1924.

NEW ZEALAND.

MINES DEPARTMENT.

GEOLOGICAL SURVEY BRANCH

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

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

CONTENTS.

LETTER OF TRANSMITTAL.

SIR,— Geological Survey Office, Wellington, 16th June, 1924.

I have the honour to forward herewith the eighteenth 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, 1924; and, in addition to my general account of the work done during the year, it contains reports on the districts examined in detail by the field Geologists, and summaries of various special reports 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 1923–24 detailed topographical and geological surveys have been 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.

Field-work in the Kaitangata Subdivision as originally planned has been completed, but, in order to enable a comprehensive report to be written, two adjoining areas need to be surveyed. Next season it is proposed to examine these areas, and to continue work in the Motueka and Rodney subdivisions.

Brief visits for various purposes were made by me to Lake Takapuna (near Auckland), Maratoto, Kairuru Marble-quarry (Nelson), Greymouth, Kumara, &c. Waihi was twice visited in order to obtain additional data for the report on the Waihi Goldfield now in course of publication. As one of the official representatives of the New Zealand Government I also attended the second Pan-Pacific Science Congress, held last August and September in Melbourne and Sydney. In connection with this Congress I visited many places of geological interest, including the Maitland section of the Hunter River Coalfield, and the famous Broken Hill district.

Dr. J. Henderson, Mining Geologist, made special visits to Ponui Island, Ongarue, and Tahunanui (near Nelson), and the Colossus Gold-mine (near Wangapeka). During the latter part of 1923, at the request of the Government of Fiji, an arrangement was made in terms of which Dr. Henderson spent six weeks in Fiji examining a reputed goldfield in the Island of Vanua Levu. The results of this examination were disappointing.

Dr. J. Marwick, Palæontologist, accompanied Dr. T. Wayland Vaughan, a distinguished American geologist, on visits to fossil localities in the North Otago, North Canterbury, Wanganui, and Kaipara districts. During most of January and the early part of February, with other members of the scientific expedition organized by the Otago Philosophical Institute, he was in the Chatham Islands, where he collected fossils and geologically explored the largest island.

Progress of Areal Survey.

During the twelve months ended 31st May, 1924, approximately 1,471 square miles was geologically surveyed in detail. Of this area about 450 square miles is in the Nelson District, 478 square miles in North Auckland, and 543 square miles in South Otago.

The present state of the detailed geological survey is given in the following table :—

	Square Miles.	Square Kilometres.
Surveys completed and work published on the scale of 1 mile to the inch	9,674	25,054·6
Surveys completed and work published on the scale of ½ mile to the inch	325	841·7
Field surveys completed, but work not yet published ..	7,819	20,250·4
Surveys in progress—area actually surveyed	1,030	2,667·6
Total area surveyed	18,848	48,814·3
Area in which work is suspended (Heaphy district) ..	293	758·8
Area resurveyed (Whatatutu and Waihi)	352	911·6

Motueka Subdivision.

Messrs. Grange and Macpherson carried on field-work in this subdivision from the latter part of September till the end of March, when Dr. Henderson joined them. This subdivision includes the greater part of the lowlands south-west of Nelson as well as a wide strip of mountainous country to the west. In the early days alluvial gold was obtained from the mountain-streams in important amount, but the payably auriferous gravels are now almost exhausted. Gold-bearing quartz veins occur, but none has been worked at a profit. Large deposits of chrysotile-asbestos and talc occur in connection with ultra-basic rocks in the north-western portion of the subdivision, but similar rocks in the south-eastern corner carry only trifling amounts of these minerals Though the rock-series that contains the valuable marbles of the Takaka district extends through the western part of the district, the area so far examined does not contain workable marble-deposits.

Rodney Subdivision.

Mr. H. T. Ferrar, Geologist, having finished the field survey of the Dargaville Subdivision, this season turned his attention to a strip of the North Auckland Peninsula lying to the south of that area. His progress in this survey is stated in the special report on the Rodney Subdivision. The principal benefits of this survey will be (1) the production of a better topographical map than that now available,

(2) the delimitation of great masses of argillaceous limestone and other cement-making materials, (3) the obtaining of data highly useful in connection with soil surveys, and (4) an increase in our geological knowledge of the very difficult North Auckland area.

Kaitangata Subdivision.

For many years past the coalfields of Otago, owing to the urgent nature of work elsewhere, have been somewhat neglected by the Geological Survey, but last season Mr. M. Ongley was deputed to make a detailed examination of the important coalfield which extends from Kaitangata to near Milton. The area originally marked out for investigation has been surveyed in considerable detail, but the examination of the older rocks of the district has brought the geologist into contact with the unsolved problem of the age of the Otago schists, and on this account alone further work is necessary before a detailed report can be written. Moreover, it has been found highly desirable to extend the surveyed area north to the Green Island Coalfield, near Dunedin. The results of the survey, so far as it has gone, are highly satisfactory. They show that in all probability the unworked portion of the Kaitangata Coalfield contains a very large amount of coal, much of which can be won without any great difficulty.

Palæontological Work.

During the year ended 31st May, 1924, Dr. J. Marwick, M.A., Palæontologist, has been engaged chiefly in examining the collections of Tertiary fossils belonging to the Geological Survey. Papers have been prepared and await publication dealing with the faunas of the Waiarekan and Wangaloan stages of the Tertiary sequence. These beds overlie the coal-bearing strata of North and South Otago respectively. In addition, papers describing the representatives in New Zealand of the important molluscan families of the Naticidæ and Veneridæ have been written. The efficient utilization of a great part of the mineral resources of New Zealand depends on the correct interpretation of the geology and structure of various regions, and this in turn is greatly aided by a precise determination of the fossil remains found in the various rock-series.

Publications and Reports.

The following publications have been issued during the year :—

Seventeenth Annual Report (New Series) of the Geological Survey (parliamentary paper C.–2c, 1923).

Palæontological Bulletin No. 10, "The Fossil Cirripedes of New Zealand," by Mr. T. H. Withers, of the Geological Department of the British Museum.

A detailed report dealing with the mines and geology of the Waihi district is now in the press, and is expected to appear before the publication of this report.

Five reports and papers by members of the staff have been published in the *New Zealand Journal of Science and Technology*. Dr. Henderson wrote the following: "Chrysotile-asbestos in the Upper Takaka District" (Vol. 6, No. 2, August, 1923); "Notes on the Geology of the Nevis Valley, Otago" (Vol. 6, No. 2); "Notes to accompany a Geological Sketch-map of the Mount Arthur District" (Vol. 6, No. 3, October, 1923); and "The Structure of the Taupo-Rotorua Region" (Vol. 6, Nos. 5 and 6, March, 1924): and Dr. Marwick wrote "Notes on a Molluscan Collection of supposed Waiarekan Age" (Vol. 6, Nos. 5 and 6). Other papers by Dr. Marwick dealing with New Zealand Palæontology read or issued during the year are "The Struthiolariidæ," "Recent and Tertiary Naticidæ and Naricidæ of New Zealand," "Palæontological Notes on some Pliocene Mollusca from Hawke's Bay" ("Transactions of the New Zealand Institute," Vol. 55); "An Examination of some of the Tertiary Mollusca claimed to be common to Australia and New Zealand" ("Report of the Australasian Association for the Advancement of Science," Vol. 16, 1923); and "*Zealeda* and *Barytellina*, New Molluscan Genera from New Zealand" ("Proceedings of the Malacological Society of London," Vol. 16). A paper entitled "The Post-Tertiary History of New Zealand," by Dr. Henderson, will appear in next year's volume of the "Transactions of the New Zealand Institute."

Owing to various circumstances, one being the cost of printing, publication of the detailed results of the Geological Survey has been much delayed during the past few years, but during the next twelve months it is hoped to publish much of the material now on hand.

Office-work, etc.

A large amount of correspondence has been attended to, numerous requests for information more or less connected with the work of the Survey have been answered, and samples of rock, minerals, &c., have been examined and identified. A considerable part of my time was taken up in editing and seeing through the press the palæontological reports of non-resident experts. I have partly prepared also a comprehensive list of New Zealand minerals, with notes on mode of occurrence, and full references to the literature.

Dr. Henderson wrote an account of the economic minerals of New Zealand, and Mr. Harris, Draughtsman, worked for over three months on a large-scale mineral map of New Zealand for the Empire Exhibition. Mr. Harris made also ten drawings of survey districts for photo-lithographic reproduction, ten drawings for blocks, forty-two field sheets, and numerous drawings and tracings for various purposes.

Mr. Fulton-Wood has attended to much miscellaneous office-work, and has acted as librarian. The library now contains over six thousand volumes, in addition to numerous pamphlets, duplicates, &c., and requires considerable attention.

SPECIAL REPORTS.

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

Introduction.

The geological examination of an area in the Nelson District, for the most part within and including almost the whole of the basin of the Motueka River, was begun in September, 1923, and was continued to May, 1924. The survey districts of Owen, Tadmor, and Gordon, as well as a portion of Wangapeka, in all an area of about 450 square miles, were examined in detail. The northern portion of the basin of the Motueka will be surveyed next season. The district adjoins the Dun Mountain Subdivision, reported on thirteen years ago (N.Z. Geol. Surv. Bull. No. 12, 1911), and forms a considerable part of the area separating that subdivision from the Parapara (Bull. No. 3, 1907) and Collingwood (Bull. No. 25, 1923) subdivisions lying to the north-west, and the Mount Radiant (Bull. No. 11, 1910) and Buller-Mokihinui (Bull. No. 17, 1915) subdivisions lying to the west and south-west.

Physiography and Structure.

The northern portion of the Alpine range of the South Island extends through the eastern part of the district, in the south-eastern corner of which the highest peaks of the so-called Red Hills rise to nearly 6,000 ft. above sea-level. The western third of the district examined covers part of the mountain-system of western Nelson, and numerous crests rise above 5,000 ft. and even 6,000 ft., the highest points being Mount Arthur (5,800 ft.) and Mount Owen (6,155 ft.). Between these highlands is a broad belt of much lower country, which, according to the ideas now accepted by most New Zealand geologists, has been depressed by fault-movements relatively to the earth-blocks forming the mountains on either side. McKay, many years ago, traced the general courses of the great fractures along the edges of the low country, that to the east being termed the Waimea fault, and that to the west the Motueka fault. The highlands are traversed by other strong faults, which in part control the courses of the streams and the distribution of the rock formations.

The principal river of the district, the Motueka, which drains almost the whole area here considered, rises in the eastern mountains and flows diagonally across the lowlands to the western side of Tasman Bay, which occupies the northern portion of the depressed area. Its chief tributaries are the Motupiko, draining the southern part of the lowlands, and the Wangapeka, which has its basin almost entirely in the western highlands. Other branches traversing the western part of the lowlands are the Tadmor and Sherry streams. The Wairoa, a stream much smaller than the Motueka, has its source in the eastern mountains, but after reaching the lowlands flows out of the subdivision.

There are no permanent snowfields in the subdivision, although these must formerly have covered considerable areas, especially in the western highlands. Corries and cirques with small tarns occur at the heads of many of the streams, some of which flow for several miles through upland glacial troughs. In some localities moraines occur down to about 2,000 ft. above sea-level, but there is no evidence that glaciers ever reached the lowlands.

General Geology.

The subdivision is interesting in containing probably the least incomplete sequence of Palæozoic rocks in New Zealand. Sediments of Mesozoic age are exposed over a small area, Tertiary rocks outcrop in several localities, and large deposits of Pleistocene gravels cover the lowlands. Granite forms a wide strip along the eastern side of the western highlands, and basic and ultra-basic igneous rocks have been intruded into the older sediments of both mountain blocks.

The oldest rocks of the district examined, the Mount Arthur Series of McKay (1879), consist chiefly of strongly folded dark carbonaceous argillites, slates, and phyllites, which are generally calcareous and in places pass into thick lenticular masses of impure limestone (marble). Beds of quartzite and quartzose greywacke also occur in the upper part of the series. These rocks form the great massif of Mount Owen, whence they continue north through the district. Two thin dark bands of argillaceous rock with pronounced slaty cleavage, and containing numerous casts of trilobites, outcrop on the saddle between Patriarch and Taylor creeks, about 60 chains north-north-east from Patriarch Trig. Fragments of encrinite stems were obtained from impure limestone a little above the Dart junction, and markings, probably graptolites, were found in pebbles of black slate occurring in Wright Creek, a small branch of the Wangapeka. The rocks of the Mount Arthur Series are thought to be of Ordovician age, or older.

Next in age is a thick series of greenish argillites, greywackes, and quartzose greywackes, also strongly folded, extending along the western edge of the subdivision. For the most part these rocks are separated from those of the Mount Arthur Series by powerful faults or by areas of younger rocks, but are in contact with them near the Wangapeka Forks. Here coarse greenish greywackes pass downward into dark-greyish quartzites which are interbedded with black slates and phyllites, and these, though not in direct continuity with any area of typical Mount Arthur strata, exactly resemble the predominant rocks of that series. The greywackes and argillites of the younger series cannot be distinguished lithologically from similar rocks forming the Aorere Series of Collingwood and the west coast of the South Island.

Folded rocks of the Baton River Series, which consists chiefly of quartzite-conglomerates, quartzites, and calcareous quartzites with minor bands of carbonaceous shale, overlie the Mount Arthur beds, but, so far as known, are nowhere, within the area examined, in contact with those of Aorere age. They outcrop over a wide belt west of the Mount Arthur rocks, extending north from Rolling River and lying chiefly to the west of the Wangapeka River. Their distribution clearly indicates that they overlie the Mount Arthur beds with strong unconformity, but no section showing actual contact was found. In several localities the calcareous quartzites contain poorly preserved fossils. These are supposed to be of Silurian (Wenlock) age.

The sedimentary rocks of the eastern highlands are quite distinct from those described above. With the exception of a narrow strip of Triassic strata along part of the western base of the mountains all are of Palæozoic age. These older beds are divided into the Pelorus (E. de C. Clarke MS.) and Maitai series, the former outcropping east of and the latter west of great masses of basic and ultra-basic intrusive rocks. The rocks of the Pelorus Series, which occur only in the south-eastern corner of the district, are greenish conglomerates and greywackes, and in the absence of fossils are provisionally referred to a Palæozoic age. They are placed by McKay in the Te Anau Series.

The beds of the Maitai Series are grits, greywackes, green and red argillites with irregular bands of limestone near the base of the formation. The strata are disposed in close folds, which in the northern half of Gordon Survey District strike north-east and in the southern half north-north-east, thus roughly following the trend of the Waimea fault. Fossils occur in the limestone near the base of the series in the Dun Mountain Subdivision immediately to the north-east, and have been referred to the Permo-Carboniferous period by C. T. Trechmann.

A great fault trending east-north-east separates the Triassic sediments from rocks of Maitai age. The beds, which consist of argillites, greywackes, grits, and granitic conglomerates, are closely folded in an east-north-east direction. Many fossils have been collected from the well-known fossiliferous horizon of Eighty-eight Valley.

Tertiary rocks, upturned along the fault-zone separating the lowlands from the western uplands, form a narrow strip along the Sherry and upper Tadmor valleys. Tertiary rocks also outcrop at two or three points at the foot of the eastern highlands, and probably extend beneath the gravels that cover the Waimea Plain and adjoining lowlands. Patches of Tertiary strata also occur in several localities among the western mountains, where they have been depressed by fault-movements and so partly preserved from erosion. The distribution of these patches suggests that a continuous sheet formerly extended over the whole area now occupied by the western highlands.

The lower Tertiary beds consist for the most part of quartzose grits and sandstones, evidently derived from the denudation of granitic areas. Layers of carbonaceous sandy mudstone and micaceous shale are intercalated at many places, as well as occasional thin seams and streaks of coal. The upper beds are chiefly greenish and bluish argillaceous sandstones, which are calcareous in many localities and in a few pass into limestones. In the upper Tadmor and Sherry valleys the blue sandstones are succeeded by arkositic grits and sandstones with thin bands of carbonaceous mudstone and fragments of lignitized wood.

The thick deposits of gravel covering the greater part of the depressed area between the mountains rest unconformably on the Tertiary rocks. Where seen they are horizontally bedded and have not been affected by deformative movements. They consist for the most part of well-rounded pebbles and cobbles of greywacke in an impervious clay-sand matrix. They are deeply weathered to a yellow-brown colour, their original pale-grey tint being visible at few points. These fluviatile gravels are much dissected by the streams, and in the southern part of the subdivision form hills rising to over 2,000 ft. above sea-level.

Granite, in places porphyritic, forms the eastern portion of the western highlands, extending north and south through Tadmor Survey District. Granite outcrops also over a small area in the south headwater branch of Wangapeka River. This exposure is probably connected with the large masses of acid igneous rock that cover such large areas in west and south-west Nelson. The granites intrude the Mount Arthur and Aorere rocks, and are therefore post-Ordovician in age; and since granitic conglomerates occur in the Triassic beds, acid igneous rocks must have been exposed in early Mesozoic times.

Great masses of basic and ultra-basic plutonic rocks intrude the younger Palæozoic sediments of the eastern portion of the district. Gabbros and dunites with various intermediate types, in places altered to serpentine, and traversed by dykes of diorite and "rodingite" (Bull. No. 12, pp. 31–35), occur. Small dykes of diabase intrude the ancient rocks of the western highlands at many points. These are probably genetically connected with the large basic and ultra-basic intrusions of the Mount Arthur district lying immediately to the north.

Economic Geology.

The Recent gravels of the Rolling and Sherry rivers and of other streams in the western highlands have been extensively worked for alluvial gold. The principal part of the gold was obtained during the fifteen years following 1865, but many miners were constantly employed until 1900 and later. At the present time mining for alluvial gold has all but ceased.

The detrital gold of the Rolling River and its branches Blue, Nuggety, and Connor creeks was undoubtedly derived from the extensive system of auriferous-quartz lodes traversing the rocks of this locality. Similarly, the veins of Mount Luna have supplied gold to Kinzett and Taylor creeks, draining its northern flanks, as well as to several southward-flowing branches of the north branch of the Wangapeka. On the other hand, the gold obtained from the gravels of the numerous small streams entering the Sherry from the west had its immediate source in the quartz grits and conglomerates at the base of the Tertiary beds. Part of the gold of the upper Wangapeka no doubt has a similar origin. The Pleistocene gravels in places carry a little gold, and, in parts of the Tadmor Valley where their base is exposed, loose gravels rewashed from them were profitably worked.

Since their discovery in 1870 the auriferous lodes of the Rolling River valley have been prospected on several occasions, but so far no payable ore-body has been found. Many of them contain sulphides of lead, zinc, and copper. Very little prospecting has been done on any of the numerous quartz veins traversing the rocks in the neighbourhood of Mount Luna. Several veins in both localities as well as the general conditions appear favourable.

A coal-seam, between 3 ft. and 4 ft. thick, and dipping gently westward, outcrops near the saddle between the Karamea and Mokihinui rivers, and one about 2 ft. thick is reported to occur in a small tributary of the north branch of the Wangapeka.

Most of the minerals usually associated with ultra-basic intrusions have been found. Chrysotile-asbestos in veins not exceeding $\frac{1}{5}$ in. wide occurs in the serpentine of the Red Hills at several points.

Veins of talc and pectolite(?) up to 1 in. wide were also observed. Chromite in grains and (rarely) in small lenses is found in dunite; the largest observed lens is 4 ft. long and 6 in. wide. Platinum in very small quantity has been found in the Lee (or Lea) River gravels a short distance outside the area examined during the past season (W. F. Worley, N.Z. Jour. Sci. & Tech., Vol. 6, No. 3, pp. 136–138, 1923).

2. Rodney Subdivision. (By H. T. Ferrar.)

Introduction.

The geological survey of North Auckland as summarized progressively in previous reports has been systematically continued. The Rodney Subdivision includes the following survey districts: Te Kuri, Hukatere, Otamatea, Pakiri, Rodney, North Head, Okaka, Tauhoa, Mahurangi, Kawau, Waioneke, Kaipara, Waiwera, and Tiritiri. Of these Te Kuri and North Head and parts of Hukatere and Okaka were surveyed last year; Otamatea, Pakiri, Rodney, and parts of Hukatere, Okaka, Tauhoa, and Mahurangi were surveyed this year; and the remaining portions of this area can be mapped next field season.

The country mapped this year, on a scale of 20 chains to the inch, is approximately 478 square miles in area, and lies immediately south of the strip of country surveyed the previous year. It extends from Cape Rodney, on the east coast of the North Auckland Peninsula, to Kaipara South Head, on the west coast. The field season opened on the 25th October, 1923, and closed on the 26th May, 1924, during which period valuable assistance was again rendered by Mr. P. T. Cox, M.A. (Canterbury College).

Physiography.

The district displays four types of country, namely—(1) Deeply dissected sandstone highlands, with peaks often more than 1,000 ft. high, which occupy the greater part of Pakiri and Tauhoa survey districts; (2) dissected claystone and limestone areas, 400 ft. to 500 ft. above sea-level, which are largely developed in Hukatere and Otamatea survey districts; (3) the consolidated sand-dunes of Okaka Survey District, 400 ft. to 500 ft. high; and (4) the belts of moving sand-dunes extending northwards from Pakiri estuary on the east coast, and southwards from Kaipara South Head on the west coast. The whole country has suffered many and sometimes great fluctuations in level, the penultimate movement having been one of depression, which submerged many river-valleys. These drowned valleys now form the ramifying arms of Kaipara Harbour, and are particularly numerous in Hukatere and Otamatea survey districts.

General Geology.

The following 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, alluvial and drift sand	..	Recent.
..	Consolidated sand-dunes, gravel terraces ..	..	Pleistocene.
Purua Beds ..	Fresh-water leaf-beds, sandstones, and tuffs ..	(?) Wanganuian ..	Pliocene.
Pakaurangi and Cape Rodney Beds	Fossiliferous sandstones and tuffs; massive sandstones and fossiliferous grits	Oamaruian ..	Miocene and Oligocene.
Whangarei Formation	Crystalline limestone and brown sandstone with coal in places, or crystalline limestone, brown sandstone, and greensand		
	(Unconformity.)		
Onerahi Formation ..	Claystones, argillaceous limestone, greensand, grit, and conglomerate	Waiparan ..	Cretaceous.
	(Unconformity.)		
Otamatea Beds ..	Silicified claystone, sandstone with cone-in-cone limestone, *Inoceramus*, and ammonites		
	(Unconformity.)		
Waipapa Formation ..	Greywackes and argillites	Hokanuian ..	Trias-Jura(?).

Previous geological-survey work in the area under review was carried out by S. H. Cox in the year 1879 ("Reports of Geological Explorations during 1879–80," No. 13, 1881), and by J. Park in 1885 (Rep. Geol. Explor. No. 17, 1886). In the light of detailed examination it is found that their interpretation of the stratigraphy of the district requires some modification. Visits of short duration have also been made by McKay, Marshall, Bartrum, Morgan, and others to special localities, such as Pahi, Batley, Pakaurangi, Leigh, &c., where fossiliferous beds provide evidence as to the precise age of some of the strata.

The account of North Auckland stratigraphy as outlined in preceding annual reports still holds good. As the survey proceeds, new series of sediments are encountered which fill some of the gaps in the earlier published stratigraphical tables, and thus help to elucidate the geological history of the region, without which no sure assessment of the natural resources of the region can be made.

The oldest rocks in the district are the usual shattered greywackes and argillites of Trias-Jura(?) age. These rocks are of great thickness, but in the area examined outcrop over small areas only at Te Arai Point and at Cape Rodney.

Next in order are the concretionary sandstones of upper Cretaceous age which occur in the Otamatea district. These sandstones are characterized by the presence of one or more of the following—namely, cone-in-cone limestone, concretions of barytes, spherical calcareous concretions, and fossil remains of *Inoceramus* and of ammonites.

The claystones and argillaceous limestones of the Onerahi Formation cover large areas in Hukatere and Otamatea survey districts, and occur at Kaipara Flats and Warkworth. These beds, which are similar to the claystones and argillaceous limestone series of the Whangarei - Bay of Islands Subdivision, unconformably overlie the ammonite-bearing beds. They are correlated with the Amuri limestone, and, in the absence of fossils other than Foraminifera, are regarded as of late Cretaceous age.

The Whangarei Formation, which includes the coal-measures of North Auckland, is found only in the vicinity of Pahi, where greensands containing fossils of Waiarekan aspect unconformably overlie the argillaceous limestone.

The massive sandstones and fine and coarse grit beds, which make up the bulk of the sandstone highland area of Pakiri and Tauhoa survey districts, were called the Tamahua (Tamahunga) greensands by Cox and Park. This series contains a fossiliferous grit at its base on the east coast near Cape Rodney, and pockets or lenses of basaltic agglomerate at various higher horizons on the Kaipara side. Coaly partings are not uncommon, but coal-seams of economic value are wanting. The beds at Pakaurangi Point are highly fossiliferous, and probably belong to the Hutchinsonian stage of the Oamaruian System.

Above the Pakaurangi sandstones are thick beds of basaltic and pumiceous tuffs, which pass upward into fresh-water sandstones, containing lenses of coal of no commercial value and lignitized and silicified tree-trunks. These beds are probably of Pliocene age, and are well developed on the west side of Hukatere Peninsula, where they are partly covered by sheets of lava.

Pleistocene deposits are represented by a few gravel terraces and by the consolidated sand-dunes of Pakiri on the east coast and of the Kaipara Heads on the west coast.

The igneous rocks of the district fall into three categories: (1.) Sheared plutonic rocks are found as pebbles at various horizons in the Miocene sandstones and grits, but such rocks have not been found *in situ*. (2.) Gabbroid masses, largely altered to serpentine, occur fairly frequently. These masses appear as gently rounded domes, usually surrounded by argillaceous limestone of the Onerahi Series, but no evidence is obtainable in the vicinity as to whether the original gabbroid rock underlies or intrudes this series. (3.) Volcanic breccias containing fragments of Tertiary sedimentary rocks occur in Otamatea Survey District. The vulcanism which gave rise to these breccias also gave rise to the tuffs and ash-beds of Hukatere Peninsula, and at a later stage to basaltic lavas. The breccias may perhaps be correlated with the agglomerates of the Whangarei Heads district, and the tuffs and lava-flows with the Kerikeri Series of the Whangarei - Bay of Islands Subdivision.

Economic Geology.

The geological survey of North Auckland embraces a stock-taking of its natural resources with a view to develop such as are of economic value. Traces of metals such as copper have long been known to exist in the district under review, and money has been wasted in endeavours to discover workable deposits. The copper occurs in the native state as segregations 1 in. or more in length locally disseminated in the Otamatea beds. Traces of coal in the form of coaly partings in the younger or Cape Rodney sandstones have led to the belief that payable coal exists in the district. The occurrences, however, whether of coal or of copper, are of no economic importance.

Vast deposits of limestone suitable for cement-making, and in a less degree for agricultural purposes, exist in the district. They are worked at two points only—namely, at Warkworth and at Mark's Bluff, near Pahi. At Warkworth, Wilson's (N.Z.) Portland Cement Company has its works near the spot from which "building-lime" was shipped to Auckland as long ago as 1849; at Mark's Bluff the Northern Wairoa Lime Company is pulverizing the limestone for agricultural use, although the lime content is not as high as that of portions of the same formation which occur in just as accessible a position on the eastern side of Otamatea estuary.

Outcrops of rock suitable for macadamizing roads, means of access to them, and their position relative to main roads, have been studied. Four classes of rock are noteworthy—namely, the greywackes (which occur abundantly in some localities), the occasional masses of serpentinized gabbro, the widespread volcanic agglomerates, and the gritty sandstones. The gritty sandstones are the poorest, but, since they occur in quantity in localities where better material is wanting, their free application to newly graded roads may be advisable.

Other natural products have little value at present. No freestone occurs in the district, but the younger sandstones occasionally display structures which allow them to be used as building-stones. Clays for making earthenware utensils, and sands suitable for glass-making, occur in places. Kauri-resin deposits, which are so abundant farther north, are no longer an economic factor in the present area.

The soils of the district belong mainly to five categories, which accord with the rocks from which they are derived. The table on page 6 gives the names, and to some extent describes the various rock formations which have been geologically mapped. Of these the Otamatea sandstones form rough inferior country which is prone to slip, and is therefore largely neglected. The Onerahi claystones and limestones give rise to good pasture-lands. These were the lands taken up by the early settlers, and they are now the best in the district. The Cape Rodney sandstones cover rough hilly country. They form, however, a fertile soil, which supports rich pastures. The soils covering the Pakaurangi sandstones and tuffs are poor, and at present are largely covered by manuka scrub. The alluvial soils, which cover small areas only, are in greatest demand. Since the productivity of the soil and its textural and chemical constitution depend so largely upon the underlying rock formations, a geological map of the district will be of great value in connection with the soil survey that is mooted.

3. Kaitangata Subdivision. (By M. Ongley.)

During the period from 13th October, 1923, to 20th March, 1924, the Kaitangata, Taratu, Waronui, and near-by coalfields and adjoining country were examined by the writer, who was assisted by Mr. R. G. Penseler, B.Sc., of Otago University. Altogether some 543 square miles of country, extending from the Taieri River to Romahapa, and from the coast thirty-three miles inland, were examined and mapped, and about a fifth of this was found to be possibly coal-bearing. The adjoining Tuapeka district was examined in 1915 by Dr. P. Marshall, and his report, "The Geology of the Tuapeka District," published in 1918 as Geological Survey Bulletin No. 19, has facilitated the work in the Kaitangata Subdivision.

Topography.

In the north and east the subdivision consists of two asymmetrical tilted fault-blocks trending 30° east of north with long gentle eastward slopes and steep westward-facing scarps, and in the west a third long eastward slope rising to a dissected plateau. The fault-angle depressions are occupied by tidal lagoons and low alluvial plains. The block in the east rises gently from the east coast near Quoin Point to a ridge 550 ft. high two miles inland, and drops abruptly to a depression that contains the tidal flats at Akatore. From the depression a long gentle slope rises five miles westward to 1,500 ft. in the watershed between the streams that flow seaward and those that flow inland to the long depression occupied by Lake Tuakitoto, Lovell's Flat, the Tokomairiro Plain, Lake Waihola, Lake Waipori, and, farther north, the Taieri Plain. West of the summit the ridge is faulted, and extends a mile westward as a lower step 1,000 ft. high, rising again to 1,500 ft. at Gorge Hill. From the hill the country falls steeply to the tidal lakes and Tokomairiro Plain, which, as already mentioned, occupy the fault-angle. From the depression the country rises again westward, interrupted in places by volcanic peaks, for some seven miles to Mount Stuart (1,418 ft.) and the surrounding plateau. From this the country slopes away gently south-westward to the 300 ft. downs along the foot of the scarp that, trending south of east to Nugget Point, forms the front of the 1,500 ft. plateau to the south.

General Geology.

An immense thickness of unfossiliferous greywacke grading downward into schist, corresponding with Marshall's "Tuapeka Series," covers 274 square miles; greywacke, argillite, and conglomerate not less than 20,000 ft. thick, containing in places Ladino-Carnic fossils, occupy 51 square miles; unfossiliferous coarse greywacke conglomerate at least 300 ft. thick, corresponding with Marshall's "auriferous conglomerate," occupies 35 square miles, including the Kaitangata Coalfield; quartz conglomerate grading up into sandstone, containing the Wangaloa Eocene fossils, 1,000 ft. thick, corresponding with Marshall's "quartz grits," covers 68 square miles, including the Taratu, Waronui, Benhar, and other coalfields; green-sandstone, limestone with phosphate rock, and brown sandstone occupy 2 square miles, and contain Ototaran fossils; post-Ototaran basalt covers 4 square miles; and alluvium covers 110 square miles. These different formations have been mapped to show their location and boundaries. The lowest two are not of general interest and need not here be further described; the upper ones, containing coal, gold, phosphate, limestone, &c., will be more fully described under the next heading.

Economic Geology.

The Kaitangata conglomerate consists of 2–6 in. well-rounded pebbles, most of greywacke, some of schist, and a few of quartz, set in a sandy matrix of finer pieces of the same rocks. In places the matrix is red and loose, but in others it is dark and compact. Generally it is not visibly bedded, but in places it has in it some bands of sandstone. Between Kaitangata and Clutha mouth it is not less than 300 ft. thick, and, as no underlying rock is exposed to mark its base, its thickness cannot be estimated. The same rock in the Tuapeka district, called by Marshall the "auriferous conglomerate or cement," was estimated as 565 ft. thick. This conglomerate, which is worked for gold in Tuapeka, is important in the Kaitangata area for its coal-seams. The coal has been worked since 1864, and, as little prospecting has been required to enable the output to meet the demand, the resources of the field are not even approximately known. Moreover, little information can be got by examining the surface, for on the west the coal is prevented from outcropping by many strike faults, and on the east the beds dip parallel with the surface and disappear under overlying rock. Further, as the seams are broken by numerous faults, the prospecting-bores hitherto drilled have given information concerning small blocks of country only, and in this respect have been unsatisfactory. Extensive prospecting is warranted, but probably will not be undertaken as long as enough coal to supply the market can be easily found. The evidence available indicates that a great quantity of coal remains, and is as follows: The coal-measures are anticlinal. The western limb, broken by at least eight faults which turn the coal up more steeply farther west, in the early days of settlement showed an outcrop of a 3–4 ft. seam, which was the first mined. In working that seam others were discovered, and thick coal is known near the mines for about a mile along the strike and through about 120 ft. of beds containing 30 ft., 18 ft., and 8 ft. seams. As yet, on account of its greater accessibility, only this western broken area has been worked; but in the mines and in the outcrops it is evident that the coal-measures turn over and dip gently to the east, showing that they extend eastward toward the coast at shallow depth. From Clutha mouth for a mile north they can be seen in the lower part of the sea-cliff, and in them carbonaceous shale bands 10 ft. thick, and coal-seams 3 ft. thick, were seen. Hence workable seams probably extend over this distance. Although the Kaitangata seams were followed into poor coal to the north and into poor coal and to a fault to the south, the coal-measures continue, and probably other payable areas will be found to the north and south along the strike. The rocks in which the thick seams occur are continuous at the surface over 4 square miles, and, as is shown by the outcrops in Saddle and Two-stone creeks, are also present close below the surface in much of the country occupied by the quartz grits; thick seams will probably be found in patches over this area. In the larger and more remote area, however, where these rocks outcrop from the Taieri River for eighteen miles southward past Mount Misery into the head of Wangaloa Creek, only one thin outcrop has been found.

Above the Kaitangata conglomerate lies the Taratu conglomerate, described by Marshall as the quartz grits. It consists of ½–2 in. worn pieces of quartz derived from schist set in an abundant matrix of white sand, in many places cemented with limonite and in some silicified into hard quartzite. It is 1,000 ft. thick, and extends over 68 square miles. Its upper part contains lenses of sand, and grades into ferruginous lenticular sandstone in which are found the Wangaloa fossils of Eocene age. Near the base occur the coal-seams that are being mined at Castle Hill, Taratu, Waronui, Benhar, and elsewhere. At Castle Hill, seams 25 ft., 8 ft., 11 ft., 12 ft., and 8 ft. thick are mined; the Taratu Coal and Railway Company is mining two seams 30 ft. and 18 ft. thick, and has many

other known outcrops on its property. Over the adjoining country, towards the coast, thick seams are known in many places, and are mined at Kaituna, Kaibrook, and Kaidale mines; and the first coal worked in the district in 1858 was in a seam in this formation in the sea-cliff at Coal Point. Thick seams are being mined at Benhar, Lovell's Flat, Crichton Hill, Waronui, and Akatore, and many other thick outcrops are known in less accessible places. The mines at present working could supply a much larger market, and these and others yet to be opened in this formation will be producing coal for many years to come. It is probable that thick seams could be found in these strata close to the railway-line by boring near Crichton Hill.

In the adjoining Tuapeka Subdivision rocks corresponding with the Kaitangata and the Taratu conglomerates are worked for gold; but, although they probably contain gold in this district also, no payable areas are known. At Benhar, close to the thick coal-seams near the base of the Taratu conglomerate, occur thick extensive beds of high-grade white clay, from which acid-resisting bricks, pipes, basins, and sanitary ware are being manufactured. Pottery-works are being built according to the latest Staffordshire designs, and, it is expected, will shortly be producing sanitary ware, &c., in quantity sufficient to meet all local requirements. Similar beds of clay as well as layers of fine white sand occur in many places in the Taratu conglomerate, and will supply a large amount of raw material. The Taratu conglomerate, moreover, consisting of 1 in. subangular pieces of quartz, is used extensively for roadmaking.

The Milburn greensand and limestone cover 1 square mile of the surface and underlie some 3 square miles of lava. At present about a hundred men are employed in the quarrying of the limestone, and in the pulverizing and calcining plants of the Milburn and Dominion companies. The bulk of the limestone is being used for agriculture; some, however, for cement-making. There is a local prejudice against limestone containing any greensand. Since the greenish colour is due to the presence of glauconite, which in many parts of the world is used as a potash fertilizer, the greenish limestone is of more value than the white limestone, and the prejudice against its use is unreasonable.

In pockets on the surface of the limestone occur concentrations of phosphate rock, which has been used in the preparation of fertilizers; but, as the Nauru phosphate now supplies the market, the Clarendon phosphate is not being quarried. It could well be ground with the limestone to increase the value of the product. There is no necessity to apply phosphate as manufactured superphosphate, for it has been shown that finely ground raw phosphates are equally valuable. The following extract from Waggerman and Wagner on the agricultural availability of raw ground phosphates is quoted from Bulletin No. 7 of the Geological Survey of Nigeria, 1924:—

"Out of the thirty-seven tests [extending over a period of five years or more] twenty-two were carried on with a view to comparing the relative merits of raw rock and acid phosphates [*i.e.*, superphosphates]. The conditions under which such a comparison was attempted varied greatly, but it may be said that in a general way thirteen of these experiments, or 59·1 per cent., gave crop yields as favourable to raw rock as to the more soluble form of phosphoric acid. Of the nine experiments in which raw rock did not compare favourably with acid phosphate, two were conducted on fields unresponsive to phosphate treatment, and two gave results which could be classed as either favourable or unfavourable, depending on the method of interpretation employed. Of the fifteen experiments in which no comparison between raw ground rock and acid phosphate was attempted, eleven, or 73·3 per cent., gave results strongly indicating beneficial effects from the application of the former material, and two of the remaining four experiments were conducted on fields showing little or no response to phosphate treatment. In twenty-one experiments the applications of raw rock were relatively light (250 lb. or less per acre), yet fifteen of these experiments, or 71·4 per cent., showed distinctly favourable increases in yields on the fields treated with this material. In sixteen experiments where the raw-rock applications were more liberal, thirteen, or 81·3 per cent., resulted favourably to raw rock phosphate, and the remaining three experiments were conducted on soils showing little or no response to phosphate treatment."

Other experiments are quoted in support; and it is pointed out that the raw phosphate is more effective if finely ground and if decomposing organic matter is present in the soil.

Above the limestone is an unjointed homogeneous sandstone, which has been used locally as a building-stone, and is of first-class quality. On the south-west of Waihola Hill it is more than 30 ft. thick, and, as no rocks could be seen in contact with it, its boundaries are unknown. It would not be difficult to trench the hillside above the limestone and below the volcanic cap and find out how much sandstone is there. Probably it encircles the hill above the limestone and could supply a great quantity of first-class building-material. Basalt has been found covering in all about 4½ square miles, and is in common use for roadmaking; much stone, however, is still imported from Dunedin.

The residual surface clay on the greywacke in many places is thick, and east of Milton is being used to manufacture bricks and pipes. The amount of this material in the district surveyed last season is very great.

4. Lake Takapuna Water-supply. (Summary of Report by P. G. Morgan.)

From the 25th to the 27th September last, at the request of the Lake Takapuna Board of Control, I made an investigation of Lake Takapuna and surroundings. This lake is at present the only source of water-supply (apart from rain-water caught on roofs) for the 18,400 inhabitants or more of Devonport, Takapuna, Northcote, and Birkenhead boroughs.

The lake is a nearly circular basin, with a shallow bay at the north-east corner. Its area is 270 acres, and its maximum depth, when at its highest level, about 200 ft. No stream runs into it, but it receives the surface drainage of about 200 acres of land, and is evidently fed to some extent by springs. As well known, it occupies an explosion crater, formed during a comparatively late period of volcanic activity. The surrounding rocks are loosely compacted tuff and scoria, underlain in many places by a flow of basalt, the whole resting on the tuffaceous claystones of the Waitemata Series.

Since 1895, when water was first pumped from Lake Takapuna, the population of the district has greatly increased, and is still rapidly growing. Since 1911 the lake has not been able to supply all the

water required by the surrounding district. In that year the height of its surface above sea-level (presumably mean high water) varied from 11 ft. to 14 ft., but in the early part of 1915, following the unusually dry season of 1914, its level was lowered to about 2½ ft. above sea-level. Since then, owing to a series of wet seasons and restrictions on the consumption of water, its level has slightly risen, and in September last was about 5 ft. above the sea-level.

The loss by evaporation has not been determined by observation and experiment, but probably amounts to over 80 per cent. of the rainfall, which on the average is 42·98 in. per annum. It follows that Lake Takapuna receives a large amount of water from sources outside its drainage basin. There is little reason to suppose that lowering the level of the lake will materially add to the amount of water entering by springs, though the increase of head thus caused may have a slight effect. Clearly, therefore, another source of water-supply will have to be sought by the Takapuna, Devonport, and other boroughs on the north side of Waitemata Harbour.

The question has been raised as to whether, in the case of the surface of Lake Takapuna being lowered below sea-level, there is any danger of an irruption of sea-water through the narrow belt of porous basaltic tuff that separates the lake from the sea. If the tuffs extend below sea-level, this will happen when the level of the lake is lowered to half-tide mark or thereabouts. If, on the other hand, the Waitemata claystones which underlie the tuff have their upper surface everywhere around the lake above sea-level, the lake is in a watertight basin, and its level can safely be lowered many feet. Mr. J. A. Bartrum, Lecturer on Geology to Auckland University College, holds the opinion that this is the case, and after I had been shown outcrops of the Waitemata beds on the seaward side of Takapuna and elsewhere, and had heard Mr. Bartrum's explanation of the finer points of the local geology, I was able to accept his view as probably the correct one. Since it will be some years before additional water can be brought to the North Shore boroughs from Rangitopuni Stream or elsewhere, it is to be hoped that this view will stand the test of time.

[5. Underground Water, Tahunanui, Nelson. (Summary of Report by J. Henderson.)

On the 22nd January last a visit was made to Tahunanui, near the Town of Nelson, in order to advise the Tahunanui Town District Council on the possibility of obtaining a supply of water by boring. Numerous wells sunk from 12 ft. to 20 ft. on the flats at Tahunanui reach the water-table, and are said to yield a constant, though small, supply of water, which, however, is not of first-class quality. Favourable conditions for artesian water are probably present in some part of the Tahunanui flats. The beds most likely to yield large amounts of good water are the gravels of the ancient buried valleys of the various streams that issue from the hills, and which once, when the land as a whole stood higher, flowed at a relatively lower level. O'Brien Creek probably has such an ancient valley or channel, which continues across the flats in a general north-westerly direction. A bore near the abattoirs should reach the nearly impervious bed-rock at a shallow depth. Farther north-west the depth to bed-rock will increase, and the position of the floor of the buried valley will be more uncertain. On the other hand, the quantity of water to be obtained from a deeper bore will probably be larger.

6. Rolling River Lodes. (Summary of Report by J. Henderson.)

The area being prospected by the Colossus Gold-mining Development Company was visited between the 17th and the 21st January last. Since it is included in the Motueka Subdivision, now being geologically surveyed in detail, and will be described in the report which will be written after the completion of that survey, the description now given will be brief.

A series of steeply dipping lodes striking in a general north-west direction crosses the northern end of the long precipitous spur or ridge between Blue and Nuggety creeks, headwater branches of the Rolling River, a tributary of the Wangapeka. Several lodes of another series, striking nearly north, outcrop in the valley of Connor Creek, a stream entering Rolling River from the east about 60 chains north from the junction of Blue and Nuggety creeks. The rocks traversed by the lodes are subschistose greywacke and argillite, quartzite, marble, and schist of Palæozoic age.

The lodes consist chiefly of quartz, and at a little depth from the surface contain grains, nests, streaks, and pockets of sulphides of iron, lead, zinc, and copper. In places some arsenic occurs. Gold and silver are present in varying amount, and appear to be associated with the sulphides. A large amount of alluvial gold has been obtained from the gravels of Rolling River and its tributaries.

The quartz veins traversing the spur between Blue and Nuggety creeks were probably first prospected late in 1869, when lodes known as Culliford's and Doran's were discovered. Later, serious mining was undertaken, a battery was built, and crushing began; but the gold-yield was small, and operations ceased. In 1888, outcrops about 20 chains south-east of Culliford's adit were unsuccessfully prospected. Again about ten years ago Mr. Van Bell, and after him the Colossus Gold-mining Development Company, prospected the lodes near Connor Creek, but nothing of value was found. Later, the Colossus Company prospected the Surprise, O'Malley, Raymond, McCarthy, and other lodes near Blue and Nuggety creeks. Of these the Surprise lode is the most promising, and has been explored by means of three adits for a length of about 350 ft. in plan. In the highest adit the lode is seen for about 50 ft. only. In the middle adit, 80 ft. below No. 1, and 250 ft. long, it is, on the average, between 2 ft. and 2½ ft. wide. In No. 3 adit, 40 ft. below No. 2, the lode has been followed for 90 ft.: here it is from 6 in. to 2 ft. or more in width.

Six samples were taken from the "back" or roof of No. 2 adit, and assayed at the Dominion Laboratory. The gold in these varied from nil to 2 dwt. 12 gr. per ton, with an average of 22½ gr., and the silver from 4 dwt. 2 gr. to 4 oz. 18 dwt. 7 gr., with an average of 1 oz. 5 dwt. 8 gr.

The samples were also tested for lead, zinc, and copper, and the average percentages were—Lead, 0·34; zinc, 0·19; copper, 0·05.

According to assays made at the instance of the company, the O'Malley lode contains a shoot of auriferous quartz about 15 ft. long, which was followed upward by a rise for 25 ft., and downward by a winze 20 ft. deep or more. The shoot is so short, and the width of the lode (12 in. to 15 in.) so small, that it cannot be worked at a profit.

7. Kumara Deep Levels; Hayes Terrace; Havill Brothers' Claim, near Callaghan's. (Summary of Reports by P. G. Morgan).

Discussion on the advisability of testing the deep gravels between Kumara and Dillmanstown having arisen, I made a search of the old reports, and on the 6th March last visited Kumara and adjoining localities.

South of Kumara, towards Dillmanstown, the gold-bearing gravels are over 140 ft. thick, and rest upon the claystone of Upper Oamaruian age known as the Blue Bottom. They lie above the level of the Taramakau River in an old channel eroded in the Blue Bottom by a large stream issuing from the ancient Taramakau glacier—or, rather, from the front of the ice-sheet that once spread over a great part of the Westland lowlands. The upper layers, which rest, as a rule, upon a "false bottom" composed of gravel of less coarse grain, according to Mr. J. Rochford, manager of the Government water-races, have yielded gold to the value of £3,500,000. The false bottom and the layers underneath it contain little gold, but towards and on the Blue Bottom richer gravels appear. These have been tapped in two places by shafts, and also by a low-level drift from near the level of the Taramakau River, which connected with the more northerly of the two shafts. According to report, the gravels near the shaft-bottoms carried from 1 dwt. to 2 dwt. of gold per load, but this would not pay to drive out.

Of the two prospecting-shafts referred to, one was sunk about 1892 and the other in 1906–7. Since the latter date practically nothing has been done to test the deep levels, although so long as the shaft remained in repair there would have been no difficulty in driving underneath the greater part of the deep ground.

The Kumara district has been geologically surveyed in detail, and the results of the survey will be found in Bulletin No. 13 (1911). On page 91 the Kumara deep levels are discussed as follows: "At Kumara the lowest portion of the ancient river-channel in the Blue Bottom has never been prospected, though attempts have been made to do so, and portions of the rim have been tested. It is practically certain that this channel, scooped out while the ancient ice-sheet was advancing by a stream which may be called the ancient Taramakau, contains a considerable amount of gold. Probably the richest layer is that resting on the Blue Bottom in the deepest part of the channel, but only trial can show whether its exploitation will be profitable or not."

Hayes Terrace.—By this name I mean the flat-topped ridge east of Kumara, between the Taramakau River and the lower part of its tributary, the Hohonu or Greenstone River. Here there are several hundred acres of fluviatile and fluvio-glacial gravels containing gold. These have been extensively sluiced at Westbrook, on the north side of the terrace. On the south side a syndicate, with Mr. Lachlan McLachlan as manager, is sluicing the upper part of the fluvio-glacial gravels at Payne's Gully, and good results are reported. Local opinion is that the whole terrace will pay for sluicing, but the abundance of enormous glacial boulders, which have to be shifted by winches, &c., is a great drawback. For the efficient working of the Hayes Terrace ground, water under a higher pressure than that given by the Trans-Taramakau water-race is desirable. References to Hayes Terrace and vicinity will be found in Bulletin No. 13, pages 87 and 90.

Havill Brothers' Claim, near Callaghan's.—Havill Brothers, having brought in a low-level tail-race from Little Kapitea Creek, are now working a claim on the north-east slope of Italian Hill by hydraulic sluicing with highly payable results, although they are hampered by want of pressure in their main water-supply (Waimea Water-race). The gravels being sluiced rest upon a sloping irregular surface of Blue Bottom, near or on which most of the gold occurs. The uppermost layers are mainly silt.

8. Chatham Islands Expedition. (Summary of Report by J. Marwick.)

Until the fossils collected have been worked up, a detailed report on the work done by the geologists attached to the Chatham Islands Expedition of January and February last cannot be given.

Schists, presumably of the same age as the Otago mica-schists, occur in the northern part of Chatham Island. In the north-west and the north-east these strike almost east and west, but midway between their strike is about north and south. Fossiliferous Middle Tertiary rocks, chiefly limestones and bedded tuffs, outcrop at many points, and are well seen along the north coast of Chatham Island, at Red Bluff north of Waitangi, and in Pitt Island. At Titirangi, on the west side of Te Whanga Lagoon, highly fossiliferous sands containing a Nukumaruian (Middle Pliocene) fauna are seen. The species represented are not numerous, but large numbers of good specimens can be obtained.

The southern part of Chatham Island was not explored to any extent. It consists mainly of basaltic flows, presumably of Middle Tertiary age.

Peat, locally reaching a thickness of over 40 ft., covers a great part of Chatham Island. It has been set on fire at several places, and at two of these is still burning. The limestone will be of value for agricultural purposes. In several localities it is so little cemented that it can be easily excavated, and then applied to the land without crushing or other treatment.

9. Waihi Goldfield. (Epitome of Reports by P. G. Morgan).

During the past year two visits were made to the Waihi Goldfield—one in November, and the other during the latter part of December, 1923, and the early part of January, 1924. Many of the data obtained have been added to the detailed report entitled "The Geology and Mines of the Waihi District, New Zealand" (N.Z. Geol. Surv. Bull. No. 26), which is now about to be issued as a volume of over two hundred pages. It may be as well to state here, as concisely as possible, the chief results set out in this report.

In the first place the more productive part of the Waihi Goldfield—that in and near the Town of Waihi—has been shown to consist of a series of andesitic (or "dacitic") flows, interspersed with minor layers of breccia, tuff, and even mudstone, and not of intrusive "dacite," as supposed by Dr. J. M. Bell and Mr. C. Fraser, the authors of Bulletin No. 15, in opposition to all previous geologists who had examined the area. This enforced return to the older view justifies lateral exploration—that is, exploration directed outwards from the known ore-bearing areas. The impoverished condition of the lodes in the Waihi and Waihi Grand Junction mines at depths exceeding 1,000 ft. is apparently due mainly to the action of descending solutions, which have dissolved much of the gold and silver as well as other minerals, in the ore-bodies. This conclusion renders probable the existence not only of "primary" ore at greater depth, but also of "secondary" ore; and it can be extended—though

this must be done with caution—to neighbouring areas, particularly to the Rosemont and Silverton hills, in the eastern part of the Waihi Borough. The Owharoa, Waitekauri, and possibly the Waihi Beach lodes may also be richer in depth than in the bottom levels of the mines that have been worked in those districts.

The lodes of the Waihi district have been found to occupy fault planes or zones, and the knowledge of their structural relations thus obtained helps to support the belief that a study of the widespread faulting in the Hauraki Peninsula will aid in the location of valuable mineral lodes.

The hypothesis that the platy or lamellar quartz of the Ohinemuri mines is pseudomorphous after calcite has been demonstrated to be erroneous, and consequently the deductions made from it have no validity. Since similar quartz occurs in many "Tertiary" goldfields, and in almost all cases has been supposed to be "pseudomorphous," the evidence brought forward at Waihi will be of value elsewhere.

The period of mineralization or lode-formation has been approximately ascertained, and the assumption often made that the Hauraki and similar lodes are the result of more than one period of mineralization has been shown to be unnecessary, and probably in great measure erroneous. Similarly, the assumption that a "critical level" of ore-deposition, determined by conditions of temperature and pressure, exists at a moderate depth is totally unproved, and probably incorrect so far as minable depths are concerned. Several other time-honoured hypotheses are endangered if the conclusions reached are approximately correct.

The investigations made at Waihi therefore tend to show, in opposition to many authorities, that the future of "Tertiary" goldfields in depth is not necessarily oblivion. On the other hand, both at Waihi and elsewhere, serious difficulties are caused by the great expense of working deep mines in volcanic rocks, intensified by the rapid increase of temperature with depth.

10. Maratoto District. (Summary of Reports by P. G. Morgan).

During the past three years the writer has made several visits to the Maratoto district, which lies in the upper part of the Hikutaia Valley, and can be reached by road from Hikutaia Railway-station, or by tracks from Waitekauri and Golden Cross. Reports have been furnished on the claims formerly known as the Silverstream, Tellurides Proprietary, &c., being prospected by Ohinemuri Gold and Silver Mines (Limited), and on the Majestic Claim, which includes areas formerly known as the United or Maratoto Consolidated Claim (Peel Creek), Walker's Maratoto, &c. These various claims are fully described in Bulletin No. 15, pages 100–104, and not a great deal can be added to the statements there made.

Faulting is prevalent in the Maratoto district, and no doubt the main lodes occupy fault planes and zones, as in the Waihi district, but not enough field-work has been done to enable the faults to be mapped.

Several of the Maratoto lodes are large and persistent bodies of veinstone, which near the surface have yielded a few thousand tons of ore, some of which was very rich in silver, but none was rich in gold. The ratio of silver to gold commonly exceeds 100 to 1, and in the richest ore may exceed 1,000 to 1. The veinstone of the United Mine contained more gold than most Maratoto stone, but was low in silver, and on the whole was not payable under the conditions of former days. The silver was mainly in the form of sulphide, and there was also some telluride. Visible gold, so far as the writer knows, has not been reported, but the "oxidized" veinstone commonly gives a tail of gold in the dish. The metallic sulphides present are mainly pyrite, with a little chalcopyrite, and possibly some zinc-blende and galena. In the upper levels, apart from the rich silver-ore, the veinstone is chiefly low-grade "oxidized" quartz, much of which is platy or lamellar, and well stained by oxides of manganese and iron. Some of the oxidized quartz, however, may assay half an ounce of gold to the ton, and even more. That large amounts of calcite were formerly present is obvious, and in the lowest levels on the Camoola lode and the United lode (McBrinn's Creek workings) the veinstone is mainly a massive intergrowth of the two minerals, quite clearly contemporaneous, as at Waihi. This material in places is traversed by bluish veinlets containing silver sulphide and speckled by chalcopyrite. Where this is so, it contains from a few ounces upward per ton in silver, and also a little gold.

Mining in the Maratoto area has been unsuccessful, and Bell and Fraser are clearly adverse to its future prospects. One of their lines of evidence, that founded on the presence of abundant calcite in the primary veinstone, is open to challenge, but on the whole the burden of disproof is on their opponents. It is clear that the upper levels of the Maratoto and other lodes have been leached by descending solutions, and this has led some persons of sanguine temperament to believe that rich secondary ores will be found in depth. Such ore, however, will not occur in quantity sufficient to reward the miner if the lodes originally were very low-grade. The available evidence points in this direction, but it is not conclusive. Hence, in order to determine the probability or otherwise of ore in depth, a detailed re-examination of the Maratoto district by an experienced mining geologist is needed. To determine the probability of ore in the Maratoto district by analogy with Waihi would be dangerous and useless. The writer has to point out that, while the genesis of the mineral lodes in the two districts is similar, there are important differences in several respects quite sufficient to invalidate the analogy that is sought to be drawn. One must not assume that all or even a majority of the Hauraki lodes were payable or nearly payable when first formed, as may have been the case at Waihi. Maratoto and other mining districts must stand or fall on their own merits.

It is important to decide whether the small but rich patches of silver-ore that have been worked at Maratoto are primary or secondary. If they are in the main primary, hope of rich ore in quantity at greater depth would be justifiable; if they are secondary, as appears to be the case, only similar small shoots are likely to be found by further exploration, either laterally or in depth.

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