1911.
NEW ZEALAND.

NEW ZEALAND GEOLOGICAL SURVEY

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

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

CONTENTS.

REPORT.

LETTER OF TRANSMITTAL.

SIR,— Geological Survey Office, Wellington, 30th June, 1911.

I have the honour to forward you herewith the annual report of the Geological Survey Branch of the Mines Department for the twelve months ending 31st May, 1911.

I have, &c.,

P. G. MORGAN,

The Hon. R. McKenzie, Minister of Mines, Wellington. Director, Geological Survey.

INTRODUCTION.

THE present report, which is the fifth since the reorganization of the Survey, deals with the twelve months from 1st June, 1910, to 31st May, 1911. For over nine months of this time Dr. J. M. Bell was Director, and it is only since the 1st April, 1911, that the survey has been under my control.

STAFF.

On the 10th March, 1911, Dr. J. M. Bell, who had been Director of the Geological Survey of New Zealand since the 21st January, 1905, severed his connection with the Survey. It is well known that under Dr. Bell's direction the Geological Survey was reorganized, with results that have been highly praised by scientific men in all parts of the world.

Mr. Colin Fraser, M.Sc., Mining Geologist, who had been connected with the Survey since the 28th March, 1905, also resigned his position, and left the service at the end of March. Mr. K. M. Graham, who had joined the Survey as Topographer on the 1st October, 1908, was transferred to the Defence Department at the close of the year under review. I wish here to record my appreciation of the zealous and capable service which both Mr. Fraser and Mr. Graham rendered to the Geological Survey.

The vacancies caused by the retirement of Dr. Bell and Mr. Fraser were filled by the appointment of myself as Director and of Dr. J. Henderson as Mining Geologist. An important forward step has been taken by appointing Mr. J. Allan Thomson, M.Sc., F.G.S., to the position of Palæontologist. The two last-named gentlemen took up their duties on the 1st June, 1911.

SUMMARY OF OPERATIONS.

During the twelve months under review detailed field-work has been under way in the Tairua-Waihi, Aroha, New Plymouth, and Mokihinui Subdivisions.

The survey of the Waihi-Tairua Subdivision has been brought to a conclusion, and a detailed report upon the area has been written by Dr. Bell and Mr. Fraser. This report, which is now being revised by the authors prior to publication, will be accompanied by a number of geological and topographical maps, together with numerous mine-plans, &c.

Work in the Aroha Subdivision was confined almost entirely to topographical surveys by Mr. K. M. Graham in the Waitawheta and Waiorongomai Valleys.

During the past summer Mr. E. de C. Clarke, formerly a member of the staff, completed the survey of the New Plymouth Subdivision under a special agreement, and has since supplied a detailed report on the area. Owing to the large amount of other work on hand, it may be some time before Mr. Clarke's report can be published, and a brief summary dealing mainly with the economic features of the New Plymouth Subdivision is therefore published with this report.

Since the middle of January of this year detailed field-work in the Buller-Mokihinui Subdivision has been conducted by myself, with the assistance of Mr. H. S. Whitehorn, Assistant Topographer, in the topographical work.

During the year flying visits were made by Dr. Bell to Ngaruawahia, Whangarei, and other places, and by myself to the Brighton district, south of Westport.

PUBLICATIONS.

Within the past year, besides the fourth annual report, three bulletins, Nos. 9, 10, and 11, have been issued. Bulletin No. 9, entitled "The Geology of the Whatatutu Subdivision, Raukumara Division, Poverty Bay," was written by Mr. J. H. Adams. The area with which it deals contains oil-springs and other indications of petroleum. Bulletin No. 10, "The Geology of the Thames Subdivision, Hauraki, Auckland," is the work of Mr. Colin Fraser. This publication, which describes a district that contains the oldest quartz-mining field in the Dominion, is of great economic and scientific interest. Mr. E. J. H. Webb is the author of Bulletin No. 11, "The Geology of the Mount Radiant Subdivision, Westport Division," which gives a full account, *inter alia*, of a cupriferous district situated a few miles to the south-east of Karamea.

At the present time two other bulletins, one entitled "The Geology of the Dun Mountain Subdivision, Nelson," and the other "The Geology of the Greymouth Subdivision, North Westland," are in the press.

FIELD-WORK IN THE BULLER-MOKIHINUI SUBDIVISION.

INTRODUCTION.

The Buller-Mokihinui Subdivision contains the very important Buller Coalfield, which lies between the Buller and Mokihinui Rivers. Between thirty-five and forty years ago the greater part of the coalfield was topographically surveyed, under the direction of Sir James Hector, by Mr. W. M. Cooper. Mr. S. H. Cox (now Professor of Mining in the Imperial College of Science and Technology, London) reported on the geology of the area, and the late Mr. R. B. Denniston described the coal outcrops with considerable minuteness. A topographical map of the surveyed area which showed coal outcrops, &c., was prepared, on a scale of 20 chains to the inch, and published about 1878. Very few copies of this map are now in existence, so that the information it contains is practically inaccessible to the general public.

Two portions of the Buller Coalfield, however, were not surveyed in detail. These are the areas to the north and to the south-east, known respectively as the Mokihinui and the Mackley Coalfields. The former of these has been visited several times by Sir James Hector and Mr. Alex. McKay, but concerning the latter area very little is known. The chief objects of the detailed survey of the Buller-Mokihinui Subdivision now being made are to ascertain the coal-bearing potentialities of these two districts, to collect further information regarding the main area, and to investigate the possibility of coal being found in a down-faulted block seaward of the plateau on which the principal mines are situated.

During the past few months field-work has been almost entirely confined to the valleys of the Ngakawau and Mokihinui Rivers. In this district is situated the whole of the so-called Mokihinui Coalfield. Since this coalfield is merely the northern continuation of the Buller Coalfield, it will in this report be sometimes termed the Mokihinui section, or as an alternative name, the Seddonville-Charming Creek coal-area.

Coal has been mined in the Seddonville district for many years with not altogether profitable results, at first by private companies and latterly by the State. During the past two years prospecting operations in search of coal have been under way in the valley of Charming Creek, a tributary of the Ngakawau River. In view of the importance of determining whether or not a block of coal sufficiently large to justify the opening-out of a mine is present between the workings of the State coal-mine and the southern border of the Charming Creek watershed, a somewhat full description of the area will be given in connection with the following account of the geology and mineral resources of the area surveyed. This will be arranged under the headings of (I) Physiography, (II) General Geology, (III) Economic Geology.

I. PHYSIOGRAPHY.

Physiographically the Mokihinui section of the Buller Coalfield and the adjoining country may be divided into three parts—the coastal plain, the foothill country, and the mountainous background. These features are largely determined by two great faults, presently to be mentioned.

The coastal plain is part of a much larger area of lowland that extends some distance to the south of Westport. As seen in the area under description, it is a narrow strip of flat and, in places, swampy land extending from the mouth of the Ngakawau River to a short distance north of the Mokihinui River. At one point (Torea Rocks) the *débris* of a slip from the neighbouring hills reaches the coast, and thus the coastal plain is locally obliterated.

The surface of the coastal plain consists of marine gravels and sands deposited upon a down-faulted block of Miocene, Eocene, and older rocks.

The foothill country is a belt from four to seven miles in width, which reaches from the coastal plain or, north of the Mokihinui, from the shore-line to the foot of the Marina Mountains. It may be regarded as the northern extension of the so-called Denniston plateau, but, owing to erosion and other factors, has a more varied relief than the country to the south. The highest part of the foothill country is formed by a ridge that rises steeply from the coastal plain to heights of from 1,300 ft. to almost 1,750 ft. Inland of this coastal range is a succession of irregular ridges, some of which are decidedly flat-topped. In the Upper Ngakawau Valley terraces of varying height have been carved by stream-action in the soft mudstone of the coal-measures. Coarse gravels cover these terraces more or less, and become prominent as the foot of the mountains is approached. Here also talus-deposits are in evidence.

Structurally the foothill country is a block bounded east and west by great faults, each of which has downthrow to the west. In the area under notice this block is in a general way slightly tilted to the east. It is, moreover, warped along a north-and-south line in such a way that the beds dip northward from the Ngakawau Gorge to the valley of Charming Creek, and thence to near Chasm Creek dip southward. The northerly dip is then renewed. Numerous minor faults, folds, and crumplings complicate the structure thus described.

The rugged Marina Range, which forms the hinterland of the foothill country, rises to heights of 4,700 ft. or more. It thus follows that it represents an upthrow of well over 3,000 ft. as compared with the neighbouring foothill country. There is no permanent snow on the range, but former glaciation is evidenced by cirque-like valleys at the heads of the streams, and by a tarn, Lake Boyle, that apparently occupies a rock-basin high on the eastern slope of the range. The ancient glaciers, however, were small, and probably did not extend beyond the mountain valleys.

The principal streams of the area are the Mokihinui and Ngakawau Rivers. The Mokihinui has its sources to the east of the Marina Range, through which it flows at grade in a profound gorge. It is therefore tolerably certain that the river is of more ancient date than the mountain range. After flowing through the Seddonville Flat, the Mokihinui breaks through the coastal range by another gorge, and enters the sea. Its mouth is navigable for small vessels at high water, when, it is said, there is 18 ft. of water on the bar.

The much smaller Ngakawau River has its watershed wholly within the Buller-Mokihinui Subdivision. The main stream rises on the western slope of the Marina Range and, after being joined by a number of tributaries, enters a deep gorge with precipitous sides. This gorge is of so remarkable a character that it is described in an old sketch of the locality as a " hill cleft in twain," but it is, of course, entirely formed by stream-erosion. From the gorge the river does not emerge until the coastal plain is reached.

Forest covers by far the greater part of the country north of the Ngakawau River. Considerable clearings, however, have been made near Seddonville, and nearly all the bush has disappeared from the narrow coastal plain. In places, especially where coal-measure grit or sandstone forms the surface-rock, there are *pakihis*, or areas destitute of forest. In one *pakihi* the surface is underlain by coarse granitic gravel, below which comes mudstone of the coal-measures. The largest *pakihis* are the one near the head of Charming Creek and that between the middle part of Charming Creek and the Ngakawau River.

II. General Geology.

The oldest sedimentary rocks of the Buller-Mokihinui Subdivision are grauwackes and argillites which, with their metamorphic equivalents, are believed to be of approximately Ordovician age, and to belong to the Aorere Series of Bulletin No. 3. Granites certainly intrusive into the supposed Aorere rocks are associated with gneiss that may be older than the latter. Coal-measures of probable Eocene age rest with evident unconformity upon the various rocks mentioned above. Miocene strata overlie the coal-measures with some degree of unconformity. The youngest rocks of the subdivision are stream and marine gravels of Pleistocene and Recent age. Near Westport morainic material, probably deposited by the ancient Buller Glacier, is present.

The following table shows the geological formations represented in the area surveyed during the past season, together with their provisional ages :—

Name.	Provisional Age.
Sedimentary Rocks.	
Marine gravels	Recent.
Younger fluviatile gravels	Recent.
Older fluviatile gravels	Pleistocene.
UNCONFORMITY.	
Kongahu Series (Webb)	Miocene.
MODERATE UNCONFORMITY.	
Coal-measures	Eocene.
GREAT UNCONFORMITY.	
Aorere Series	Ordovician.
Igneous Rocks.	
Granite (Tuhua formation of Bulletin No. 1)	Post-Aorere.
Metamorphic Igneous Rocks.	
Gneiss	Probably Pre-Aorere.

Aorere Series.

The ancient sedimentary rocks of the area under description have been placed in the Aorere Series of Bulletin No. 3 mainly because they are in continuity with the similar rocks in the Mount Radiant Subdivision, which were referred by E. J. H. Webb to that series. There is reason also for thinking that the rocks in question represent the Greenland Series of Bulletin No. 6. If this is so, it follows that the Greenland Series is of Ordovician age. Further reference to this matter will be found in a bulletin upon the Greymouth Subdivision, which is now in the press.

The rocks of the Aorere Series consist mainly of grauwacke, which in many places has been transformed into hornfels by thermal metamorphism induced by intruding masses of granite. Occasionally, near granite contacts, a further transformation into a micaceous schist containing cordierite or allied mineral may be observed. Silky argillites are in evidence towards the head of the Ngakawau River.

The Aorere rocks are extensively exposed on the eastern side of Mount Kilmarnock and on the western slopes of the Marina Range. Several outcrops of hornfels, which are evidently large inclusions in granite, occur along the course of Chasm Creek.

Strike is not always observable in the Aorere rocks, but if detectable is usually approximately north and south. The dip is invariably at high angles, and more commonly to the east than to the west.

Coal-measures.

The greater part of the foothill country south of the Mokihinui River, and a small area to the north, are occupied by rocks of the coal-measures. These rocks, which are believed to be of Eocene age, consist of a basal conglomerate followed by grits, sandstones, and shales containing coal-seams, above which comes a thick stratum of marine mudstone with subordinate limestone.

The basal conglomerate is not invariably present, and where it does occur may vary from a few inches to perhaps 50 ft. or 60 ft. in thickness. The pebbles, which are never large, consist mainly of grauwacke, granite, and quartz.

The grits and sandstones are composed almost entirely of quartz grains, but the former rocks in particular may contain fragments of feldspar and other minerals. Pebbles of grauwacke and of granite are not uncommon in the grits, which, as these increase in size and number, pass into conglomerate. On the other hand, the grits may become finer in grain, and thus grade into sandstone or even shale. It thus follows that, as a rule, a specified stratum cannot be traced any great distance. In the watershed of Coal Creek it is even probable that the upper fresh-water grits and sandstones pass into marine sandstone and mudstone.

The shales of the coal-measures are of minor importance. They occur in bands varying in thickness from an inch or two to perhaps 10 ft.

The grits, sandstones, and shales, with their contained coal-seams, have an estimated average thickness of about 200 ft. in the Seddonville district. In portions of Charming Creek valley, however, the thickness may reach, or exceed, 300 ft.

The marine sandstone mentioned in a previous paragraph occurs over a limited area between Coal and Chasm Creeks. It contains *Ostrea*, *Turritella*, and other fossils.

The mudstone of the coal-measures is a dark-bluish calcareous rock of marine origin, that only in a few places shows distinct bedding. Very exceptionally it passes into a lighter-coloured highly calcareous rock, and thus becomes an impure limestone. In one or two localities it contains interbedded pebble bands. Owing to extensive overlap, there are considerable areas where the mudstone rests upon granite, gneiss, or grauwacke. At such contacts with the ancient rocks as have been seen the lowest layers of the mudstone are very tough, dark, and hard. In one or two places a thin pebble bed is present at the contact.

The mudstone was originally of great thickness, but in much of the area under discussion has been greatly affected by erosion. On the ridges it has either quite disappeared or remains as a thin layer only. In Charming Creek valley a thickness of 300 ft. is probably attained. A much greater thickness is reached in the Upper Ngakawau watershed and in the area north of the Mokihinui.

The mudstone is in places moderately fossiliferous. Its most characteristic fossil is *Amusium zittelli*, which occurs on the north side of the Mokihinui River and near Chasm Creek (McKay). Echinoids are common, but are always crushed and specifically unrecognizable. A species of *Flabelllum* was observed in the Chasm Creek mudstone. *Foraminifera* occur almost everywhere, and evidently form the main part of the calcareous content.

Limestone occurs in Fletcher Brook, in St. David Creek, and on the saddle between the Ngakawau and Mackley, over which the foot-track passes. It is formed mainly of the remains of a species of calcareous alga (probably *Lithothamnion*) and of *Foraminifera*.

It is unquestionable that the coal-measures of the Buller district are of the same age as those of the Greymouth Subdivision. The lower or coal-bearing horizon of the Buller coal-measures corresponds to the Brunner Beds of the Greymouth area. The Island sandstone of the latter district is very poorly represented in the Buller Coalfield, its place being taken largely by the marine mudstone mentioned above. This mudstone corresponds exactly in its lithological characters with the Kaiata Mudstone, of which its upper layers must be the exact equivalent.

A brief account of the structure of the coal-measures will be given in the section on Economic Geology.

Kongahu Series.

Rocks which may be referred to the Kongahu Series of Webb are extensively developed north of the Mokihinui River, and there are small outcrops near Nikau. The greater part of the area over which the Kongahu Series occurs was not surveyed in detail last season, so that it cannot now be described at any length.

The Kongahu rocks are mainly impure limestones, but in places sandstones and mudstones appear. A sandy mudstone seen in Podge's Creek is remarkable for containing water-worn pebbles of coal. It thus corresponds in character with the Omotumotu Beds near Greymouth, though coal-fragments are far more numerous in the latter strata.

The following analyses show the composition of waterworn coal-pebbles from the Omotumotu Beds and from Podge's Creek :—

	(1.) Per Cent.	(2.) Per Cent.	(3.) Per Cent.	(4.) Per Cent.	(5.) Per Cent.
Fixed carbon	40·70	35·59	39·33	17·37	41·96
Volatile hydrocarbons ..	45·61	47·28	49·00	29·38	46·19
Water	7·37	5·05	8·15	4·55	8·10
Ash	6·32	12·08	3·52	48·70	3·75
	100·00	100·00	100·00	100·00	100·00
Total sulphur	..	..	0·96	0·91	1·46

(1) and (2). From "Omotumotu Ridge." Samples collected by Alex. McKay in December, 1873. Analyses by W. Skey.

(3.) From upper part of Kaiata Creek, Greymouth district.
(4.) From Podge's Creek; impure coal.
(5.) From Podge's Creek; bright coal.

The occurrence of waterworn pebbles of coal in the Miocene strata near Greymouth and near Seddonville is of great interest and importance, for it clearly indicates an unconformity between the coal-measures and the overlying Miocene rocks.

Pleistocene and Recent Deposits.

Gravels that may be regarded as of Pleistocene age form, as already mentioned, terraces in the Upper Ngakawau Valley, and the terraces that border the Seddonville Flat in places. The Pleistocene gravels grade into talus on the one hand, and into younger gravels, such as those on the Seddonville Flat, on the other. The coastal plain is covered by Recent marine gravels.

Granite.

Granite forms the core and most of the crest of the Marina Range. A narrow band of granite can be traced along the base of the range for some miles. There are many exposures in the foothill country, especially in Chasm Creek and in the gorges of the Ngakawau River and some of its tributaries. It appears also in the Upper Mackley watershed. Its metamorphic influence on the Aorere rocks has already been mentioned.

Gneiss.

West of a line drawn about two miles from the base of the Marina Range there are many outcrops of gneiss and gneissic granite. These are especially noticeable in the gorges cut by the Ngakawau River and most of its tributaries through the coal-measure rocks. Gneiss underlies the coal-measures in Charming Creek valley, as is shown by the records of Nos. 3 and 6 bores.

In all the main exposures the gneiss is seen to pass here and there into unfoliated granite in an irregular and puzzling way. It may be that the gneiss is simply a foliated phase of the granite. On this supposition it is extremely difficult to account for the foliation of the gneiss. Appearances support the view that the granite is a recrystallized phase of the gneiss. How this may have come about is a question not suitable for discussion here.

III. Economic Geology.

In bygone years a considerable amount of alluvial gold was obtained in the area examined during the past season. The main mineral resource of the district, however, is its coal. Other economic materials, such as building-stone, agricultural limestone, &c., hardly call for more than passing mention at the present time. Hence the economic geology of the area may be considered under two headings only—(1) Alluvial Gold, and (2) Coal.

(1.) *Alluvial Gold.*

Near the mouth of the Mokihinui River a rich beach-lead was discovered in 1865, and after being worked for some years was abandoned as exhausted. About 1887 a continuation of the lead was discovered, but apparently this was of no great extent, and was soon worked out.

Hodges Creek, a stream descending from Mount Kilmarnock to the Rough-and-Tumble (a tributary of the Mokihinui) has been somewhat extensively worked for alluvial gold, but has been deserted for many years. The various streams that drain the western slopes of the Marina Range cut through grauwackes of the Aorere Series containing small quartz veins, and might therefore be expected to contain alluvial gold, but so far as the writer knows nothing but scant colours can be obtained from the creek gravels. The Mackley River may be to some extent an exception, but the head of this stream has been tested with unsatisfactory results.

In the upper course of Watson Brook, a tributary of Charming Creek, gravels clearly derived from the Marina Range occur. These yield colours of gold, and on that account prospectors have sunk one or two test-pits. These, however, on account of water, did not reach bed-rock, upon which possibly payable washdirt may lie.

(2.) *Coal.*

Many years ago attention was drawn to the coal resources of the Mokihinui district by Sir James Hector, who apparently entertained a very high opinion of the area as a coalfield, and mapped the greater part of it as containing coal. Attempts to mine the coal began about 1879, and since 1889 exploitation has been carried on almost continuously. Unfortunately, however, the patchy nature of the coal-seams, their liability to spontaneous combustion, the friable nature of the coal, much of which is unmarketable at the present time, and the occurrence of faults, have proved serious drawbacks to successful working. Until economic and other conditions change considerably, it is apparent that the task of winning coal from the area at a profit will be difficult, and, now that the best areas have been partly worked, perhaps impossible. If, however, a satisfactory commercial method of utilizing the friable coal could be evolved, the prospects of success would be immensely improved.

Coal-seams.—In the coal-bearing areas an upper and a lower seam are generally recognized. The lower or main seam appears in a horizon which is generally about 50 ft. below the upper seam, and 100 ft. below the marine beds. The thickness varies from a few inches to 25 ft. In the present workings of the State mine it is almost everywhere over 14 ft. In the old Cardiff Mine the coal was of good thickness in most places. Near the mouth of Chasm Creek, where coal was mined many years ago, the seam does not average more than 4 ft. or 5 ft. in thickness, and to the south-west becomes still thinner and dirty. In Charming Creek valley Nos. 1 and 5 bores each show 20 ft. of coal, the top of the coal in No. 1 bore being 91 ft. and in No. 2 bore 75 ft. below the surface. No. 8 bore, lately drilled, has passed through 21 ft. 9 in. of coal. In No. 6 bore, however, the main seam is represented by 2½ ft. of coal only, pierced at a depth of 234 ft. In several other bores the main seam was not found, apparently owing to its completely thinning out.

In Coal Creek valley there are various outcrops of a seam varying in thickness from 5 ft. to 32 ft.* This lies immediately below the marine portion of the coal-measures, and therefore may be in a different horizon from either the upper or the lower seam. Since, however, no underlying seam, except a 7½ ft. seam reported to have been found by boring to lie 18 ft. below the 32 ft. outcrop in Coal Creek, is known to exist, it is possible that the Coal Creek seam ("Hut seam") corresponds to the main seam of the State mine, notwithstanding the difference in the overlying beds. Again, it may represent a local thickening of the "upper seam."

Near Seddonville and along the course of Chasm Creek the floor of the main seam is usually shale, which passes downwards into sandstone and grit. In places only a few feet of these rocks intervenes between the coal and the basement granite or gneiss. The roof is generally grit or sandstone. The floor of the seam near Coal Creek consists of a little shale, followed downwards by grit. The roof is grit or sandstone, but the outcrops in Coal Creek itself show that the marine mudstone almost immediately follows.

The coal of the main seam is in general of good quality, though, as already noted, much of it is friable, and therefore unsaleable at a profit under present economic conditions. Dirt or stone bands appear in some places, but seldom to such an extent as to render the seam unworkable. There are also some irregular inclusions of sandstone and shale ("floaters").

The following analyses show the general composition and quality of the coal:—

	(1.) Per Cent.	(2.) Per Cent.	(3.) Per Cent.
Fixed carbon	58·97	51·12	52·27
Hydrocarbons	32·42	42·24	41·20
Water	7·30	4·36	4·65
Ash	1·31	2·28	1·88
	100·00	100·00	100·00
Total sulphur	n.d.	4·94	4·99
Calories per gram, by calorimeter	..	7,402	7,354
British thermal units per pound	..	13,324	13,237
Theoretical evaporative power, in pounds of water at 212° Fahr.	..	13·81	13·73
Practical evaporative power, assuming 60 per cent. efficiency..	..	8·29	8·24

(1.) Average of seven analyses (probably by Skey) of outcrops near Coal Creek. Analyses given by Sir James Hector in Rep. G.S. during 1886–87 (Vol. 18), p. 159.

(2.) From State coal-mine, Seddonville: solid working-face [near] Chasm Creek Bridge. Seam, 8 ft. thick.

(3.) From State coal-mine, Seddonville: solid working-face [near] Grant's Face. Seam, 20 ft. thick.

Analyses (2) and (3) (by Messrs. W. Donovan and L. Andrew) are quoted from Dr. J. S. Maclaurin's "Report on Analyses of New Zealand Coals," 1907.

The upper seam, where present, occurs in a horizon 37 ft. to 50 ft. above the lower seam, and varies in thickness from a few inches to 3 ft. In a shaft sunk on the flat-topped ridge above the main tunnel of the State coal-mine it has its greatest-known thickness of 3 ft. In Charming Creek there are numerous outcrops from 10 in. to 2 ft. thick. Near Watson's Sawmill what may be the upper seam is 14 in. in thickness.

The upper seam has a grit or sandstone roof. The floor may exhibit a few inches of shale, or the coal may rest practically immediately upon grit or sandstone.

The hard coal, of which the upper seam nearly everywhere consists, is in many places more or less stony. The following analysis of a sample taken from a cut in the seam where it crosses Charming Creek a short distance below No. 1 bore shows that it is here of good quality, except that it contains a somewhat high percentage of sulphur, much of which is probably combined with the carbonaceous constituents:—

	Per Cent.
Fixed carbon	49·22
Volatile hydrocarbons	46·59
Water	1·74
Ash	2·45
	100·00
Total sulphur	5·73

* At this outcrop was the entrance to the mine worked by the now defunct Mokihinui Company and later on by a co-operative party of miners, but, owing to mining operations and the effects of a fire caused by spontaneous combustion, the outcrop has disappeared.

The coal forms a dense hard coke. The ash is grey in colour.

By comparison with similar coals, the evaporative power should be, approximately, 14 lb. per pound.

Conditions of Deposition.—Deposition of the coal-measure strata began under fluviatile conditions. These were maintained until the coal-seams had been formed. Then, owing to gradual sinking of the land, marine conditions supervened. As might be expected, the marine sediments were in general much finer than the fluviatile sediments, so that they consist almost wholly of mudstone, with a little fine sandstone in the lowest horizon, and in places some limestone.

It is evident that deposition of the Mokihinui coal-measures began in a basin-like area, probably entirely bounded by higher ground to the east, north, and west. To the south the land was lower, but even here there was a low ridge, and there were also hills of granite and gneiss within the basin. As deposition continued, however, the inequalities of the surface were removed, and after the sea had invaded the area the transgression of the upper beds over the lower became very pronounced. It thus follows that the marine beds are found over a very much larger area than the lower coal-bearing strata. Again, for reasons that cannot be positively stated, coal-seams are not continuous through the fluviatile beds, though the explanation is doubtless connected with the mode of formation, and could be deduced from this if it were certainly known.

There are, however, some blanks in the coal easily explained as caused by the hills within the basin mentioned above. These rose above the area in which coal was being deposited. It has been the custom to speak of these hills as "granite intrusions," a term that gives an entirely wrong impression, for the granite or gneiss was in existence long before the coal was deposited.

Mode of Formation.—Reference to this matter will aid in a comprehension of the reason why the coal-seams do not extend through the whole area containing beds of coal-measure age. In the Mokihinui section of the Buller Coalfield, as in many other parts of New Zealand, the available evidence favours the "drift" theory of coal-formation, or more probably some modification of it. The time-honoured hypothesis of a buried forest is entirely inapplicable to this, or for that matter to any New Zealand coalfield known to the writer. The "peat-bog" theory may possibly be made to apply. It seems best to suppose that the coal has in the main been formed from quick-growing aquatic plants that had no fixed roots, and were therefore capable of transportation by water. These, it may be supposed, accumulated in quiet, shallow ponds and lakes.

Conditions affecting Development of Coal-seams.—In most parts of the Seddonville-Charming Creek coal-area the coal-measures have a dip not exceeding 18°, or, say, 1 in 3. As a rule, the dip is considerably less, and may average 10°. The beds are somewhat irregularly crumpled, so that the directions of strike and dip vary much. It has already been explained (under "Physiography") that from the Ngakawau River to Charming Creek the beds dip north, from Charming Creek to near Chasm Creek the dip is on the whole southerly, and from the neighbourhood of Chasm Creek the dip is again to the north.

The greater part of the coal is level-free—that is, can be drained by adits, and therefore pumping machinery is not required except for a limited portion of the field. Owing to numerous faults and the deep stream valleys, the coal is cut into a number of blocks, so that development is expensive.

Spontaneous Combustion.—The liability of the Seddonville coal to spontaneous combustion places considerable restrictions on the methods of working. Hitherto no system of panel working has been adopted, and therefore considerable pillars must be left in order to prevent crushing and extensive falls of the roof. Were this not done, the resulting masses of crushed and broken coal would soon heat, and finally reach the ignition-point. The coal in the old Cardiff Mine has been on fire since January, 1900, and is still burning strongly. At Coal Creek the old Mokihinui Mine workings are also on fire. The fire, however, now appears to be dying out. The area affected is not more than 6 or 7 acres.

On the south side of Chasm Creek, west of Dove's Drive, the coal over an area of several acres has been burnt, or, rather, coked. It was presumably set on fire by lightning or other natural agency. The resulting coke is of a very impure character.

Areas worked.—The areas hitherto worked are mainly on the north-east side of Chasm Creek, west and south of Seddonville. The old Cardiff Company worked a small area on the western side of Chasm Creek, and another small area has been worked by the State. Near Coal Creek a few acres were exploited by the old Mokihinui Coal Company and by co-operative parties of miners.

Areas remaining to be worked.—Neighbourhood of Seddonville: From Seddonville to the eastern side of Coal Creek is low country underlain by coal-measures. That coal exists in this area may be regarded as entirely probable, and that north of the Mokihinui River it would thin out is, unfortunately, also probable. No bores having ever been put down, the extent of coal, its thickness, quality, &c., are unknown. West of the lower part of Chasm Creek there are various coal-outcrops in an area formerly included in what was known as Patten's Lease. Some of the outcrops show hard, clean-looking coal of workable thickness, but the coal-bearing area, as shown by survey, is not great.

An analysis of a sample taken from a 7-ft. outcrop, which is exposed in a trench at a barometric height of 915 ft. above sea-level, is as follows:—

	Per Cent.
Fixed carbon	52·08
Volatile hydrocarbons	43·60
Water	3·10
Ash	1·22
	100·00
Total sulphur	7·26
Calories per gram, by calorimeter	7,382·00

South of State coal-mine: South-west of Chasm Creek there is a considerable extent of coal-bearing country, which, as already indicated, has been but little worked. This area, though not without some inconvenience, can be developed from the present workings of the State mine. Since, however, the coal-outcrops are not so thick as in the ground now being worked, and in many cases are of poorer quality, careful exploration is necessary in order to determine whether a profitable block of coal exists or not. Between four and five years ago a limited portion of the area was prospected by means of hand-drilled bore-holes. In only one of these bores was coal found. The others are reported to have struck granite, but it may be questioned whether the rock penetrated was not a coarse grit, *débris* from which could easily be mistaken for granite. In such a case the results of the boring are quite inconclusive. It should be mentioned, however, that in workings extended towards the prospected area from Chasm Creek the coal was found to be thin.

Charming Creek Area: South-westward of the last area is the valley of Charming Creek. In the central part of this valley a 2 ft. seam of coal outcrops, and below this, at depths of 37½ ft. to 50 ft., boring has proved the existence of a seam reaching a thickness of 20 ft. and more. In No. 6 bore, however, the seam is only 2½ ft. thick. The geological survey, moreover, shows that to the east, south, and west this seam either thins out altogether, or is reduced to a trifling thickness. East and west this conclusion is confirmed by bores. Northward the 20 ft. seam (which undoubtedly corresponds to the main seam in the Seddonville Colliery) may be expected to extend towards Chasm Creek, and finally to connect with the outcrops in that locality.

Since Nos. 1 and 5 bores, in which 20 ft. of coal was proved, are only 21 chains apart, and No. 6 bore, with 2½ ft. of coal, is only 35 chains to the west of No. 5, it follows that the width of the area with thick coal (say, over 6 ft.) is not likely to exceed three-quarters of a mile. Southward, the thinning out of the coal is probably rapid, so that the amount of workable coal in that direction is presumably small. Northward, towards the watershed of Chasm Creek, the coal-bearing area is considerable, and, together with the area near Chasm Creek, probably exceeds 1¼ square miles. Thus there is scope for the opening-out of a new mine. Systematic boring, however, is necessary in order to prove the exact extent, thickness, and quality of the coal.

It may be useful here to state what could have been ascertained by a geological survey alone, and what assistance has been given by boring. Since, as already stated, the coal undoubtedly thins out to the east, south, and west of Charming Creek valley, and since the outcrops immediately to the north are somewhat poor, the geologist could not have reasonably inferred the existence of a thick seam in the central part, though the basin character of the area might have justified a suspicion. On the other hand, the possible coal-bearing area would have been thought somewhat greater than is actually the case. Thus the boring has been useful in proving thick coal over a portion of the area, and in partly defining its limits.

On the whole, the Charming Creek coal-measures dip from north and south towards the central line of the valley. The axis of the syncline thus formed pitches gently from east and west towards a point Near No. 4 bore, so that the beds lie in an elongated basin, with its deepest part probably somewhat east of No. 4 bore. Owing to minor crumplings and rolls of the strata, their strike and dip are somewhat variable. A number of small faults have been observed, and there are doubtless others. In addition, a line of disturbance, passing into a considerable fault, runs north-east from the mouth of Reed Brook to a point in Chasm Creek west of the present State-mine workings. Another strong fault crosses the north-eastern part of the area considered to be coal-bearing.

It is evident that the greater part of the coal-bearing area near Charming Creek, if worked at all, would have to be exploited from a shaft. The natural outlet for the coal is down Charming Creek valley, and thence down the Ngakawau River to the existing railway-line between Seddonville and Westport.

Recommendations.

The area immediately south of Chasm Creek may be prospected by further boring and by driving from the coal-outcrops. Since the coal horizon is for the most part less than 200 ft. and in many places must be under 100 ft. below the surface, hand-boring would be, as a rule, cheaper than machine-drilling. Samples of the drillings should be taken at regular intervals and whenever a change of rock is apparent. These should be very carefully examined, in order to determine when the coal-measures are penetrated, otherwise grit may be mistaken for granite, and *vice versa*. All samples ought to be correctly labelled and preserved, so that in case of doubt they could be referred to a geologist.

In order to ascertain the extent of coal in the Charming Creek basin, several more bores are necessary north and south of bores Nos. 1, 5, and 6. These bores should be approximately at 20-chain intervals, and located as systematically as the nature of the ground will permit. It is better to spend a few pounds in transporting boring machinery to the right place than to locate it at the most convenient spot and later on be compelled to drill another hole in order to obtain information that might have been obtained from a single bore.

At the present moment the prospects of success in opening out the Charming Creek area are uncertain. From the bores that are proposed data that will justify mining operations may be obtained, but on present knowledge the only expenditure warranted is that needed for prospecting operations such as boreholes, small shafts, &c.

SUMMARY OF MR. E. DE C. CLARKE'S REPORT ON THE NEW PLYMOUTH SUBDIVISION.

The following is a brief summary of the more important features of the detailed report which Mr. E. de C. Clarke has submitted, and which it is hoped to publish in a few months' time.

Geologically, the New Plymouth Subdivision presents few features of economic importance save the occurrence of oil. The present investigation was undertaken with the object of supplying such geological knowledge as would enable oil-prospecting to be carried on in a systematic manner.

Physiographically, the New Plymouth Subdivision may be described as a deeply trenched plain showing no marked elevations, but exhibiting a distinct belt of higher country which separates a low-lying coastal belt of variable width from an open plain to the south, through which flow some of the numerous streams draining the slopes of Mount Egmont. The coastal plain, of comparatively recent elevation, is in places being rapidly encroached upon by the sea, and must at one time have extended over a considerable portion of the North Taranaki Bight.

Outline of Geology.

The beds of the district may be separated into the

Onairo Series, }
Pouakai Series, } Miocene.
Pleistocene and Recent.

The oldest rocks belong to the Onairo Series, and consist of claystones, sandstones, and conglomerates, to which, from palæontological considerations, a Miocene age is assigned.

The Pouakai Series, which overlies the Onairo Series with apparent unconformity, consist of volcanic *débris* of all grades of coarseness. The age of this series cannot be definitely fixed, but the beds are believed to be but little younger than those of the Onairo Series.

The alluvial deposits in the valleys of the various streams, together with the sand-dunes of the coast and various marine and fluvio-marine accumulations, may be classed as Pleistocene and Recent.*

Economic Geology.

Oil.

After a study of the very imperfectly revealed geological structure of the subdivision and a careful comparison of the generally unsatisfactory bore records, the following conclusions have been reached:

(1.) The chief oil and gas producing strata are the rocks of the Onairo Series.

(2.) The gas which is found escaping in considerable quantity from the rocks of the overlying Pouakai Series, and the oil, of which a few undoubted seepages from the same rocks occur, originated mainly or wholly in the Onairo rocks.

(3.) There is no evidence as to the mode of origin of the gas and oil.

(4.) No distinct anticlines and synclines can be distinguished in the rocks of either the Onairo or the Pouakai Series, nor are there any geological data which justify the selection of bore-sites.

(5.) Petrolaceous substances exist at or near the surface in the country to the east of the New Plymouth Subdivision.

(6.) The rocks in which the petrolaceous substances occur conformably underlie the Miocene rocks which are exposed in the subdivision, and are probably over 5,000 ft. below the surface in the neighbourhood of New Plymouth.

(7.) Oil has been found in payable quantities on the Taranaki Petroleum Company's property.

(8.) The oil horizons as disclosed by boring lie approximately 1,000 ft., 2,000 ft., and 3,000 ft. below sea-level near New Plymouth, but, owing to the variable character of the strata, are ill defined, and are at greatly varying distances from the surface in neighbouring bores.

(9.) The 3,000 ft. horizon is the most productive.

(10.) The 1,000 ft. horizon is of least importance, but merits more careful prospecting than it has yet received, especially near Booth's well.

(11.) The position of oil-reservoirs in the subdivision can be determined only by systematic deep boring.

(12.) A belt of country about three miles wide in which gas-vents occur extends from the Sugar-loaves in an E.S.E. direction for at least fifteen miles.

Recommemdations concerning Oil-prospecting.

In view of the above conclusions Mr. Clarke recommends,—

(1.) A thorough geological examination of the country to the E. and N.E. of the subdivision, in the hope that payable oil-reservoirs may there be located nearer the surface.

(2.) A systematic prospecting of the subdivision by means of deep bores at regular and considerable distances. No bore should be abandoned as "dry" unless it has reached a depth of 3,000 ft. below sea-level without obtaining oil.

(3.) The systematic recording of the strata passed through in the bores, and the keeping of large and accurately labelled samples of these strata.

(4.) The co-operation of all parties engaged in oil-prospecting, more especially in regard to the comparison of the strata passed through. The only way to obtain comparable results is to secure the constant presence on the field of a competent geologist, who should examine and record all the specimens obtained.

(5.) Although geological data are very meagre, the most likely zone for exploration by deep boring is the strip of gas-producing country defined above.

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* For a fuller account of the geology of the New Plymouth Subdivision see the Fourth Annual Report of the New Zealand Geological Survey, 1910, pp. 19–23.

Iron-ores.

From an economic standpoint, the only iron-ores which require notice are the deposits of black-sand. In some localities—*e.g.*, in the neighbourhood of Paritutu—very large accumulations of almost pure magnetic ironsand occur. At many places, however, the pure ironsand has been sorted by the action of the waves and the wind, so that it forms only a thin covering to a more heterogeneous sand. It would therefore be advisable, before any erection of smelting-works is undertaken, to carry out a thorough and exhaustive sampling of the ironsand deposits. In such examination mere surface samples should not be allowed to predominate unduly, but the character of the sand from various depths should be fully taken into account.

Tests of ironsand from the Patea district have been lately made in the Dominion Laboratory, with the result, *inter alia*, that 0·16 per cent. of vanadium was found to be present. It is probable that the New Plymouth ironsand also contains vanadium, and, if so, its commercial value as a source of steel may be notably increased, provided that not more than 50 per cent. of the vanadium is lost in the smelting and steel-making processes.

COAL IN THE CHARLESTON AND BRIGHTON DISTRICTS.

During the last week of March I made a hasty examination of coal outcrops in the Charleston and Brighton districts. The report then supplied was placed under the headings of—(1) Charleston lignite; (2) Brighton lignite; (3) Bullock Creek coal; (4) Fox River coal and anthracite; (5) Porarari River coal; (6) Extent of coal areas; (7) Economic value of coal-areas; (8) General remarks; and was substantially as follows:—

(1.) *Charleston Lignite.*

A lignite-seam which affords a good household fuel, locally sold at 5s. per ton, occurs over a considerable area in and near the Township of Charleston. It lies almost flat, and, as a rule, has very little cover, so that it is mined opencast. The seam in many places is at least 12 ft. to 20 ft. thick, but the floor is hardly anywhere visible, and therefore the maximum thickness may be much greater. In some pits the seam exhibits dirt bands and partings which, where it thins out towards the west and south, pass into shaly bands of some thickness. At one place the lignite contains numerous lensoid inclusions of clay, shale, and flinty material. Resin is everywhere abundant in the form of small bands and lumps.

An analysis of the Charleston lignite, made upon a partly air-dried sample, is as follows:—

	Per Cent.
Fixed carbon	33·55
Volatile hydrocarbons	44·53
Water	19·17
Ash	2·75
	100·00
Total sulphur	6.0

The Charleston lignite is decidedly younger than the steam-coals of the Greymouth and Buller districts, and is probably of Upper Miocene age. It may be correlated with the lignite at Addison's and near Cape Foulwind, and perhaps also with that at Brighton, twelve miles to the south.

The Charleston coal, like most lignites, is very easily set on fire, and hence the numerous outcrops form a source of danger. From time to time one or another becomes ignited through surface fires, and some expense has been incurred in extinguishing the burning coal, but so far no serious damage has been done by these fires.

A mile or so south of Charleston the lignite thins out on an old land-surface of gneiss. Farther south there are other outcrops, but the lignite appears to lie in small basins, and only in one or two places to be of any great thickness.

(2.) *Brighton Lignite.*

On the terrace slope facing the sea near Brighton a lignite-seam of good quality outcrops at a height of about 50 ft. above sea-level. The seam, which lies almost flat, is 10 ft. thick. It is overlain by sandstone, above which comes limestone. The immediate floor could not be seen, but at a horizon a few feet below conglomerate appears. This conglomerate probably rests on granite or gneiss, rocks which are seen along the coast-line two or three miles to the north and to the south.

The Brighton lignite has been mined to some extent for household purposes, and has also been used by the small steamers that at one time traded to Brighton. The following analysis shows its composition:—

	Per Cent.
Fixed carbon	29·48
Volatile hydrocarbons	48·64
Water	17·36
Ash	4·52
	100·00
Total sulphur	5·65

About a mile above the mouth of the Fox River the same seam as that last mentioned outcrops on the north bank. It is here 6 ft. to 8 ft. thick, and of the same good quality as at Brighton, except that the lower portion is stony. The roof is a light-coloured sandstone, which is overlain by several hundred feet of limestone. The immediate floor is grit. The seam, as near the sea-coast, lies practically level, and is here not more than 30 ft. or 40 ft. above tide-mark. Upstream the strata dip gently to the east, so that in this direction the lignite must pass below sea-level.

From fossils obtained at and near Woodpecker Bay, in strata that overlie the lignite, a Miocene age may be inferred for the Brighton coal-measures. It is thought, however, that they are somewhat older than the Charleston lignite, and probably of Lower Miocene age.

(3.) *Bullock Creek Coal.*

About half a mile up Bovis Creek, a small stream that enters Bullock Creek on the north side some two miles and a half above the track-crossing near Mr. E. O'Brien's hut, highly inclined sandstone and shale with thin seams of bituminous coal outcrop in the stream-bed. The section, in downward order, is as follows :—

8 ft. of banded sandstone.
18 in. of dark shale with thin layers of coal.
7 ft. of sandstone (with a little shale, &c.).
8 in. to 10 in. of impure coal.
Sandstone floor.

These beds strike 258°, and dip at 80°–85° to the west of north. The elevation above sea-level is about 800 ft.

Two chains and a half up stream coal outcrops on the right or western bank of the creek, but in such a way that its thickness cannot be determined without considerable excavation. Five or six feet of coal is visible in two bands, which apparently belong to one and the same seam, separated by a fault. The dip of the enclosing beds is probably about 85° to the north-west. The coal is much crushed, and contains some dirt or stony matter, as well as a few waterworn pebbles. The following analysis* shows its quality :—

	Per Cent.
Fixed carbon	75·52
Volatile hydrocarbons	15·45
Water	0·63
Ash	8·40
	100·00
Total sulphur	1·49

Two to three chains up stream loose coal is seen on the right bank. Above this are alternating bands of sandstone and conglomerate that strike 229°, and have a dip near 90°. The barometric height is 830 ft.

A quarter of a mile further upstream a slip shows on the left or eastern bank. Towards the top of this, at a barometric height of 1,370 ft., 8 ft. of much-crushed coal is visible. The seam stands almost vertical, but is slightly overturned. Stratigraphically below, but apparently above, is some shale. Beyond this is an outcrop of highly shattered gneiss. That the coal is involved in a fault is obvious.

The coal of Bullock Creek and of the localities mentioned under the next two headings may be correlated with the bituminous coal of the Greymouth and Buller coalfields. It is, therefore, probably of Eocene age.

(4.) *Fox River Coal and Anthracite.*

About seven miles up the Fox River (northern branch), at a point less than a mile above the junction of Henniker Stream, alternating beds of shale, sandstone, and conglomerate are visible on the south bank at a barometric height of 470 ft. These beds contain several small coal-seams, varying from 2 in. to 9 in. in thickness. The strike is 233° to 241°; the dip about 45° to the south-east. The following analysis shows the composition of the coal in the 9 in. seam :—

	Per Cent.
Fixed carbon	45·57
Volatile hydrocarbons	41·17
Water	3·21
Ash	10·05
	100·00
Total sulphur	0·32

A quarter of a mile upstream from the outcrops just mentioned a very similar but thicker section is again seen on the south bank, sandstone, shale, conglomerate, and small coal-seams alternating with one another. The largest seam now visible is not more than 1 ft. thick. The strata strike 198° to 202°, and dip at 75° to 80° to the north of west. Thus these beds form part of a syncline, the other limb of which appears downstream, and was described in the last paragraph. A little farther upstream

* It is possible that the sample from the Fox River was analysed as Bullock Creek coal through an error in the labelling, and *vice versa*. Hence the analysis needs confirmation.

is a thick band of carbonaceous shale with small coal-seams. The rock is intensely crushed. A slip on the hillside above marks the spot where 26 ft. of much-crushed coal is stated to have been disclosed by the prospecting operations carried out some years ago. Not far away is the point where 7 ft. of hard anthracitic coal was discovered by the prospecting party.

Beyond the carbonaceous shale-band are layers of sandstone, grit, and conglomerate, with one or two small coal-seams. These beds strike 226°, and dip at 80° to the north-west. The height above sea-level by barometric observation is 600 ft. For some distance upstream conglomerate and breccia form the outcropping rocks, but no coal is visible.

The following analyses of the Fox River anthracite were made some years ago:—

	(1.) Per Cent.	(2.) Per Cent.
Fixed carbon	90·9	82·42
Volatile hydrocarbons	5·1	11·07
Water	0·8	0·23
Ash	3·2	6·28
	100·0	100·00
Total sulphur	Undetermined	0·56

It is stated that the prospecting party found an outcrop of anthracitic coal some distance to the south of the Fox River outcrops, in the valley of Henniker Stream. Loose coal has been found in Dilemma Creek, the south branch of the Fox River, and an outcrop of coal has been observed towards the head of its tributary, Fossil Creek.

(5.) *Porarari River Coal.*

From information supplied by Messrs. T. Thompson (Buller County Engineer), Low (Seddonville), and J. Parsons (Charleston), it appears that one or more thick seams of coal outcrop in the watershed of the Porarari River (also called Pareora and Pareroa), in the south-eastern part of the Brighton Survey District. The outcrops occur at elevations of 1,500 ft. to 3,000 ft. above sea-level.

(6.) *Extent of Coal-areas.*

There is a considerable area of lignite-bearing country around Charleston, and northward of that township, towards Cape Foulwind. A detailed geological survey is necessary in order to determine whether the coal extends eastward from Charleston towards the Paparoa Range under the limestone visible in that direction. The lignite is probably patchy, and therefore boring will in any case be needed in order to ascertain the exact area over which it occurs.

The Brighton lignite will probably be found at some depth under much of the limestone-covered country in the Fox River and Bullock Creek watersheds.

The various outcrops of bituminous coal and anthracite mentioned in former paragraphs are found in a narrow belt extending from the northern branch of the Fox River to the Porarari (Pareora). The coal-measures are denuded from the higher portions of the Paparoa Range (except perhaps in the upper Porarari watershed), but probably extend westward for some distance under the Miocene strata. The geological evidence shows that the bituminous coal-measures are at a considerable, perhaps great, depth, and die out against an ancient land-surface before reaching the coast. The western area, it may be mentioned, is separated by a great fault from the eastern area, in which outcrops are visible. This fault marks the western base of the Paparoa Mountains, and has a downthrow probably of thousands of feet to the west.

(7.) *Economic Value of Coal-areas.*

At Charleston the lignite is of much value for local consumption, and if the locality were connected with Westport by railway, it would, owing to the cheapness with which it can be mined, be able to compete to some extent with higher-grade coals as far afield as Wellington. Since, however, it will not stand exposure to the weather, its transport would be more expensive than that of bituminous coal; nor can it be said that the market likely to be developed justifies the building of a railway at the present time. Shipping the coal direct from Charleston in any quantity would necessitate the construction of an artificial harbour, so that this proposition need not be seriously considered.

Similar remarks to those of the last paragraph may be made concerning the Brighton lignite. This, though of somewhat better quality than the Charleston coal, and probably occurring over a large area, cannot be economically worked at the present time, except to supply the wants of the very small local population.

The narrow belt of coal-bearing country extending from the Fox River to Bullock Creek has practically no value. The seams of anthracitic and bituminous coal are for the most part crushed, are variable in composition, are extremely faulted, stand at high angles, and are remote from population. The coal in the Porarari watershed may have some future value: it cannot be said to have more than a trifling present value.

As regards the possible extension of the Fox River anthracite,* under the low country west of the Paparoa Range, this also may be considered of little or no present value. In the first place, the coal is not proved; in the second place, if present, it is deep; in the third place, before the coal could be utilized either a railway to Westport would have to be made, or an artificial harbour constructed at Brighton. The present value of a coalfield which cannot be worked for a number of years can be

* The anthracite probably passes into bituminous coal west of the main fault line.

calculated on the basis of an assumed yearly production, provided the approximate amount of coal, probable cost of working, and probable selling-price are known, and in most cases is found to be much less than would be supposed by those unacquainted with the manner in which compound interest accumulates. In any case, the value of the field, even a hundred years hence, is problematical, and only on the most favourable suppositions of any consequence.

(8.) *General Remarks.*

A fear has been expressed that the clearing of the land in what is known as the Brighton Block would result in the coal being set on fire. Of this there is not the least danger over the greater part of the Brighton Survey District, and more particularly over the area fit for settlement, for all the coal is under a thick cover of Miocene rocks. The area in which bituminous coal and anthracite outcrop is poor land, mostly at somewhat high elevations, and not suitable for settlement. Even if the bush on this land were felled and burnt, the most ordinary precautions would obviate any risk of the coal being set on fire.

The geology of the Brighton district is interesting, and of some importance. The detailed survey of the area between the Grey Coalfield and the Buller will give much information concerning the order of succession and age of the various coal-measures. It is likely, indeed, that the district contains a key to the stratigraphical relations of the New Zealand coalfields. These, Hector and McKay maintain, in the main belong to one great system, the Cretaceo-tertiary, which they suppose contains coal in two closely adjoining horizons only. Hutton and other geologists are inclined to place the coal-seams in two or more formations of different ages, though in a recent paper* by Marshall, Speight, and Cotton a return to the views of Hector and McKay is to some degree noticeable.

* "The Younger Rock-series of New Zealand," Trans. of N.Z. Inst. for 1910, Vol. xliii, 1911, pp. 378–407.

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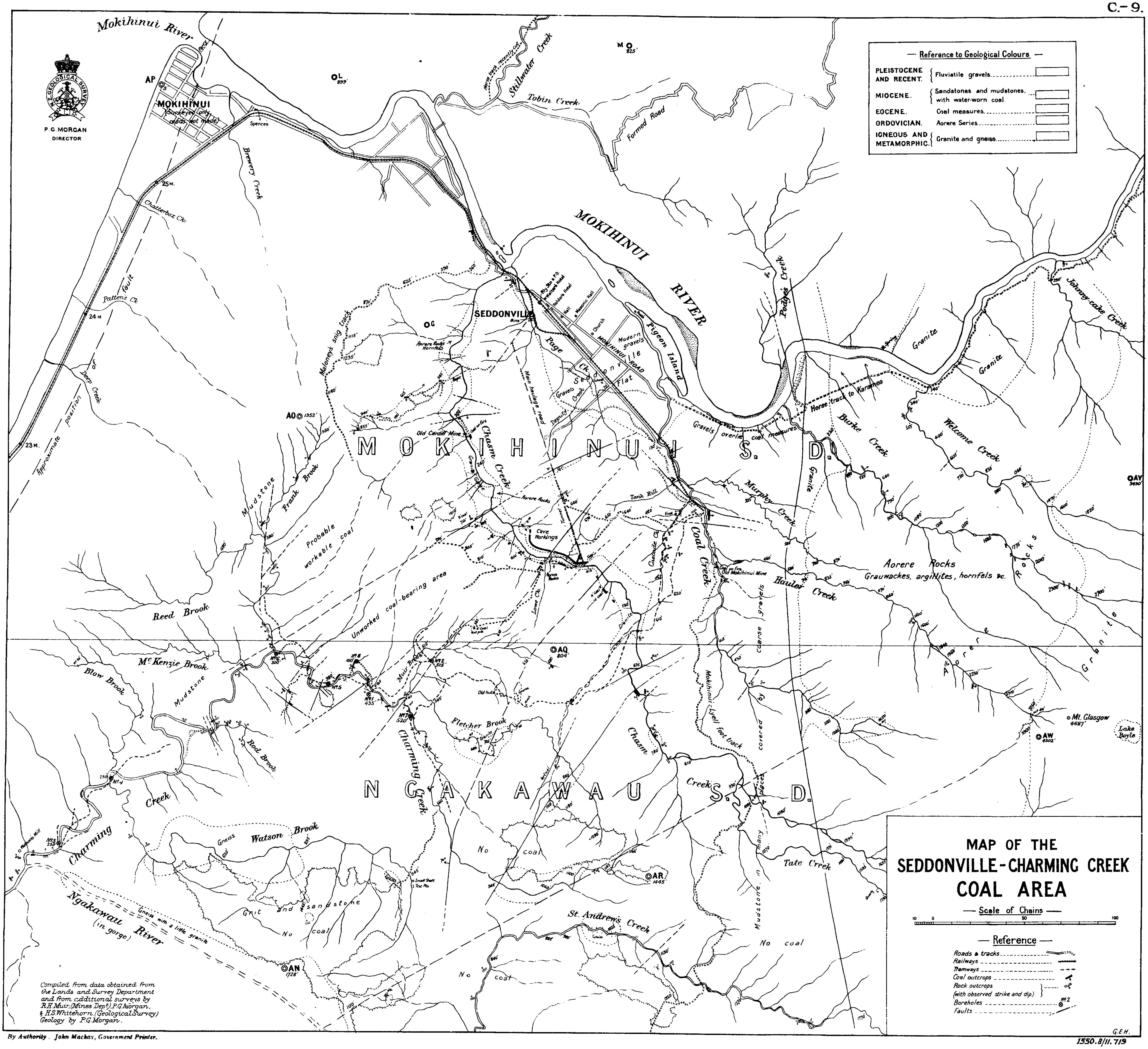
MAP OF THE
SEDDONVILLE-CHARMING CREEK
COAL AREA
Scale of Chains
Reference
Roads & tracks
Railways
Tramways
Coal outcrops
Rock outcrops (with observed strike and dip)
Boreholes
Faults
Reference to Geological Colours
PLEISTOCENE AND RECENT. Fluviatile gravels
MIOCENE. Sandstones and mudstones, with water-worn coal.
EOCENE. Coal measures.
ORDOVICIAN. Aorere Series.
IGNEOUS AND METAMORPHIC. Granite and gneiss.
N.Z. GEOLOGICAL SURVEY
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DIRECTOR
MOKIHINUI S. D.
NGAKAWAU S. D.
Mokihinui River
MOKIHINUI RIVER
MOKIHINUI
SEDDONVILLE
Ngakawau River (in gorge)
Charming Creek
Chasm Creek
Coal Creek
Aorere Rocks
Grauwackes, argillites, hornfels &c.
Probable workable coal
Unworked coal-bearing area
Approximate position of fault
Mt. Glasgow 4687'
Lake Boyle
Compiled from data obtained from the Lands and Survey Department and from additional surveys by R.H. Muir, (Mines Dept.) P.G. Morgan, & H.S. Whitehorn, (Geological Survey) Geology by P.G. Morgan.
G.E.H.