ART. LXII.—*A Geological Reconnaissance of Northernmost New Zealand.*

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[*Read before the Auckland Institute, 22nd November*, 1909.]

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INTRODUCTORY.

Introduction.

THE northern portion of the North Auckland Peninsula is an area of both geological and geographical interest. The sedimentary strata differ considerably in lithological character, and also apparently in age. The igneous rocks, while showing marked diversity in texture, mineralogical character, and mode of origin, will probably be found to display a relatively close similarity in chemical composition. Several geographic cycles have passed over this sea-bordered area, each leaving its mark on the land.

The area may, for the sake of convenience, be called the Aupouri Peninsula, after the Maori tribe that formerly occupied it in considerable numbers.

A hurried reconnaissance of the Aupouri Peninsula made by us during the spring of 1908 had as its chief object the obtaining of a general conception of the main geological and geographical features for purposes of comparison with those of the Whangaroa Subdivision, further south, where detailed observations were at that time proceeding. The present paper is to be considered as a very imperfect summary of the geology of northernmost New Zealand.

Previous Investigations.

As early as 1840 Dieffenbach* visited the locality, but that energetic scientist Sir James Hector† was apparently the first to examine the area at all systematically. Later Mr. A. McKay,‡ the veteran geologist, carried out further geological surveys. Dr. Marshall,§ in recent papers, mentions very briefly some features of the Aupouri geology.

Physiography.

At the northern part of the Aupouri Peninsula a low, much-dissected tableland rises to a height of about 1,000 ft. This tableland seems to represent a portion of an old peneplain, which, formed in the Miocene period, has been tilted in many directions and elevated to varying heights since that time.

The tableland occupies a great portion of the peninsula north of the Harbour of Parengarenga. Southward of this inlet the tableland merges gradually into lower country, showing less-pronounced relief. Flat-topped hills, gradually decreasing in altitude, border the eastern seaboard to Hohoura, where the more elevated country forming Mount Camel marks the occurrence of an outcrop of harder and more ancient rocks. South of Parengarenga sandhills extend inland from the western sea-coast, and, south of Hohoura, cover the entire width of the peninsula.

It will be apparent from the foregoing description that the peninsula consists essentially of a northern rather rugged mass of hard igneous and sedimentary rocks connected, by a long low tongue of less-resistant rocks, to the main mass of the North Auckland Peninsula. The outline of the Aupouri Peninsula would therefore seem to have been determined largely by the varying character of the rocks that compose it.

The sequence of events indicated by the present contour of the Aupouri Peninsula is apparently similar to that which may be deduced from a study of the physiography of the whole of the North Auckland Peninsula.

The northern part of the Aupouri Peninsula has probably been subjected to atmospheric denudation since the close of Miocene times, when it was apparently reduced to a peneplain. Elevation since that time has caused subaerial agencies to renew their work—a work now far advanced, as is evidenced by the rounded contour of the hills, the general absence of rock-waste, and the sluggish, well-graded character of most of the streams. In comparatively recent times a depression has taken place, of which the drowned river-valleys now forming the harbours of Hohoura and Parengarenga are the most striking evidences. A slight elevation may now be in progress, but of this there is not as yet satisfactory evidence.

The Land.

The land-surface of the Aupouri Peninsula may conveniently be discussed under the following headings: (1) The tableland; (2) the low hills bordering the eastern seaboard; (3) the sand country.

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* "Travels in New Zealand," 1843, p. 199.

† "Geological Sketch-map of Northern District of Auckland."

‡ Rep. G.S., 1894: "On the Geology of Hokianga and Mongonui Counties, Northern Auckland."

§ "Distribution of the Igneous Rocks of New Zealand," Aust. Assn. Adv. Sci, 1907, p. 366; "Geology of Centre and North of North Island New Zealand," Trans. N.Z. Inst., vol. xl, p. 79.

(1.) *The Tableland.*—The surface of the tableland consists of uplands covered with scanty scrub, and trenched by rather steep-sided, well-graded valleys, often swampy. The valleys contain some standing bush, not generally of very good quality. The land-surface is generally free from rock outcrops, but along the sea-margin mural precipices rise in many places abruptly from the water's edge. Further description of this feature will be found in the account of the sea-coast.

Near Cape Maria van Diemen, and thence southward towards Scott Point, that portion of the tableland which borders on the sea is cloaked with sand piled up by the prevailing westerly winds. In this part of the area the sand seems to be advancing rapidly, and after every gale the changes wrought by it in destroying vegetation, filling up hollows, and damming streams to form small temporary lakes are very apparent.

In Rahia Bay, where stratified Pleistocene sands and gravels, with peat-beds, outcrop on the shore, a rather remarkable topography is exhibited, resembling somewhat that of the Bad Lands of South Dakota. Here well-sculptured cliffs, with outstanding pillars of bizarre form, border the sea and extend up the narrow valleys (Plate LIII, fig. 2).

(2.) *The low hills bordering the eastern seaboard* form a practically even-crested ridge, rising almost imperceptibly from the sea-shore on the east and from the sand-waste on the west. Gentle undulations are, however, apparent in places, and shallow valleys occur at frequent intervals. Formerly—possibly before the advent of the Maoris—dense kauri forest covered this part of the peninsula, but now a scant covering of scrub has replaced the luxuriant vegetation. The sand is encroaching on this part also, and producing the same effects as noted in the previous section. Doubtless the particularly mild relief of this portion of the area is due in part to cloaking by the sand.

(3.) *The sand country*, which extends eastward from the broad, hard, western Seventy-mile Beach, and, in smaller patches, inland from the eastern sea-beach, consists of rolling sand-dunes of gentle gradient on the windward side, but steep-sloped on the leeward side (Plate LIII, fig. 1). In the hollows between the more or less parallel ridges of sandhills small ponds of water occur. Ponds are also formed in the neighbourhood of the higher land where the ever-moving sands have formed dams across the streams. As these become filled with more wind-blown material, quicksands are formed, which may be dangerous to the traveller.

The Coast-line.

The coast-line of the Aupouri Peninsula is one of great variety, presenting marked divergence in character between the places where soft comparatively recent sedimentary strata occupy the coastal region, and where the resistant igneous and older sedimentary rocks confront the ocean. Along the western seaboard shifting sands alone appear, except at the extreme north. Thus an almost straight shore-line with a broad sand-beach, and with sand-dunes extending inland, borders the sea. The shore-line here, owing to the softness of the rocks, seems to have almost reached maturity.

The northern shore-line presents a series of gravel- or sand-bordered bays diversified by steep rock-precipices. The sunken stream-mouths and the occasional islets and skerries off the coast testify that the shore-line is recently depressed, and that it is consequently a young feature. That it is not absolutely infantile is proved by the numerous cliffs cut in the

rocky ridges, by the marked rock-benches which occur in places (Plate LIV, fig. 2) and by the sand- and gravel-bays which represent aggraded sunken stream-mouths (Plate LIV, fig. 1).

The eastern shore-line resembles the western margin. There are two pronounced indentations—the harbours of Parengarenga and Hohoura. Both are sunken stream-mouths. Parengarenga, with its branching bays, is of very irregular outline. At low tide the greater part of the inlet is bare of water, save for the channels of the numerous streams which ramify through the mud-flat and unite to flow as a single stream through the narrow entrance. Hohoura Harbour resembles Parengarenga in general character, but is smaller and of simpler outline.

Drainage.

The drainage of the Aupouri Peninsula is insequent in type—that is, the streams flow independently of the structure of the rocks.

The area is well and maturely dissected. Many of the streams flow practically at grade to their headwaters.

The principal streams are the Waitiki, Mitimiti, and Te Kao, entering Parengarenga Harbour, and the Werahi and Waitangi, draining into the sea on the northern seaboard. All are short and small, as would be expected from the small area and low relief of the country they drain.

Geology.

Introduction.

Owing to the inspection of the Aupouri Peninsula being only in the nature of a reconnaissance, we were unable to investigate for ourselves many interesting questions dealt with in the reports of Sir James Hector and Mr. Alexander McKay. In order to present as complete an outline as possible of the geology, the remainder of this paper is partly a compilation from these previous reports, but in every case where the conclusions given are not the result of our observations the authority for them is quoted.

The following provisional names will be applied to the stratigraphical groups recognisable in the area under consideration: Mount Camel Series, Whangakea Series, Rahia Series, Coal Point Series, Older Débris, Newer Débris.

It has been thought advisable, in consideration of the isolated position of the area and the scanty palæontological data available for comparative purposes, to apply local names to all the series, although in the case of the Coal Point Series identity with beds developed elsewhere is proved.

Mount Camel Series.

Mount Camel and the low hills to the north-west are composed, according to McKay,* of rocks which bear a close resemblance to the supposedly Palæozoic rocks occupying the greater part of the coast-line between Whangaroa and Mangonui. Hector† describes them as a "development of diorites and tufaceous sandstones with mineral impregnations" similar to the series found in several localities further south, and notably in the Puhipuhi area. Where rocks of the series were seen by the writers at the head of Hohoura Harbour, they consist apparently of argillites and grau-

* Rep. G.S., 1894, p. 72.
† Rep. G.S., 1892, p. lxxxi.

wackes, and contain veins of barren quartz. The Palæozoic age is doubtful, and it is probable that they are of more recent deposition.

Marshall, who examined the area between Mangonui and Ahipara,* maps the older rocks in that area as igneous, whereas McKay† considers that both sedimentary and igneous rocks are represented. We think that the older rocks on the coast-line north of Whangaroa Harbour, which Marshall maps as igneous, contain representatives both of sedimentary and igneous rocks. However, in consideration of Marshall's pronounced view, the older rocks between Mangonui and Ahipara are shown as igneous on the map accompanying this paper.

About twelve miles north of Waipapakauri, on the west coast, the prominent hill of Hukatere rises some 300 ft. above the surrounding sandy waste. All outcrops on this hill are at present obscured by a covering of drifted sand, but from its markedly greater elevation it seems probable that it is composed of older rocks—possibly of the Mount Camel Series. The outlying pierced island of Matapia may possibly be of the same nature.

On the high land in the immediate neighbourhood of the North Cape headland, according to McKay,‡ associated with the igneous rocks to be presently described are "slates and sandstones," which he assigns to the same age as the Mount Camel Series.

Whangakea Series.

The rocks which are tentatively placed under this series consist of greenish and purplish indurated stratified rocks, possibly in part argillites, associated with basic and semi-basic igneous rocks, probably both intrusive and contemporaneous. These rocks are either synchronous with or later than the Mount Camel Series.

The Whangakea Series is exposed along the northern coast-line between Cape Maria van Diemen and the western (Whangakea) end of Spirits Bay. At the latter place occur purplish and greyish apparently argillaceous rocks, often much brecciated, and containing rounded lenses of harder material, which give them a conglomeratic appearance. A microscopic examination of these lenses shows that they are largely composed of comminuted fragments of a basic igneous rock—whether plutonic or volcanic in origin is not clear. In places definite igneous rocks appear in close association with those just described, though, owing to the intense brecciation, it is difficult to be sure whether they are contemporaneous with or intrusive into the seemingly argillaceous strata. It is probable that the latter are tuffs.

Rocks of even more nondescript character occupy the sea-front from Cape Maria van Diemen to Spirits Bay. The pink-weathering sedimentaries cut by basic plutonics near Kerr Point probably belong to the Whangakea Series.

McKay,§ on palæontological grounds, considered the rocks of the Whangakea Series to be Triassic. Hector,‖ however, thought that they possibly belonged to the Maitai Series (Lower Carboniferous). We are unable to offer fresh evidence on this important question, beyond saying

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* Trans. N.Z. Inst., xl, 1907, p. 82.
† Rep. G.S., No. 22, 1894, map facing p. 80.
‡ Rep. G.S., 1894, p. 89.
§ Rep. G.S., 1894, p. 90.
‖ Rep. G.S., 1894, p. xix.

that the series under discussion bears a fairly close lithological resemblance to certain strata found near Whangaroa Harbour, which we consider may be of late Palæozoic or early Mesozoic age.

Rahia Series.

This name it is proposed to apply to the series of thin bedded purplish and greenish claystones and well-stratified greyish greensandstones which is exposed in the area under consideration.

The rocks of the Rahia Series outcrop on the shore of Parengarenga Harbour near Yates's house, and again in the low cliffs bordering the harbour towards the mouth of Waitiki Creek, and form the two limbs of an anticline.

At the south end of Rahia Bay the Rahia rocks, consisting of purplish and greenish shales, and well-bedded, greyish greensandstones, in some places containing many plant-remains, have been intruded and baked by igneous rocks, to be presently described, and are unconformably overlain by the gravels of the Older Débris. A little north of this outcrop the rocks are seen in their unaltered state; but farther north still, in Taupiri Bay, they are again associated with igneous rocks.

No clear evidence of the geological age of the Rahia Series has yet been adduced, but Hector* considers it to be Cretaceo-tertiary. Certainly the members of this series bear a considerable lithological resemblance to certain facies of a series near Whangaroa, to which a late Mesozoic or early Tertiary age has been assigned both by McKay† and ourselves.

Coal Point Series.

We would tentatively apply this name to a series of sedimentary and pyroclastic rocks which, beginning in the hills north of Te Kao Settlement, forms a semicircular belt touching the north coast at Spirits Bay, and having a considerable exposure on the east coast near Coal Point.

(1.) *Lower Beds.*—The lowest beds of the Coal Point Series are impure carbonaceous greensandstones, mudstones, and grits, with molluscan and plant remains, fragments of andesitic rock, and thin inconstant coaly partings. These beds are exposed at the north head of Parengarenga Harbour, and it is probable that within the last sixty or seventy years they were also to be seen at the south head of Parengarenga Harbour, where they have since been covered by the advancing sands.

In places the carbonaceous sandstones and grits contain irregular lenses of lignite. At the time of our visit the best outcrops of the "coal" were said to be covered by drifted sand. Those seen were too poor in quality and limited in quantity to be of any commercial value.

Hector‡ gives the following analysis of the lignite:—

Fixed carbon	41·65
Hydrocarbon	18·11
Water	30·03
Ash	10·21
	100·00

* Rep. G.S., 1894, pp. xvi and 86.
† Rep. G.S., 1894, p. 86.
‡ Rep. G.S., 1894, p. xvii.

A very similar grit-bed occurs at the north end of Wharekau Bay, unconformably overlying the mass of igneous and sedimentary rocks which constitutes the North Cape headland.

(2.) *Upper Beds.*—Between Parengarenga North Head and Wharekau Bay the Coal Point Series forms a syncline, the upper beds being exposed along the coast-line. These beds, which are coarse volcanic breccias including fragments of stone up to 2 ft. in diameter, interbedded in their lowest parts with finer sedimentaries, occupy the sea-front as far as Coal Point. They exhibit a rude stratification, and are in some places seamed with calcite veinlets, and in others with stringers of opal.

At Coal Point a seam of impure lignite about 6 chains long and 1 ft. 6 in. thick, striking east and west, and dipping to the south at 35°, is interbedded with the breccias. The outcrop is interesting as affording evidence of the probable presence of a land-surface here during the accumulation of the breccias, but is of no economic importance.

The Coal Point Series throughout the rest of the area in which it occurs is represented only by the breccias which belong to the upper horizon. Good exposures are to be seen on the track from Parengarenga Harbour to Te Paki Sheep-station, where pebbles of sedimentary rocks occur amongst the volcanic fragments, and at the eastern point of Spirits Bay. At this latter place "the lower three or four feet" of the breccias "are so crowded with remains of a species of *Scalpellum* as to form an impure shelly limestone."*

(3.) *Petrology.*—Megascopically the constituent fragments of the Coal Point grits and breccias would be identified as andesitic rocks of medium grain, showing phenocrysts of plagioclase and pyroxene. The small fragments from the lower grits are usually more basic in appearance than the boulders of the coarse breccias.

Microscopic sections of the basal grits show that they are composed of fragments of lava closely agreeing with those found in the overlying coarse breccias. In the grit fragments, however, crystals of highly altered olivine are rather frequent. The grits are much seamed with veinlets of a zeolite, apparently natrolite.

Representative sections from the coarse breccias show that the prevalent rock is an augite-andesite, with a hyalopilitic groundmass in which glass predominates over feldspar laths and augite granules. The augite phenocrysts, which vary much in abundance in different sections, are pale brown or yellow in colour. Porphyritic feldspars are abundant, the dominant ones being andesine and labradorite, the latter being the more frequent and having many glass inclusions. (Plate LVI, fig. 1.)

(4.) *Correlation and Age.*—The lowest beds of the Coal Point Series contain fossil *Mollusca* which are apparently of Miocene age. McKay† correlates them with the lignite-bearing beds of Cooper's Beach and the fine-grained tuffs at the base of the volcanic breccias of Whangaroa Harbour.

The *Scalpellum* found at the base of the breccias in Spirits Bay is regarded by Hector and McKay as identical with that‡ occurring at Chamberlain's Island, near Auckland, in strata which, it is agreed by Cox,§ Park,‖

* McKay, Rep. G.S., 1894, p. 82.

† Rep. G.S., 1894, pp. 82, 83.

‡ More recently described by Benham as *Pollicipes aucklandicus*: Geol. Mag., March, 1903, p. 110.

§ Rep. G.S., 1879–80, p. 16.

‖ Trans. N.Z. Inst., 1889, p. 394.

Mulgan,* and Fox,† pass conformably up into the Manukau breccias—a series of volcanic agglomerates and breccias of extensive development on the west coast north of the Manukau Heads. It is evident, therefore, that the Coal Point Series is to be correlated with the Manukau and Whangaroa breccias and the strata which conformably underlie these breccias. It may be noted that petrologically the component rocks of the Coal Point and Whangaroa breccias show a striking similarity, and that this resemblance seems also to extend to the Manukau breccias and other closely related volcanic beds of the Auckland Isthmus.‡

In this connection the two following analyses of general samples—(1) of fragments of Coal Point breccia, (2) of fragments from breccia at St. Paul's, Whangaroa—may be of interest:—

	(1.)	(2.)
Silica (SiO_2)	59·20	58·20
Alumina (Al_2O_3)	18·03	18·35
Ferric oxide (Fe_2O_3)	1·40	1·44
Ferrous oxide (FeO)	2·88	3·46
Manganous oxide (MnO)	0·40	0·35
Lime (CaO)	7·03	6·20
Magnesia (MgO)	2·51	3·49
Potash (K_2O)	2·28	2·96
Soda (Na_2O)	2·93	2·63
Titanium-dioxide (TiO_2)	1·26	0·87
Carbonic anhydride (CO_2)	Nil	Nil
Water and organic matter	2·08	2·05
	100·00	100·00

Since no unconformity has been recorded between the Coal Point and Rahia Series, it is quite possible that the latter will ultimately prove to be of Miocene age, just as the Waitemata beds, at one time considered to be Cretaceo-tertiary, are now generally admitted to be conformable to the Manukau breccias, and Miocene in age; but further field study will be necessary before any definite opinion can be given on this point.

Older Débris.

Under this heading we propose to place a series of horizontally stratified sands and water-worn gravels that outcrop at various places in the area. The relation of these beds to the Coal Point Series is not clear, but they lie unconformably on the Rahia and older series.

The rocks of the Rahia Series are seen at the southern end of Rahia Bay to be unconformably succeeded by a horizontal layer of fine gravel 6 ft. or 7 ft. thick, followed by 100 ft. or more of horizontal sandstones. In various places throughout the Aupouri Peninsula—as, for instance, on the track from Hukatere to Hohoura—similar beds, horizontally stratified, are seen cropping out of the newer drifting sands. At Scott Point they may be observed filling up the irregularities in the much-dissected older igneous rocks, and forming a flat-topped hill, rising 300 ft. or 400 ft. above sea-level.

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* Trans. N.Z. Inst., 1901, p. 429.

† Trans. N.Z. Inst., 1901, p. 492.

‡ See Mulgan and Fox, *loc. cit.*; also Marshall, Trans. N.Z. Inst, xl, 1907, p. 96. Hypersthene, which Marshall finds so widely distributed in the Manukau breccias, is not invariably present in sections of Coal Point breccias.

Inconstant beds of highly carbonised brown or black peat, apparently overlying the uppermost layers of the Older Débris, but possibly unconformable to them, occur in various places, especially at the north end of Rahia Bay. Trunks of trees and roots *in situ* are of frequent occurrence in these deposits, which are too small to be of value as fuel. Kauri-gum is, however, found in fair quantity in and immediately under them.

The firmer scrub-covered country which lies to the east of the ever-advancing west-coast sands, the similar minor accumulations in Spirits Bay, the low sandy flat which separates the North Cape headland from the rest of the high land, and the low flats in the south-east part of Parengarenga Harbour, although doubtless much younger than the stratified beds just described, are also included under this heading. The occurrence of great quantities of kauri-gum and of abundant remains of large trees in the swamps on the land-surface—formed of these beds—points to a protracted period when the land became clothed with a great kauri forest.

Newer Débris.

The most important of the recent deposits are the widespread sand-dunes at present drifting in from the east and west coasts, and the alluvial deposits accumulating in the various swamps and ponds.

Judging from its present rapid rate of advance, the wind-blown sand can only have begun its inroads since the destruction of the kauri forest by the early Maoris. The peculiar topography produced by these drifting sands has already been described. It only remains here to notice the remarkable difference between the east- and west-coast sands. That of the east coast is almost pure silica, and was in former days used for moulding in the ironworks at Onehunga and in the manufacture of glass at Auckland. That of the west coast is of the more ordinary type of quartz and shell sand. Some of the sands near Cape Maria van Diemen and in Spirits Bay consist entirely of finely comminuted shells of great beauty.

*Older Igneous Rocks.**

We propose to subdivide the igneous rocks of the Aupouri Peninsula into an older (or pre-Miocene) and a younger (or Miocene) group. The two series have not been found in contact. The only evidence for this division of the igneous rocks consists in the petrological differences between the two series, and in the much greater degree of alteration of the group regarded as older. The younger group has already been described under the Coal Point Series. The older igneous rocks may belong to one or more distant periods. Some, apparently, are associated with Mount Camel rocks.† Some are found associated with the Whangakea Series, though whether contemporaneous or intrusive is not clear. Others are found intruding and altering Rahia rocks. In other cases they occur unassociated with sedimentaries.

Whether or not, therefore, the whole assemblage is to be regarded as of post-Rahia date must for the present remain uncertain. We propose merely to describe the most important occurrences. Speaking broadly, it may be said that the older igneous rocks are more plutonic in character to the east—*i.e.*, towards North Cape—and more effusive in aspect towards Cape Maria van Diemen and the west coast.

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* In this part we are much indebted to Professor Marshall, who examined the microscope sections and gave us valuable notes on them. For the final results we are, of course, solely responsible.

† Hector, Rep. G.S, 1892, p. lxxxi.

(1.) *Igneous Rocks associated with the Rahia Series.*—The largest occurrence of old volcanic rocks is at Scott Point. In the field this rock shows remarkable spheroidal structure, probably due to movement after partial consolidation of the lava, which gives it a pseudo-agglomeratic appearance. In the more decomposed, clayey material between the harder blocks calcite and chlorite are often developed.

In hand-specimens the rock at Scott Point is a very fine grained, dull-green and reddish rock, containing no identifiable mineral except secondary calcite, which is abundant, both as finely disseminated grains and also as amygdules.

Microscopically, the rock, which is somewhat decomposed, and stained yellow with limonite, appears to be an olivine basalt. The phenocrysts are few, and are feldspar (labradorite chiefly), containing numerous glass inclusions and seldom showing multiple twinning, and olivine with characteristic form but largely altered to calcite. The groundmass is made up of elongated feldspar laths, between which are scattered numerous granules of augite. Professor Marshall notes that the rock resembles the basalt near Ahipara and Takahue described by him in a recent paper.*

Similar igneous rocks occur at Rahia Bay, where, as already stated, they intrude and alter the Rahia Series, and again on the higher sand-shrouded land between Rahia Bay and Cape Maria van Diemen. In this locality, however, it seems doubtful whether or not some of these rocks are contemporaneous flows.

(2.) *Igneous Rocks associated with the Whangakea Series.*—Some doubt exists as to the relationship of the apparently sedimentary rocks to the undoubtedly igneous at Cape Maria van Diemen and at Whangakea. At the latter place there is an extensive development of basalt similar to that occurring at Scott Point, though the olivine crystals are smaller, more numerous, and have been corroded by the action of the unconsolidated magma. Large feldspars are absent, and the small laths show no tendency to arrangement in flow-lines (Plate LVI, fig. 2). A little to the east of Whangakea is seen a coarser igneous rock—possibly a mica-diorite. Darky Hill and the neighbouring high ridges appear to be chiefly composed of a very compact igneous rock in which a finely crystalline structure and small feldspars are visible to the naked eye. Under the microscope this rock proves to be a somewhat altered augite-andesite, in which fairly large, very light brown augites and elongated feldspars (andesine and labradorite) are the only phenocrysts. The groundmass is now obscure, but contains abundant grains of ilmenite, and was apparently made up of feldspar laths and granules of augite and ilmenite imbedded in a glassy base.

(3.) *Igneous Rocks associated with the Mount Camel Series.*—According to McKay,† "intrusive or bedded contemporaneous flocs of crystalline rocks—syenite and diorite" occur at the North Cape headland, on the northern coast west of Spirits Bay, and at the head of Parengarenga Harbour. We were able to visit only the first of these localities.

The rock forming the greater part of the North Cape headland is a basic plutonic showing considerable range in structure and in mineralogical composition. On the south the plutonic is overlain by grit-beds of Miocene age, while along its western boundary—near Kerr Point—it has intruded and altered argillaceous rocks which may belong to the Whangakea Series.

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* Trans. N.Z. Inst., vol. xl, 1907, p. 82.
† Rep. G.S., 1894, p. 90.

The dominant types of crystalline rock encountered in the North Cape promontory are norites and gabbros, passing at places into hartzbergites and lherzolites.

In hand-specimens the gabbros and norites vary in texture from coarse to rather fine. The most coarsely grained rock is a norite obtained near Kerr Point, made up of very conspicuous crystals of enstatite, ½ in. and more in length, apparently imbedded in a crystalline mass of feldspar. A somewhat finer and more even grained rock is the gabbro from North Cape, hand-specimens of which show dark-green augites and white and occasionally pinkish feldspars fairly evenly distributed. A much finer gabbro occurring in the cliffs east of Tom Bowling's Bay, in hand-specimens can only be described as a brownish rock consisting of a fine-grained mixture of rather clear feldspar and somewhat decomposed ferro-magnesian minerals.

Under the microscope the plutonics are seen to be holocrystalline. The feldspars range from labradorite to anorthite, and are usually fresh. In the gabbros the ferro-magnesian mineral is a light-brown pyroxene, seldom showing the diallage structure to any marked extent, and often partially altered to bluish-green hornblende or to uralite. Very much altered olivine is occasionally found. In the norites the hypersthene occasionally is seen to be partially altered into brown or bluish-green hornblende (Plate LVI, fig. 3). In the case of the very coarse rock from Kerr Point, bastite has partly taken the place of enstatite.

The hartzbergite which is found near Kerr Point is in hand-specimens a pale olive-green rock much flecked with white. It is crossed by a number of fine cracks, along which alteration-products have accumulated. The phenocrysts are large pyroxenes, the greater part of each being dull and earthy, but the cores having a metallic lustre. Microscopic sections show that the rock is made up mainly of serpentinised olivine, which surrounds numerous crystals of enstatite now nearly completely altered to bastite. A considerable quantity of chromite and magnetite occurs in the serpentinised olivine. This rock shows a general resemblance to the hartzbergite from Milford Sound, of which Professor Marshall has kindly lent us sections. The North Cape rock is, however, much more decomposed than that from Milford Sound. Lherzolite has been recognised in bands traversing the gabbro at North Cape. Megascopically the rock is coal-black, finely crystalline, and traversed by irregular streaks of white, which are probably decomposition-products. Under the microscope the lherzolite proves to be composed mainly of olivine, much of which is converted into serpentine. Some enstatite, diallage, and brown hornblende also occur. This rock, on the whole, shows a closer resemblance to the hartzbergite from Milford Sound than to the lherzolite from Cow Saddle, to the north-east of Milford Sound.* Nevertheless, the presence of diallage seems to place it amongst the lherzolites (Plate LVII, fig. 1). Cutting the lherzolite at North Cape are several clearly defined bands, 1 ft. or more in thickness, of a dull green homogeneous-looking rock, with a hardness of about 6. Microscopic examination shows this rock to be a very fine grained aggregate of diopside and sphene, with a little feldspar (Plate LVII, fig. 2).

The occurrence of ultra-basic rocks closely allied to those found near Milford Sound and elsewhere in the South Island is of great interest. The foregoing notes, unaccompanied as they are by chemical analyses, must be regarded as of a purely preliminary character.

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* Marshall, Trans. N.Z. Inst., 1904, p. 483. (See Marshall, Trans. N.Z. Inst., 1905, p. 564.)

(4.) *Economic Deposits in the Older Igneous Rocks.*—A few veins of rusty calcite and of quartz pseudomorphic after pyrite were noted in igneous rocks near Kerr Point. An assay of a sample from these veins yielded—

Gold	.. 1 dwt. 21 gr.	Value per ton	.. 7s. 6d.
Silver	.. 0 „ 15 „		

In the same locality bands rich in pyrite and containing some chalcopyrite also occur. These were examined for gold, silver, copper, cobalt, and nickel, but yielded only—

Silver	.. 7 dwt. 13 gr. per ton.
Copper	.. 6·24 per cent.

The surface of the high land forming the North Cape Promontory is strewn with blocks of hydrous ferric oxide derived from the decomposition of the underlying basic rocks. An analysis of this is subjoined, which is interesting as showing the high percentage of chromic oxide—probably derived from the chromite of the ultra-basic rocks :—

Silica (SiO_2)	2·89
Alumina (Al_2O_3)	7·69
Ferric oxide* (Fe_2O_3)	69·07
Manganous oxide (MnO)	0·10
Lime (CaO)	Nil
Magnesia (MgO)	0·60
Chromic oxide (Cr_2O_3)	3·25
Loss on ignition	16·01
Undetermined	0·39
* Equivalent to metallic iron 48·35 per cent.	100·00

Dr. Maclaurin, the Dominion Analyst, adds the following note: "On heating, the sample gives a colour similar to that of Parapara iron-ore when burnt, and therefore should be suitable for paint."

EXPLANATION OF PLATES LII–LVII.

Plate LII.

Map of the northernmost portion of New Zealand.

Plate LIII.

Fig. 1. Sand-dunes on sea-coast near Te Paki.
Fig. 2. "Bad Lands" topography, Rahia Bay.

Plate LIV.

Fig. 1. Spirits Bay, from Whangakea end.
Fig. 2. Rock bench at Cape Maria van Diemen.

Plate LV.

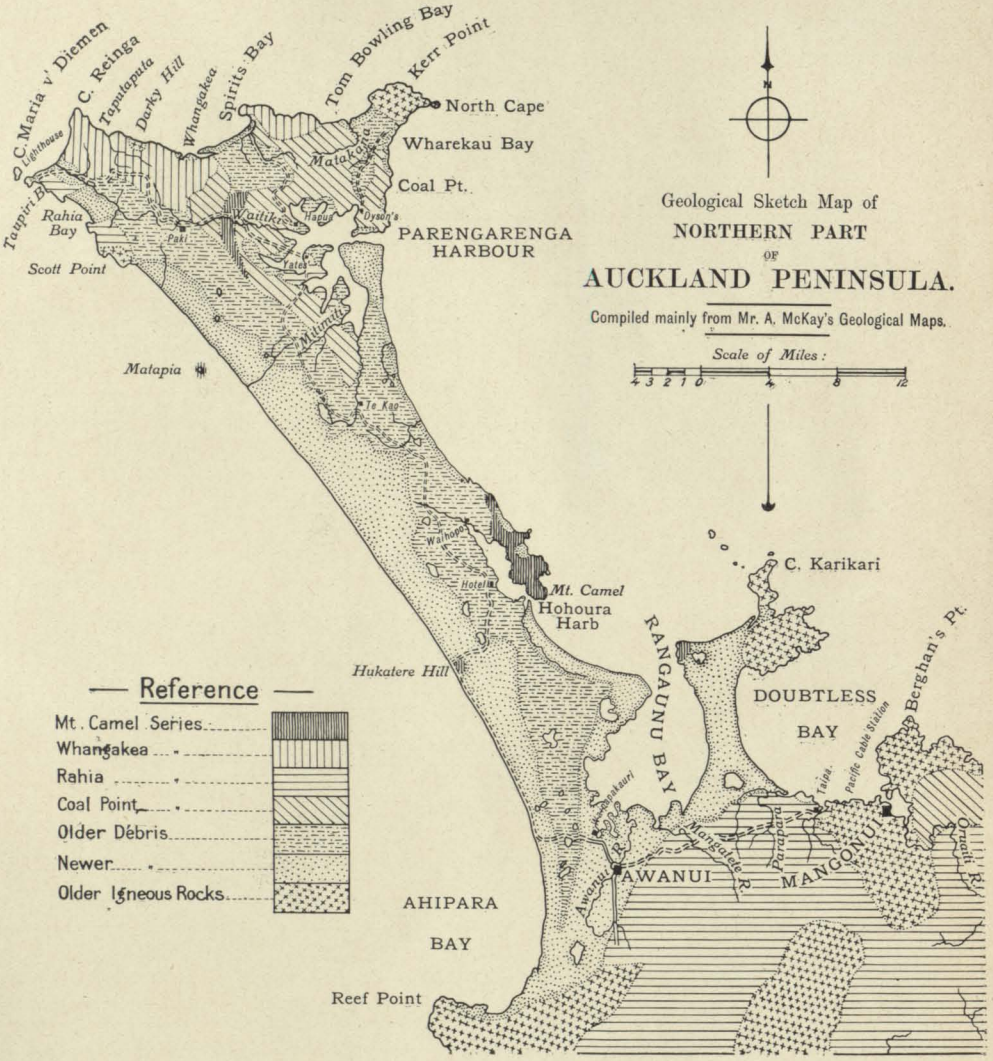
Fig. 1. Boundary between sand-dunes and Older Dèbris near Te Paki. Shows ponds formed by clogging action of advancing sand.
Fig. 2. Advancing sand near Cape Maria van Diemen. The scrub-covered hill is an outcrop of the Older Dèbris nearly overwhelmed by the sand.

Plate LVI.

Fig. 1. Andesite breccia from near Coal Point.
Fig. 2. Basalt from Whangakea, west end of Spirits Bay.
Fig. 3. Norite from north end of Wharekau Bay.

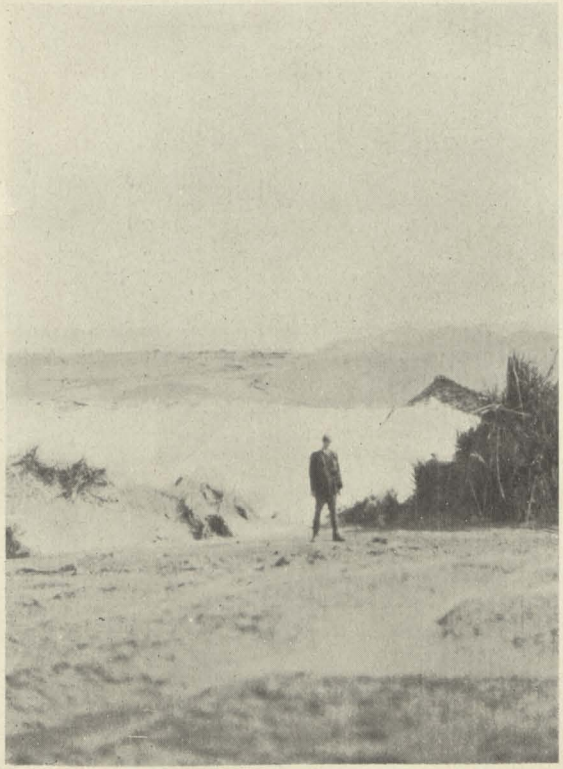
Plate LVII.

Fig. 1. Lherzolite from mainland just inside North Cape Island.
Fig. 2. Diopside-sphene band cutting the rock shown in fig. 1.



MAP OF NORTHERNMOST NEW ZEALAND.—BELL AND CLARKE.

Face p. 624.



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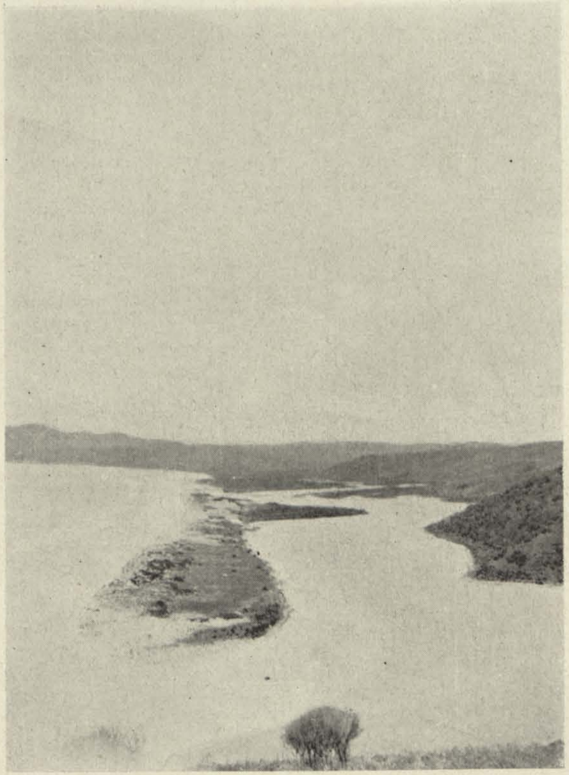

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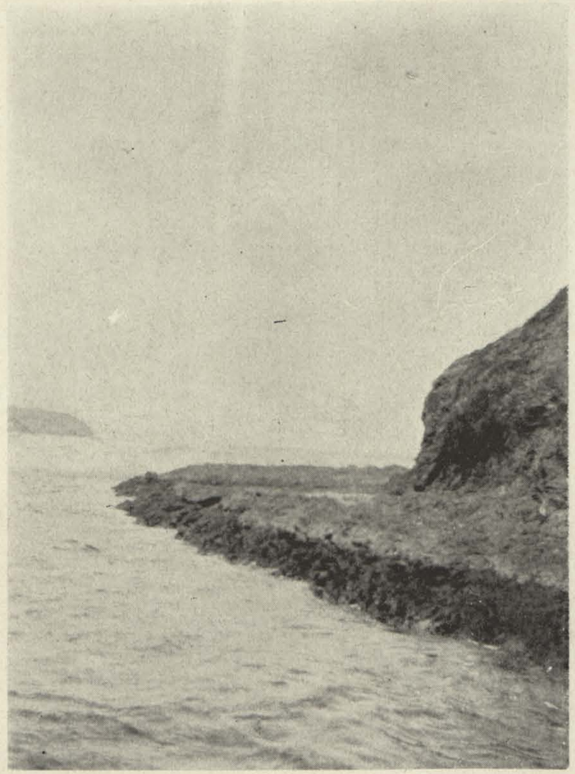

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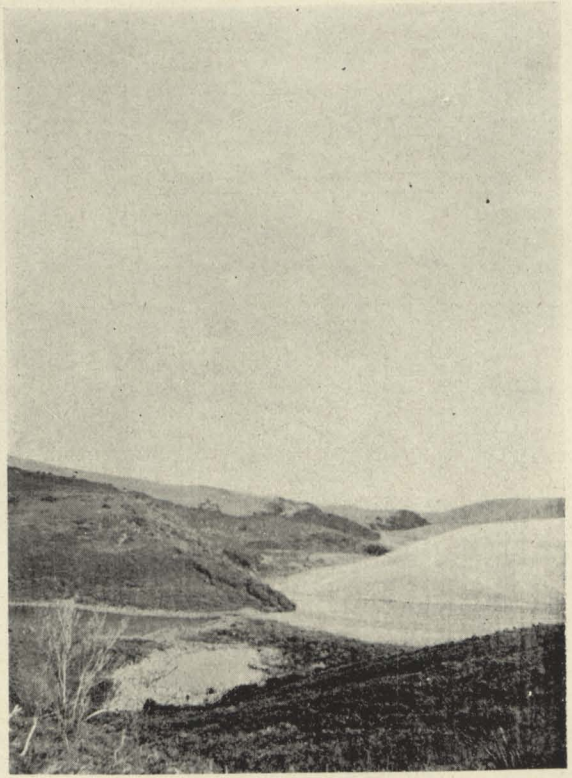

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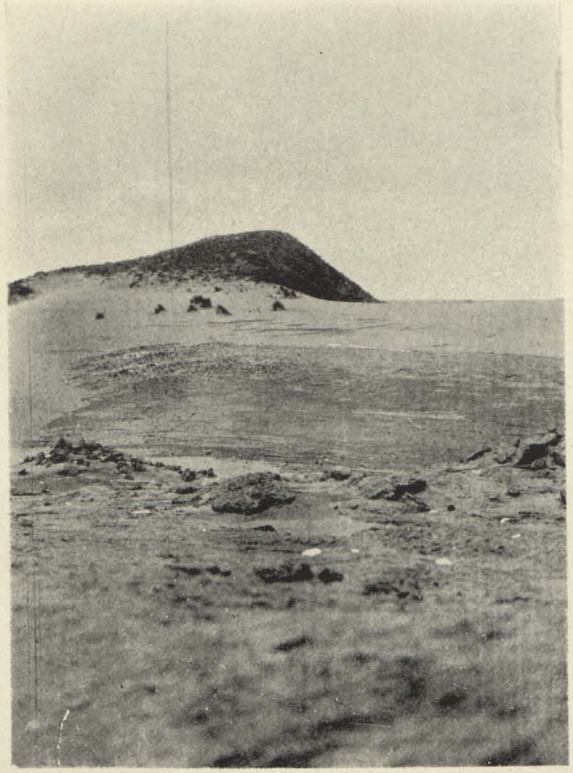

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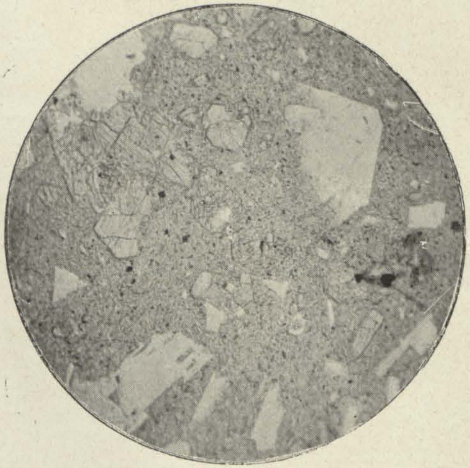
GEOLOGY OF NORTHERNMOST NEW ZEALAND.—Bell and Clarke.



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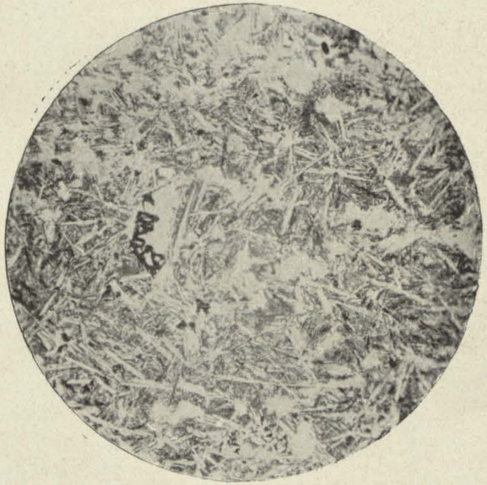

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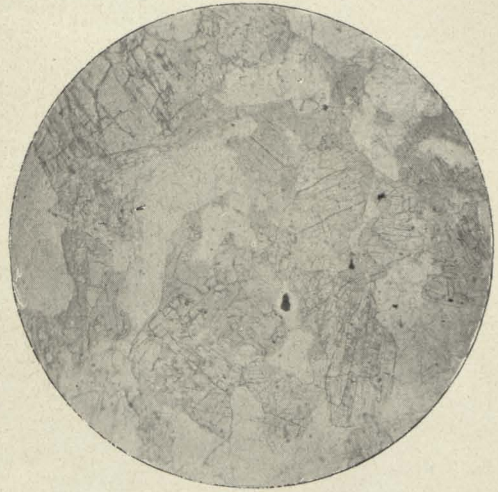

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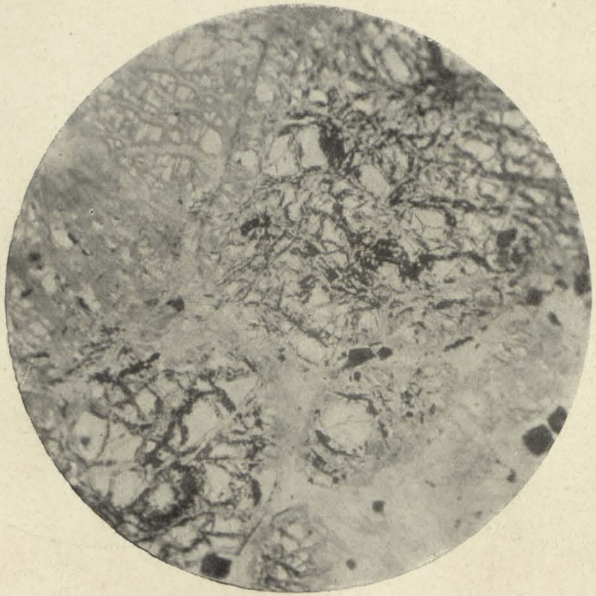
GEOLOGY OF NORTHERNMOST NEW ZEALAND.—Bell and Clarke.



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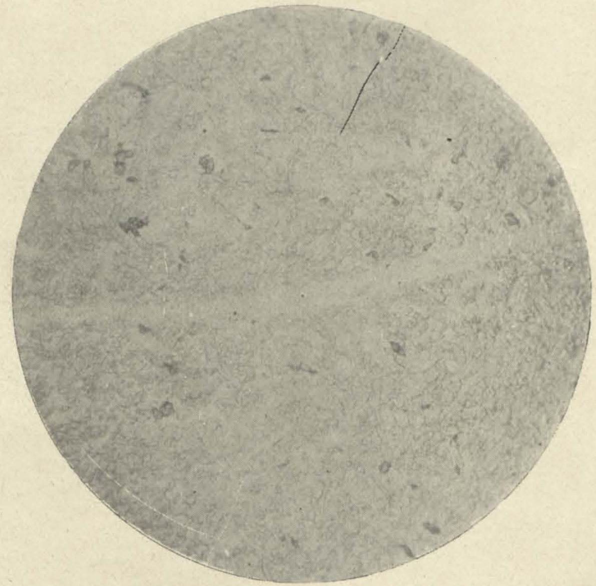

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GEOLOGY OF NORTHERNMOST NEW ZEALAND.—Bell and Clarke.