from the mountains, have formed the more modern fluviatile and marine gravels. The modern coastal plain is still being built slowly seaward by the material brought down by the rivers. During the past forty years débris from the sluicing claims has formed a considerable portion of the stony burden borne seaward by the rivers.

During Late Pleistocene and Recent times some uplift of the land has taken place, for marine gravels and sands are found at elevations approaching 200 ft. in various places. Very noticeable is a raised beach of sea-worn sand in the neighbourhood of Paroa. This beach indicates recent elevation to the extent of 20 ft. to 25 ft.

Economic Geology.

The economic geology of the Greymouth Subdivision, so far as yet investigated, may be described under the headings of (1) Alluvial Gold, (2) Auriferous Quartz veins, (3) Antimony, (4) Coal, (5) Petroleum, (6) Building-stone, and materials for Lime, Cement, Brick, &c.

(1.) Alluvial Gold.—The first discovery of payable gold in Westland was made by a prospector named Albert Hunt in 1864. The locality of Hunt's find was Maori Point, a bend of the Big Hohonu or Greenstone River. During the next few years richly auriferous gravels were found at many places within the subdivision. Among these may be noted Stafford, Goldsborough, and other localities in the Waimea watershed, Callaghan's, Marsden, Cameron's, Rutherglen, Maori Creek (Dunganville), Maori Gully (south side of Arnold River), Candlelight, Notown, Red Jack's, Moonlight (famous for its big nuggets), the Lamplough Lead near Chesterfield, and the Auckland Lead on the coast north of the Waimea Creek. The Kumara Goldfield, however, perhaps the most important of all, was not discovered until 1876.

At the present time the richer surface deposits are nearly all worked out, and the population of the goldfields is steadily diminishing. There are, however, still very large quantities of unworked gravel believed to be payably auriferous if only an abundant and cheap supply of water could be obtained for sluicing. In addition, there are certain areas that are rendered unprofitable owing to the lack of fall for tailings or because the upkeep of the great length of sluice-boxes required to carry the tailings away is too expensive. In some of these cases high-pressure water might profitably be employed in hydraulic elevators, or for furnishing motive power to drive bucket elevators, as is done in the Wheel of Fortune Sluicing Claim near Stafford.

Among the areas in which unworked auriferous gravels are expected to afford payable results if an adequate water-supply were obtained may be mentioned Cape and Hayes Terraces near Kumara, the neighbourhood of Notown, Red Jack's, and Kangaroo Creek.

There are several localities where deep leads are supposed to exist. One of these is the old stream-valley between Kumara and Dillmanstown, where on a false bottom the bulk of the Kumara gold has been obtained. There is much reason for believing that on the Blue Bottom a rich layer exists; but prospecting shafts, though sunk to a depth of 140 ft., have failed to bottom, and efforts to sink deeper have been frustrated by water. Probably this ground could be prospected by means of a Keystone Driller or similar machine. A low-level tunnel which would tap the ground at 180 ft. or more below the surface could be driven from the Teremakau River, and, it is not at all improbable, would be at a sufficiently low level to test the ground. There is apparently no reason why the water difficulty, of which there seems to be much unnecessary dread, should not be overcome by a moderate expenditure on pumping machinery. Taking all factors into consideration, the probabilities are so much in favour of payable gold as to justify the outlay necessary to prospect the deep ground beneath the Kumara Flat.

Many old miners believe that there is a deep lead between Kumara and the Kapitea Stream. If this is the case the working of the deep ground just mentioned will probably give definite information.

The valley of the Ongionui Creek from one to three miles above Notown contains deep ground which has never been bottomed, although a shaft is said to have been sunk to a depth of 110 ft. Since a number of small streams draining into the Ongionui have been worked with highly profitable results, there can be little doubt that the ground contains gold.

Prospecting by means of the Keystone Driller or by a low-level drive from the neighbourhood of Notown may be recommended for this area.

(2.) Auriferous Quartz Veins.—Small quartz veins are found in the Greenland rocks exposed near Brunner and on the Paparoa Range. In Langdon Creek some of the veins have been worked for their gold contents, but work has been suspended for a number of years. In the larger areas of Greenland rocks immediately to the north of the subdivision there is more scope for auriferous lodes, and, as a matter of fact, two mining properties—the Blackwater and the Taffy—are now being worked in these localities with successful results.

(3.) Antimony.—Near the head of Langdon Creek is a quartz vein about 2 ft. thick that carries a considerable percentage of antimony sulphide and oxide. Gold is also present in the stone. Many years ago this vein was worked to some extent under the name of Langdon's Antimony Mine, but is now abandoned. It appears to deserve further attention.

(4.) Coal.—Practically the whole of the Grey Coalfield is within the limits of the subdivision. Coal was first discovered as far back as 1847 or 1848 by Mr. Thomas Brunner, surveyor and explorer, as he was ascending the Grey River by canoe*. Coal-mining began at Brunner soon after the first gold discoveries, and has been carried on steadily ever since. The mines now operating—the State Coal Mine, the Blackball, and the Brunner—have an annual output totalling nearly 400,000 tons. Two new mines—the North Brunner and the Paparoa—have almost reached the producing stage. The total production of the field up to the end of 1908 may be estimated as 5,100,100 tons, only a small fraction of the amount yet to be mined; but since the investigation of the coal-bearing area is not yet complete no detailed estimate of the tonnage of coal still available for extraction can at present be given. North of the Grey River much of the coal is "level-free"—that is, it can be won from adits driven above drainage-level. West of Brunnerton, at Taylorville, Wallsend, and Dobson, there is a large area of proved coal-bearing country that can be worked from shafts of moderate depth. Of this area a very small portion was actually worked from the shafts of the Wallsend Mine, which was closed down many years ago. Coal probably continues westward from Dobson, but at such a depth that under present conditions it could not be profitably worked. Again, it is likely that the coal-measures continue eastward of the Brunner anticline towards the base of the Southern Alps.

In the Brunnerton district, the only part of the coalfield that has yet received detailed examination, there appears to be but one workable seam, the Brunner. Its thickness varies from 8 ft. to 20 ft., but may be said to average 14 ft. Near Mount Sewell, on the Paparoa Range, the main seam, probably a continuation of the Brunner seam, as seen in various outcrops, is under 6 ft. in thickness; but the thinning-out is merely local.

The Brunner coal is in general of excellent quality, and may be used for household, steam, or gas-making purposes. Its chief defect is its softness, which causes a large proportion to become "slack" in the processes of mining and transport.

Reference may here be made to the coal-bearing grits and mudstones seen in Kaiata, Racecourse, and Omotumotu creeks. Some thin bands of grit, consisting mainly of water-borne grains of coal, have, it would seem, been mistaken for coal-seams, and thought to be indications of thicker seams in the same beds.† Again, the water-worn fragments of coal, derived from the Miocene beds, have been considered as signs of the neighbourhood of an outcropping coal-seam. These erroneous ideas have led to some useless prospecting. The true coal-measures in these localities are some distance beneath the surface, and can be proved only by boring or shaft-sinking.

(5.) Petroleum.—The existence of petroleum in the Kotuku district has been known since 1900. In that year an exudation of oil was discovered on the bank of Petroleum Creek, near its junction with Deep Creek. Since then prospecting operations have disclosed numerous seepages of oil between this locality and Sawpit or Red Creek, about half a mile to the north. A company that was formed to develop the oilfield is said to have spent £5,000, but the only visible results of its operations are a few shallow test pits and a borehole 167 ft. deep. Since this concern failed, prospecting has been actively carried on by the Lake Brunner Oil Company and by Mr. Joseph Taylor of Greymouth. The Lake Brunner Oil Company has put down nine bores on its own property, varying in depth from 104 ft. to 821 ft. Mr. Taylor has sunk a shaft to a depth of 83 ft., and put down a number of bores, the deepest of which reached a depth of 446 ft. On his property there are also two shallow bores drilled by the Lake Brunner Oil Company under an option. With two exceptions, all these bores have been put down within or near the area in which oil-seepages occur, and all, except one, have yielded more or less oil. The exception was bored near the Kotuku Railway Station to a depth of 485 ft. without penetrating the modern gravels which here shroud the Miocene rocks. Several of the shallow wells continue to yield small quantities of petroleum with great regularity.

There can be no doubt that over a certain area the surface gravels and the upper layers of the Miocene rocks are more or less saturated with petroleum. Hence any shallow bore within this area will yield some oil and often payable or almost payable results. This very fact has, however, militated against prospecting by boring being spread over a sufficiently wide area. It so happened that the

* "Handbook of New Zealand Mines," 1887, Part I, p. 96. "Cyclopædia of New Zealand," Vol. V, 1906, p. 469.
† See McKay: "Report on Supposed Coal-seams in Kaiata Range, Greymouth," C.–10, 1907, p. 7.

two bores outside the oil-saturat d area met with difficulties, and neither gave results of any great importance. Had it not been for the various bores, however, little could have been learnt concerning the geology of the district, for modern gravels hide almost all the older rocks. Thus the bores have given much useful information.

The occurrence of petroleum itself is the best possible indication of an oilfield, but other indications seen at Kotuku are gas-escapes, mineral springs, and, above all, the presence in the Miocene limestone of salt water in large quantity. The Miocene strata are gently folded, and, while some of the beds are of an impervious character, and therefore able to retain the oil, others are fairly pervious, and thus suitable for acting as oil-reservoirs. So far, the geological conditions for the occurrence of oil in quantity are very favourable. One has, however, to take into consideration the probable source of the oil and the probable position of any large reservoir before giving a final opinion.

Since small quantities of oil and natural gas occur in the conglomerate that underlies the limestone, it is practically certain that the Kotuku petroleum has a deeper source. It may therefore be concluded that rocks of coal-measures age underlie the conglomerate, and have given rise to the oil which appears in the overlying beds. This view is supported by the occurrence of petroleum and natural gas in the Greymouth Habour Board's No. 3 bore at Dobson. According to the log, natural gas was encountered in the bore at a depth of 1,457 ft., and petroleum at a depth of 1,747 ft. If the supposed coal-measures at Kotuku have the same thickness as at Brunner, and were not denuded before the deposition of the Miocene beds, it is probable that the petroleum originates at a great depth, possibly 4,000 ft. or 5,000 ft. Since, owing to water-pressure, oil tends to rise in the strata, the main oil-reservoirs may be at any less depth. Again, since in all known oilfields of any importance petroleum has been encountered at varying horizons, it is obvious that in a new and practically unprospected district the exact depth at which oil may be expected must be ascertained by trial bores.

The tendency of oil to occur along anticlinal axes is well known, and therefore it is important to locate any anticlines that may be present in the Kotuku strata. The examination of the surface exposures of the Miocene beds in Deep Creek and the surrounding areas show that a gentle anticline with an approximate north-and-south course may be expected to traverse the district in the vicinity of Deep Creek. The surveys made in other districts show that the coal-measures of Westland, though not strictly conformable, agree in folding with the Miocene strata. It is therefore tolerably certain that any anticline in the Miocene beds will also be represented in the coal-measures beneath, and *vice versa*. The data obtained from the various bores seem to show that the anticlinal axis is to the west of Deep Creek, in the area between Petroleum and Sawpit creeks. Further boring, however, is necessary to determine with certainty the presence and exact position of an anticline. This need not be of a costly character.

To sum up, it may be said that the prospects of obtaining oil in quantity at Kotuku are so promising that the expenditure of a considerable amount of capital in further trial borings would be fully justified.

Petroleum at Dobson.—In the Greymouth Harbour Board's No. 3 bore, near Dobson, beds yielding natural gas and petroleum, as already mentioned, were passed through at depth of 1,457 ft. and 1,747 ft. At the present time, mineral water, bubbles of inflammable gas, and small amounts of semi-solid hydrocarbons (petroleum butter) are issuing from the top of the bore. If there were petroleum in quantity in this district one would expect to find signs of it in the neighbourhood of the Brunner anticline, and more especially in the domed section near Mount Buckley. This is not the case, and, therefore, until more definite data are obtained, it would appear to be inadvisable to incur expenditure in prospecting for petroleum in the Dobson district. Against this view might be urged the possibility of oil in the southern continuation of the Brunner anticline—say, beneath the dividing ridge between Kaiata Creek and the Stillwater Valley.

(6.) Building-stones, and Materials for Lime, Cement, Brick, &c.—*Building-stones.*—The granites of the Hohonu Range and Mount Te Kinga are of varying quality, but, if sufficient demand should arise, could yield practically an inexhaustible supply of good building and monumental stone. From a quarry near Te Kinga Railway-station (just outside the subdivision) some fine granite has already been obtained.

At Dobson, in the upper horizon of the Island Sandstone, the Westland Stone Company is now operating on a fine-grained grey sandstone, easily worked, and well adapted for building and monumental purposes. According to tests made in the Canterbury College School of Engineering on 2½ in. cubes (approximate dimensions) the average crushing load was 706·3 tons per square foot, and the absorption in seventy-two hours only 3·705 per cent. A weathering test made on 1 in. cubes gave very satisfactory results.

The limestone and calcareous sandstone of the Cobden Beds are often suitable for building purposes. At Greymouth these rocks have been extensively quarried to obtain material for the breakwater and for road-metal, &c.

Lime and Cement.—At Greymouth the more calcareous layers of the Cobden Beds have been quarried for making lime, but are too arenaceous to be suitable for the purpose. Elsewhere—for example, at the head of Saltwater Creek and in Fireball Creek (near Kumara)—much purer limestone may be found. At both these localities Blue Bottom clays are found in the immediate vicinity, so that in course of time the manufacture of cement may possibly be undertaken.

Brick.—The Blue Bottom clays are suitable for brickmaking, and near Greymouth are used for that purpose. At Brunnerton an excellent fireclay that occurs under the main coal-seam is being manufactured into all classes of firebrick and other fireclay goods.

Miscellaneous Economic Resources.

At the present time the most important industry of the Grey Subdivision is probably sawmilling. Though much of the more accessible bush has been cut out, the area yet remaining ought to maintain a large and profitable timber trade for many years to come.

Since the Grey Subdivision contains but a limited area of high country, it lacks the abundance of water available for power purposes that characterizes other portions of Westland. Additional factors contributing to this result are the smaller rainfall, and more particularly the absence of permanent snowfields.

Permanent supplies of water in sufficient quantity for hydraulic sluicing on a large scale can be obtained only from a few localities. Among these may be mentioned the headwaters of the Big Hohonu and Eastern Hohonu streams. These could be brought to Hayes Terrace, near Kumara, at a higher elevation than the water-supply that it is proposed to take across the Teremakau River from Kumara. Lake Hochstetter, which could furnish a permanent supply to the Notown and Red Jack's districts (though at great expense), is some miles outside the boundaries of the subdivision.

MR. COLIN FRASER, MINING GEOLOGIST.

Throughout the year ended 31st May, 1909, Mr. Fraser has been engaged almost continuously in field and office work connected with the detailed geological survey of the Thames Subdivision, Hauraki, Auckland. A portion of the Tairua-Waihi Subdivision, covering some 15 square miles, was also examined and surveyed in detail, since it was deemed economical to carry out the work in conjunction with that on the adjoining portion of the Thames area.

Mr. J. A. Bartrum, Assistant Geologist, assisted in the field-work in this area from June to early in October, 1908.

Field-work in the Thames Subdivision.

Extent and Position of the Area.—During the period under review, the field-work in connection with the geological survey of the Thames Subdivision has been completed. This subdivision comprises the three survey districts of Hastings, Thames, and Waihou, and covers an area of about 385 square miles. This stretch of country extends from Kirita Bay in the north to three miles beyond Paeroa in the south, and constitutes the western half of the southern portion of the Hauraki Peninsula and a contiguous portion of the mainland. The portion of this area actually examined during the past field season consists of all that lying to the south of a straight line drawn from the village of Tapu on the western coast-line to the trigonometrical station (97) on Table Mountain.

Nature of Work carried out. — The nature of the geological, topographical, and mineral prospecting work carried out in this subdivision is precisely the same as that described in connection with the neighbouring Coromandel area in the annual report of 1907. The survey of the mining centre of Thames, however, occupied much more time and involved considerably more detailed examination than that of any special area yet examined by myself in Hauraki or elsewhere. The maze of underground workings to which the adits and shafts give access was carefully examined, and the ascertained data were plotted on the working-plans. As regards conditions obtaining in the numerous inaccessible mine-workings of this old field, the collecting of reliable information from every available quarter proved no small task.

General Geology.

General Classification of Rock Formations.—The following classification of the rock formations occurring in the area is the same as that set forth in describing the northern portion of this same subdivision in the annual report of 1908:—

(1.) Pre-Jurassic and Jurassic stratified rocks.
(2.) Tertiary volcanic rocks of the "First Period."
(3.) " "Second Period."
(4.) " "Third Period."
(5.) Intrusive rocks of various periods.
(6.) Unconsolidated and loosely consolidated débris.

(1.) *Pre-Jurassic and Jurassic Stratified Rocks.*—Both Pre-Jurassic and Jurassic strata outcrop over one or two small areas at and near Rocky Point, some two miles north of the town of Thames. These are the most southerly occurrences of the basement rocks in the peninsula. Pre-Jurassic argillites and rhyolite mudstones (Tokatea Hill Series) were, however, struck in a borehole near the mouth of the Moanataiari tunnel, Thames, at a depth of 1,240 ft. below sea-level. This determination, obtained by boring, taken in conjunction with Rocky Point outcrop, throws considerable light on the geological structure of the deeper horizons of the Thames mining centre.

(2.) *Tertiary Volcanic Rocks of the "First Period."*—Andesites and dacites of this period, in places fairly fresh, but generally in various stages of alteration, form essentially the "auriferous series" of the Thames area. It is here sufficient to state that they cover the whole stretch of country—excepting the small areas at Rocky Point—from Tapu Stream southward to the town of Thames, and again a few more isolated areas in the country further to the southward. Only in the borehole referred to above has the depth to which these rocks descend below sea-level been ascertained.

(3.) *Tertiary Volcanic Rocks of the "Second Period."*—These andesitic and dacitic rocks, better known as the Beeson's Island Series, overlie the older Tertiary volcanics, coaly partings in some place

marking the unconformity. Within the area examined they form the rocks of a great part of the Kauaeranga Valley, and extend southward over the western portion of the hilly country skirting the Hauraki Plains.

(4.) *Tertiary Volcanic Rocks of the "Third Period."*—Rhyolitic tuffs, breccias, and lavas constitute this rock group. Within the area examined they extend from the head of the Kauaeranga River and follow the high country of the main divide to the heads of the Kirikiri and Puriri streams. From here they gradually stretch further to the westward, in many places simply capping the andesitic hills, but near Hikutaia forming the foothills bordering the Hauraki Plains.

(5.) *Intrusive Rocks, of Various Periods.*—The identification of intrusive rocks, as such, in the extensive andesitic complex of this area is by no means easy, owing to the general lithological similarity of the intruded and the intrusive rocks, and to the very general alteration and decomposition which most of the rocks exhibit. That the basement sedimentaries underlying the andesitic formation at Thames are in places largely intruded by andesite and porphyrite dykes has been proved by the results of boring operations.

By far the largest and most conspicuous intrusive belt in the whole area is that which forms the Table Mountain plateau lying between the headwaters of the Waiwawa and Kauaeranga rivers. The rock is a black, lustrous, glassy hypersthene andesite, and, being intrusive into rhyolites, is certainly one of the youngest igneous rocks on the peninsula.

(6.) *Unconsolidated and Loosely Consolidated Debris.*—The fluviatile muds, sands, and gravels which form the extensive Hauraki Plains of the lower Thames-Piako Valley are the most widely developed of the deposits coming under this heading. Next in order of abundance is the fluviatile débris of the lower flood-plains and high-level terraces of the Kauaeranga River and smaller streams. Elevated sea-beaches occurring here and there between Thames and Tapu are of scientific interest rather than of areal importance.

Economic Geology.

The economic branch of the work within that portion of the Thames Subdivision examined during the past season may be briefly discussed under the following headings:—

(1.) Gold-silver quartz veins.
(2.) Metalliferous deposits other than gold-silver.
(3.) Stone for building and roadmaking.
(4.) Water-power.

(1.) Gold-silver Quartz Veins.—The only metalliferous deposits that are now being worked within the area under review are gold-silver quartz veins.

The payable veins occur in the andesites and the dacites, which have been grouped under the heading of "Tertiary volcanic rocks of the 'First Period.'."

Neither in the andesitic rocks of the "Second Period," nor in the still younger rhyolitic rocks of the "Third Period" have payably auriferous quartz veins been located in the Thames area, and, in the writer's opinion, such veins do not exist. The "Second Period" volcanics (Beeson's Island Series) have, unfortunately, when viewed from the economic standpoint, a considerable development in the Thames area, and the "auriferous series" exposed at the surface is therefore rather circumscribed. That certain areas within the rhyolite country ("Third Period" volcanics), which have been subjected to hydrothermal action, certainly carry gold is evidenced by the prospecting work carried out in the stream-beds. This gold, however, when traced to its parent source, is found to come not from quartz veins, or from any very definite silicified bands, but from rock masses which have been very sparsely impregnated with the precious metal by thermal waters. While at certain localities beyond the boundaries of the Thames area (Pakirarahi Mountain, &c.) there exists silicified rhyolitic ash or breccia of this character which may yet be worked for its gold-silver content at a small margin of profit, no such extensive deposits appear to exist in the particular area under review.

The andesites and dacites in the vicinity of the veins have invariably been altered by hydrothermal agencies to the light-coloured softer rock frequently termed propylite. The rhyolites also have undergone a similar alteration; while the sedimentaries exhibit alteration, although in less degree, due to the same agencies which have effected the propylitisation of the volcanics.

Remnants of hard dark unaltered rock are not uncommon within the propylitic areas, and are locally termed "hard bars." Any vein fissures which intersect them are usually represented by mere puggy seams.

Special attention has been directed towards the mapping of the auriferous belts or areas occurring within that portion of the subdivision under review. A careful examination of the country, supplemented by the results of surface prospecting operations, suggests that the discovery of auriferous areas altogether independent of those already known is unlikely. It can here be stated generally that, although the country is deeply incised by streams, prospecting work is both difficult and expensive. This is due mainly to the proneness of the vein-bearing rocks to weathering. A heavy mantle of surface débris covers practically the whole country. The area is, moreover, thickly wooded, and the dense intertwined undergrowth presents a very formidable barrier to the prospector once he attempts to leave the stream-beds.

Waiomo Valley and Adjacent Country.—Propylitised andesitic rocks of somewhat coarse texture form the vein-bearing country of Waiomo and adjacent localities. In fact, much the same class of rocks—alternating irregular beds of andesitic and dacitic lavas and breccias, in general much altered—have extension from Tapu Valley to near Kuranui Creek. The principal vein-occurrences are confined to the altered lava flows rather than to the brecciated rocks.

The gold output of Waiomo Valley has been derived mostly from complex sulphide ores. Free-milling ore was mined in former days from the Parraquet and Gem claims, but the amount was inconsiderable. The predominant sulphides are galena, zinc blende, pyrite, and chalcopyrite.

The principal veins are the Monowai, in the Monowai and old Broken Hill claims, and the Comstock, in the Colorado Claim.

The already located pay-ores of the upper horizons of these veins bears evidence of a secondary enrichment, and, with the exception of certain small shoots associated with vuggy bands or pipes in the veins, the primary sulphide ore opened up in the lowest levels is not of high grade. A good deal of practically unprospected ground exists on the Monowai vein, even in the upper levels, between the workings of the Monowai and those of the Broken Hill.

Prospects of gold are obtainable from many of the branches of the Waiomo Stream, but so far no veins other than those mentioned giving satisfactory results have been located.

In the valleys of the Puhoi, Oturuturu, Whalebone, and Diehard creeks are quartz veins, some of which carry a percentage of the same sulphides as found at the Monowai Mine. Near the head of the Puhoi Creek, which appears to follow a line of faulting or structural weakness, is located the Mount Zeehan Claim. Here several quartz veins carrying bunches and lenses of auriferous complex sulphides are now being prospected. Of the other creeks the Whalebone gives the best dish prospects, and the valley of this stream is worthy of further attention on the part of the prospector.

Te Puru Valley and Adjacent Country.—The Puru Stream drains a fairly wide stretch of country over which a little gold can be got by careful panning. No active mining is to-day being carried on here. Only in the old Puru Consolidated Claim has much underground work been done. The "country" here being fairly heavy, all the entrances to the old adits have collapsed, and examination is impossible. The principal vein appears to have averaged about 3 ft. or 4 ft. in width, and was enclosed in very fair "country"—a propylitised flow andesite. The ore was free-milling, and carried pockets of "specimen stone"—rather a marked difference from the ore of the neighbouring Waiomo Valley. The claim workings, which have an elevation of 1,300 ft., were connected by aerial tram with a battery situated alongside the main creek. Regular though non-payable returns were obtained for some time. It is certain that this claim was never worked to the best advantage, but, with the meagre data now available, little can be said as to its future prospects.

A quartz vein which measures about 40 ft. through where intersected occurs close to the northern margin of the main Puru Stream at an elevation of about 630 ft. (The area is known as the "Puru Big Reefs.") The vein-stone in great part consists of a mixture of quartz and silicified rock, and its value in the crosscut over a width of 37 ft. amounts to less than 2s. 6d. per ton. A quartz band some 3 ft. wide on the footwall side has been driven on for a short distance, giving average assays of 15s. 6d. per ton. The position of the reef from a mining point of view is poor. It occurs close to the base of the valley, and strikes nearly parallel to the stream-bed, therefore little backs would be available from adit workings.

Many other quartz veins exist in this area, some in very favourable-looking country rock. Probably it is the history of mining failures in the valley that weighs with the prospector in neglecting this locality.

Several small creeks incise the country between Puru and Tararu creeks, and, in places, altered vein-bearing rocks are exposed. Although a little detrital gold is obtainable in some of these creeks—notably the Otohi—no vein of any importance has yet been located.

Tararu.—The country lying to the south side of Tararu Creek as far up as Ohio Junction, and also to the south side of the Ohio Branch itself, falls within the Thames Special Area, and need not be considered here.

Fairly coarse-textured propylitised andesites and breccias constitute the prevailing rock of Tararu, bars of unaltered andesite being rather uncommon. The Vulcan reef of the Eclipse Claim out-turned the greater part of the gold of the upper Tararu Valley, but mining has been discontinued in this quarter, and the plant and machinery removed. The vein is a fairly large one, measuring from 4 ft. to 16 ft. An examination of the plans and records (many of the mine-workings are inaccessible) gives one the impression that this claim may have been prematurely abandoned.

The Scandinavian is a claim in which the outcrop ore of Lowrie's reef is said to have been highly payable. Subsequent development at the deeper levels has so far proved disappointing, the vein-stone carrying values too low to be payable. The high-grade oxidized surface ore was evidently a product of long-continued secondary enrichment of the primary vein-stone.

Detrital gold is obtainable in many of the branches of the Tararu Creek, especially those draining from the northern side. The country on the other side in the vicinity of Look-out Rocks has been profoundly altered by thermal solutions, but these solutions were non-auriferous, and the area is a barren one.

The Kauaeranga Valley.—The Kauaeranga is by far the largest stream in this portion of the Thames Subdivision, its drainage area measuring approximately 49 square miles. Of this stretch of country, 12 square miles lie within the Tairua Subdivision, but the geological and prospecting work was extended over the whole of this portion, and its prospects may therefore conveniently be considered here.

From the statement made in the general geology section, that the andesites of the Beeson's Island Series and also the rhyolitic tuffs of more recent age have considerable development in this valley, the prospects of the area from a mining point of view would appear small. Surface prospecting carried on over the whole area indicates that such is the case. With the single exception of the relatively small area drained by the Otanui and certain neighbouring branches of the Mangakirikiri, the prospects of payable gold ever being found are decidedly remote. Certain streams, the headwaters of which drain the tufaceous rhyolitic country of the main range separating the watershed of the Kauaeranga from

that of the Tairua, carry some detrital gold. The source of this gold, however, is not quartz veins, but altered tuffs, which, as before stated, carry in places a sparse dissemination of the precious metals. Narrow clay-filled fissures in these tuff or ash beds in places contain an appreciable quantity of gold derived from the surface leaching of the rock itself. Such seams have here and there been prospected, but they have always proved erratic and non-persistent.

At Otanui gold to the value of perhaps £15,000 was in years past mined from the surface levels of veins intersecting altered andesitic lavas and breccias. The country rock on the whole resembles that of the upper Karaka, and it probably belongs to the same series. The work of crosscutting these veins at greater depth is now progressing. From the dish prospects afforded by the creeks adjacent to the Otanui, and the character of the country rock exposed in this area, further prospecting here would seem advisable.

Kirikiri-Wharehoe-Matatoki Area.—In this fairly extensive area lying between Kauaeranga and Puriri a payable gold proposition has never been located, and, in the writer's opinion, is never likely to be located. The country at the actual head of the Kirikiri, in which is located the Kirikiri Mine, lies without the boundary of the subdivision, and is excepted in this review. Andesitic rocks of the Beeson's Island Series, and tufaceous and intrusive rhyolites of more recent age, are the prevailing if not the only rocks occurring in this area.

Puriri Area.—The principal mining country of the Puriri lies in the upper valley of the main left branch (Apakura), a district, however, which is not included in the subdivision. Andesitic rocks of the "First Period"—the "Auriferous Series"—outcrop in the Puriri Valley, and are flanked or capped by andesites of the Beeson's Island Series or by tufaceous rhyolites. The contact between the andesites and the younger rhyolites is a most irregular one, the latter having been deposited upon a land surface very much the character of what exists to-day in the same locality.

The strongest vein, and the one that has proved the most productive within the area under review, is the Joker, which traverses the spur separating the two main branches of the Puriri. This vein, which is enclosed in propylitised andesites, averages about 15 in. in width, and has been traced and partially worked over a distance of 20 chains along its strike, yielding in places pockets of "specimen stone." Both English and Auckland capital has been expended in exploiting the prospect, but mismanagement, in great part, killed what chances there were of returns to the investors.

Small rich pockets of "specimen ore" were in the early days obtained in the Captain Cook Claim, in the lower valley of the Puriri. The range of propylitisation of the andesites is here very limited, and the prospect of the particular vein located is a poor one. Occurrences of this kind—small pockets of "specimen" veinstone invariably giving out at a very short distance below the surface—have been rather characteristic of the Puriri area.

Within the rhyolite formation altered and silicified areas occur which carry gold, but, unfortunately, not in payable quantity. A potentially more important rhyolite area includes Pakirarahi Mountain, the locus of the Champion and other claims, but this lies outside the subdivision now under survey.

Thames Special Area.—What has here been designated the Thames Special Area is the Thames mining centre proper, and lies between the Tararu-Ohio Stream and the Hape Creek.

As a good deal has been written about the geology and the mining of this famous old quartz-reefing centre, any such general description as could here be submitted would serve no special purpose. In the complete report which is now being prepared dealing with the Thames Subdivision, the geology and mining of this special area will be discussed at length. It is hoped that the recent detailed survey of the field, embracing new data that have been afforded by mining operations since the previous reports were published, will throw further light upon certain difficult problems connected with the structure and the ore occurrences of the area. The quartz veins of this field, it need hardly be remarked, are of the bonanza type, and are contained in propylitised andesitic rocks.

The hopes of the field are at present centred in development of the deeper levels. So far, 630 ft. below high-water mark is the lowest level at which a prospecting crosscut of any length has been driven. This crosscut from the Old Big Pump shaft southward was advanced scarcely as far as the Prince Imperial shaft. No great amount of work was done at this level apart from the actual driving of the crosscut, but yet sufficient, it would seem, to prove the unproductiveness of the country crosscut at this horizon. It seems reasonable to suppose that, had the crosscut been advanced further southward, productive country would have been intersected. The general dip of the zone of country on the hanging-wall or seaward side of the Moanataiari fault, which contained the rich bonanzas of the past, is south or south-west. The discovery, therefore, of pay-ore in the veins of the southern and south-western portion of the same zone at greater depths than yet exploited may be expected. The Victoria, the Saxon, and the May Queen are the properties in which the southern extension or deeper portions of this ore-bearing zone should occur. The driving of a crosscut at the 1,000 ft. level, northward from the well-equipped Thames-Hauraki shaft, is now under consideration by the May Queen, Saxon, Victoria, Waiotahi, and Kuranui-Caledonian companies jointly. The shaft named is well placed in the southern portion of the area in question, and such a crosscut should command the unexploited portions of the ore-bearing zone mentioned, as well as prospect the stretch of country further northward.

It is more than likely that the diamond drill will play an important part in further prospecting this northern portion of the field below the 1,000 ft. level. The cores afforded by the Kuranui-Caledonian bore from a depth of 1,034 ft.—that is, before the bore penetrated the Moanataiari fault—gave some indication that an ore-bearing zone may exist on the seaward side of the fault at and below the depth mentioned. Boring from suitable offset drives projected westward from the main 1,000 ft. level crosscut, will certainly prove the most economical method of initially prospecting the deeper horizons and of thus throwing further light on this vital question.

(2.) Metalliferous Deposits other than Gold-silver.—The only metalliferous products other than gold-silver bullion exported from the Thames Subdivision consist of lead, copper, and zinc contained in certain auriferous concentrates that have been shipped to Australia for smelting purposes. These concentrates were derived from the ores of the Monowai and Comstock veins at Waiomo, and of the Sylvia vein at Tararu. The ores are, however, essentially gold-silver ores, the value of the baser metals being relatively low.

Cinnabar occurs in the Mangakirikiri Valley, Kauaeranga, but so far, prospecting operations have failed to locate any payable deposit. The workings that had not collapsed were examined, and the mineral was observed to occur in isolated pockets in a nearly flat-lying narrow band of chalcedonic quartz enclosed in altered andesites.

(3.) Stone for Building and Roadmaking.—The andesites throughout the area are so closely and so irregularly jointed that even the hard unaltered rock is unsuitable for building-stone. Furthermore, andesitic rocks in general are noted for their lack of rift, thus rendering dressing very expensive.

Tufaceous rhyolites are found in the upper Kauaeranga Valley, some of which, had they occurred in a more accessible position, would have a value for constructional purposes.

The hard unaltered andesite—"blue metal"—is the rock generally used throughout the district for macadamising roads. Rock suitable for such purposes is fairly abundant, but the locality of an outcrop is the main factor in assessing its value. The occasional crosscutting of "hard bars" in the mines affords some fairly good rock, which can be cheaply handled.

(4.) Water-power.—The following statement, which appeared in my last annual report, is equally applicable here:—

"The streams of the area, owing to the relatively short distances of any portion of the water-parting from the sea-coast, normally carry rather small volumes of water. Further, their gradients, as mentioned before, are low, usually right back to the junction of the rapidly descending head-water branches. These characteristics render the streams unimportant as the sources of any considerable amount of water-power."

The largest stream in this portion of the subdivision is the Kauaeranga, flowing into the Firth of Thames at Shortland. This is the source of the county water-supply, which affords power for many of the batteries and other industrial concerns at Thames. The water of this stream is picked up at the Hihi Junction, and the supply is supplemented by intakes from all the larger right-hand branches of the river below this point.

All the other streams of the area are comparatively small. Certain of them, however, are of value as limited sources of power, if such power should be required in their immediate vicinities. No gauging of the volume of these streams was deemed advisable.

MR. E. J. H. WEBB, ASSISTANT GEOLOGIST.

From about the middle of June till the middle of September, 1908, I was engaged in the Wellington office in the preparation of the annual report and other work. On the 16th September, 1908, I reached my camp on the Little Wanganui River, and since then I have been continuously engaged in field-work in the Mount Radiant Subdivision.

Work in the Mount Radiant Subdivision.

The Mount Radiant Subdivision, comprising in all an area of 205 square miles, consists of the survey districts of Kongahu and Otumahana, lying in the extreme north of the Westport Division. It is bounded on the west by the Tasman Sea, and on the east by an arbitrary line 12½ miles in length and distant 13½ miles from the coast at its northern and 19½ miles at the southern extremity. Topographical and geological work is now nearing completion, only a small portion in the south-west of the subdivision still requiring examination. Traverses with chain and compass have been made of the rivers and streams of the subdivision, while a triangulation with the theodolite of the mountain ranges has been completed. The results of the survey will be embodied in a detailed report to be submitted shortly.

General Geology.

General Classification.—The general classification adopted in last year's report is retained, pending a more detailed microscopical and palæontological examination:—

(1.) Ordovician	Aorere Series	Argillaceous grauwackes and spotted schists.
(2.) Miocene	Oamaru Series	Breccias, claystones, grits, limestones and sandstones, and conglomerates with carbonaceous seams.
(3.) Pleistocene and Recent	..	Beach and river débris, talus slopes.
(4.) Post-Aorere	..	Igneous rocks.

(1.) *Aorere Series.*—Rocks of the Aorere Series are of comparatively rare occurrence within the subdivision, being confined as far as present examination shows to a narrow belt along the southern end of Stormy Range. They consist of argillaceous grauwackes interbedded with spotted schists, and are frequently brecciated and much folded with south-easterly strike, effects due to the intrusion and subsequent elevation through faulting of the granite mass now forming Stormy Range.

(2.) *Oamaru Series.*—The beds which have been classed in this series occur throughout the greater portion of the subdivision, forming as they do the "upland region," and extending through the graben valley of Stormy Range to the valley of the Kakapo River. They also make their appearance at a considerable elevation in the extreme south-east of the subdivision, where denudation has not effected their entire removal. The upper members of this series have their greatest development in the north-west of the subdivision; the lower members in the south-east and extreme south-west. The beds consist, in ascending order, of breccias, more or less calcareous claystones, with bands of grit, shelly arenaceous limestones, soft fine-grained sandstones (frequently argillaceous), followed by beds of loosely consolidated conglomerate with carbonaceous seams, and coarse granite sandstones. The beds are as a rule but slightly inclined from the horizontal except near the boundary of the "old land," where the strata are faulted and sharply upturned. Fossils are abundant except in the uppermost beds of the series.

(3.) *Beach and River Débris, Talus Slopes.*—From the mouth of Little Wanganui River northwards the littoral deposits consist almost entirely of sands and muds, the coarser river débris having been deposited before reaching the coast. South of the river, however, the high escarpments of Tertiary rocks have covered the beaches with boulders, while at the extreme southern point granite débris derived from the underlying basement rock, which here makes its appearance, is strongly in evidence. Recent deposits also appear in the beds, flood-plains, and terraces of all the streams, and in the talus slopes common on the mountain-sides.

(4.) *Igneous Rocks.*—The uplifted mountainous interior of the subdivision consists of granite overlain in places by unaltered rocks of the Oamaru Series. The same rock also appears at Kongahu Point, the most southerly headland on the coast of the subdivision. The granite is found intruding the rocks of the Aorere Series, and hence in point of age it is post-Ordovician and pre-Miocene. The prevalent type is a dark-grey porphyritic biotite granite; but bands of dark basic segregations are common, while pegmatite dykes are not infrequently encountered. Particular attention is drawn to these rocks, on account of the metalliferous veins occurring in them.

Economic Geology.

Occurrences within the subdivision of minerals of economic interest may now be briefly discussed under the headings of (1) Copper and Molybdenum, (2) Lead and Zinc, (3) Alluvial Gold, (4) Coal, (5) Materials for Lime and Cement, and (6) Petroleum. Owing, however, to the fact that the results of sample analyses are yet not to hand, definite conclusions regarding the economic values of the various occurrences cannot be announced.

(1.) Copper and Molybdenum.—Veins carrying ores of copper and molybdenum appear to be practically confined within the subdivision to the Mount Radiant Range and its southern continuation, Mount Scarlett.

Of those veins of which mention was made in the last annual report little need be said. No further visit has been paid to any of these veins, with the exception of the New Anaconda reef, upon which a more elaborate sampling was undertaken by the Survey, about two tons of ore being removed in the process. In doing so a better exposure was made of the vein, and some fresh light thrown on its structure.

New Anaconda Reef.—The vein shows a maximum width of 19 ft., its western wall being well-defined, with a strike of 165° (true), and an apparent steep easterly dip. Its eastern or hanging wall presents a series of veinlets and stringers roughly parallel to the main vein, and hence is not so well defined. The main ore-streak has a strike coincident with that of the vein, and is well exposed at the southern end of the outcrop, where its width varies from 2 ft. 8 in. to 6 ft. 4 in. The vein has recently been rendered more accessible by the construction of a well-graded foot-track from the mouth of Specimen Creek.

Johnson River.—Indications of copper and molybdenum were observed in Johnson River above Fugel Creek. Here, at an altitude of 2,230 ft., a vein formation 5 ft. 3 in. in width shows a number of 2 in. parallel stringers crossing the river-bed with a north-easterly strike and steep south-easterly dip. Several of the stringers carry small branches of pyrite and chalcopyrite, with traces of molybdenite. Lower down the river as far as Fugel Creek similar veinlets are occasionally encountered.

Fugel Creek.—At the mouth of Fugel Creek, at an elevation of 2,150 ft. above sea-level, a 6 in. to 9 in. vein with north-easterly strike and dip of 40° to the south-east is exposed for a distance of 15 ft., and is highly impregnated with pyrite, chalcopyrite, and molybdenite, and their oxidation products. The metalliferous contents are fairly constant in quantity throughout the whole length of the exposure.

Gold Creek.—Near the head of Gold Creek, a left-hand branch of Fugel Creek, at an elevation of 3,560 ft., a vein of 2 ft. 3 in. in width is exposed along its strike for 16 ft. It strikes 76° true, and dips steeply north. The quartz gangue is of a flinty appearance, frequently stained rusty, and carries a little chalcopyrite and pyrite both finely disseminated and in small bunches an inch in thickness. Traces of molybdenite were also observed. Lower down, at an elevation of 2,530 ft., a vertical vein 18 in. wide with strike of 26° true outcrops in the stream-bed. Throughout the quartz gangue chalcopyrite with a little molybdenite is desseminated along fracture planes parallel to the strike of the vein. Melaconite and bornite are also present.

(2.) Lead and Zinc.—On the crest and slope of Mount Gorgeous, a lateral range from Mount Radiant that flanks Johnson River on its south-western side, a well-defined vein was noted by the Survey. It has a northerly strike, with a dip of about 30° to the west, its well-defined hanging-wall showing down the mountain-side for 30 ft. The width at the top is 18 in., increasing to 7 ft. at the bottom of the outcrop. It is said to carry large bunches of galena and zinc-blende. Samples taken by the Survey showed small amounts of these minerals.

(3.) Alluvial Gold.—Alluvial gold occurs in several parts of the subdivision, notably in Mullocky Creek, in Kimberley Creek, and other branches of Granite Creek, in Glasseye Creek, and, associated with leads of black sand, along the beach north of Little Wanganui River. In the past a considerable amount of gold has been won from the streams mentioned, but operations are at present confined to the beach, where "beach-combing" is occasionally resorted to after heavy weather.

The beds of loosely consolidated conglomerates associated with the upper members of the Oamaru Series carry a little fine gold, the reconcentration of which by small creeks has, it is likely, produced in some cases payable leads. The gold in Glasseye Creek, as well as much of that on the beach, is probably derived from auriferous veins in the Aorere rocks to the south of the subdivision. That in Kimberley Creek is apparently derived from auriferous wash deposited by the Karamea River in Pleistocene or early Recent times.

(4.) Coal.—Associated with the conglomerates in the upper beds of the Oamaru Series are thin seams of carbonaceous shale, or inferior lignite. These outcrop in the low hills bordering the coastal plain, but good exposures are rarely encountered. The largest seam noted by the Survey had a thickness of 1 ft.

(5.) Materials for Lime and Cement.—The bed of limestone occurring as one of the lower members of the Oamaru Series and outcropping along the base of the mountain ranges is nowhere of any considerable thickness. The quality of the rock is also so variable as to render it unfit for the manufacture of cement on a very large scale. Analyses that may show the suitability of certain of the calcareous claystones in this direction are not yet to hand.

(6.) Petroleum.—The claystones forming one of the lowest members of the Oamaru Series frequently yield a distinct smell of petroleum. Beyond this no other indications of the presence of mineral oil have been noted by the Survey; and, owing to the synclinal arrangement of the strata, it seems unlikely that a payable oilfield exists in this locality.

Mr. J. H. ADAMS, ASSISTANT GEOLOGIST.

Except for a short interval during June, 1908, when he was engaged in office-work at Wellington, Mr. Adams has been continuously occupied in field-work in the Whatatutu Subdivision, Poverty Bay. His work in this area is now completed, and he is about to prepare a comprehensive report on its geology and economic resources. Mr. Adams's interim report for the season is as follows:—

Work in the Whatatutu Subdivision.

The area which constitutes the Whatatutu Subdivision of Raukumara, Hawke's Bay, comprises the Mangatu and Waingaromia survey districts, and is a rectangle of 25 miles by 12½ miles, thus having an area of 312½ square miles.

The chief interest in the geological survey of this subdivision from an economic point of view arises from the occurrence of good surface indications of petroleum-oil at Waitangi Hill. With a view to locating the most suitable sites for tapping by deep boring the petroleum-bearing formation, a very detailed survey of the area has been made. Three favourable sites for deep boring have been located, on one of which, already proposed in a former report,* the Gisborne Oil Company is at the present time sinking a deep borehole.

During the past season operations have been extended over an area of some two hundred square miles, in which the principal watercourses are the Waipaoa, Mangatu, and Waihora rivers, the Wheao Stream, a portion of the Waikohu River, and the head branches of the Pakarae River.

Five shallow bores were sunk at Waitangi Hill to a depth of about 60 ft., in order to ascertain the nature of the rock below the surface material. One hole was sunk on what is now the site of the Waitangi borehole of the Gisborne Oil Company. Three are within a radius of 9 chains of this; the last is situated 21¼ chains away. Each of the first four holes had a small flow of water at about 10 ft., and showed claystone or argillaceous sandstone downwards from 40 ft. The last borehole was dry to 48 ft., and the claystone or argillaceous sandstone occurred downwards from 12 ft.

General Geology.

The formations occurring within the Whatatutu Subdivision have been classified as follows:—

Formation.	Age.
(*a.*) Whatatutu Series	Upper Miocene.
(*b.*) Waipaoa Beds	Pliocene.
(*c.*) River and terrace gravels	Pleistocene and Recent.

(*a.*) Whatatutu Series.—Almost the whole of the rocks occurring within the subdivision have been classed under this heading, since no absolute evidence of stratigraphical unconformity was seen, nor do the fossils collected from all parts of the area vary sufficiently to indicate that such unconformity exists. There is, however, a certain association of beds which permits of the series being subdivided in ascending order as follows:—

(1.) Clay-shale; chalky limestone; glauconitic sandstone.
(2.) Claystone and argillaceous sandstone, with calcareous concretions.
(3.) Claystone and argillaceous sandstone; limestone; conglomerate; fossiliferous argillaceous sandstone; coarse sandstone.

* Second Annual Report N.Z. Geol. Survey, 1908, pp. 11 and 35.

(1.) *Clay-shale; Chalky Limestone; Glauconitic Sandstone.*—The north-western portion of the subdivision is composed mainly of the rocks belonging to this group of the series.

Clay-shale occurs in the Mangatahu Valley and in the head-water valley of the Waitangirua, in both cases overlain by chalky limestone. It is a laminated rock, finely textured, dark grey in colour, containing about 4 per cent. of carbonate of lime ($CaCO_3$).

Chalky limestone occurs in the valleys of the Mangatu River, Mangamaia, the Makerewau and the Mangapapa streams, and also forms spurs and ridges in the vicinity of these watercourses. It is exposed in the Mangatu Valley for a distance of seven miles below the northern boundary of the subdivision; in Slip Stream and in the Waipaoa River; in the valley of the Mangataikapua Stream; and as an inlier in the valley of the Makahakaha Ngarara Stream near Hokoroa Homestead. The rock is of whitish appearance, often tinged pale green or brown by ferruginous minerals. Veinlets of calcite occur frequently, varying from an inch in thickness to mere threadlike streaks.

Glauconitic sandstone occurs overlying the chalky limestone. The largest continuous outcrop covers an area of about thirteen square miles, extending from the middle course of the Mangatahu Stream south and south-west down the valleys of the Mangamaia and Makerewau streams. Glauconitic sandstone forms the Pulpit Rocks on the left or eastern bank of the Mangatu River opposite the mouth of the Mangamaia Stream. From here inliers of the same strata occur at intervals in a general westerly direction as far as Waitangi Hill. The glauconitic sandstone is a moderately well-compacted rock, varying in texture. Its colour is olive green on unweathered surfaces and dun-coloured on weathered surfaces. At the Pulpit Rocks it contains veinlets of calcite, small druses of rock crystal, and chalcedony.

(2.) *Claystone and Argillaceous Sandstone, with Calcareous Concretions.*—Claystone and argillaceous sandstone, with calcareous concretions, occur mainly in the valleys of the Waingaromia, the Waihora, and the Waikohu rivers. In general, the rocks show no stratification, and their relative position in the series can only be judged approximately, since actual contacts with the first group of the series are indistinctly shown. The claystone and argillaceous sandstone are finely textured grey-black rocks, which frit and crumble on exposure. The concretions are of very hard, fine-grained, calcareous claystone, and occur either as spheroidal and tubular masses or as interrupted bands. These concretions are said to have yielded specimens of the fossil Inoceramus*; none, however, was found during the present survey.

(3.) *Claystone and Argillaceous Sandstone; Limestone; Conglomerate; Fossiliferous Argillaceous Sandstone; Coarse Sandstone.*—The claystone and argillaceous sandstone of this group are lithologically similar to those of the last; the distinction made is purely a structural one. These formations occur either singly, showing stratification, or together, interbedded, with or without one or more of the following: finely textured sandstone bands, shelly conglomerate bands, concretionary bands, limestone bands. The concretionary bands referred to are highly calcareous sandstone, containing a variable quantity of fossil shells. The limestone bands occur but sparingly. They are hard crystalline rocks, containing grains of sand or of glauconite.

The limestone of this group is that referred to by Mr. McKay† as the coralline limestone at the base of what he terms the lower Tertiary Series. It occurs on Sub-Trigonometrical Station A (Mangatu Survey District); on Trigonometrical Station I (Waikohu Survey District); and near the head of a right branch of the Tawa Stream. It is of a light-pink colour, is finely textured, very compact, and contains an abundance of fossil shells. It occurs overlying the claystone and argillaceous sandstone of this group of the Whatatutu Series, but nowhere in the subdivision has a rock formation directly overlying it been observed, so that its actual relative position is uncertain.

Bands of conglomerate‡ consisting of pebbles and boulders cemented together by an arenaceous or an argillaceous medium were located in four different localities, in all cases interbedded with claystone and argillaceous sandstone. The largest outcrop is in Conglomerate Stream, a small right branch of the Waipaoa River entering opposite Waipaoa Homestead. Exposures in this stream show intermittently from a point on the ridge about 20 chains to the east of Wheturau Hill down almost to the mouth of the stream. The best exposure lies between the ridge by which the Mangatu–Waipaoa Stock Track crosses the stream, and the waterfall over which the stream flows before entering the river. Here occur, resting on the claystone and argillaceous sandstone, bands of extremely fine conglomerate, followed by bands containing boulders up to 2 ft. in diameter, with occasional interstratified bands of argillaceous sandstone. The total thickness of the coarse bands is over 20 ft. On the ridge large blocks of coarse material occur, while just below it are bands with pebbles averaging 6 in. in diameter. A second outcrop of this formation occurs in the Waikohu Valley on the boundary between Belmont and Waihuka Stations, a mile and a half (air-line) west of Poututu Accommodation-house. This outcrop consists mainly of very fine material, with, as far as was observed, only one or two bands containing inclusions as large as 6 in. A third outcrop with moderately coarse bands occurs in the Urukokomoku Stream, about four miles (air-line) above its mouth. A fourth outcrop occurs in the waterfall of Atarau Stream, a left branch of the Mangaorango.

The material contained in these bands consists of water-worn pebbles and boulders of igneous origin, fragments of concretionary boulders, and occasional small pieces of quartz. The igneous boulders consist of diorite, gneiss, gabbro, &c., and, as no rocks of similar character have been described as occurring *in situ* anywhere in the North Island of New Zealand, their source is at present doubtful.

An argillaceous sandstone containing an abundance of fossil shells covers a large area in the south-western portion of the subdivision. Owing to the fact that it occurs for the most part in the troughs of synclines, it has been placed in the upper part of the Whatatutu Series.

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*Mines Report, 1901, C.–10, p. 23. †Mines Report, 1901, C.–10, p. 24. ‡See reference under "Material for macadamising Roads."

A coarse sandstone occurring on the spurs in the vicinity of Atarau Peak, and forming the crest of a portion of the Tutamoe Ridge (slightly north of the subdivision), is probably the closing bed of the series.

Structure of the Series.—The necessity that geological work in the petroliferous area of Poverty Bay should be done with the utmost detail is clearly evidenced by the result of mapping the strikes and dips of the formations examined in the subdivision. The structure, as indicated by this mapping, is one of considerable complexity. The rocks have been folded into a series of very irregular folds—in places wide and open; again, much compressed.

Two main well-defined anticlines running approximately parallel to one another have been located. The first of these lies in the eastern portion of the subdivision, and, running in a general N.N.E. direction from about the Village of Te Karaka, passes through Toromiro Hill, and crosses the valleys of the Makahakaha Ngarara and Parariki streams. This anticline is crossed by a shorter one with a general N.E.–S.W. direction, the intersection giving rise to a dome at a point about a mile and a half north of Hokoroa Homestead. Near the northern boundary of the subdivision are two short subsidiary anticlines to the east of and approximately parallel to this main one. The second main anticline is that passing through Waitangi Hill. From this point its strike is about due north to the northern limits of the subdivision, and slightly south of west to a point about one mile west of the confluence of the Mangamaia Stream and the Mangatu River. At the last-named point a dome is formed by its conjunction with an anticline with a general north and south direction. The main anticline continues, from this dome, about one mile in a southerly direction, and then bifurcates—one branch running about north-west between Mangahaumia and Big Slip, the other branch running first south, then west across the Urukokomoku Stream and up the valley of the Wheao Stream. At Waitangi Hill a dome is formed by the crossing of a short anticline running in a N.W.–S.E. direction.

In the extreme eastern portion of the subdivision there is evidence of an anticlinal arrangement of strata near the confluence of the Makahakaha and Whakauranga streams.

From the above description it will be seen that the rock-folding in the area is very irregular, and that it is unsafe to assume that any fold will continue in the same direction for even a few miles. Hence, to know definitely the structure of the interesting localities of the occurrence of the petroleum indications at the head of the Totangi Stream, and the mud and gas springs at Waimata, both of which are situated about five miles without the southern boundary of the subdivision, an extension of the detailed geological work will be necessary.

The frequent occurrence of creeps, and slumps or landslides, has obliterated to a large extent the surface indications of major faults. The petroleum indications at Waitangi Hill are probably on a line of fault extending thence in a W.S.W. direction to the Waipaoa River, a distance of five miles. From the occurrence of outcrops of the older group of the Whatatutu Series on the north side, and of the younger group on the south side of this supposed fault-line, it may be inferred that the downthrow of the fault is to the north.

The disturbed state of the strata in the Weraroa Stream and the occurrence of gas springs on the spur to the north seem to indicate the presence of a fault running in a general east-and-west direction in this vicinity.

Minor faults are of frequent occurrence, and are very well shown in cliff-faces and in river-beds.

(*b.*) Waipaoa Beds.—The Waipaoa Beds are sandy pumiceous deposits, the material of which is probably derived from an area outside the subdivision. They occur mainly in the Waipaoa Valley between the Puha and Whatatutu villages, where they show in cuttings and cliff-faces underlying the terrace gravels and overlying unconformably the claystone rock of the locality. Outcrops not covered by gravels occur on the low spurs on the right and left banks of the river, and the presence of this formation is easily detected by the sparseness of the vegetation it supports. Small outcrops were also noted in the Waikohu River bed; on the spur to the north of Tawa Stream; and in a right branch of the Makahakaha Stream (branch of the Whakauranga).

(*c.*) River and Terrace Gravels.—The valleys of the larger streams show high- and low-level terraces of some considerable extent, the surfaces of which are covered to a depth of 10 ft. or more with loosely consolidated débris, consisting of water-worn material derived from the more resistant strata occurring in the area.

Economic Geology.

Petroleum.—The mineral of chief interest within the subdivision is petroleum. The existence of surface indications of this mineral at Waitangi Hill—a description of which has appeared in a former report*—has been known since 1873. Various petroleum companies have operated within the subdivision since that date, but all were unsuccessful in obtaining oil in payable quantities. It is extremely unfortunate, from a geological as well as from an economic point of view, that so little information is on record concerning the actual results obtained during these operations.

Of nine holes bored within the subdivision, the majority were sunk at or in the immediate vicinity of the surface indications at Waitangi Hill, and these reached depths ranging to 500 ft. The South Pacific and Minerva holes are, however, located some distance away.

The South Pacific borehole is situated about a mile and a quarter (air-line) due south of Waitangi Hill (Trigonometrical Station 138). It was commenced on the 11th December, 1884, and in December, 1887, had attained a depth of 1,321 ft. It is said that at this depth oil was struck, causing a "blow-out." The oil became ignited, burned down the derrick, and generally wrecked the machinery. A new plant was erected, and another 15 ft. bored without any oil being obtained. The hole was then abandoned. That this borehole should manifest such strong evidence of the presence of petroleum, and then prove

* Second Annual Report, N.Z. Geol. Survey, 1908, p. 33.

'dry" on the resumption of boring, seems a little extraordinary, and it is not surprising that many are inclined to question the genuineness of this "blow-out." The "log" of this bore is given in a paper on "The Oil Prospects of Poverty Bay and District," by Mr. H. Hill,* and the rocks passed through appear to be claystone and fossiliferous sandstone—that is, the upper portion of the Whatatutu Series. Indications of oil, it is stated, were obtained in this hole in "sand-bands" at depths 470 ft. to 483 ft., and from 793 ft. to 900 ft. Theoretically, the choice of the position of this borehole was unfortunate, since the hole is located almost in the trough of a syncline.

The Minerva borehole, commenced in 1888, is situated on the left or eastern bank of the Waipaoa River, distant five miles (air-line) south-west of Waitangi Hill. Very little information is available concerning this hole, but it is said to have reached a depth of about 800 ft. At a depth of 700 ft. gas emanated freely, and when caused to issue through a 1 in. pipe burned continuously with a flame over 2 ft. in length. At 750 ft. a red shale impregnated with oil was struck.† This hole is situated about one mile to the south of the crest of the anticline already described as passing through Waitangi Hill.

Various small gas-emanations occur in the subdivision, which in all cases appear to be either on lines of faulting or on breaks produced by slumping. It is probable that some of these emanations are due to the decay of vegetable matter but a short distance below the surface.

The following are results of analyses of samples of oil obtained from the springs at Waitangi Hill. Nos. 2 and 3 are from the main oil spring, while No. 1 is from a test pit sunk about 3 chains distant from the main spring:—

	(1.)	(2.)	(3.)
Water	0·3	0·2	Nil
Oils distilling below 150° C. (benzine, &c.)	0·2	0·5	Nil
Oils distilling between 150° and 300° (burning-oil)	41·0 S.G. 0·8459	39·0 S.G. 0·8344	47·2 S.G. 0·836
Residual oil distilling above 300° (lubricating-oils, paraffin, &c.).. ..	5·85 S.G. 0·9107	60·3 S.G. 0·9002	52·8

From these analyses it will be seen that the oil contains an average of over 40 per cent. of burning-oils and a large percentage of lubricating-oils. On account of the moderately large percentage of burning-oils the crude product is of special importance, since it can in certain cases be used for heating purposes without any refinement.

From the geological examination of this subdivision, which has just been completed, it would appear that the petroleum-bearing stratum is nowhere exposed at the surface. The petroleum showing on the springs is probably derived from a stratum considerably below the surface at this point, and makes its way to the surface by rising up a "break" or fault-plane. The fact that the oil indications show on the same line for a distance of 16 chains in itself suggests that they are on a line of fault.

The depth at which the petroleum-bearing stratum occurs can only be a matter of speculation until some information as to the nature of the strata underlying the lowest beds exposed on the surface in the area examined has been obtained by deep boring. It is therefore essential for the future prospects of a petroleum industry for Poverty Bay that a full and true record should be kept of the operations now in progress.

Gold.—Some prospecting for gold has been done in this area, especially while the greater portion was still covered with native bush. Small pieces of quartz carrying gold are reported to have been found, but from the nature of the geological formations of the subdivision, it seems likely that these specimens have their parent veins in other districts. It is highly improbable that any auriferous quartz veins will be found in this area. The one possibility of gold being found is as alluvial gold in the conglomerate bands described above (see page 24). The chances here even are very slender indeed, since such pieces of quartz as have been seen that were included in the conglomerate are of a decidedly "hungry" appearance, and "dish" prospects taken from the bands gave not a "colour" of gold.

Coal.—No evidence of the occurrence of payable coal-seams was obtained during the survey of the area. If such do occur, it is below the formations which appear at the surface, and their presence will probably only be detected by deep boring. A sample of lignite within the area was submitted for analysis, but is of very poor quality, and contains an excessive amount of ash.

Material for macadamising Roads.—Of the rock formations exposed in the area, the most suitable for macadamising-material is the conglomerate described under the heading of *General Geology*. This material is sufficiently hard to resist crushing under traffic, and the dust formed by its abrasion, when moistened, will form a cementing medium for the larger chunks of stone. The conglomerate bands contain material ranging from fine gravel to stones of 3 ft. and up to 5 ft. in diameter.

The localities of occurrence have been described under *General Geology*. The most accessible of these is that in the Waikohu Valley; but, unless further investigation should prove the existence of more bands of coarse material than were observed in the river-bed, the supply here is but small. At Conglomerate Stream is the most suitable deposit to supply a large quantity of material.

Brickmaking.—Samples of clays taken from the surface bores at Waitangi Hill were submitted for analysis in order to ascertain their value for brickmaking. Though the clays contain too much iron-oxide to be of value for fine pottery-making or fireclays, they should be suitable for brickmaking.

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*Trans. N.Z. Inst., Vol. xxi, 1888, pp. 320–25. †Article by Mr. Ackroyd, *Poverty Bay Herald*, May 4, 1901, p. 2.

CEMENT.—Samples selected from various outcrops of limestone have been submitted for analysis, with a view to ascertaining their value for cement manufacture. These analyses in general show a content low in magnesia and in iron-oxide, moderately low in free silica, and sufficiently high in carbonate of lime. The limestones can be easily pulverised, and are fairly homogeneous. Should a sufficient supply of cheap fuel be available, good cement could be economically produced.

SUITABLE SITES FOR DEEP BORING.—In a petroliferous area, the geological formation of which consists of alternating porous and impervious beds that have been subjected to folding, it is reasonable to suppose that the petroleum will be collected in anticlines. Since oil is lighter than water, and does not mix with water, it will be buoyed or forced upwards towards the anticlines, while the pressure of the gas in the petroliferous area also assists in effecting the same result. A point where two anticlines cross, forming a dome, should therefore have a maximum accumulation of oil.

From the structure of the Whatatutu Series described under *General Geology* it may be deduced that three favourable sites for deep boring for petroleum occur in the subdivision. One at Waitangi Hill has already been proposed as a suitable site;* the two remaining are,—

(1.) On the northern bank of the Mangamaia Stream, in the vicinity of the Mangatu River;
(2.) In the valley of the Makahakaha Ngarara Stream (left branch of the Waingaromia River), a mile and a half to two miles north of Hokoroa Homestead.

At each of these sites a dome has been located, and for this reason they should be suitable sites for deep boring.

MR. K. M. GRAHAM, TOPOGRAPHER.

FIELD-WORK IN THE WAIHI SUBDIVISION.

On the 21st October Mr. Graham entered upon the work of making a detailed topographical survey of the Whitianga and Tairua survey districts. These districts occupy the middle and eastern portions of the Thames-Coromandel Peninsula, and have a land-area of approximately 116 square miles and 135 square miles respectively.

Mr. Graham's work involved the traversing of the main rivers and their tributaries, the fixing of the main watersheds, and the mapping of the natural features of the country, in so far as was necessary for the subsequent carrying-out of a geological examination.

The survey of the Whitianga district was completed in the early part of May, and a start was then made in the northern part of the Tairua district.

At the end of May field operations were suspended for the winter months, and the preparation of the complete maps of the area surveyed is now in progress.

MR. H. RICHARDSON, TEMPORARY ASSISTANT TOPOGRAPHER.

During June, 1908, Mr. Richardson was engaged in traversing the Big River and its tributaries, Heaphy Subdivision, Karamea, Nelson. He then returned to headquarters, where for some months he was employed in draughting work. Early in October Mr. Richardson resumed the topographical survey of the Heaphy Subdivision, and was so occupied until the end of the field season. During this time he completed an accurate traverse of the coast-line from the Turimawiwi River to a point beyond the Big River, and surveyed in detail the country drained by Raukawa Creek, the Anaweka River, the Turimawiwi River, and their various tributaries. Previously the valleys of these streams were practically unsurveyed, their courses being simply roughly sketched on the available maps.

During the past season Mr. A. J. Whitehorn, chainman, acting under Mr. Richardson's directions, has topographically surveyed portions of the Heaphy, Gunner, Kowhai, and Murray valleys, in the Whakapoai and Gouland survey districts.

Mr. Richardson reports that the country surveyed by him contains a considerable area of fairly good land, together with some of first-class quality. It is mostly covered by mixed bush, and in some localities contains good milling-timber.

As noted on a previous page, what may prove to be most important discoveries of sub-bituminous† coal of excellent quality were made by Mr. Richardson in the Raukawa, Turimawiwi, and Anaweka valleys. The explored area containing coal-seams is about three square miles, but the coal-measures probably continue to the north and north-east of the known outcrops until they join those of the West Wanganui district. Southwards the coal-measures are interrupted by granite for some miles, but reappear in the Heaphy Valley, where new outcrops, in addition to those formerly known, have been

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*Second Annual Report, N.Z. Geol. Survey, 1908, p. 11. †The term "sub-bituminous" is here used in accordance with the classification of coals adopted by the United States Geological Survey. Coals having the composition and physical properties of the coal in question have in New Zealand hitherto been classed as brown coals; but, since they are much superior in every respect to the typical brown coals—for instance, those of Germany—it is obviously desirable that they should be distinguished by another name. See an article by Marius R. Campbell in *Economic Geology* for March–April, 1908, entitled "A Practical Classification for Low-grade Coals."

located by Mr. Whitehorn's party. Analyses by the Dominion Laboratory of the coal from the outcrops are as follows :—

	(1.)	(2.)	
Fixed carbon	35·40	36·35	per cent.
Volatile hydrocarbons	49·49	46·76	,,
Water	12·16	14·34	,,
Ash	2·95	2·55	,,
	100·00	100·00	,,
Total sulphur	4·38	3·86	per cent.
Calories per gram	6,257	5,936	
British thermal units per pound	11,262	10,685	
Evaporative power per pound from calorimeter ..	11·67	11·08	lb.
Practical evaporative power* (assuming 60 per cent. efficiency)	7·00	6·65	lb.

Each of these coals gives a dark-coloured ash. The various seams all show a bright, hard coal, which evidently withstands weathering excellently. The samples analysed were necessarily obtained from the outcrops, and it may be anticipated that at a little depth even higher-grade coal will be found.

Mr. Richardson has submitted the following special report on the coal occurrences :—

Coal-seams in Turimawiwi-Anaweka District.

A number of coal-seams have been discovered, extending from a point situated about half a mile to the north-east of trig. Centre Peak to the Raukawa Stream, three miles away to the west. About a mile and a half up the Raukawa Stream from the sea coal outcrops in a small tributary about 10 chains to the east of the main stream. One seam is 2 ft. in thickness, and two 9 in. each. Coal outcrops again in Jackson's Creek, about a mile and a quarter to the east of the Raukawa Creek seam. Three seams are exposed, one being 5 ft. to 6 ft. in thickness, another about 3 ft., whilst a small seam seen on the hillside above the stream is 9 in. in thickness.

In the vicinity of trig. Centre Peak quite a number of seams are exposed, varying from 3 ft. to 4 ft. in width. About 25 chains to the north of trig. Centre Peak three seams are visible, two of which are from 3 ft. to 4 ft. in thickness. The third seam is in the stream-bed, and the width has not yet been ascertained. Some 30 chains to the north-east of trig. Centre Peak a seam of 3 ft. is exposed along the bank of the Pukatea Stream, and in the stream-bed another seam is visible. The thickness of this seam has not yet been ascertained.

All the seams mentioned have a slight dip to the west, and appear to be fairly uniform. The altitude of the Centre Peak outcrops is about 1,100 ft. to 1,200 ft., while those in Jackson's and Raukawa Streams range from 200 ft. to 300 ft. Roughly speaking, the known coal-bearing area is about three square miles. The Turimawiwi and Anaweka rivers have cut through this area, making the actual extent somewhat less. It will, however, be difficult to state accurately the coal-bearing area until the geological survey of the district has been made.

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* Practical evaporative power is calculated on a boiler efficiency which is obtained under good working-conditions.

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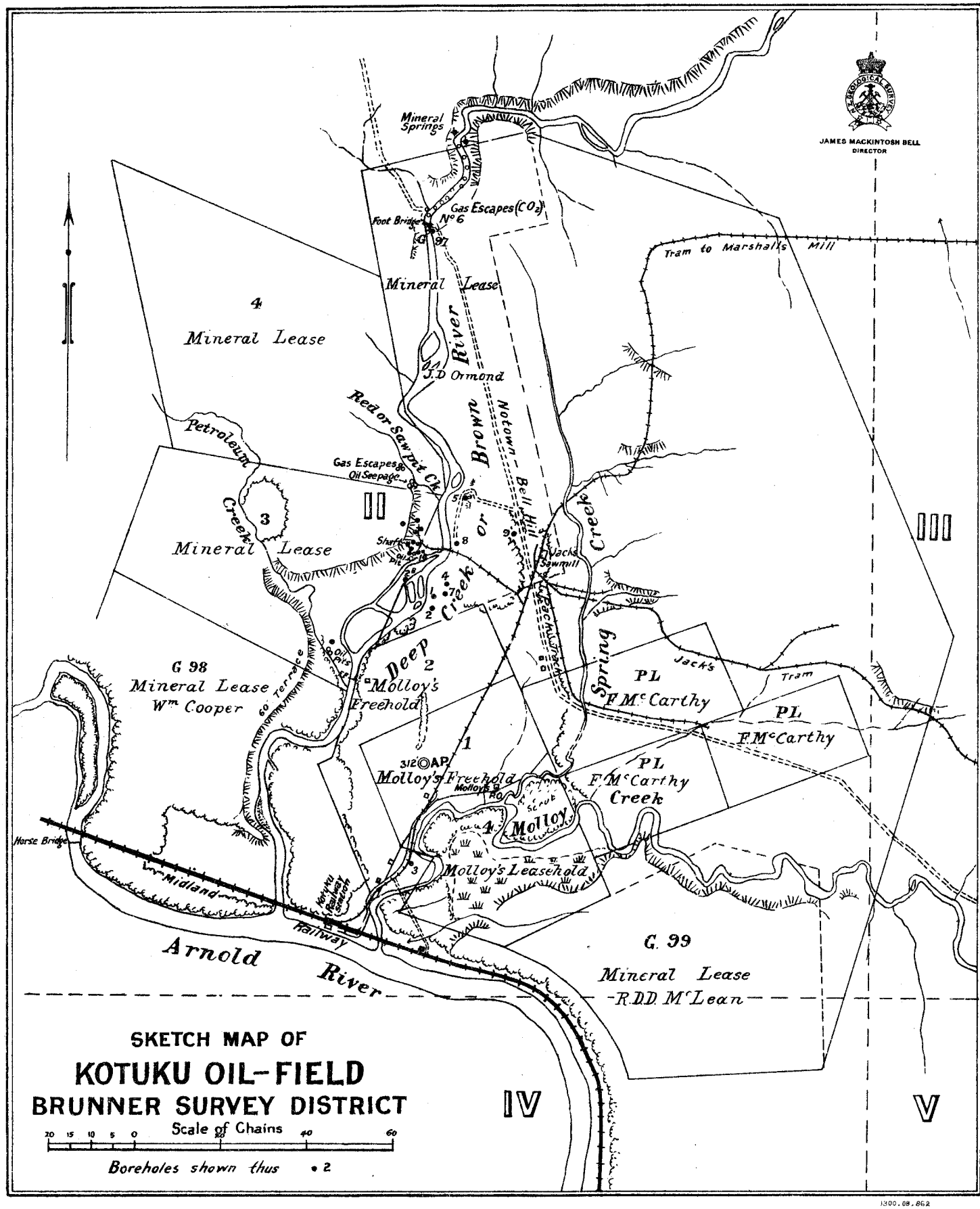

JAMES MACKINTOSH BELL
DIRECTOR

SKETCH MAP OF
KOTUKU OIL-FIELD
BRUNNER SURVEY DISTRICT

Scale of Chains
20 15 10 5 0 40 60

Boreholes shown thus • 2

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