1925.

NEW ZEALAND.

MINES DEPARTMENT:

GEOLOGICAL SURVEY BRANCH

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

Laid on the Table of the House of Representatives by Leave.

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LETTER OF TRANSMITTAL.

SIR,— Geological Survey, Office, Wellington, 23rd June, 1925.

I have the honour to forward herewith the nineteenth annual report of the Geological Survey Branch of the Mines Department. This report covers the work of the Geological Survey for the twelve months ended 31st May, 1925. In addition to a general account of the work done, it contains reports on the districts examined in detail by the field geologists, and various special reports (somewhat abridged) supplied during the year.

I have, &c.,

P. G. MORGAN,

Director, Geological Survey.

The Hon. G. J. Anderson, Minister of Mines, Wellington.

DIRECTOR'S REPORT.

Summary of Field Operations.

During the field season of 1924–25 detailed topographical and geological surveys were carried out in the following areas :—

(1.) Motueka Subdivision, Nelson, by J. Henderson, M.A., D.Sc., B.E., A.O.S.M., Mining Geologist; L. I. Grange, M.Sc., A.O.S.M., and E. O. Macpherson, Assistant Geologists.

(2.) Rodney Subdivision, North Auckland, under the charge of H. T. Ferrar, M.A., F.G.S., Geologist.

(3.) Kaitangata Subdivision, East Otago, under the charge of M. Ongley, M.A., B.Sc., Assistant Geologist.

Brief visits were made by me to North Blackwater, Waihi, and Muir's Reefs (near Te Puke). I also spent a fortnight in Taranaki, principally with the object of collecting additional data for a report on the Egmont Subdivision, which is now being prepared for publication. Dr. J. Marwick, Palæontologist, made visits to the Wanganui-Nukumaru and North Otago districts in order to collect representative suites of fossils from known horizons.

Progress of Areal Surveys.

During the twelve months ended 31st May, 1925, approximately 1,201 square miles was examined in detail. Of this area 440 square miles is in North Auckland, 367 square miles in Nelson, and 394 square miles in east Otago. Since the reorganization of the Geological Survey in 1905 an area of 20,049 square miles has been geologically surveyed, but the results of nearly half these surveys are still unpublished.

Rodney Subdivision.

The survey of the Rodney Subdivision has been completed by Mr. Ferrar, and, since its geology is similar to that of the adjoining Dargaville Subdivision, he is now writing a detailed report on the two subdivisions considered as one area. A brief account of the work done last season is given on a later page.

Waiapu Subdivision.

The Waiapu Subdivision was geologically surveyed during the years 1920–23 by Messrs. Ongley and Macpherson. Last winter a draft report was written, and this is now being revised for publication. Lately options over large areas in the Gisborne – East Cape district have been obtained by oil speculators, and therefore every effort will be made to issue the Waiapu report and the geological maps that are to accompany it at an early date.

Tongaporutu-Ohura Subdivision.

A detailed report on the areas in north Taranaki geologically surveyed during the years 1920–23 has been written by Mr. L. I. Grange, the geologist who did most of the field-work, and this is now being prepared for publication. Owing to the oil-prospecting now in progress in Taranaki the early publication of Mr. Grange's report and of the geological maps which will accompany it is very desirable.

Egmont Subdivision.

Field-work in the Egmont Subdivision was practically completed in 1917, but recently I spent nearly a fortnight in the subdivision, collecting new data and checking some of the former surveys. The preliminary report written by Mr. W. Gibson has been rewritten and enlarged by me, but much work has yet to be done before it will be ready for publication. The numerous other duties to which I have to give attention will probably prevent this report from being completed before the end of the year.

Motueka Subdivision.

Owing to the difficulties of transport, the bad season, and inadequate labour, the survey of the Motueka Subdivision has not progressed so far as was hoped. A detailed report upon the country surveyed during the past two seasons is in hand, but a small additional area has yet to be mapped, and in order to complete the examination of the marble-bearing districts of Nelson an extension of the survey northward is necessary. It is proposed to embody the results of this in a separate report.

Geological data of considerable value have been obtained during the survey of the Motueka Subdivision, and the asbestos and other mineral deposits have been closely examined.

An account of the work done during the past season is given on another page.

Kaitangata Subdivision.

During the past season Mr. Ongley, as stated more in detail later, has examined areas to the west and north-east of the Kaitangata Subdivision as originally planned, but the Green Island Coalfield still remains to be surveyed before a complete report can be written. Very interesting results, some of which will be of importance to the coal-mining industry, are being obtained.

Palæontological Work.

The following is a synopsis of the work done by Dr. J. Marwick, Palæontologist, during the year: Collections were made in the neighbourhood of Wanganui and along the coast to Nukumaru, also at several localities in north Otago. The numerous specimens gathered will be of service not only for the study of the fossil faunas of New Zealand, but also as a means of procuring by exchange collections of fossils from other countries. Among the fossils collected by field parties, perhaps the most interesting are those from Clinton. They include examples of *Chonetes* and *Zaphrentis*, which show that the enclosing rocks are of Upper Palaeozoic age—that is, either Permian or Carboniferous. The underlying Otago schists must therefore be at least pre-Permian, and are probably very much older. Several trilobites collected in the Collingwood and Wangapeka districts were submitted to Dr. F. R. Cowper Reed, of Cambridge, who considers them to be of Lower Ordovician and Ordovician age respectively. The graptolites found in the Mount Arthur district will, it is hoped, provide equally useful evidence of the age of the containing strata.

The classification of Tertiary Mollusca was proceeded with, and several papers were submitted for publication in the "Transactions of the New Zealand Institute" and the *New Zealand Journal of Science and Technology*.

Publications and Reports.

During the year the following official publications were issued:—

"Eighteenth Annual Report (New Series) of the Geological Survey" (parliamentary paper C.-2c, 1923).

Geological Bulletin No. 26, "The Geology and Mines of the Waihi District, Hauraki Goldfield, New Zealand," by P. G. Morgan.

Several palæontological papers by Dr. J. Marwick appear in Volume 55 of the "Transactions of the New Zealand Institute." These are: "The Struthiolariidæ," "Palæontological Notes on some Pliocene Mollusca from Hawke's Bay," and "The Tertiary and Recent Naticidæ and Naricidæ of New Zealand." The following articles in the same volume describe fossil material partly or wholly collected by the New Zealand Geological Survey: "*Lahillia* and some other Fossils from the Upper Senonian of New Zealand," by Otto Wilckens (Bonn); "A New Fossil Gasteropod from New Zealand," by A. E. Trueman (Swansea); "Otoliths of Fishes from the Tertiary Formations of New Zealand," by G. A. Frost (London).

Various other papers or articles by members of the staff have appeared in the *New Zealand Journal of Science and Technology* or elsewhere, but do not call for further mention here.

The manuscripts of the following bulletins are in the hands of the printer:—

"The Geology of the Whangarei-Bay of Islands Subdivision," by H. T. Ferrar and others (J. A. Bartrum, W. H. Cropp).

"The Geology of the Huntly-Kawhia Subdivision, Pirongia Division," by J. Henderson and L. I. Grange.

"The Cretaceous and Tertiary Foraminifera of New Zealand, with an Appendix on the Ostracoda," by Frederick Chapman.

"Contributions to the Palæontology of the New Zealand Trias," by Otto Wilckens.

Office-work, etc.

The preparation and revision of the various detailed reports already mentioned occupied the various professional members of the Geological Survey staff during the whole of the winter months. All through the year much of my time has been taken up with similar work. Numerous requests for information connected with the work of the survey have been answered, and many samples of rocks, minerals, &c., have been examined and identified.

The draughting staff has drawn eleven maps, each covering one or more survey districts, for photo-lithographic reproduction, as well as a large scale map of the Greymouth Coalfield, and forty-four field-sheets. In addition a good deal of miscellaneous work has been performed.

The library has received the usual attention, and several hundred volumes, mostly received in exchange for the Survey's publications, have been placed on the shelves, now much overcrowded. Though incomplete in some respects, the library is invaluable for reference purposes.

SPECIAL REPORTS.

1. Motueka Subdivision.

(By J. Henderson, L. I. Grange, and E. O. Macpherson.)

Introduction.

The second season's field-work in the Motueka Subdivision was begun on the 4th November, 1924, and ended on the 23rd May, 1925. Parts of the survey districts of Harapaki, Flora, Leslie, Matawai, Mount Arthur, Motueka, Tasman, Wangapeka, Wai-iti, and Tadmor were geologically surveyed. In all about 367 square miles was examined in detail.

During the greater part of the season work was confined to the uninhabited mountainous western half of the subdivision, where access is by poorly graded and, for the most part, ill-kept pack-tracks, and by trails blazed by hunters and old-time miners.

The highland area contains deposits of commercial value in the chrysotile-bearing serpentine and talc of the upper valley of the Takaka and in the extensive beds of marble traversing the subdivision. The gold-bearing gravels that formerly attracted many diggers are now no longer worked, and the auriferous quartz veins of the area up to the present have not been profitably mined.

Forests cover the greater part of the mountains, but on their eastern side the lower slopes and the valley-bottoms are largely cleared and used as pasture-ground for sheep and cattle. The extensive fellfields of the higher mountains are also grazed during the summer months. The eastern half of the district is now for the most part denuded of forest. The hilly portion is covered with a thin, meagre soil which supports a scanty herbage. Orchards and pine plantations occupy small areas. The fertile valley-bottoms and delta-plains are closely settled. Root crops and cereals are extensively grown; there are numerous orchards, and toward the mountains, where the rainfall is heavier, dairying is carried on.

Physiography and Structure.

The Motueka Subdivision consists of a wide lowland structurally depressed between the mountains of west Nelson and the northern continuation of the main Alpine chain of the South Island, here without a definite name, but farther south known as the St. Arnaud and Spenser ranges. Great fracture-zones edge the depression—that on the east, McKay's Waimea fault, striking about north-east, and that on the west, the Motueka fault of the same geologist, trending, on the whole, north-north-east.

After all or most of the great earth-movements that roughed out the present land forms had ceased, the depression was covered with river-gravels, which formed a vast deposit sloping in a general northerly direction to Tasman Bay. These gravels are now much dissected. The wide terraces of the principal streams and the extensive delta plains at their mouths suggest considerable oscillation of the land since the deposition of the gravels.

Great fractures, of which the more important strike north-east and north-north-east, traverse the western highlands and separate the differentially elevated blocks that form their mass. These fractures and the tilts and warps of the individual earth-blocks more or less control the position of the stream-channels and the extent of the drainage-basins.

The Motueka, the chief river of the subdivision, rises in the eastern mountains, crosses the lowlands obliquely, and flows along their western edge to Tasman Bay.

No permanent snowfields occur, but some valleys were anciently glaciated as low as 2,500 ft., and many at higher levels.

General Geology.

The western highlands consist of a vast thickness of older Palæozoic rocks strongly folded along north and south lines, and intruded at many points by acidic, basic, and ultrabasic rocks. Tertiary strata occur in the mountains along fault-angles and flooring depressions, and extend in an irregular strip along the western edge of the lowlands from the southern boundary of the subdivision north nearly to the junction of the Tadmor and Motueka rivers.

The oldest rocks of the subdivision are chiefly indurated argillites, greywackes, and quartzose greywackes, assigned to the Aorere Series. In their upper portion thick bands of quartzite, interbedded with thin bands of black carbonaceous shale, in many localities altered to slate, occur. At some points lenses of marble are present in the carbonaceous shales. In many places the finer-grained sediments are schistose, as are also the greywackes toward the base of the series or near granitic intrusions. The rocks form a broad belt extending meridionally through the western part of the district, where they are intruded by vast granitic batholiths. Graptolites occur in the carbonaceous shales of the upper part of the series.

The Aorere greywackes pass upward into grits, conglomerates, and breccia conglomerate, which form the typical rocks of the Haupiri Series of Bell, Webb, and Clarke (Parapara Subdivision). Thick beds of quartzite and phyllite, in places containing lenses of impure marble, also occur, as well as green schists, probably altered igneous rocks. The coarser beds, which in some places are many thousands of feet thick, are throughout interbedded with greywacke, and grade laterally into greywacke and quartzite. The Haupiri rocks form a broad band extending north and south through the district immediately east of the Aorere rocks, and, like them, have a general dip to the east.

The green greywackes and schistose argillites that form the upper part of the Haupiri Series are interbedded with bands of black phyllite, which increase in number and thickness upward till they constitute the main mass of the strata. These black phyllites are the most characteristic rock of the Mount Arthur Series. They are usually calcareous, and at many points pass into thick bands of marble. In places they are strongly siliceous and grade into dark quartzite. The Mount Arthur rocks lie east of the belt occupied by Haupiri strata. They are much contorted and confusedly crumpled. In the southern part of the subdivision they form a syncline, of which, in the northern part, the western limb only is present. Graptolites were collected from the Mount Arthur rocks near the top of Lodestone Peak and on the track along Flora Stream, a headwater branch of Takaka River.

Most previous writers on Nelson geology have placed the rocks of the Mount Arthur Series below those of the Aorere Series, but they occupy a much higher stratigraphical position, as will be fully set out in the detailed report now being prepared.

The youngest Palæozoic rocks, the Baton River Series of McKay, in the typical section along the Baton River, are dark calcareous argillites. They grade downward into light-coloured blue and green argillites, more or less schistose, and these in turn are underlain by the black phyllites typical of the Mount Arthur Series. North and south from the Baton River the calcareous argillites grade laterally into calcareous quartzites and quartzites interbedded with bands of marble and dark argillite. The Baton River rocks occupy the trough of the syncline of Mount Arthur strata extending from the Wangapeka to the Baton River, north of which they are not known to occur. In the Wangapeka district they appear to rest unconformably on the Mount Arthur rocks. The fossils of the Baton River Series indicate a Middle Silurian (Wenlock) age.

The Tertiary rocks consist of arkositic grits and sandstones grading up into sandy limestones, which in turn are overlain by argillaceous sandstones and mudstones. There are several considerable areas of Tertiary strata in the western highlands preserved from denudation by occupying fault-angles or trough depressions. Tertiary rocks also outcrop along the western edge of the depressed eastern portion of the subdivision from the southern boundary north to within three miles of the junction of the Wangapeka with the Motueka River.

The Moutere gravels, a vast mass of river deposits occupying the relatively low eastern half of the subdivision, were laid down after the main block-faulting at the close of Tertiary times had ceased. These are now crossed by numerous valleys, of which the terraces and flood-plains, together with similar deposits along the mountain-valleys, form the Recent and younger Pleistocene deposits of the district.

Basic dykes occur at many points in the Palæozoic beds of the subdivision. They are especially numerous in the Haupiri Series, in which also are large intrusive masses of basic and ultrabasic rocks in part altered to serpentine. Two large patches of these rocks covering several square miles are exposed in Flora Survey District. Another mass of basic and ultrabasic rocks, elongated like a huge dyke, extends northward from the Baton Valley through the valleys of the Pearse, Graham, and Pokororo streams into that of Riwaka River. This mass is intruded in Mount Arthur strata.

Granitic rocks, intrusive into Palæozoic strata, occupy three separate areas. A batholith of grey granite lies along the western border of the subdivision. Another great batholith forms the eastern edge of the western highlands. A much smaller mass of granite containing large phenocrysts of pink feldspar occurs in the middle part of the basin of Crow River.

Economic Geology.

Alluvial gold was formerly obtained from the beds and terraces of many of the streams of the western highlands and the western edge of the lowlands. Its immediate source is either the gold of the quartz lodes traversing the ancient rocks, or the detrital gold contained in the basal Tertiary rocks, or both. Some of the quartz veins are known to be auriferous, a few have been prospected, but at present not one is being worked.

Grains of platinum or of alloys of the platinum metals occur with the alluvial gold in some localities.

Thin seams of coal are present in the basal Tertiary rocks of the middle part of the Baton Valley. They are much faulted and have no commercial value.

Chrysotile-asbestos occurs in quantity in the more northerly mass of ultrabasic rock present in Flora Survey District. The deposit has been known for many years, and from time to time has been prospected and even worked in a small way. At present it is reached by a sixteen-mile bridle-track through the mountains, but until much better access is given it cannot be profitably worked.

Talc and magnesite are associated with the ultrabasic rocks of the subdivision, chiefly in the large masses in Flora Survey District, where also chromite occurs in irregular segregations, streaks, and lenses.

In places the marble occurring in the subdivision contains too much sand for easy working as a building-stone, but there are large masses of light- and dark-grey marbles suitable for quarrying were they more readily accessible. The most easily reached deposit examined last season is that occurring along the south side of the south branch of Graham River and outcropping about a mile from the end of the road along that stream. It consists of light-coloured coarse-grained stone. Northward, in an area proposed to be examined next season, very large areas are covered by marble.

The other building-stones of the district are ultrabasic rocks, serpentines, and granites. The ultrabasic rocks are hard and dark-coloured, and the occurrences in the Baton and Graham valleys are readily accessible. Beautifully mottled serpentine occurs in Flora Survey District, and a fine granite with large pink feldspars in the valley of Crow River; both deposits are too difficult of access to be of commercial value. Grey granite outcrops at many points along the eastern edge of the highlands. Though it is generally deeply weathered, faces of fresh rock could readily be opened.

2. Rodney Subdivision.

(By H. T. Ferrar.)

Introduction.

The geological examination of the remaining portions of Rodney Subdivision, as tentatively defined in last year's annual report, was continued during the past field season. Field-work was commenced on the 3rd November, 1924, and ceased on the 17th April, 1925, during which period the following survey districts were surveyed: Kawau, Waioneke, Kaipara, Waiwera, Tiritiri, and portions of Tauhoa, Mahurangi, Kumeu, and Waitemata. These cover a block of country which extends from coast to coast across the North Auckland Peninsula, and includes the small towns of Helensville and Warkworth, as well as a number of growing villages. The country surveyed is 440 square miles in area, of which 28 square miles lie to the south of the subdivision. Geological assistance was rendered by Mr. F. J. Turner, B.Sc., for three and a half months, and Mr. D. A. Grant, F.R.G.S., who has been a member of the North Auckland field-party for five out of six seasons, assisted with topographical work.

Physiography.

The district surveyed is part of a deeply dissected land which has been partly submerged, so that the sea finds its way far inland up numerous drowned valleys. Insilting of these valleys and a recent small elevation counteract to some extent the encroachments of the sea. From the highest hills, few of which are more than 1,000 ft. high, the land falls gradually to heights of 500 ft. or less, and the landscape is in general of low relief.

The drainage of the district is effected by streams flowing east and west from a meridional divide which is situated rather nearer to the east than to the west coast. The streams are deeply entrenched, especially where the land is comparatively high; but in places, as at Kaipara Flats, broad open reaches occur in the midst of the hill tracts. The stream-pattern is very intricate, a complex history being thereby indicated. The chief eastward-flowing streams are the Puhoi, Waiwera, Orewa, and Wade (Weiti), and those flowing westward into Kaipara Harbour are the Waiparera, Makarau, and Kaukapakapa.

The Kaipara South Head peninsula, on the west side of the district, forms a separate physiographic unit. Here a range of hills, 400 ft. to 500 ft. high, with drainage flowing eastward into Kaipara Harbour, extends north-westward subparallel to the open sea-coast. Between the coast and the hills there is a belt of drifting sand, 20 ft. to 50 ft. above sea-level, separated from the hills by a chain of swamps and shallow lakes. In places the drift sand is being blown on to the hill-tract, and in consequence the watershed is migrating eastward. The mouths of those streams draining eastward are drowned, and are now occupied by extensive mangrove-flats.

General Geology.

The following provisional table gives a synopsis of the geological sequence in North Auckland, together with the approximate age of the several formations:—

Local Name.	Description of Strata.	Series or System.	Approximate Age.
..	Swamps, alluvium and drift-sand	..	Recent.
..	Scoria-cones and later basaltic lavas ..	..	Recent to Pleistocene.
..	Consolidated sand-dunes; gravel terraces ..	..	Pleistocene.
Kerikeri Series ..	Basalts and basaltic andesites	..	Pleistocene or Pliocene
Purua beds	Fresh-water leaf-beds, lignitic sandstones, tuffs	..	Pliocene.
Manukau breccias ..	Andesitic lavas, breccias, and tuffs (Wairakau Series)	..	Miocene.
Waitemata Series ..	Argillaceous sandstones with calcareous volcanic grits; fossiliferous sandstones and conglomerates (Cape Rodney Beds); tuffs and fossiliferous sandstone (Pakaurangi Beds) *(Local unconformity.)*	Oamaruian	Miocene.
Whangarei Formation	Crystalline limestone, glauconitic sandstone, coal, and conglomerates *(Unconformity.)*	Oamaruian	Oligocene.
..	Rhyolites and dacites (Parahaki Series); ultrabasic intrusions ("serpentine")	..	Eocene (?).
Onerahi Formation ..	Argillaceous limestone, greensand in places, claystones and conglomerates *(Unconformity.)*	Waiparan ..	Cretaceous
Otamatea beds ..	Silicified claystones, grey sandstone with cone-in-cone limestone, ammonites, and *Inoceramus* *(Unconformity.)*	Waiparan ..	Cretaceous
Waipapa Series ..	Greywackes, argillites, and minor limestones	Hokanuian (? in part only)	Trias-Jura (?).

Previous geological work in the area under review was first carried out by F. von Hochstetter in 1859. Official examinations of portions of the area have been made by J. Hector, S. H. Cox, A. McKay, J. Park, P. G. Morgan, and J. Henderson. Private workers in this field include E. K. Mulgan and J. A. Bartrum, the latter of whom recently mapped portions of Kaipara and Waiwera survey districts.

The account of North Auckland stratigraphy as outlined in preceding annual reports still holds good, and as the survey proceeds new series of sediments are placed in the table. Sometimes difficulty is experienced in deciding which of two sediments is the older, for the beds, owing to erosion, cannot be traced continuously across country and the fossil contents are not sufficiently definite.

The oldest rocks in the district are shattered non-fossiliferous greywackes and argillites of Trias-Jura (?) age. They crop out only on the east side of the district on Tawharanui Point, on Kawau, and on one or two other islands in the neighbourhood, and on Tiritiri Island. These rocks are of great thickness, and westward probably underlie the other formations.

Next in order are concretionary sandstones considered to be equivalent to the Otamatea beds, which are of upper Cretaceous age. These appear only on the east side of the district—namely, at Snell's Beach and at Orewa and Silverdale ("Wade" of the old Geological Survey reports)—where they occur as small inliers. At Snell's Beach the rock is a claystone rather than a sandstone, but it possesses other characters which agree with the Otamatea beds as defined in last year's report. At Orewa fragments of *Inoceramus* were found, but in the Silverdale area the calcareous concretions contain only the usual nests of carbonized plant-fragments.

The argillaceous limestones and claystones occur as large and small inliers, chiefly in Waiwera Survey District—that is, toward the east side of the region, but to the west of the older Otamatea beds. In many cases the argillaceous limestones occur to the west of the claystone areas, which is further evidence in favour of the view that they are the youngest beds in the series. They contain no recognizable fossils other than Foraminifera, but being similar to the argillaceous limestones and claystones of the Onerahi Formation of the Whangarei-Bay of Islands Subdivision, they are taken to be part of the same series and correlated with the Amuri limestone of late Cretaceous age.

The lower sandstones and crystalline limestone of the Whangarei Formation thin out southward of Maungaturoto and Pahi, and appear to be absent from the area surveyed this year. The thick beds of gritty sandstone that form the hilly country to the south of Warkworth and around Puhoi belong to the Waitemata Series. South of Puhoi these beds decrease in thickness and gradually become more argillaceous, and from Redvale, in the south-east corner of the area, they can be followed continuously to Auckland Harbour. In Waiwera and Tiritiri survey districts soft clayey sandstones pass downward into a peculiar calcareous grit, similar to the Parnell grit. In places this grit forms part of an apparently conformable succession, but in other places there is a distinct disconformity between its conglomeratic base and the bed of sandstone next below. Fossiliferous sandstones and conglomerates occur at the bottom of the Waitemata Series on Tawharanui Point and on Kawau Island, and on Tiritiri Island conglomerate veneers Mesozoic (Waipapa) rocks.

In the south-western portions of Tauhoa Survey District there are outliers of andesitic lavas, breccias, and conglomerates overlying the Waitemata beds. These andesitic rocks thin out in the middle of Kaipara Survey District, but appear again towards its southern border, and apparently extend southward to form the Waitakerei Hills, west of Auckland. They are succeeded by white fissile clays containing silicified wood, which may be correlated with the fresh-water lignitic beds of Hukatere Peninsula, tentatively assigned to the Purua beds of supposed Pliocene age.

Pleistocene deposits are represented by raised beaches, by occasional gravel terraces, and by the consolidated sand-dunes of Orewa on the east coast and of Kaipara South Head peninsula on the west coast. This latter formation, except where interrupted by the mouth of Kaipara Harbour, extends from Muriwai to Mangonui Bluff, a distance of nearly ninety miles.

The igneous rocks found in the district fall into three categories—namely, those in the conglomerates of the Waitemata Series, intrusions of ultrabasic rock now largely serpentinized, and the andesitic lavas and breccias previously mentioned. The Waitemata conglomerates largely consist of pebbles derived from plutonic rock-masses not known to occur in the district; the serpentinized masses intrude the late Cretaceous argillaceous limestone and claystone, and are thus of approximately Eocene age; and the andesitic lavas are Upper Miocene or Lower Pliocene.

Economic Geology.

The coaly partings so common in the Waitemata Series have led to the belief that payable coal exists in Rodney and Waitemata counties. The present survey shows that this belief is groundless. The older Onerahi and Otamatea beds, which locally appear from beneath the Waitemata Series, are likewise barren of coal, so the country as far north as Maungaturoto may now be definitely regarded as not coal-bearing.

The New Zealand Mining Handbook, 1906, while reporting the occurrence of copper and half a dozen other metals, gives little or no information with regard to them, but points out that much of the country is but little explored. The present survey has fulfilled this want. Of the metals reported, most occur as traces of no economic value, the copper of Kawau Island being the only one that might repay the miner.

The copper-lode on Kawau was worked under difficulties over seventy years ago. The ore first mined yielded 16 per cent. of copper, but its tenor fell off at the bottom of the workings to about 5 per cent. About twenty-five years ago the old shaft, situated between tide-marks, was unwatered, but, although the richest ore is said to occur here, the mine was not kept open long. The workings, except those above high-water mark, are now full of water.

Limestone suitable for cement-making occurs in quantity at Warkworth, at Cooper's Flat, at Dairy Flat, at Silverdale, and at Redvale. Calcined limestone was produced at Warkworth in 1849. Many years later cement-works were established there, but these, now owned by Wilson's (N.Z.) Portland Cement Company, were shut down in November, 1924. At Silverdale and at Redvale argillaceous limestone is pulverised, and sold locally and in Auckland for agricultural purposes. The lime-works near Kaukapakapa have been closed for the past three years.

Roadmaking material is well distributed throughout the district under review. The conglomerates in the Waitemata Series occur as thick beds in the hilly tract of country between Cooper's Flat and Wainui, and, being easily quarried, are in demand for roadmaking. Serpentinized dykes are numerous

near the Kaukapakapa–Silverdale Road, but, although this type of rock makes a good road for rubber-tired vehicles, it is little used. The andesites that cover considerable areas north and south of Helensville are good tough rocks, and form a reserve of roadmaking material which is practically neglected. The argillaceous limestone, though soft, is used locally, and would be of service as a foundation to support a well macadamized road.

Perhaps the greatest immediate economic result of the present survey is the topographical and lithological map. This map, with slight modifications, would form a soil-map such as that required by all those concerned with the broader aspects of agriculture. Five types of soil, which accord with the rocks from which they are derived, cover the greater part of the countryside referred to in this report. The almost barren claystone soils of the Onerahi Formation around Wainui, White Hills, and Redvale, once worked for their kauri-resin, have reverted to fern and stunted manuka. The sandstone soils of the Waitemata Series may be separated into two subtypes which grade into one another. The sandstone hills near Warkworth and Puhoi in Rodney County are covered by fertile soils which support rich pastures, but in the northern portions of Waitemata County the rocks of the same series form less fertile soils. Here the land was once covered by kauri forests, but now it carries only poor pastures, and in places none at all. The andesitic soils are likewise of low fertility, but, being more retentive of water, are more drought-resistant than those on the Waitemata sandstones. The older sand-dunes on the western side of Kaipara Harbour are covered by good pasture. The newer dunes farther to the west are either thinly grassed or form wastes of drift sand. In this western stretch of country there are large areas which would lend themselves to afforestation. Near Helensville, in the valley of the Kaipara River and its tributaries, are valuable and extensive alluvial flats.

3. Kaitangata Subdivision.

(M. Ongley.)

During the past field season, from the 6th November to the 30th May, the writer continued field-work in the Kaitangata Subdivision, and for three months of this time was assisted by Mr. R. G. Penseler, M.Sc., of Otago University. Some 190 square miles west of the district examined in 1923–24, and 204 square miles north-east of it, were geologically mapped on the scale of 20 chains to the inch. The western part comprises Warepa and Pomahaka survey districts, and the north-eastern part Mangatua, Otokia, West Taieri, and parts of East Taieri and Waihola.

Topography.

In the western area the land rises gently away from the Molyneux River from 250 ft. to 600 ft. above sea-level, but is being dissected by the Molyneux and Pomahaka, which have here cut their main valleys down to 60 ft. above sea-level. South-west of the lowland country are the Kaihiku Ranges, a series of parallel hog-back ridges 2,000 ft. high, of which a part twelve miles long from north-west to south-east and eight miles wide is in the subdivision.

In the middle of the north-eastern area is the Taieri Plain, twenty-five miles long from north-east to south-west, and four miles wide. In the southern part of it the tidal lakes Waihola and Waipori cover six square miles. From them the plain rises gradually northward to 100 ft. near Wingatui and North Taieri. East of the plain an unsymmetrical ridge rises steeply 600 ft. high in the south and 1,000 ft. in the north, and slopes away gently eastward to the coast. On its crest are the volcanic masses forming the two peaks of Saddle Hill (1,565 ft. and 1,414 ft.) and Scrogg's Hill (1,162 ft.). West of the Taieri Plain Maungatua Mountain rises steeply to a height of 2,944 ft., and descends gently to 2,000 ft. at the western boundary of the subdivision, four miles away.

General Geology.

The rocks of the Kaitangata Subdivision are similar to those in the Tuapeka District described by Marshall in Geological Survey Bulletin No. 19. On the evidence available the rocks so far examined are classified as follows :—

Nature of Beds.	Approximate Age.
Loose conglomerates and gravels (100 ft.) Lignite, clay, and conglomerate (30 ft.)	Recent and Pleistocene.
(Erosion interval.)	
Basalt Scoria and conglomerate (50 ft.)	Upper Tertiary.
(Erosion interval.)	
Limestone and greensand (150 ft.)	Ototaran [Oligocene].
(Erosion interval.)	
Glauconitic mudstone and sandstone (800 ft.) Fossiliferous sandstone (1–10 ft.) Fine conglomerate of quartz pebbles (900 ft.)	Lower Tertiary.
(Erosion interval.)	
Fossiliferous shell-rock (50 ft.) Fine conglomerate of quartz pebbles, with finer beds and coal-seams (100 ft.)	Upper Cretaceous.
(Erosion interval.)	
Coarse conglomerate of greywacke and schist pebbles, with finer beds and coal-seams (500 ft.)	Upper Cretaceous.
(Erosion interval.)	
Argillaceous greywacke and argillite, with one bed of plant-remains at the top and two beds of marine Jurassic fossils (5,400 ft.)	Jurassic.
Arenaceous greywacke and argillite, with five beds of upper Triassic fossils, coarse conglomerate of greywacke, diorite, porphyrite, &c. (4,500 ft.)	Upper Triassic.
(Erosion interval.)	
Greywacke and argillite, with a bed containing Upper Palaeozoic fossils, coarse conglomerate of greywacke, diorite, porphyrite, &c. (5,000 ft.)	Permian or Carboniferous.
(Erosion interval.)	
Hard greywacke, in places intruded by diorite, porphyrite, &c. (of great thickness) Quartz and mica schists (of great thickness)	Middle or Lower Palaeozoic.

Economic Geology.

In the Jurassic greywacke in Warepa Survey District, at the south edge of the bush on Dromedary Hill, the grassy slope is littered with large boulders of magnetite and of greywacke containing more or less magnetite. The greywacke is banded dark, grey, and light by the distribution of the magnetite grains more or less abundantly among the quartz grains. The bedrock is not exposed, and it is impossible to say how wide or how long the magnetite layer is. The line of boulders on the hillside runs with the strike of the near-by greywackes. Along the strike in Puerua Stream, a quarter of a mile to the south and on the road half a mile to the north, the magnetite was not found.

Higher in the Jurassic greywackes are claystone bands containing plant-remains and thin seams of coking-coal. In February, 1925, Mr. J. G. Byers, of Awatea, was prospecting on his farm for workable coal in vertical beds of mudstone of this character. Mr. Byers states that two "dowsers," or "diviners," have independently reported that thick coal-seams occur at a depth of about 1,000 ft. As the beds are vertical and well exposed in many places along the strike, and nowhere show more than a few inches of coal, evidently no thick seam occurs. In 1917 Professor Park* reported unfavourably on a similar occurrence in Woodland Survey District, about half a mile from Maclennan Railway-station, which is not far outside the subdivision.

The local schist and schistose greywacke were used by the early settlers in a few buildings, and after standing sixty years the stone is still unweathered. No easily worked stone has, however, been found.

The conglomerate of greywacke and schist that contains the coal-seams at Kaitangata extends over 15 square miles on the west of the hills north of the lower Taieri Gorge, and in several places it has in it thin seams of coal 1 in. to 3 in. thick. Parts of this area have been previously prospected for coal without success. The nearest thick seam known in the conglomerate is some twenty-five miles away to the south; and as in the intervening part no thick seam is known, it is unlikely that one occurs.

Quartz conglomerate correlated with the conglomerate that contains the coal-seams at Taratu occurs at the north end of the Taieri Plain on both sides. On the coastal side, at Green Island and Saddle Hill, coal has long been mined. New mines are now being opened at Mosgiel Colliery and Willowbank Mine, on the north and west of Saddle Hill, in a seam more than 10 ft. thick. On the other side of the plain, near Salisbury Railway-station, a seam from 5 ft. to 8 ft. thick was worked for a few years, but the coal thinned, and about 1893 the mine was closed.

The Milburn limestone, examined in the 1923–24 season, is being quarried at the rate of 250 tons a day. The phosphate in the Ewing Phosphate Company's property is still not being worked; but on the south side of the hill the Dominion Lime and Phosphate Company is grinding together the phosphatic limestone, the glauconitic greensand, and the white limestone. The fertilizer produced is reported to be giving good results.

In Pomahaka Survey District three lignite-pits are being worked in a flat bed 6 ft. to 10 ft. thick. The lignite-beds were found to extend over 36 square miles. At the Burning Plains the lignite has been on fire for many years.

Above the lignite is a bed of fine white clay; where seen it is 1 ft. to 10 ft. thick. Samples were taken for testing.

In the north-west of the subdivision the Pleistocene gravel in the Verter Burn has been worked for gold. Much gravel remains, but can be only slowly worked with the scant water available. Close to the subdivision both the greywacke-schist conglomerate and the quartz conglomerate are worked for gold, and payable patches may yet be found in the Kaitangata Subdivision. A rich specimen of gold-bearing quartz has recently been found in the North Taieri district, but has not yet been traced to its source.

4. North Blackwater Mines (Limited), Reefton Goldfield.

Abridged report by P. G. Morgan.

On the 27th August, 1924, accompanied by Mr. J. F. Downey, Inspector of Mines, I visited the North Blackwater Mine, near Waiuta, Waitahu Survey District.

The claims held by the North Blackwater Mines (Limited) have a total area of 510 acres, and are as follow: Prohibition Special Claim (100 acres), Scott's S.C. (10 acres), Lord Reading S.C. (100 acres), Mills and Fry's S.C. (100 acres), Cameron S.C. (100 acres), and Williams's S.C. (100 acres). Most of the older prospecting-drifts in this area are shown on a plan (No. 13) published in Geological Survey Bulletin No. 18, 1917 (see also page 173).

In 1915 or thereabouts the North Blackwater Development Syndicate began to sink a shaft in Scott's S.C. at a point a few hundred feet north of the Blackwater Mine workings, in the expectation of finding at a depth of 1,000 ft. or less the Birthday or Blackwater lode, and with it a continuation of the northernmost ore-shoot of the Blackwater Mine. The shaft has since been s nk to a depth of 1,360 ft., and at intervals seven chambers for levels have been excavated. From No. 6 (1,200 ft.) and No. 7 (1,350 ft.) level crosscuts have been driven south-eastward, and both have intersected several bodies of gold-bearing quartz, all striking west-south-west. The No. 6 crosscut at 35 ft. from the shaft cuts what is called the "6-in. leader." The quartz is in well-banded bunches of good appearance, and assays well. At 80 ft. there is another small vein, which on the south side appears to be cut off by a fault. At 160 ft. there is a larger vein, which, however, at this point is very close to a fault, if not involved in it. Close to the end of the drift, at 272 ft., is a small lode of well-banded quartz, varying in thickness from a few inches to 15 in. or more. At the time of my visit this had only lately been intersected, and no driving on it or the other veins had been done.

* James Park: "Coal at Maclennan, Catlin's District." Eleventh Annual Report of the New Zealand Geological Survey, C.–2B, p. 18, 1917.

The crosscut at No. 7 level has been driven for about 300 ft. It cuts small veins at 17 ft. and 35 ft. and larger bodies of quartz at 120 ft. and 220 ft. A drift following the 120 ft. lode extends for 15 ft. to the north-north-east, but at 10 ft. the lode is cut off by faulted ground The faulting is irregular, but the lode ends at a break striking 277° and dipping at 45° to the north. Again a drift on the course of the lode has been extended for 142 ft. to the south-south-west, but at 112 ft. the lode ends against a break which strikes in a north-wseterly directionand dips at (say) 50° to the north-east. At the end of the drift a crosscut has been driven for 23 ft. to the north-west, but no lode has been found. Probably the lode-track continues to the south-south-west without much displacement. If so, it contains no quartz where exposed beyond the break by the drift, but there may be veinstone farther south.

At 150 ft. and 170 ft. in the main crosscut there is drag quartz in a considerable fault or fault-zone which seems to strike about 340°–345°, and to dip steeply eastward. A drift on the lode exposed at 220 ft. goes 74 ft. northward, but at 70 ft. the lode is cut off by a break striking 266°, and dipping at 40° northward. The lode is followed southward by a drift, but at 21 ft. is cut off by a strong fault, apparently that mentioned above as striking 340°–345°. The drift, bending to east of south, follows this fault for another 25½ ft., and at its end is a crosscut to the east for 20 ft., and one to the west for 10 ft.

The lodes cut at 120 ft. and 220 ft. in the crosscut vary in width from 1 ft. to 2 ft. 6 in. The quartz in these and in the smaller veins assays from several pennyweights to several ounces of gold per ton, and the average assay is well over an ounce. Under ordinary circumstances the two larger bodies might be expected to pay for working, but unfortunately they are of no great length. I have no doubt but that they are portions of one and the same lode, separated by the north-north-west-striking fault previously mentioned. Further, though a little out of line, they form a continuation of the Blackwater lode.

The upward extension of the 220 ft. lode is without doubt the lode cut at the end of the No. 6 level crosscut, and similarly the upward extension of the 120 ft. lode is the vein intersected at 160 ft. in the same crosscut. The veins seen at 17 ft. and 35 ft. in the No. 7 level crosscut most likely are the same as those seen at 35 ft. and 80 ft. in the level above.

From a prospecting point of view the North Blackwater Mine may be considered to have been successful, for a continuation of the most northerly of the Blackwater Mine shoots has been found in the expected position. From a commercial point of view the results are not so satisfactory Severe faulting has broken the shoot of ore, which, moreover, so far as known, is small both in length and in width. The further exploration needed to discover new ore-shoots, if such exist, will be costly.

One point with reference to the faulting deserves mention. The lodes of the Reefton district follow fault-planes, and the shoots of quartz appear to end where (pre-mineral) faults, small or large, cross the lodes. This explanation is given by J. Henderson in Geological Survey Bulletin No. 18 (page 119), and accounts well for the peculiarities of the shoots. In addition to the early faults which preceded or accompanied the period of lode-formation, there are later faults that dislocate the lodes. In the Blackwater district the faults with north-north-west strike appear to belong to the later faulting-period. In all known cases of importance the faulting is normal, and therefore the rule, independently formulated by Schmidt and by Zimmermann, for finding the faulted portions of lodes is applicable, though sooner or later a marked exception may be expected to occur.

5. Waihi Grand Junction Mine.

(Report by P. G. Morgan, abridged and slightly modified.)

During December, 1924, several days were spent in examining the Waihi mines and the surrounding country. The principal object in view was to obtain data for a report on the diamond-drilling operations then being conducted in the Waihi Grand Junction Mine, mainly in the hope of striking a payable ore-shoot in the Martha or Empire lode below No. 11 (1,639 ft.) level, and on the advisability of further prospecting in the ground held by the Grand Junction Company.

At the time of my visit a bore (No. 1) had been drilled vertically from a special chamber close to No. 1 shaft to a depth of 600 ft., and discontinued. A second bore, No. 2, had been drilled from a chamber perhaps 30 ft. south of No. 1 bore chamber, on an inclination of 70° from the horizontal, and in a south-east azimuth (bearing approximately 127°), to a depth of 583 ft., and ultimately reached a depth of 756 ft. The boring, so far as I could ascertain, had been undertaken without geological advice.

In No. 1 bore, down to 325 ft. or thereabouts, as shown by the cores, layers of andesitic tuff and of flow andesite alternated, then tuff, in part silicified, came in, and continued to near the bottom of the hole, except that at 390–407 ft. glassy low-grade quartz with plentiful pyrite (a lode of unknown but probably small size) took its place. The rock at 600 ft. seemed to be a quartz andesite, containing numerous foreign fragments or inclusions (xenoliths). Some of the cores showed dips which varied, but on the average were probably over 10° (presumably to the south-east). The bore was not very easy to drill, but a large percentage of core was obtained, and serious trouble occurred only at 370 ft., where the diameter of the bore had to be diminished.

No. 2 bore was expected to intersect the Empire lode between (say) 350 ft. and 580 ft., but at 583 ft. was in broken rock (probably andesite). Down to this depth it had penetrated alternating bands of andesite and andesitic tuff, with andesite predominating except at 110–261 ft., together with a few small quartz veins, and at 135 ft. a foot of white quartz. At 561 ft. the rock was broken and silicified. Much trouble was experienced in drilling this hole. It does not correlate well with No. 1, and probably the greater part of it was in a fault-zone, parallel to the Martha lode, which in the crosscut south of No. 10 level is represented only by a "slide," but nevertheless is the dominant lode of the Waihi Gold-field. Probably the Empire lode does not continue downward through the plane of the Martha lode.

According to later information No 2 bore from 583 ft. to 599 ft. passed through andesite and quartz rubble; from 599 ft. to 620 ft. through tuff; from 620 ft. to 628 ft. through andesite; from 628 ft

to 633 ft. through tuff; from 633 ft. to 674 ft. through andesite; from 674 ft. to 731 ft. through silicified tuff; from 731 ft. to 737 ft. through dark tuff; from 737 ft. to 742 ft. through silicified tuff; and from 742 ft. to 756 ft. through andesite.

One of the subsidiary objects in drilling these bores, especially No. 1, was to ascertain the nature of the rocks below No. 11 level. Although this information to a depth of 500 ft. below No. 11 level is given by No. 1 bore, and to a somewhat greater depth by No. 2 bore, it could have been ascertained with a fair degree of accuracy by a geological study, based principally on the section exposed in the lower part of the Waihi Mine.

Many of the mining men at Waihi have a firm conviction that the so-called "bedded country" (tuffs, &c.) does not and will not carry payable lodes. The same view is expressed in Geological Survey Bulletin No. 15, but is combated in Bulletin No. 26. This belief is poorly founded, and at least four-fifths of its foundation is mere prejudice. One fact, easily apprehended, shows this. The richest part of the Talisman Mine, Karangahake, from No. 13 level downward, was in similar rocks. The reasons for the poverty of certain parts of the Waihi lodes, especially in depth, are to be sought mainly in other conditions than those that distinguish an andesitic tuff from an andesite. The more pronounced faulting and crushing of the bedded tuffaceous rocks is, however, an adverse factor to be considered.

I am not able to give a definite statement of the thickness of the horizon at Waihi in which bedded tuffs are prominent: it appears to be 600 ft. or 700 ft. at least. The similar horizon of alternating layers of tuff and andesite at Karangahake, which possibly is to be correlated with the Waihi occurrence, is more than 800 ft. thick. The Woodstock bore, drilled about 1903, is stated to have entered "slate" at 950 ft., but this is doubtful. A bore (No. 4) drilled in 1920 by the Talisman Company to a depth of 501 ft. from its lowest level reached a level corresponding to about 1,000 ft. in the Woodstock bore, and was there in andesite.

Future Prospecting in the Waihi Grand Junction Mine.

East Section: The most practical prospecting scheme for the Waihi Grand Junction Mine under the conditions prevailing at the end of 1924 would be one directed towards the exploration of the eastern part of the mine. This could best be done at No. 8 (1,320 ft.) level by driving east along the course of the Empire lode and crosscutting north and south. There is a large extent of unexplored ground, and prospecting need be limited only by the funds available and the difficulty of providing adequate ventilation. Exploration at No. 8 level will probably decide the value of the eastern part of the Grand Junction Mine once for all. There is little or no chance of ore above the 1,000 ft. horizon. Any ore-body with its cap much deeper than No. 8 level will not pay to work unless it is very rich.

West Section: A proposal to bore vertically in that part of the Grand Junction property west of Martha Hill has been made, but the results of such boring are not likely to be commensurate with the cost. Slightly more advisable is the further sinking of the C shaft (sunk many years ago to a depth of 516 ft.) to 1,000 ft. or more, followed by lateral exploration, but the expense of this, in comparison with the somewhat moderate chance of success, may be regarded as prohibitive. The most feasible method of testing the west section is to drive at a low level from the western part of the Waihi Mine, or to project horizontal bores from the same locality into the Grand Junction ground.

Conclusion: So far as the prospects of the Grand Junction and neighbouring mines are concerned, very little can be added to what has been said in Geological Survey Bulletin No. 26. Vertical or highly inclined bores as a mode of prospecting at Waihi must be condemned, both on general principles and on past experience, but there is some scope for horizontal drilling.

6. Muir's Gold-reefs (Limited), Te Puke.

(Summary of reports by P. G. Morgan.)

On the 20th January, and again on the 26th May, 1925, I examined the Muir's Gold-reefs Mine and the surrounding country. Previous visits were made in November, 1921, and December, 1922.

Since the end of 1922 the adit levels of Muir's Gold-reefs have been extended, and a considerable amount of ore extracted and treated in the twenty-stamp battery. Owing to the nearly complete exhaustion of the payable veinstone the battery was closed down during 1924. Up to that time the Muir lode, with the assistance of a very small amount of ore from the Massey lode, had yielded 66,763 tons of ore, from which gold and silver to the value of £164,777 had been obtained. Several winzes sunk below No. 3 adit level showed that the Muir lode, though maintaining its size, was not payable. An assay of about £2 per ton was obtained in a short prospecting-drift off No. 3 winze at a depth of 145 ft., but water prevented the further sinking of the winze at this time.

The company then concentrated its energies on deepening a shaft already under way, with a view of driving crosscuts to both the Muir lode and the Fleming or Massey lode, situated 800 ft. to the west. During 1924 the shaft was sunk to a depth of 515 ft., and a chamber opened at 500 ft., which is approximately 450 ft. below the lowest adit level, and 300 ft. below the point at which water was encountered in No. 3 winze. From the chamber two crosscuts have been driven—one to the south-east to intersect the Muir lode at a point below the best part of the ore-shoot in the upper levels, and the other south-south-west to intersect the Massey lode.

Muir Lode Crosscut.—In May last the crosscut to the Muir lode had been driven for 756 ft. A short distance from the shaft it passed through a fault or "slide," dipping, at a rough guess, 20°–25° eastward. At 562 ft. another flatly-dipping slide was met: this had a westerly dip of roughly 15°. At 590 ft. the crosscut passed out of the slide. At 617 ft. lode quartz was intersected, and the crosscut was turned eastward nearly at right angles to the course of the lode. Quartz with bands of country (andesitic rock) continued almost to the end of the crosscut. Close to the face, in the roof, some hard clayey material of light colour ("pug," or fault-comminuted rock) appeared. Holes bored in the lower part of the face had reached puggy material. Without much doubt a considerable fault is ahead, and this view is confirmed by the surface topography.

On the 26th May water was issuing in great quantity from the sides, roof, and face of the crosscut through the formation.

Since my visit, a round, or part of a round, of holes has been fired in the face. The result was a great inrush of water, which drove the workmen out, and in a few hours filled the low-level workings, notwithstanding the efforts of the pumps. The water rose high in the shaft, and reached the bottom of No. 3 winze, which was then 202 ft. deep. This inflow of water is possibly due to further lode formation ahead of the face of the Muir crosscut, or the water, more likely, may have issued from fissures in the country.

The lode formation is of great size, being between 130 ft. and 140 ft. in width. The quartz is of various colours, yellowish to brownish "oxidized" material probably predominating. Some is bluish and contains small specks of pyrite. The quartz throughout does not look promising, and assays show that it is low-grade.

The lode formation is no doubt the Muir lode, dislocated a few feet above the crosscut by the flatly dipping slide or fault seen to the west in the crosscut. The upper part of the lode, and of course the enclosing rock, have been moved as a whole a good many feet to the west.

Massey Lode Crosscut.—The crosscut to the south-south-west toward the Massey lode in May had a length of 1,150 ft. At 535 ft. it entered heavy swelling ground—a fault-zone—nearly parallel to the Massey lode, and at 800 ft., being still in the fault-zone, was turned westward. Firmer ground was then soon reached. At 1,000–1,050 ft. the crosscut was near the line of the Massey lode, but no sign of the lode was seen. At the face the rock is a mottled greyish-green and reddish andesite, somewhat disturbed. There is, however, no indication of any lode being near. The rock is free from moisture, shows no quartz veinlets, and no parallel jointing or sheeting. A little slickensiding is visible, indicative of slight fault movement. In the latter part of the crosscut two very small veinlets containing quartz were seen, and films of calcite fill some of the rock-joints. Something abnormal has happened to the Massey lode in depth, and probably the explanation is to be found in faulting.

No. 3 Winze (below No. 3 Adit Level).—Lately, as the water drained away through pumping from the low level, this winze has been considerably deepened. At the time of my visit it was 180 ft. deep, and it has since been sunk to 202 ft. The lode is wider than the winze, and the quartz is of a good description. The average of seven assays from 155 ft. to 176 ft. is 12s. 10d. per ton, and the average of seven more assays from 179 ft. to 197 ft. is £1 2s. 10d. per ton. At 200 ft. the lode was crosscut and found to be at least 15 ft. wide, but the assays are all below £1 per ton.

Water.—For many weeks prior to my visit the pumps, when a full supply of electric power was available, were raising about 750 gallons per minute. Evidently the stored water in the Muir lode was being pumped, for the sinking of No. 3 winze, as mentioned above, was able to proceed without hindrance from water.

Future Exploration.—The continued sinking of No. 3 winze (for which a mechanical hoist of some kind is necessary), and driving at the 500 ft. level southward in the Muir lode formation toward the point where this winze will reach the 500 ft. level, are clearly advisable. Some difficulty may be experienced in making the connection between the winze and the low level, owing to the complication caused by the slide previously described, which dislocates the lode. Other exploratory work is necessary, but what this should be depends partly upon the result of the prospecting now being done and partly upon the amount of money available to the company.

Faults.—Geological and mining conditions at Muir's Reefs are strongly controlled by faulting. Three important faults striking a little east of north and dipping steeply are now known to exist. One of these is about 30 chains west of the Massey lode (see Mr. J. A. Bartrum's report and map of 1913); another is between the Massey and Muir lodes, as shown by the low-level workings (it is also indicated by the gully between the outcrops of these two lodes); and the third is on the east side of the Muir lode. As already stated, it seems to have been reached, or all but reached, by the low-level crosscut through the Muir lode. In addition two flatly dipping faults or slides have been intersected in the Muir lode crosscut. One of these dips at 20° to 25° eastward, the other, that near the lode, dips westward at 15°, more or less. The non-appearance of the Massey lode in the crosscut driven first south-south-west and then westward from the shaft is most probably due to faulting. In the absence of any data the possible fault could be given various directions and dips.

7. Limestone (Calcareous Sinter), North of Opunake, Egmont County.

(Slightly abridged report by P. G. Morgan).

On the 30th April, 1925, accompanied by several farmers in the Opunake district, I visited various deposits of calcareous sinter or travertine near Wiremu Road, seven or eight miles north of Opunake (not four miles, as stated in Geological Survey Bulletin No. 22, page 127, 1917).

Some of the calcareous sinter deposits in this locality were inspected by Mr. M. Ongley, Assistant Geologist, in March, 1917. The substance of the report made by him is quoted in Bulletin No. 22, pages 127–128. My inspection enables some additions to Mr. Ongley's report to be made.

General Description of Deposits.—The known deposits are situated on both sides of Wiremu Road, west of Ihaia Road, and for the most part, but not wholly, east of Arawhata Road. In Mr. G. Looney's land, on the south side of Wiremu Road, three mounds of calcareous sinter, deposited on the surface by springs, occur on the north bank of a small swampy stream, draining, I believe, to Heimama Stream. The mound farthest to the north appears to be over 40 yd. long and 15 yd. wide. The average thickness of the deposit is probably 6 ft. Since Mr. Ongley's visit Mr. Looney has quarried and calcined or "burnt" some of the material in a little kiln near Wiremu Road. A few chains down the little stream, at a barometric height of 670 ft. above sea-level, is another travertine mound, not quite so large. I estimated its length at nearly 40 yd., its breadth at 15 yd., and its average thickness as probably 6 ft. The third mound still lower down the creek I did not see, but I was assured that it is as large as the one where quarrying has been done.

A little to the north of Wiremu Road, not far from the lime-kiln, is a travertine deposit which I did not see. Mr. Looney informed me that it is equal in size and quality to any of the deposits on his land on the south side of Wiremu Road.

Some distance to the north, travertine appears on the north-west bank of Heimama Creek for a distance of over 30 yards. To the west is a swampy area of about 2 acres, and travertine occurs under a part or perhaps nearly the whole of this area, which is roughly 770 ft. above sea-level (as determined by an aneroid observation).

Some distance to the north-west, near the line of Arawhata Road (which is not formed north of Wiremu Road), two pits have been dug in travertine, and one of these shows that the deposit is at least 5 ft. thick.

Farther north, on Mr. H. Bartle's land, a few chains inside the present bush-line, calcareous sinter shows for more than 5 chains (probably 10 chains) along the banks of a small creek draining to the Oanui Stream. Travertine is also seen on the banks of a tributary rill.

What is said to be a large deposit of calcareous sinter has lately been discovered on Mr. S. Campbell's land, nearer to the Egmont National Park boundary than any of the deposits seen by me. I was not able to visit this, no guide being available.

I was also reliably informed that in a large swamp on the line of Arawhata Road, towards the Egmont National Park boundary, several outcrops of calcareous sinter forming mounds have been seen. Deposits of sinter also occur on the banks of the Oanui Stream, west of the upper (unformed) part of Arawhata Road, not far from Bartle's sawmill.

Quantity of Limestone available.—In comparison with most limestone deposits, the calcareous sinters or spring-deposited limestones of the Opunake district are small. Until the various deposits are opened up no reliable statement of the amount of sinter can be made. Yet, since some idea of the quantity available is better than none at all, I give the following very rough estimates as a kind of guide to what may be expected: Mound on south side of Wiremu Road near lime-kiln in subsection 25 (G. Looney's), 2,000 tons; next mound to south, 1,500 tons; mound still farther south (not seen), 2,000 tons (?); Heimama Creek and neighbouring swamp (subsection 28), 5,000 tons (?); deposit seen on line of Arawhata Road, about a mile (?) north of Wiremu Road—no estimate of any kind can be made; deposit on Mr. H. Bartle's land near tributary of Oanui Stream—no estimate can be made, but there are certainly some thousands of tons.

I think one may safely say that at least 10,000 tons of limestone can be obtained from the deposits seen by me. Small though this amount is, it is greater than I expected. How far future exploration will add to the quantity of limestone in sight is uncertain, but from what I saw and was told I anticipate that ultimately not less than 25,000 to 30,000 tons of limestone will be found, and possibly a good deal more.

Value of Deposits.—Notwithstanding the smallness of the deposits, they are worth developing, for they are situated in a district where lime is badly needed. Moreover, they are reasonably accessible, and can be easily worked. Thus, so far as they go, if carefully worked, they will be of great value for the next few years to the surrounding district.

Method of Working the Deposits.—The first thing to be done is to drain the more accessible of the sinter deposits, and to cut such trenches and dig such pits as may be necessary to determine at least roughly the amount of stone in each. Each of the deposits seen by me can be easily drained. The rubbish obtained in working the material should be systematically put in such a place that it will not impede the working-out of the whole of the deposit. The sinter for the most part is fairly soft and porous, so that it can be easily quarried and broken.

Utilization.—The calcareous sinter may be pulverized and used direct as a soil-dressing. I recommend crushing the lumps (after drying) in a portable pulverizer. Electrical power to work this can be obtained from the Opunake Power Board. The drying of the sinter before pulverization will need careful attention. The lumps of sinter could be burned or calcined, but the individual deposits are so small and scattered that the expense of a regular lime-kiln is not likely to be warranted. In any case there will be a considerable amount of fine material that cannot be burnt in a kiln, and also of small stuff mixed with soil, &c., which will be useful for local soil-dressing. The smallness of the deposits makes it necessary to utilize all the material so far as that is possible.

Need for Lime.—The land of the Opunake district is inclined to be sour, and for this and other reasons needs lime very badly. The sinter deposits just described will at best supply the requirements of a few thousand acres for a few years, and will then be exhausted. Ultimately the Opunake district, and indeed practically all Taranaki, must obtain lime or pulverised limestone from outside localities.

Need for Phosphate.—An even greater necessity than lime for Taranaki land is phosphoric acid. Near Opunake basic slag, as used by some of the farmers, has given splendid results, and I see no reason why finely-ground Nauru phosphate, if properly applied in the right quantities and at the right season of the year, should not give just as good results. Now that the railway from Te Roti, south of Eltham, to Opunake is almost finished, and harbour-works are under way, the farmers in the near future will be able to obtain cheaper supplies of phosphate, lime, and other fertilizers.

Conclusion.—If carefully worked, I believe that the deposits of calcareous sinter in the Opunake district will be found to be of great value for the next few years. As already indicated, they are not sufficiently large to supply the whole of the Opunake district with the lime it so much needs.

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