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GEOLOGY OF THE COROMANDEL GOLDFIELDS.

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CONTENTS.

I.—Introduction.

An accurate knowledge of the geology of a goldfield is of such prime economic importance to those engaged in mining operations on that field that a monograph having for its object the amplification and consolidation of our geological knowledge of the Coromandel Goldfield needs, therefore, but little apology.

Though Coromandel is the oldest goldfield in New Zealand, and though nearly five decades have elapsed since its discovery, we have even now no connected plan of its reefs. It is no uncommon occurrence, as many tributers can testify, for a shoot of gold with boundless potentialities of wealth to abruptly end in disused workings, the position of which should years before have been delineated on a public plan. Again, owing to the prevalent impression that the reefs of the Hauraki system were auriferous only when they maintained a north-east and south-west strike, levels were driven north-west and south-east, parallel to Legge's or Hauraki No. 2 reef, which, unearthed by the merest accident, after forty years' prospecting in the district, yielded over £300,000 in three years.

With an extended geological knowledge, the many egregious mistakes committed in the past will be avoided to some extent in the future, and thousands of pounds saved to mining investors.

As will be seen from the appended bibliography of the subject, many geological notices have been made of the Coromandel field. These, however, with but one or two exceptions, have been of the most cursory nature. No geological map of the district was published before 1897, in which year Mr. A. McKay, F.G.S., Government Geologist, and Mr. James Park, F.G.S., each published a map of the Hauraki Peninsula, which includes the Coromandel district. The map of the latter was on a scale of two miles, and that of the former four miles, to the inch, manifestly too small to show detail. The only microscopic determinations of rock-sections are some three or four sections described by Captain F. W. Hutton, F.R.S., in papers read before the Australasian Association for the Advancement of Science.

The recent developments in mining have brought to light many facts of geological interest unattainable when the preceding papers were written, so that, in fine, I have reasonable ground to hope that the present monograph and accompanying maps may throw some light on obscure points, and prove of interest and service.

I take this opportunity of thanking Captain Francis Hodge, John Reilly, Esq., B.A., C.E., and various mine-managers, to all of whom I am indebted for data concerning the auriferous reefs. My thanks are also due to Mr. T. Wrigley, my late laboratory assistant, whose rock-analyses have assisted me considerably in my determinations.

II.—Physical Geography.

The Coromandel Goldfield is situated in the Auckland Province of the North Island of New Zealand, and some forty-five miles east of the City of Auckland. It lies for the most part on the western slope of the main dividing range, and about midway along the western coast of the Hauraki Peninsula, on the shores of the Coromandel Harbour—a landlocked sheet of water accessible at all times. Indeed, Coromandel is, in point of situation, an ideal goldfield. The climate is equable and healthy, water is abundant, and the township within four hours' steam of one of the great traffic-routes of the world—advantages paralleled on few goldfields.

The peninsula at this point has an average width of twelve miles, and is longitudinally bisected by the main Cape Colville or Dividing Range, which at its northern prolongation has, in Te Moehau, a height of 2,950 ft. In the Coromandel area it reaches an altitude at the Tokatea of 1,536 ft., rising over 1,700 ft. above the Success Mine, and falling to 1,200 ft. at the saddle over which the road to Whangapoua and the East Coast passes. It culminates in the south in the high castellated peak of Motutere, or Castle Rock, 1,724 ft. in height.

The sides of the main range are scored by the valleys of the principal streams, and again transversely by the tributary valleys, into which a third system of valleys runs, parallel to the first. The general valley system is, however, masked to a considerable extent, in the case of the smaller valleys, by the dense bush, which also precludes the possibility of accurately mapping the various formations.

Flanking the main range in the north-west portion of the goldfield is a smaller subsidiary ridge with an average height of 350 ft. above sea-level and a general southerly trend. Before reaching the township the ridge bifurcates, the southerly extension terminating at the Kathleen Crown Mine and the south-westerly prolongation at Keven's Point.

Again, in the central portion of the goldfields, the main range is separated from a flanking range, little inferior in height, by the head-waters of the Tiki and Cadman's Creeks, and in the southern area the Waiau River separates a low parallel range from the main Castle Rock Range.

The streams of the district in order from the north are the Kikowhakarere, Kapanga, Karaka, and Waiau on the western slope, and the Harataunga, Waikoromiko, and Waitekauri on the eastern aspect. Of these, the Waiau is the longest and carries the greatest volume of water. All, however, are short in course, falling sharply from their sources until the alluvial flats are reached, and thence meandering to the sea.

Alluvial flats occupy a considerable portion of the area under discussion. These are all derived from the denudation of the adjacent hills, owing nothing to marine action. On the northern extremity of the main alluvial area the township of Coromandel is built.

III.—History of the Goldfield.

Coromandel Harbour was well known to the navigators of the early years of this century, and many visits were made in order to recruit ships' crews, and also to obtain spars (kauri) for the navy. It is to one of these ships, the "Coromandel," which entered the harbour in 1820, that the district owes its name.

It was not, however, until 1852 that any suspicion of the auriferous nature of the district was entertained. In that year a Goldfields Reward Committee was formed in Auckland, and offered £500 for the discovery of a payable goldfield in the northern portion of the Island. This reward was immediately claimed by Mr. Charles Ring, an experienced Californian digger, who, in support of his claim, produced auriferous quartz and gold-dust obtained from the Kapanga Stream, Coromandel. The report of the Reward Committee confirmed the existence of gold, but, not being satisfied as to the payable nature of the field, withheld the stipulated reward.*

A rush immediately set in, and in a month three thousand diggers were at work. Even at that early stage of operations it was discovered that the auriferous areas were non-continuous, and, as a result, camps were formed at Coolahan's Diggings (now known as the Upper Township of Coromandel), and at the Waiau Diggings, along the course of the Waiau and Matawai Streams. The results were very disappointing, and after six months the digging population melted away, having obtained gold valued at about £1,200—the largest nugget, valued at £10, being a "shoading" from an auriferous quartz reef.

Though not the first highly payable field, yet Coromandel may lay claim to be the oldest goldfield of New Zealand, the rich alluvial deposits of Gabriel's Gully, in Otago, being discovered nine years later—viz., in 1861.

Further exploitation of the field was prevented for many years by the threatening attitude of the Natives, but in 1861 a new rush set in, and in 1862 the district was proclaimed a goldfield. The Kapanga (Scotty's) area then became the scene of great activity, and many rich "pockets" were discovered, the most notable of which yielded 2,198 oz. gold from 1,706 lb. quartz, and 1,120 oz. gold from 40 tons quartz. One mine obtained in ten months £7,143 of bullion.†

Work was carried on vigorously with more or less satisfactory results until 1866, when the discovery of the wonderfully rich goldfields at the Thames, thirty-five miles to the south, deprived Coromandel of the greater part of its digging population.

In 1869–70 a fresh impetus was given to mining in Coromandel by the discovery of gold on the Tokatea Range by a party of prospectors, who, with wonderful assiduity, had followed up the faint trail of gold from the Harataunga Creek until they unearthed the rich quartz leader now known as the Tokatea reef. From this reef phenomenally rich yields of gold were obtained. The Tokatea No. 1 reef or Tribute leader, though only 250 ft. to the south and equally rich, was not discovered until some three years later. It is curious to record that, notwithstanding the richness of these

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* Hochstetter: "Reise der Novara," English edition, pp. 94–98.

† Hector: "Geology of the Cape Colville District," Progress Report, New Zealand Geological Survey, 1870.

reefs, the original prospectors, in working upwards from the low grounds towards the outcrops of the reefs, found but a stray colour here and there as a reward of many dishfuls of soil "panned off." A further fillip to the industry was furnished in 1872 by the discovery of the famous Green Harp shoot of gold in what is now the Union Beach section of the Hauraki Mine. This yielded over £40,000 of gold.

After this period the yield of gold gradually decreased, and there is nothing of note to record until 1885, when a mild rush to Blackmore's Find at the Tiki took place. Vigorous prospecting here, however, gave but poor returns, and the field generally declined until the discovery of Legge's rich tribute leader in 1895. From this leader over three hundred thousand pounds' worth of gold has been taken, precipitating the recent boom, with its attendant pegging-out of mining claims, and consequent prospecting. Unfortunately, no new finds of importance have been made in the Coromandel area, and attention is now solely directed to the old-established centres—viz., Tokatea, Kapanga, Hauraki, and Tiki.

IV.—Previous Geological Investigations.

The first geological notices of the Coromandel Goldfields were contributed by Major Heaphy in papers read before the Geological Society of London in 1854 and 1855. In these papers, however, the author falls into the error of describing the Miocene trachytic and andesitic breccias at the entrance to the harbour as granite and granite porphyry.*

In June, 1859, however, Coromandel was visited by a geologist of some repute, in the person of Baron Ferdinand von Hochstetter, who was then accompanying the Austrian frigate "Novara" on a voyage of scientific discovery. He described the trachytic breccias of Beeson's Island, at the mouth of the harbour, but stated they were intruded by doleritic and basaltic dykes; and, further, that the auriferous reefs occur in the Palæozoic clay-slate formation—that is to say, in the beds which he afterwards grouped with his Maitai series.† In this connection, though it has been found of recent years that reefs in the slaty shales are auriferous in the Tokatea area, yet no auriferous reef in the slates could possibly have been exposed at the time of this visit, and it is now quite certain that the gold to which he refers was shed into the creeks from reefs, not in the Palæozoic slates, but in the decomposed volcanic andesites or porphyrites (propylites of Park).

Five years later, and again in April, 1868, Sir James Hector visited the field. The rock at Keven's Point (Hauraki area) he then described as a light-grey tufaceous porphyry, probably an original claystone porphyry, decomposed along fissures to a mottled pipeclay. Though reefs had been found in this area, they were, so far as was then known, barren and worthless. On the occasion of Dr. Hector's second visit, in 1868, he collected, for the first time in New Zealand, specimens of native arsenic. These came from the 300 ft. level of the Kapanga Mine. At the same time he re-examined the Tokatea, Kennedy Bay,‡ Whangapoua, and Tiki districts.

In November, 1880, Mr. S. Herbert Cox, F.G.S., then Assistant Geologist, examined the field with a view to determining the age of the auriferous series. The trachytic breccias (Beeson's Island beds) were correlated with the Tertiary breccias of the Manukau Heads, to the west of Auckland, making them younger than the main auriferous andesitic series, and also younger than the coal series of Cabbage Bay. On examining the sedimentary beds in the Torehine section, he concluded that the main auriferous series was overlain by the Lower Eocene beds, and hence was Pre-tertiary. As will be seen later, this view is not supported by other observers. Re-examining the Tokatea district in 1882, he came to the conclusion that the felsite (felsitic tuff of Hutton) must be grouped with the underlying slaty shales, and not with the overlying volcanic series.§

The first correct interpretation of the Torehine section was made in 1883 by Mr. A. McKay, F.G.S., who considered the main auriferous series to unconformably overlie the upper limestone beds, and hence to be later than Lower Eocene (Cretaceo-tertiary of the New Zealand Geological Survey).||

In a paper read by Professor Hutton before the Australasian Association for the Advancement of Science are the first published notes on the micro-petrology of the district, sections of an augite and a hornblende andesite from Coromandel being described.¶

Mr. James Park, F.G.S., in 1897 published a report on the Hauraki Goldfields, which include Coromandel, dealing briefly with the formations and the most important reefs.**

In 1897 also appeared the most comprehensive report on the Hauraki Goldfield yet published††—namely, that by Mr. A. McKay, F.G.S., Government Geologist, who in a reconnaissance survey mapped out the boundaries of the various formations; and it is to this report that we are indebted for our first detailed information on the distribution of the various beds throughout the peninsula. Mr. McKay, however, divides the auriferous andesitic series into upper and lower divisions, or the Thames-Tokatea and Kapanga series—a position which appears to me to be quite untenable, for reasons that will be detailed at a later stage.

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* Heaphy: Q.J.G.S., Vol. x. (1854), p. 311, "On the Coromandel Goldfields"; Vol. xi. (1855), p. 31, "Gold-bearing District of Coromandel Harbour, New Zealand."

† Hochstetter: "Geology of New Zealand," pp. 14 and 51, Auckland, 1864; "Reise der Novara," Geologischer Theil, I. Band, p. 24, Wien, 1864; "New Zealand," p. 94, Stuttgart, 1867.

‡ Hector: Progress Reports, Geological Survey, 1866–67, p. 32; 1868–69, p. viii.

§ Geological Reports, 1881, p. 36; 1882, p. 4.

|| Geological Reports, 1885, p. 192.

¶ Trans. Aust. Assoc. Adv. Sci., Vol. I., p. 245.

** "Geology and Veins of the Hauraki Goldfields," Auckland, 1897.

†† "Report on the Geology of the Cape Colville Peninsula, Auckland"—C.-9 of 1897.

V.—Table of Formations.

Formation.	*Characteristic Rocks.*
6. Carboniferous (Maitai slates of Hochstetter) ..	Slaty shales, graywackes, sandstones, crushed breccias, felsites and felsitic tuffs.
5. Lower Eocene (Cretaceo-tertiary of Geological Survey Department)	Clay marls, slate conglomerates, foraminiferal limestones, with small coal-seams.
4. Upper Eocene or Oligocene	Andesites (augite and hornblende) fresh and decomposed, fine-grained tuffs.
3. Miocene	Trachytic and andesitic agglomerates, breccias, and dykes.
2. Pleistocene	River-terraces, lacustrine beds.
1. Recent	Alluvial flats, harbour-muds, swamp-deposits.

In the above table I have included the Lower Eocene sedimentary beds of Cabbage Bay, which, though lying several miles to the north of the district under consideration, are yet essential to the correct interpretation of the homotaxial relations of the beds to be discussed.

VI.—Carboniferous (Maitai) Slates.

These rocks, so far as is yet known, form the basement rock both of the Cape Colville Peninsula and of the North Island of New Zealand. They are the Maitai slates of Hochstetter, forming part of one of the most important groups in the New Zealand sequence, giving rise to the chief orographical features in the North, and playing no inconsiderable part in the mountain structure of the South Island. In the former region they consist exclusively of fine-grained argillaceous slates, but on the west coast of the South Island—viz., at Reefton—they pass downwards conformably into a fossiliferous limestone, the nature of the contained fossils sufficiently indicating the homotaxial relations of the beds. The most important fossil forms are *Productus brachythærus*, *Spirifera glaber*, *S. bisulcata*, *Cyathocrinus*, and *Cyathophyllum*. At Reefton the slates overlying the limestone contain auriferous reefs which have been worked with very satisfactory results.

So far, no distinct fossils have been discovered in the slaty shales of the peninsula, or of the North Island, though indistinct markings which may be of organic origin are mentioned by Mr. James Park, F.G.S., from Tararu, Thames, and from Stony Bay, beyond Port Charles.

In the Coromandel district these rocks consist of fine-grained dark- or light-coloured graywackes and slaty shales and coarse sandstones, together with interbedded sheets of a volcanic rock, which, from its felsitic nature, and from the preponderance of soda in the alkalies, I have termed a ceratophyre. The shales weather readily into a yellowish-white thin soil, forming very poor land. In places, so stained with percolating iron solutions from the adjacent volcanic rocks are the clays, and so brilliant are the blue and red hues resulting therefrom, that they may easily be mistaken for andesitic decomposition products.

The most northerly outcrop of the Palæozoic rocks is in Paul's Creek, which falls into Koputauaiki Bay, about three miles north of the township. Here they are exposed in the bed of the creek for a considerable distance, and consist of slaty shales interbedded with soda-felsites or ceratophyres. To the east and south-east they are overlain by the tuffs and andesites of the Kapanga area. Proceeding east the slaty shales are next met with in the low levels driven into the Tokatea Hill, interbedded with a felsitic rock, which is exposed on the surface on the eastern slope of the ridge, extending from the Tokatea saddle to the Kennedy Bay Flat. The upper portion of this area is traversed by a dyke-like mass with a north-to-south course, and a dip to the west. In this rock, as first pointed out by Mr. A. McKay, bipyramidal crystals of quartz occur, and the rock may well be termed a quartz-porphyry. It is apparently intrusive through the surrounding felsitic area. Running parallel and some 20 chains to the west is the main Tokatea reef, and it is worthy of notice that from the area between the dyke-mass and the reef nearly all the gold from the Tokatea Goldfield has been recovered. (See Fig. 1.)

On the western slope of the main range the slates are exposed by a level in the Pigmy Mine, 1,000 ft. above sea-level, and this height represents probably the extreme height to which the slaty shales reach in this quarter.

Mr. James Park, F.G.S., in a report on the Hauraki (Cape Colville) Peninsula, mentions an exposure of slate south of the Kapanga shaft. Here the clays are bright-hued, and resemble much the decomposition product of the slaty shales, but that it is a slate area is disproved by the mine-workings beneath, which are all in decomposed andesite.

The slaty shales are, however, exposed in the creek behind the Upper Township, and from thence outcrop, gradually increasing in breadth south-east for a distance of four miles and a half. Behind the Buffalo Reserve the outcrop is about 30 chains wide, while on the road to the Success Mine the breadth of outcrop is about half a mile, and reaches from 350 ft. to 600 ft. above sea-level. The upper surface of the slaty shales is here well marked by the presence of lacustrine beds of small extent and thickness, including fine-grained clays, fine earthy conglomerates, and small coal-seams. Similar beds occur also further to the south, and overlying the slaty shales. On the Kuaotunu Road the slates have a width of 80 chains, and rise from the alluvial flat to a height of 1,000 ft. The long tongue running out into the alluvial flat south of the Kapanga Township is composed of slaty shales. The exposures along the Kuaotunu Road show the slaty shales weathering to reddish-brown or brown to yellow clays.

In the Karaka Creek, further to the south, the slates may be traced toward the source as far as the falls, which are of considerable height. About 10 to 20 chains above the falls the slate gives place to the overlying volcanic rock. At the junction, and near it, occur several reefs containing a notable percentage of galena and copper ores. These will, however, be described in a later chapter.

Following the base of the hills from the Karaka Creek, the slaty shales are seen to occupy the beds of the several creeks as they debouch on the alluvial flat. From Elmslie's Creek the boundary of the slates curves to the south-east, and crosses the ridge into the Tiki Creek. Proceeding up the Tiki Creek the dip of the slaty shales is south-east, and the strike north-east and south-west; and a short distance further up, at the junction of the Tiki and Pukewhau Creeks, the soda-felsite or ceratophyre of the Tokatea is found to be interbedded with the slates, standing out above them as a huge dyke-like mass, much as it does in the Tokatea area. The Tiki Creek runs across the strike of the slaty shales for a distance of a mile and a half with the usual scenery of these rocks—deep gorges and numerous rock-pools. For the first 10 chains above the junction with the Pukewhau the Tiki Stream runs along a slickensided fault wall, striking north to south, and dipping west 55° to 60°. The felsite here weathers into a fine grit without clay or mud. Crushed and recemented breccias 2 ft. wide are met with along the course of the creek. The strike of the slates in the upper portion of the Tiki is east-north-east and west-south-west, with a dip to the east-south-east at high angles, giving a thickness in this section of not less than 5,000 ft.

On the Pukewhau track to Opitonui the slaty shales rise from the alluvial flat, and at a height of 770 ft. above sea-level are traversed by the Castle Rock dyke. At 950 ft. they culminate on the Pukewhau saddle. From the Pukewhau they may be traced to the Matawai, where they have much the same breadth of outcrop as in the Pukewhau area. At the Matawai Falls, however, the Palæozoic rocks are composed of false-bedded sandstones overlying a softer band of slate.

In the Awakanae Creek, a short distance from the mouth, an outcrop of the slaty shales occurs, which persists nearly to the source. The shales are here regularly bedded, and strike north-north-east and west-south-west, and dip north-north-west at steep angles, thus apparently forming a syncline with those of the Pukewhau and Matawai districts. The beds are composed of alternate coarse- and fine-grained sheets, varying from 2 in. to 6 in. in width. From the Awakanae the shales extend south to the Mill Creek. In this Palæozoic area the soil is devoid of bush and scrub, and the shales may be traced by the yellowish-white soil, poor herbage, and generally barren appearance. The overlying volcanic rocks, on the other hand, weather to a deep brownish-red ochreous soil, carrying a rich, green sward.

The junction between the shales and volcanic rocks may be easily distinguished along the course of the Mill Creek. In the andesites the valley is broad, shallow, and straight, but on passing into the slates it abruptly becomes narrow, deep, and sinuous, as shown in Fig. 2.

In the Mill Creek the slates strike north to south and dip west, but are evidently much disturbed.

On the Thames Road, a few chains to the north of the Mill Creek Bridge, they consist of fine-grained slates and overlying coarse sandstones. The underlying slates are considerably contorted. From this point the slate outcrop runs south out of the area under discussion.

A microscopic section of the above sandstone throws some interesting light on its origin. It is a dark-coloured even-grained rock, which under the microscope is seen to be composed of rounded and subangular fragments, cemented by a dark siliceous base. Quartz in rounded grains is fairly abundant, showing no crystallographic contours. Orthoclase is present, showing Carlsbad twins. A single fragment shows polysynthetic twinning, and is an albite felspar. Chlorite, resulting probably from the decomposition of hornblende, is present in long green lath-shaped crystals, exhibiting feeble dichroism from pale-green to dark-green. The most interesting fragments, however, are the inclusions of an ancient rhyolitic flow. These are from 1 to 2 mm. in diameter. In them the lath-shaped felspars are set with their longer axes approximately parallel, indicating the direction of flow of the ancient lava. When the lath felspars encounter a porphyritic crystal they curve round it and resume their parallelism on the farther side of the crystal, as exemplified in many modern rhyolites. The section, therefore, indicates that the slates and sandstones derived part of their materials from the denudation of an ancient acidic volcanic district.

Further evidences of the existence of contemporaneous volcanic outbursts are supplied by the interbedded ancient lava-flows of the Tiki Creek, the Tokatea Hill, and Koputauaiki Creek. In the Tiki Creek they are seen to be both underlain and overlain by black slaty shales, and to have a dip corresponding with that of the shales. The ceratophyres weather to a homogeneous rock by the elimination of the porphyritic felspars, and of the ferro-magnesian silicates, revealing then but little evidence of their igneous origin. The freshest specimen of this rock collected was from the No. 7 level of the Royal Oak Mine, Tokatea. It is a compact, whitish rock, translucent on thin edges, and breaking with a subconchoidal fracture. In thin sections under the microscope the base is felsitic, consisting of a cryptocrystalline aggregate of quartz and felspar, the result of devitrification. The felspars are large, varying in length and breadth from 2 to 4 mm. Polysynthetic twinning is abundant, and the extinction angle, 14°, indicates an acid type of felspar. The larger phenocrysts show zonal banding; some, however, are so much decomposed that they can be traced only by the outlines of their decomposition products. The ferro-magnesian silicate originally present has weathered, or rather decomposed, to chlorite, magnetite, and iron-pyrites, the magnetite occurring mainly along the crystal edges. On analysis, the rock gave the following percentages:—

Silica (SiO_2)	59·35	per cent.
Alumina (Al_2O_3)	21·30	„
Iron-protoxide (FeO)	10·06	„
Lime (CaO)	1·58	„
Magnesia (MgO	0·48	„
Potash (K_2O)	0·34	„
Soda (Na_2O)	7·68	„
	100·79	

The presence of a soda-lime felspar, together with the preponderance of soda, as shown by the above analysis, will therefore bring this rock under the group of ceratophyres (keratophyr), and I have named it accordingly.

The uppermost horizon of the slates on the Tokatea is occupied by a clastic rock which is evidently derived from the waste of the above or similar rock. Under the microscope it appears as a fine-grained aggregate of quartz and felspar—a true graywacke. The analysis shows as follows:—

Silica (SiO_2)	60·42	per cent.
Iron-protoxide (FeO)	6·36	"
Alumina (Al_2O_3)	18·40	"
Lime (CaO)	2·31	"
Magnesia (MgO)	2·15	"
Potash (K_2O)	2·97	"
Soda (Na_2O)	7·22	"
	99·83	

On comparison with the analysis of the ceratophyre it will be seen that in all essential points the two rocks show a marked correspondence.

My analysis also of the underlying black slaty shales corresponds very fairly with both the above, and this somewhat unexpected result would tend to show a common origin for the whole series.

Silica (SiO_2)	59·80	per cent.
Iron-protoxide (FeO)	12·51	"
Alumina (Al_2O_3)	19·40	"
Lime (CaO)	2·10	"
Magnesia (MgO)	1·18	"
Potash (K_2O)	1·18	"
Soda (Na_2O)	4·38	"
	100·55	

VII.—Lower Eocene Strata of Cabbage Bay.

These beds, though lying some six or seven miles to the north of the Coromandel Goldfield, must yet be included in treating of the geology of the field, since they furnish the best evidence of the age of the auriferous volcanic series, which extends continuously to and beyond Cabbage Bay.

At Torehine, on the coast, the dense bush and scrub prevents the tracing of the junction of the sedimentary and volcanic rocks; and further inland, on the Umangawha Creek, running into Cabbage Bay, the small patches of sedimentary rocks are so much disturbed that it is almost impossible to trace their stratigraphical relations to the volcanic series, so that these volcanic beds must be correlated rather by negative than by direct evidence.* The negative evidence is, however, of its kind, fairly conclusive.

The sequence disclosed along the coast-line from Tawhetarangi to Torehine shows the beds to be dipping north-north-west at low angles. The lowest member of the series is a sandy marl containing numerous dicotyledonous leaf-impressions, and also numerous casts of small lamellibranchate mollusca.

The marls are, in all probability, estuarine. Synchronous, or possibly overlying, is a thick bed of conglomerate, consisting of water-worn pebbles from the Palæozoic slaty shales. Though the most diligent search was made, no trace of volcanic rock was found in the conglomerate, thus proving, at the least, that the river that brought down the conglomerate did not flow through volcanic deposits. Since at the present day volcanic rocks flank these sedimentary strata on three sides, it is difficult to imagine that, had the volcanic rocks been deposited prior to the conglomerates, the latter would not have contained some pebbles from the former.

Overlying the conglomerate, and dipping north-north-east, are fine sandy clays containing *Ostrea wullerstorfi*. These are generally covered with recent beach-sand, but, under favourable conditions of wind and tide, are occasionally exposed for a distance of 2 to 3 chains. These beds dip at a low angle, and pass imperceptibly into a highly calcareous sandstone containing *Turritella gigantea; Fusus sp.*, *Cucullæa sp.*, and *Pentacrinus stellatus*. The next highest member of the series is a foraminiferal limestone, which is exposed on the beach for a distance of 3 chains. This, the highest of the series, is also met with in Anthony's Creek, reaching back from the sea for about a mile in places, forming characteristic limestone outcrops. Everywhere the limestone is composed of foraminifera, interspersed throughout with the column-joints of *Pentacrinus stellatus* and with occasional teeth of *Lamna huttoni*. The total length of exposure along the coast is approximately a mile. At about a mile and a half inland Miocene breccias overlie directly, so far as can be seen, the sedimentary series.

Another sequence of sedimentary rocks is exposed towards the head of the Tawhetarangi Creek, but here the conglomerates are absent, and are replaced by blue sandy marls thickly studded in places with *Ostrea wullerstorfi* and *Cucullæa*. Here also occurs a thin seam of coal together with carbonaceous shales. As exposed the coal-seam is small and of little importance, but the carbonaceous shales contain from 2 to 4 per cent. of heavy hydrocarbon oils and the same quantity of

* Mr. A. McKay, F.G.S., however, informs the author that he has discovered a section at Cabbage Bay which leaves no doubt of the superposition of the volcanic series.

light oil, and hence may be of economic value for their distillation products. Associated with the carbonaceous shales are blue marls containing numerous Lamna teeth, generally blue with an incrustation of vivianite.

On the other side of the range, as shown in the accompanying plan, the limestones, clays, and coal-seams outcrop at about the same height (600 ft. to 700 ft.) as in the Tawhetarangi Creek. The most important coal-seam was about 5 ft. thick when first opened up, with an average north-east and south-west strike, and a flat dip to the east. On further working the seam soon diminished in size to a mere carbonaceous parting. The coal-measures, moreover, are here but a short distance above the slaty shales—a fact which, of course, precludes the possibility of a payable coalfield being developed.

The following is an average of several analyses of these coals made by the author :—

Fixed carbon	56·66 per cent.
Hydrocarbons	2·81 "
Water	4·77 "
Ash	35·76 "
	100·00

Evaporative power: 56·66 × ·13 = 7·36 lb.

The fossils enumerated above assign to the sedimentary beds a position at the base of the Tertiary rocks, and they may hence be grouped with the Oamaru series of Hutton or the Cretaceo-tertiary series of the New Zealand Geological Survey.

Recently, however, the author has discovered a hitherto unknown outcrop of these beds at Waiaro, about four miles to the north of Cabbage Bay. It is situated at an elevation of 1,200 ft. above sea-level, and consists, so far as could be seen—for the dense bush renders investigation very difficult—of blue clays and shales, together with several seams of coal, the largest of which is 5 ft. in thickness. The lowest member of the series is a bed of blue shaly clay, which rests directly on the Palæozoic clay slates, here weathering to a white friable rock. At 40 ft. above the Palæozoic rocks is the main coal-seam, striking north to south, and dipping east at a fairly high angle. Above the main coal-seam are clays similar to those underlying, and containing small coal-seams and carbonaceous bands, and also a fine band of slate conglomerate corresponding to and closely resembling that occurring at Torehine, but differing in being composed of finer pebbles. The line of outcrop is approximately horizontal, and was traced for a distance of nearly a mile along the western slope of the range. The approximate thickness of the beds is 150 ft. (See Fig. 3.)

The coal in the large seam is highly carbonaceous, analysing as follows :—

Fixed carbon	82·47 per cent.
Hydrocarbons	6·53 "
Water	0·50 "
Ash	10·50 "
	100·00

The remarkable percentage of carbon in coal from this horizon seemed at first to indicate the presence of a dyke, metamorphosing the brown coal into its present anthracitic state; but on further investigation nothing of the sort could be found. It is therefore probable that the alteration is due to thrust movement along the coal-seam, and this is the more probable as the coal is parted by parallel layers of graphite which may represent the planes of movement.

Associated with the coal, and in dark carbonaceous shales, are well-preserved plant-remains, with the following characteristics: Fronds pinnate, probably of considerable length. Pinnæ narrowly lanceolate or obovate, some acutely pointed, some rounded at the ends. Texture probably coriaceous. Edges entire or finely toothed. Two distinct forms of pinnæ, possibly barren and fertile. Secondary nerves fork at an acute angle. (See Fig. 4.) This form I consider identical with the *Blechnum priscum** of Ettingshausen (*Alethopteris* of Hector?), allied to the living *B. occidentale* indigenous to Central America, and to the fossil *B. atavium* (Sap.) from the Sezanne beds. Forms also occur which may be referred to *Flabellaria sublongirachis* (Ettingsh.) and *Bambusites australis* (Ettingsh.). In a carbonaceous band found near the top of the series numerous dicotyledonous leaves occur which may be referred to *Fagus*. (See Fig. 5.)

On the whole, the above forms resemble markedly the fossil flora of the Pakawau beds, Nelson Province. Von Ettingshausen very strongly insisted on a Cretaceous age for these Pakawau beds, which are placed by the New Zealand Geological Survey at the base of the Cretaceo-tertiary. These land-fossils at Waiaro therefore contradict somewhat the evidence of the Torehine marine fossils, which are undoubtedly Lower Tertiary in age. Still, the Waiaro beds are certainly lower in horizon than the calcareous sandstones and limestones that furnish the Torehine fossils if these outcrops may be correlated by the bed of slate conglomerate—the lowest member at Torehine, and yet occupying a fairly high horizon at Waiaro.

VIII.—Upper Eocene Volcanic Rocks.

This series is by far the most important in the Coromandel area, containing as it does the principal auriferous reefs. It consists of lavas, tuffs, and breccias, for the most part highly decomposed, but in places solid and unaltered. Dykes of this age are absent, or at any rate have not been recognised; the "dykes" of the miners consisting merely of zones of unaltered lavas. When fresh the andesites are dark-coloured, in places almost black, with no porphyritic constituents. A

* Ettingsh: Transl. Beitrage zur Kentniss der Fossilen Flora Neueeslands, Wien, 1887.

few exposures, however, show a dark-grey andesite, which owes its light colour to the predominance of porphyritic plagioclase felspar. The latter form weathers to a light-grey to greenish-grey incoherent rock—the "sandstone" of the miners; the former often to a brownish-red or brownish-yellow clay.

The eruptions of this period seem to have produced lavas remarkably deficient in steam and in other vapours, for vesicular structure—and consequent amygdaloids—is entirely absent. The whole faces of the lavas of this period indicates a flow such as might emanate from a fissure rather than from separate vents, and the few tuffs and breccias met with result, I am inclined to think, from parasitic cones on the lava-flow, and not from the main fissure-vent.

Mr. A. McKay, F.G.S., Government Geologist, separates the auriferous andesites of the peninsula into two groups *—a lower or Thames-Tokatea group, and an upper or Kapanga group; at the same time admitting that the rocks of the two groups are indentical both in petrological and lithological characters.

In this determination he relies on the following conclusions, which I will traverse seriatim :—

(*a.*) The greater alteration of the rocks of the Thames-Tokatea group is a proof of greater antiquity. While admitting a greater alteration in a limited area on the Tokatea ridge, yet further south—viz., near Castle Rock—we find andesite on the same horizon as the Tokatea perfectly fresh and undecomposed, proving at the least that the greater alteration is not universal. Again, speaking generally, the Thames-Tokatea group of Mr. McKay occupies a more elevated position than the Kapanga group, which is disposed nearer to and at sea-level. Hence, since it follows that the more elevated rocks must, other things being equal, suffer greater decomposition owing to the unrestricted circulation of percolating waters, the Thames-Tokatea group—*i.e.*, the andesites on the higher levels—may be expected to show greater alteration than the Kapanga andesites, or those on the lower levels.

(*b.*) The evidence of cessation of eruption furnished by the fine coal-seams in the Triumph Mine, and elsewhere to the north of the Coromandel area, is a proof of unconformity. This cessation need not, however, have been of very long duration, geologically speaking. After the Krakatoa eruption of 1883, when more than two-thirds of the island was blown away, and all vegetation entirely obliterated, it was found that in 1886—in three years' time—an abundant vegetation had established itself on the decaying green algæ†; and it might well be that the carbonaceous beds, or rather partings, in the Triumph Mine took no longer than a hundred years to form—a period certainly not of sufficient duration to constitute a geological unconformity. At any rate, no greater lapse of time can be proved by these carbonaceous partings than the actual time required for the growth of the vegetation from whence they have been derived.

(*c.*) Proofs of long-continued denudation after the deposition of the Thames-Tokatea group, and before the eruption of the Kapanga rocks. Mr. McKay's arguments are, briefly, two in number: the first, that since the deposits of the Thames-Tokatea group were piled up along the higher part of mountain-range (of which there is no proof, to the best of my belief), the slates of the western portion of that supposititious range—for I am inclined to believe that the first eruptions were submarine rather than subaerial, and in this belief I am supported by the evidence of the marine beds of Torehine—could not have escaped covering by the Thames-Tokatea group, and that, therefore, this covering must have been eroded long before the deposition of the Kapanga group of rocks, an operation which would necessarily occupy a considerable time. But this presupposes that the total elevation of the peninsula took place prior to the eruption of the Kapanga group, and that no elevation was concomitant with the Kapanga eruptions or those of the Miocene times; for, if otherwise, since the slates are now only 1,000 ft. above sea-level, and apparently no depression has taken place, the slates could have been no higher than, say, 500 ft. above sea-level at the commencement of the deposition of the volcanic rocks, and the mountain-range postulated would then be non-existent.

Mr. McKay's second argument in favour of long-continued denudation is based on the presence of rolled boulders, &c., in the Waiau Valley, at the base of his Kapanga group. I am not clear as to the exact position of the section from which Mr. McKay made his determination, and can therefore say nothing on this point. From Mr. McKay's own account, however, these are of no great thickness.‡

I have endeavoured to briefly state Mr. McKay's arguments as fairly as possible, and have also set down the objections that have occurred to me. Taking into account, therefore, the identical petrological and lithological characters of the rocks, and the absence of a well-marked geological unconformity, it appears to me reasonable to group the whole of the andesites together as manifestations of an eruption confined to a single geological period.

In the Tokatea district, next to the east, the andesites have now but a small development, the ancient extensive flows which were deposited along the Success Range being almost wholly removed by the agents of denudation. South of the hotel, and along the extreme crest of the ridge, they have a width of 1 to 5 chains, and are disposed as a southern prolongation of the main northern or Triumph area. They are also preserved in a small area on the eastern aspect of the range below the Tokatea Hotel. On proceeding eastward along the Waikoromiko track the andesites become more solid, and two miles from the ridge they are dark-grey, porphyritic, and undecomposed, which features they maintain as far as mapped in that direction.

The auriferous andesites occupy nearly the whole breadth of the northern extremity of the area under discussion. They consist in the west of great flows of a dark-grey pyroxene andesite,

* "Report on the Geology of the Cape Colville Peninsula, Auckland,"—C.-9 of 1897.

† M. Treub.: "Notice sur la nouvelle Flore de Krakatoa," Ann. Jard. Bot. Buitzonzorq, Vol. xii., p. 213, 1888.

‡ Since writing the above, Mr. McKay informs me that, on further investigation, he is inclined to abandon this argument.

forming a bluff 500 ft. to 600 ft. in height, about half a mile to the west of the Kapanga shaft. The lavas here are rudely columnar, the columns being, on an average, 1 ft. in breadth. The flows are dipping south at angles approximating to 45°.

The rocks of the Kapanga and Scotty's Mines are fine-grained tuffs, interstratified with solid flows of a dark hornblende andesite. The breccias and lava dip to the south-west and south at low angles. They are overlain to the west by the Miocene breccias of the Blagrove's Freehold Mine. Through the older tuffs and lavas the Kapanga shaft has been sunk to a depth of 1,000 ft., and from the bottom of the shaft a borehole has been put down for 150 ft., making 1,150 ft. in all. The last 500 ft. to 600 ft. was sunk entirely through tuff beds.

From the main northern mass of andesites several tongues run south and south-west. Of these the most westerly runs through Dacre's Hill and through the Hauraki district, touching the sea to the south of Paraparakino, where the andesites weather by the removal of the interstitial matter, thus leaving each felspar isolated on its little pedicel of rock, and glistening in the sun like scales of mica. The rock of the south-east slope of Dacre's Hill is obscured by scrub and surface clays, but at the summit the bare outcrop forms a scree on the southern slope. The rock here is solid, dark-coloured, and breaks with a conchoidal fracture. Under the microscope the rock appears to be an augite-andesite.

The major portion of the Hauraki area next to the south is composed of a highly decomposed andesite, probably augitic, but the nature of the ferro-magnesian silicate is a matter of some doubt, owing to the difficulty of procuring a solid undecomposed fragment. A central core of only partially decomposed andesite appears to run from the Hauraki South shaft northward through the Hauraki South, Golden Pah, Hauraki, and Bunker's Hill Mines, approximately parallel with the direction of the ridge.

The second tongue from the main body runs south from the Kapanga shaft along the eastern slope of the ridge, terminating in Trig Hill. The narrow belt consists of highly decomposed andesites, containing reefs yielding small pockets of gold.

A third prolongation, separated from the preceding by the alluvial gravels of the Kapanga streams, reaches as far south as the Kapanga Township. Its andesites are well decomposed, but, so far as is known, this tongue contains no auriferous reefs. The great development of the andesites is, however, in the eastern portion of the Coromandel area, occupying the whole of the range to the east of the Palæozoic slaty shales, and consequently descending on the western slope of the main range to an average height of 800 ft. above sea-level, ranging from 250 ft. behind the Upper Township to 950 ft. on the Pukewhau saddle. In many places along the junction of the slates and andesites the old land-surface is revealed. This is notably the case on the road to the Success Mine, where, in an old basin in the slates, the remnants of lacustrine deposits have been preserved. (See Fig. 6.)

These beds are formed of fine muds and clays and small pebble conglomerates. The pebbles are all of slate, and represent a period of deposition prior to the andesitic eruptions. The lowest beds appear to be fine slate conglomerates, or rather pebble-beds, interbedded with which are fine mud and clay partings about 2 in. in thickness. The coal-seam is 6 in. wide where exposed, but it will, of course, thin away to a feather edge on being opened up. The total thickness of the beds may be 20 ft. to 30 ft.

Throughout the eastern area of the volcanic rocks they are everywhere in the form of solid lavas, tuffs and breccias being absent. Near the junction of the slate with the andesite in the Karaka Creek is the galena lode previously mentioned. This reef strikes approximately east and west, and is exposed in the bed of the creek. On assaying a bulk sample I obtained the following ore content:—

Metal.	Quantity per Ton.	Value per Ton. £	s.	d.
Silver	2 oz. 14 dwt.	0	7	0
Gold	1 dwt.	0	4	0
Lead	16·8 per cent.	2	17	6
Copper	4 per cent.	2	10	6
Total value per ton		£5	19	0

Given a sufficient quantity of ore, and with efficient concentration, the above lode should yield a handsome profit on outlay. The quantity can, however, only be determined by prospecting-drives.

An isolated exposure of the volcanic andesites is met with in the Preece's Point peninsula, which rises slowly from the alluvial flat, and, reaching an elevation of 200 ft., runs west for nearly two miles. The andesites are well decomposed, and are identical with those of the Hauraki area, of which Preece's Point may be considered as a southern outlier. Small outliers of this rock are met with at the base of the slate hills, containing, as also does the Preece's Point rock, reefs not of a highly auriferous character. (See Fig. 7.)

The andesites, continuing southward, next form the southern extremity of the Tiki ridge, comprising the area known as the "Tiki field," where the quartz reefs contain gold in small pockets.

South of the Waiau Creek the volcanic rocks have a great development, sweeping round to the south-east, and joining the great eastern area, to the obliteration of the Palæozoic slaty shales. At the junction of the eastern boundary of the slaty shales with the andesites are the Matawai and Pukewhau fields. The rocks to the west and south-west of the Waiau Stream rise to a height of 700 ft. to 800 ft. above sea-level, and, so far as is yet known, are non-auriferous. On the western bank of the Awakanae Creek the andesite boulders on the hillside weather in a remarkable manner. Below each boulder concave plates from 6 in. to 2 ft. square and $\frac{1}{16}$ in. to $\frac{1}{14}$ in. thick may be picked up. These plates are apparently quite fresh, and I am disposed to attribute this peculiar form of weathering to unequal contraction and expansion on cooling and heating, the hillside having a northern or sunny aspect. From very large boulders the concavity is very small, and the flakes have approximately plane surfaces.

Mr. James Park, F.G.S., has suggested the term "propylite" for the decomposed andesites of the peninsula. This term was used by Rosenbusch and Becker, and revived later by Professor Judd, to designate andesites altered by solfataric action. As the majority, if not all, of the altered Coromandel andesites have been decomposed not by solfataric action, but by ordinary leaching along reefs and fissures, and by surface-weathering, the above term is obviously inapplicable. The term "porphyrite" has been adopted by some British authors to describe such a rock as the above, but, as the word is used by other authors to designate an intrusive rock intermediate between an andesite and a diorite, and as the latter is the signification generally used by myself, I have adopted throughout this paper the somewhat cumbrous term "decomposed andesite."

The following are the characteristics of the various andesites under the microscope:—

Hornblende Andesite.—Morepork Gully, north of the Kapanga Mine.—Base devitrified, dusky with magnetite grains. Felspars small, and all twinned on the albite type. Extinction angles indicate andesine as the plagioclase. Ferro-magnesian silicates are all decomposed to chlorite, but from the contours were probably hornblende. Magnetite is abundant, resulting from the decomposition of the ferro-magnesian silicate.

In situ this is a hard, black, typical andesite, analysing as follows:—

Silica (SiO_2)	56·93 per cent.
Alumina (Al_2O_3)	23·15 "
Iron-protoxide (FeO)	13·29 "
Lime (CaO)	1·97 "
Magnesia (MgO)	1·22 "
Potash (K_2O)	0·13 "
Soda (Na_2O)	3·38 "
	100·07

Hornblende Andesite. — Steep bluff, half-mile west of Kapanga Mine.—Base devitrified Phenocrysts of felspar all twinned polysynthetically, with extinction angles averaging 20°. The ferro-magnesian silicates comprise hornblende, with strong pleochroisms, well marked resorption border and cleavage-planes. Pleochroism pale greenish-yellow to brownish-black. Augite pale-green, non-pleochroic, and almost colourless.

—— *Andesite.*—Hauraki Mine.—This rock is very much decomposed, the only recognisable constituent being the felspar. Phenocrysts of plagioclase felspar twinned both on the albite and pericline types. Their extinction angles, 20°, indicate a felspar approximating very closely to labradorite.

Augite Andesite.—Dacre's Hill.—Base glassy, crowded with felspar microlites and crystallites. Phenocrysts of plagioclase, abundant, and twinned polysynthetically. Augite abundant, pale-green, non-pleochroic. Quartz occurs as a single large included fragment, hardly justifying the use of the term "dacite" for this rock.

Hornblende Andesite.—Thames–Coromandel Road, over Preece's Point ridge.—Base slightly devitrified, and dusky with inclusions of magnetite. Phenocrysts few in number, and sparsely scattered throughout the base. Plagioclase felspars show albite twinning. A single pale-green phenocryst represents all the original ferro-magnesian silicate present. This is hornblende, with a strong resorption border and distinct cleavage meeting at angles of about 120°.

—— *Andesite.*—Main range, two miles north of Castle Rock.—This is a fine-grained, somewhat decomposed, black rock with a semi-devitrified base, crowded with inclusions of magnetite. The felspars are very small indeed, rarely exceeding $\frac{1}{10}$ in. in length. Phenocrysts are twinned on the albite type, with fairly high extinction angles. All traces of the ferro-magnesian silicates have disappeared.

Hypersthene-augite Andesite. — Awakanae Creek.—Base glassy, little devitrified. Zoned plagioclase felspars twinned on the albite type. Extinction angle 19°, indicating andesine. Zonal inclusions abundant, and disposed peripherally. The ferro-magnesian silicates are hypersthene and augite, the former extinguishing straight, occurring with octagonal sections, and pleochroic in pale-green to reddish-brown colours. The augite is pale-green and non-pleochroic. This is the rock referred to on page 9 as having a peculiar spheroidal manner of weathering.

IX.—Miocene Breccias, Lavas, and Dykes.

These beds unconformably overlie the auriferous andesites, and differ widely from them in petrological and lithological characters. While the auriferous series is built up, in the main, of lavas of a somewhat basic facies, the overlying Miocene beds are composed of a vast agglomeration of coarse trachytic or highly acidic andesite breccias. With the exception of the Castle Rock dyke, they are disposed only around the Coromandel Harbour and along the sea-coast, being typically developed on Beeson's Island, which lies across the mouth of the harbour. They increase in thickness to the south, reaching a maximum thickness about the Manaia Harbour. In many places, notably at the entrance to the Coromandel Harbour, they are seen to be distinctly stratified. (For the section at this locality, see Fig. 8.)

The old crater from whence these deposits emanated is still fairly well defined, but has suffered decay by the erosion of waves impelled by the prevailing north-west wind, and is consequently breached in that direction. The soundings show that the sea-bottom here is cup-shaped, with a maximum depth of 25 fathoms.

North of the typical locality the beds are developed mainly round Kitahi Bay and in Kikowhakarere, where the breccias extend inland for a distance of a quarter of a mile. On the south shore of the bay the coarse breccias overlie a flow of grey trachytic lava rock, which appears to be the lowest member of the series, for here, and also in the two branches of the Kikowhakarere Creek, it rests directly on the auriferous series, and is comformably overlain by the coarse breccias. The latter appear in Long Bay, and form the islands off the mainland (Pita, Surflen, Goat, Rabbit Islands, &c.).

From the lava-flow in Kikowhakarere, which possibly marks the eastern portion of the main volcanic centre of this period, a main fissure was evolved running in a south-easterly direction, at first giving rise to deposits of fine-grained tuffs, but with increasing distance from the point of eruption filling the fissure only with volcanic matter. The fine-grained tuffs are met with along the line of this fissure forming the country rock of the Kathleen Crown, Kathleen, and Blagrove's Freehold Mines, and rising to a height of about 350 ft. on Trig Hill. They evidently thin out to the west, for when passed through in the Kathleen shaft they had a thickness of 168 ft. only. These tuffs are light in colour, with occasionally large boulders or fragments of solid lava, presumably ejecta from the vent. Reefs in this rock, though well defined and well mineralised, are valueless, so far as has been shown by the workings in the above-mentioned mines.

From the Kathleen Crown Mine the course of the fissure is obscured for more than two miles by the recent alluvial deposits, but is again found on the Tiki spur at an elevation of 600 ft. In the bed of the Tiki Creek it appears as a dyke at the junction of the Pukewhau and Tiki Creeks, and by a spur, which, however, does not appreciably stand out above the enclosing slaty shales, crosses the Opitonui Track at an altitude of 770 ft., and has there a width of 2 chains. Crossing the Matawai Creek it reappears on the main range at a height of 1,250 ft. above sea-level. Here the lavas have remained viscid much longer than at other points, and are consequently jointed, containing large hornblende phenocrysts. The dyke forms the spur of the main range for a distance, and finally culminates, as regards height, in Motutere or Castle Rock, 1,724 ft. above sea-level. This is a peak of remarkable outline. Its height is not, of course, remarkable; but, as it rises sheer on three sides for the last 400 ft. of ascent, it becomes a sufficiently striking feature in the landscape. The hade or dip of the dyke is to the south-west at a high angle. The width of the dyke is from 6 to 10 chains. The foot-wall is well defined, but on the south-western or hanging-wall side the junction with the overlying andesites is obscured by talus and dense bush. The rock shows fine jointing at right angles to the walls, and also a coarser jointing parallel with the dip. From the top of Castle Rock the southern prolongation of the dyke may be traced for at least three miles by a succession of bare outcrops. The total length, therefore, of the Castle Rock dyke is certainly not less than nine miles, and is probably about fourteen. The dense bush in the centre of the peninsula prevented further work in this direction of tracing the dyke to its southern extremity.

The general facies of the solid lavas of this period is a light-grey rock, with porphyritic felspars and hornblendes. Neither macroscopically nor microscopically can any distinction be made between the breccia inclusions of Beeson's Island and the dyke matter of Castle Rock. Under the microscope they present features so nearly akin that, to avoid undue repetition, I have grouped their characteristics in one description. Hornblende trachyte: Sections from Kitahi Bay, Long Bay, Little Passage, Beeson's Island, Tiki Creek dyke, and Castle Rock. Base in freshest sections glassy; in others devitrified, abundant. Phenocrysts corroded slightly, otherwise showing well-contoured crystallographic outlines. Felspars: Orthoclase not abundant, except in the section from the Little Passage, where Carlsbad twins are common. A few twinned on the Baveno type (parallel to the clinodome $2\,P\,\infty$). The greater proportion of the orthoclase belongs to the sanidine variety. Plagioclase abundant, twinned polysynthetically; average extinction angles, on sections normal to the albite lamellation, 16°, indicating either albite or oligoclase according to the + or − character of rotation. Inclusions rare. Both plagioclase and orthoclase felspars are strongly zoned; zoning due not to layers of different felspar substance, but to ultra-microscopic twinning. Quartz rare, and doubtfully primary. Ferro-magnesian silicates: Hornblende abundant in long acicular and bladed crystals, occurring in section as six-sided plates with well-marked cleavage-planes. Accompanied by strong resorption border, and altered to chlorite and magnetite. Pleochroism strongly marked—α pale greenish-yellow, β dark greenish-yellow, γ deep greenish-brown; or, stated as an absorption formula, $\gamma > \beta > \alpha$. Augite is very rare, but occurs in pale-green octagonal plates with characteristic cleavage. Secondary minerals are quartz, pyrites, magnetite, and chlorite.

The following is the mean of several analyses of the rocks:—

Silica (SiO_2)	58·50 per cent.
Alumina (Al_2O_3)	5·64 "
Iron (FeO)	17·67 "
Lime (CaO)	3·86 "
Magnesia (MgO)	1·09 "
Potash (K_2O)	7·22 "
Soda (Na_2O)	4·17 "
Loss on ignition	1·60 "
	99·75

The exceedingly low percentage of alumina in the above is probably due to the preponderance of hornblende in the rock, a fact which also accounts for the high percentage of iron-protoxide.

X.—Pleistocene Beds.

These, though differentiated on the accompanying map of the district, yet merge insensibly into the recent overlying alluvial deposits. In the southern area they are well developed at the debouchure of the Waiau and Tiki Creeks, where they form well-defined river-terraces, 30 ft. to 80 ft. above the present creek-level. Further to the south, on the southern bank of the Awakanae Creek, they form the tongue or spit of land over which the Coromandel–Thames Road passes. They are here very similar to the high-level terraces of the Kauaeranga River, Thames, being composed of highly decomposed andesitic boulders, much waterworn, and weathering concentrically. Scattered throughout the beds are waterworn and subangular fragments of quartz, wood-opal, chalcedony, and hyalite.

These are the beds referred to by previous investigators as Miocene breccias, which, indeed, they much resemble. They are well developed along the lower reaches of the Waiau Creek, where they were also mistaken for the Miocene breccias, or Beeson's Island beds. On careful examination, however, rounded quartz and chalcedonic pebbles are seen to be interspersed between the boulders, which are themselves rounded, evidently by attrition, thus pointing clearly to an aqueous rather than to an igneous deposition.

The disposition of the terraces at the mouth of the Tiki Creek appears to me to furnish the solution of a problem that has exercised many prospectors during the last thirty years. In a small creek in the slaty shales behind the Tiki Mill very rich specimens were obtained. From a given point in the creek the auriferous quartz was traced 40 yards further up to a junction of two small creeks. Higher up no trace of gold was discovered. It was naturally supposed that the specimens were shoadings from an adjacent reef, and drives were put into the banks on either side and in every direction, until at the present the place resembles nothing so much as a huge rabbit-warren. No auriferous reef was discovered, and further efforts are being made at the present time to discover it.

Considering, however, that this length of 40 yards is directly in a line with the river-terrace on the right bank of the Tiki Creek, it appears to me that the specimens formed part of the river-terrace, and came from the well-known rich Pukewhau reefs, and were lodged in a depression in the underlying slates. The sketch-plan from my field-book will probably simplify the explanation. (See Fig. 9.)

These beds are again developed along the upper course of the Kapanga Stream, where they consist of clays, sands, and highly decomposed waterworn pebbles and boulders. The Buffalo Reserve, on the right bank of Kapanga Stream, covers a considerable portion of the high-level terraces in this area.

The high-level gravels may be easily recognised in the field by their low horizontal spurs, running out into the flats parallel generally with the course of the stream that has deposited them. This feature is roughly shown in the section along such a spur shown in Fig. 10.

Corresponding with the high-level gravels, and, like them, shading insensibly into the overlying recent alluvium, are lacustrine beds, which probably underlie a considerable area of recent drift. They are exposed in one place only—viz., in the Kathleen shaft—and consist of very fine blue and yellow muds and of fine-grained sands. As shown in the section, the alluvial and lacustrine beds are here about 105 ft. in thickness, the lowest bed consisting of gravel containing free gold.

The fine-grained blue and yellow clays contain indistinct leaf-impressions, and also the rather badly preserved shell of a Unio, which from the following characteristics I am inclined to refer to *U. menziesii* (Gray): Shell oblong, high, much compressed (probably more than naturally), still covered with a thick olive-brown periostraca; teeth indistinct or hinge wanting. Shell brown, much excoriated anteriorly. Length, 2·75 in.; height, 1·5 in. The absence of the hinge-teeth makes the determination more or less unreliable. Since, to the best of my belief, no species of the Unionidæ exist on the Hauraki Peninsula at the present day, I have therefore differentiated the beds in which these fossils occur from those overlying. So far as I know, the nearest habitat of existing Unios is more than thirty miles away, across the salt waters of the Hauraki Gulf. It is very probable that this Pleistocene lake was barred from the sea by an elevated ridge of volcanic rock running from Keven's Point to Preece's Point. (See Fig. 11.)

A shaft through the recent alluvium was sunk in 1862–63 at a point to the right of the Huaroa Creek, near the main Coromandel–Thames Road. It reached a depth of 150 ft. through varying beds of sands, clays, and gravels. At 150 ft. an old "sea floor with mangrove stumps" (in the words of the owner) was reached, and, disappointed in their search for alluvial gold, the shaft was abandoned. The depths reached by the Kathleen and this shaft would therefore indicate a bed of alluvium extending across the flat certainly not less than 200 ft. in depth.

XI.—Recent Deposits.

Deposits of this period are met with at the head of Kitahi Bay, where they consist of creek-gravels and blown sands; at Long Bay; and at the head of the Coromandel Harbour, north of the Hauraki Wharf. At the last-mentioned area the recent beds are composed of material reclaimed by mangroves and other vegetation. The main alluvial area, however, lies to the south and east of the above localities. It extends from the Upper Township in the north to Lynch's Flat in the south, a distance of four miles, with an average width of one mile. This area has been filled in by the Kapanga, Karaka, Cadman's, Tiki, and Waiau Creeks, and is composed of coarse sand with occasional beds of conglomerate. Where well exposed the sands frequently show false bedding. Throughout the alluvium quartz containing gold is scattered, and in some places, especially at the mouth of the Kapanga Creek, in apparently payable quantities. The gold is still contained in the quartz, and it is therefore impossible by mechanical means to effect separation. It would appear that the gravel had not, unlike the gravel of the Otago rivers, travelled sufficiently far to secure the disintegration of the particles, and the consequent liberation of the gold.

The extent to which the harbour has been and is now being filled is shown by the shallowness of the water and the distance between low- and high-water marks, as marked on the accompanying map. An elevation of only 12 ft. would thus add several square miles to the area of the alluvial plain.

XII.—Conditions of Deposition.

The vast quantities of transported matter requisite for the formation of a thickness of slaty shales, certainly not less than 5,000 ft., sufficiently indicate the proximity of large rivers and correspondingly large masses of land in Palæozoic times. In what direction this continent lay it is perhaps impossible to definitely say. Considering, from palæontological conditions, however, that New Zealand must have been separated on the west from Australia before the Secondary period, and regard being had to the present depths of the surrounding ocean, it may be assumed that the detritus came from the east or north-east rather than from the west. Most of it was deposited in comparatively shallow water, at times at no great distance from land, as is clearly shown by the presence of coarse sandstones.

Deposition of the above beds took place in late Palæozoic times, probably in the Carboniferous period, and at the close of that period they were raised above sea-level, to suffer during long ages the onslaught of denuding agents. During the whole of the Secondary period, so far as can be at present ascertained, the beds remained above sea-level. Similar shales are, a hundred miles to the south-west, overlain by Triassic strata with *Monotis salinaria* and *Halobia lomelli,* and by Jurassic beds with characteristic Ammonites and Aucella, and it is therefore possible that contemporaneous depressions took place in the area under discussion. But, if so, all traces of these beds have been obliterated.

The dawn of the Tertiary era saw the slaty shales becoming slowly submerged, and receiving in their valleys and estuaries fluviatile beds of conglomerates and clays. With further subsidence foraminiferal limestones were deposited. At this period oscillations of the land were not infrequent, as the successive small seams of coal and carbonaceous shales show. These beds, represented now only near Cabbage Bay, are but the relics of a once widely-spread deposit that has now been eroded almost to obliteration.

Soon, however, the orogenic agencies that have modelled New Zealand came into play. A fold parallel to the great north-west protaxis of elevation of the two Islands was engendered in the Hauraki Peninsula area, the result of which was the development of that stupendous volcanic energy which, bursting through the weakened crown of the anticlinal fold, gave forth the tremendous deposits of lavas that form our volcanic series. From the general absence of tuffs and breccias among the earlier lavas, and their deposition along one direction only, I am inclined to the opinion that this early Tertiary eruption was a fissure eruption—a mighty prototype—for the fissure was probably sixty to seventy miles long—of those which have occurred within the historical period in Iceland and in the Hawaiian Islands.

With continued manifestations of volcanic activity the peninsula grew in height, both by the accretion of volcanic matter and by further raising of the anticlinal summit. These eruptions continued during Eocene times, diminishing in activity until, in the Miocene period, they took place only along the sea-coast, where the ocean waters supplied the motive-power. The final manifestation in the Coromandel area appears to have been the fissuring of the country in many directions and subsequent filling of the fissures with dyke matter.

The later eruptive rocks differ markedly in petrological characters from those laid down at the earlier period. The earliest lavas were andesites, rather basic in character, with augite as the ferro-magnesian silicate. Later lavas contain amphiboles with somewhat acid plagioclases, and in the Miocene breccias and dykes hornblende is the only ferro-magnesian silicate, and the rock is a basic trachyte, probably on the border-line between the trachytes and andesites.

Taken as a whole, the nature of the volcanic rocks on the Hauraki Peninsula shows a marked correspondence with the sequence of rocks postulated by Von Richthofen as being characteristic of every long-continued manifestation of volcanic energy. They may be tabulated as follows in order of emission :—

I. Augite andesites II. Hornblende andesites	} ...	Constituting the auriferous series throughout the peninsula.
III. Hornblende trachytes	...	Beeson's Island beds.
IV. Rhyolites ...	...	Largely developed to the south of the Coromandel district.
V. (?) Basalts ...	...	The volcanic rocks of the Auckland Isthmus.

After the Miocene period all volcanic activity ceased in the Coromandel district, the foci of eruption moving along a south-east line. The only geological work carried on since that period has resulted in the filling-in of deep bays and inlets, and this work is still in progress, and will, if allowed to progress, eventually convert the Coromandel and other harbours into landlocked plains.

XIII.—Reefs, Reef Systems, and Faults.

The reefs of the Coromandel goldfields are possibly as erratic in course, dip, and gold-content as those of any goldfield in the world. No generalisations can be deduced from an inspection of the dips and strikes, and no comparisons can be made to determine when a reef shall or shall not contain gold. Two reefs may be parallel and in close proximity, yet the first may be absolutely barren and the second highly auriferous. The proximity or otherwise of the Palæozoic slaty shales does not appear to modify the auriferous character of the reefs, for while the rich Tokatea reefs are near and in the slaty shales, the equally rich Kapanga, Scotty, and Hauraki reefs are certainly ,000 ft. above the Palæozoic rocks. Further, while some reefs, as the Tokatea, contain most gold hen almost vertical, others, as Scotty's, are richest when approximating to a horizontal position.

As a rule, the richest reefs occur in belts of decomposed andesite, from whence the gold probably came. In some cases, however, as in the Bunker's Hill reef, the foot-wall rock is hard and undecomposed, while the hanging-wall portion only is decomposed by percolating waters. Further, speaking broadly, the richest reefs are the smallest, the best returns having been obtained from reefs only 6 in. in width, and in no case have the large reefs yielded payable returns.

The reefs of the field may be divided into six systems—the Tokatea, Kapanga, Hauraki, Preece's Point, Pukewhau, and Matawai. Of these the first three only are of importance.

The Tokatea system embraces the reefs worked along the crest of the Tokatea Range as far south as the Success Mine. The striking feature of this system is the main, or Big, Tokatea reef, a reef or lode of quartz 30 ft. to 150 ft. in width, striking north to south, and dipping west at an angle of 50° to 55°. It forms a salient feature in the landscape, standing out in places as a white wall, and covering the slopes below with white quartz boulders and *débris*. In the extreme north of the area mapped the reef is coincident with the crest of the range, but on tracing its course south the reef descends on the western slope of the range. Before reaching the Success Road it bifurcates, one branch striking south-east and the other south. This latter branch is last seen in Cadman's Creek. Several trials of the lode have been made, but, as the results showed a bullion content of only 1 dwt. to 2 dwt. to the ton, these have led to no practical issue. Cross-reefs join the main reef both on the hanging- and foot-wall sides, but it is only on the foot-wall that these have yielded good returns, the hanging-wall reefs being barren and profitless.

The important reefs of this system are therefore the east and west reefs on the foot-wall side of the main lode. These are the Tokatea lode, No. 1 or Tribute lode, Rainbow, Alpine, Swedish Crown, Grin's Hope, Fern-root, Comstock, West Tokatea, Carnatic, and Colonial reefs. Of these, the first three have yielded rich gold for nearly thirty years.

A mile further to the south, and on the western slope of the range, though still on the foot-wall side of the main reef, are the Success reefs. These are the Jubilee Nos. 1 and 2, Success Nos. 1 and 2, and James's East and West reef. The first four are north to south in course, while the last is normal to the course of the main reef. These reefs are very patchy in nature, and have never yielded handsome returns to any of the numerous companies that have worked them.

The gap between the Tokatea and Kapanga system of reefs is bridged to some extent by the Standard and Warner's reefs, which have both furnished small quantities of gold. The principal reefs in the Kapanga area are Murphy's, Flying Cloud, Scotty's Nos. 1, 2, and 3, and Kapanga. The two first-mentioned, both dipping to the north-east, are possibly identical. The others all dip to the north-west at very low angles, in places occupying an almost horizontal position. In their shallow workings they have all yielded considerable quantities of gold, but in the deeper levels the reefs tend to become impoverished. It was from Scotty's reef that the first reef-gold was taken in 1861.

The Hauraki system is grouped around the mine of that name. It comprises the Hauraki No. 2 reef (Legge's reef), Hauraki Nos. 1 to 7 reefs, Iona Nos. 1, 2, and 3 reefs, and Castle Rock reef, in the immediate vicinity of the Hauraki shaft; while in the Union Beach and Golden Pah Mines the principal reefs are Meredith's, Pacific, Golden Pah, and Black reefs.

These reefs are so disturbed by minor faults and slides, and are so variable in strike and dip, that they form a confused network, and in several cases at least it seems certain that a single reef receives different names at various parts of its course. The best-known of the above is Legge's reef—only 6 in. to 12 in. wide—which during the past four years has yielded four hundred thousand pounds' worth of gold. A pocket in the Green Harp reef, in 1872, yielded about £40,000.

The Preece's Point reefs all strike north to south, having a general dip to the west, and are evidently a continuation of the Hauraki system of reefs. They have never given profitable returns, and, in consequence, have been but little worked.

The Matawai system comprises the Progress, Matawai, Pohutu, and Nelson reefs. The two former have been worked intermittently for the last forty years, and have at times yielded pockets up to £5,000 in value.

An inspection of the accompanying map will show that the great majority of the reefs and all the richest areas are included in a belt of auriferous country about two miles wide extending north-east from the Hauraki and Preece's Point areas to the Tokatea and Success Mines respectively. Probably quite 99 per cent. of the gold output of the Coromandel Goldfield has come from within this belt.

XIV.—Nature, Value, Associates, and Source of Electrum.

The gold of the miners on the field is an electrum containing on an average about 80 per cent. gold and 20 per cent. silver. In the majority of cases it has been deposited contemporaneously with the quartz, occurring throughout it as an impregnation. A specimen from the Bismarck Mine, Tokatea, is tinged a deep apple-green, owing to the presence of very finely divided gold. Again, the gold may be in coarse leaves and scales, and may have been deposited subsequently to the quartz. In the Hauraki and Kapanga districts crystallized gold is absent, but in the Tokatea area, and more especially along the crest of the range, it is the rule rather than the exception. The crystals are generally very imperfect indeed, showing only a single edge or face. The most perfect specimen that has yet come under my notice is known locally as the "Golden Butterfly." It was discovered some two years ago in the Rainbow reef, Tokatea, and came from a "vugh" or cavity in the clear crystallized quartz. It is adhering very loosely to the quartz crystals, and is raised above them in fanciful shapes, the pale-golden delicate wings of the "butterfly" on its support of clear quartz crystals forming an object of singular beauty. The body is composed of irregularly massed imperfect crystals, from which five plates or "wings" rise at an angle of about 45°. The plates are composed of lamellar rhombic dodecahedra, with faces so unequally developed as to give the crystals a monoclinic facies. There is no trace of octahedral twinning, and only on the lower sides of the crystals do cube faces appear. Taking one plate as typical of the whole, and considering one side first, we find that the basis of the form is a single rhombic dodecahedron, broken at one edge into two smaller distinct rhombic dodecahedra. The base form is surmounted by two more rhombic dodecahedral planes, and these again by a succession of octahedral faces with plane angles of 60° and interfacial angles of about 110° (109° 28′ ?), as nearly as could be estimated with the somewhat crude goniometer used. Seven, at least, of the octahedral faces are developed, being indicated by fine lines on the crystal. The reverse of the plate shows similar features, but here the octahedral planes are restricted to two, surmounting the uppermost of which is a dodecahedral face. In the centre of the plate, and with an edge parallel to the edge of an octahedron, is a cube corner. This cube corner has the apex bevelled inwards, forming a triangular pit or depression. It will therefore be seen that the specimen is probably unique in possessing a form composed of the cube, octahedron, and rhombic dodecahedron. No traces of salient edges appear.

An apparently similar, but not nearly so perfect, form has been described by Mr. W. D. Campbell, F.G.S.,* as a pseudomorph after botryogen, the red-iron vitriol; but, as I have been unable to detect botryogen, and as pyrites in any form is rare in this particular locality, it seems to me improbable that in this case, at any rate, the gold has crystallized after botryogen, more especially as the majority of the angles approximate very closely to the 120° of the rhombic dodecahedron rather than to the 117° 24′ demanded by botryogen. Again, with this theory the octahedral and cube faces are inexplicable, and, indeed, the only logical conclusion appears to me to be that the gold has crystallized in its own isometric system.

Gold is common in a calcite matrix in both the Kapanga and Tokatea districts. In all cases the gold and the calcite appear to have been deposited contemporaneously. The calcite occurs as Iceland or double-refracting spar in clear, small rhombohedra. The gold is scattered promiscuously throughout the calcite, and does not appear to have been deposited with any reference to the cleavage-planes of the calcite, which, indeed, are crossed at all angles. It is not crystallized, and occurs as coarse scales, apparently characteristic of the gold when met with in a calcite matrix. The gold is also poorer in quality in the calcite.

Where the gold is associated with native arsenic it appears to be generally massed in the hollow centre of the typical arsenic geode, and is rarely found in the divisions between the concentric spheres of growth. The gold is non-crystalline or sub-crystalline, occurring in fine dendritic threads dichotomously branched, much like the dendritic markings of the manganese-oxides on rock-surfaces. In the rich Hauraki deposits the gold was, as a rule, found as a dense impregnation throughout a thin quartz vein.

The value of the electrum or gold varies for different localities from £2 9s. 6d. per ounce to £3 5s., but is fairly constant for any given locality. The following is the average value of bullion from the different districts, though at the same time it must be remembered that two adjacent reefs, or even parts of the same reef, may furnish bullion varying widely in value: Tokatea district, £2 14s.; Kapanga district, £2 17s. 6d.; Waikoromiko district, £2 17s. 6d.; Waikoromiko district (sluicing), £3 5s.; Manaia district, £3 1s. 6d.; Matawai district, £2 13s. 6d.; Pukewhau district, £2 16s.; Success district, £2 19s. 6d.; Kennedy Bay district, £2 18s. 3d.; Blagrove's, £3; Hauraki district (beach side), £3 1s. 6d.; Hauraki district (Wynyardton), £2 18s.

From the foregoing figures it will be seen that the gold becomes poorer in quality as it approaches the slate area, averaging, in the Tokatea, Matawai, and Pukewhau districts, £2 14s. per ounce. All these districts rest directly on the slates. It is not, however, probable that the contiguity of the slates, *per se*, affects the quality of the bullion, but that the poorer quality in these districts is due rather to having been less exposed to weathering and solvent agents. For, owing to the greater solubility of silver, the bullion content of the Coromandel reefs decreases in value with increased depth.

The associates of the gold are those minerals that have influenced its precipitation. They are native arsenic, found in reefs in the Tokatea, Kapanga, and Hauraki districts. In the Matawai district antimonite and mispickel are found with the gold, sometimes so plentifully that a specimen or rich auriferous rock containing 6 oz. gold to the pound of quartz showed to the naked eye no trace of gold. In the Kapanga Mine it has been noticed that a green discolouration of the country often precedes the discovery of rich quartz—a colour due probably to melanterite or iron-sulphate.

The Coromandel reefs become poorer as they increase in width, the famous Hauraki No. 2 reef averaging only 12 in. in width. The auriferous quartz occurs in shoots in the reef, which are variable in width, depth, and dip. In the reef above mentioned the shoot of gold was 150 ft. wide, dipping north-east. The variability of these shoots will be readily understood when it is remembered that they represent the open water-channels through the reef at the time of the auriferous deposit; and, from the sinuous course of the original fissure, the passage of underground waters along the reef will be checked, both vertically and horizontally, at points where the hanging- and foot-walls are immediately in contact.

Long experience has shown that the richest points in a reef are those where a cross-reef intersects, especially if the cross-reef be pyritous in character. Here the reef carries the auriferous solution and the cross-reef supplies the precipitant. From consideration of several auriferous shoots I am convinced that, in the majority of cases, the gold, after having been formed at a junction, is swept along the reef by the water current, falling at the same time, owing to the influence of gravity. (See Fig. 12.)

Again, as illustrating this point, it is no uncommon occurrence to find the upper faces of horizontally disposed quartz crystals coated with gold, while the lower faces are devoid of the slightest trace of the metal.

The source of the gold is probably the pyroxenes of the andesites. Experiments made by Mr. James Park on the Thames andesites gave a gold content of $1\frac{1}{2}$ grains per ton, and my own experi-

* Trans. N.Z. Inst., Vol. XIV., pp. 457–458.

ments, as far as they went, supported this result in the case of the Coromandel rocks. I found, moreover, that the decomposed country rock close to the rich Hauraki No. 2 reef, when separated from the secondary pyrites, contained no gold, the former gold content probably having been leached out, to be redeposited in the reef. Assuming, therefore, that the pyroxenes of the andesites are the source of the gold, it follows then that the auriferous reefs have been filled by a process of lateral secretion, and also that the reefs in the slaty shales on the Tokatea owe their gold to downward percolation rather than to the ascension of heated water carrying vein-matter in solution.

The following tabulation shows the various precipitants that may have been concerned in the precipitation of the gold after being leached from the country rock:—

(1.) The most obvious reducing agent is the ferrous sulphate or proto-sulphate of iron, which in the Hauraki Mine forms small green stalactites in dry places in the levels. In all probability the finely divided gold occurring as an impregnation in the quartz is due to this precipitant, if we may judge by the finely divided precipitate (Faraday's gold) resulting from laboratory experiments. The finely divided green gold from the Bismarck Claim has already been mentioned. In the absence, however, of any knowledge of the accretive power of finely divided gold, we must look in another direction for the slugs and leaves of gold found in the Coromandel reefs.

(2.) Native arsenic is undoubtedly competent to precipitate gold. In the course of laboratory experiments I suspended 15 grains native arsenic in a weak solution of gold-chloride (1 gr. $AuCl_3$ to 4 oz. water). In two hours and a half the arsenic was distinctly yellow-coated, and in twelve hours two plates of gold were precipitated. The plates were certainly only loosely coherent in texture, but it requires no great stretch of imagination to suppose the grains welded together by pressure into the slugs found in reefs. In twenty-four hours the solution was free from gold, and had lost its original amber tinge, giving no reaction either with tin-chloride or with the more delicate Skey test.

(3.) Metallic sulphides are probably the main precipitating agents. Following out the line of Skey's experiments*, I suspended all the sulphides found locally associated with the gold, in turn, in a weak solution of gold-chloride (1 gr. $AuCl_3$ to 4 oz. H_2O), and found that all precipitated gold from its chloride solution. The sulphides experimented on were iron-pyrites, copper-pyrites, stibnite, mispickel, and galena.

It has been generally insisted that the gold in solution is in the form of a sulphide, and that the solvent agent is an alkaline sulphide; but this appears to me to fail as a generalisation. On analysis of the Kathleen Mine waters, I found 0·254 per cent. of free hydrochloric acid, and in no case that has yet come under my notice have the local mine-waters been found to be alkaline. With the above percentage of free hydrochloric acid it is not difficult to trace the evolution of free chlorine, an excellent gold solvent, and the consequent formation of gold-chloride.

(4.) The researches of Daintree showed that organic matter is competent to precipitate gold from its chloride solution. I am, however, not in possession of any data that would lead to the belief that this had been the precipitating agent in the local reefs.

(5.) I am of opinion that the part played by gaseous agents in gold-precipitation has not received the consideration due to it, and I have accordingly made experiments with a view to finding possible gaseous precipitants. The best of these, and, so far as I can see, the only one worthy of consideration in the present connection, is arseniuretted hydrogen (AsH_3). On passing a weak current of this gas through a solution of gold-chloride, a beautiful floating film of metallic gold was formed—a film so coherent that it was possible to partly lift it from the solution. Complete precipitation took place in half a minute. The objection to this gas, however, as a precipitant is that it, so far as I could ascertain, fails in extremely weak solutions. That arseniuretted hydrogen may be produced naturally is very probable from the occurrence of the allied sulphuretted hydrogen and the deposits of native arsenic, the latter being deposited on decomposition of the arseniuretted hydrogen.

XV.—Minerals occurring on the Field.

A.—*Non-metallic.*

Coal.—Occurs under the conditions described in Chapter VII., and also in small quantities as carbonaceous partings in the andesites and in the breccias, representing a cessation of volcanic activity.

Calcite.—Occurs in rhombohedra, scalenohedra, prisms, and combinations of these, varying indefinitely in form. Generally colourless or milky, but occasionally yellow to amber, due probably to the presence of yellow iron-oxide. Iceland spar is common in the Tokatea mines, perfect crystals up to ½ in. being obtainable. In the colourless varieties, however, the cleavage-planes are so visibly abundant as to render the crystals valueless for Nicol's prisms, &c. The calcite and carbonate of lime in the Tokatea area is derived from the underlying and surrounding calcareous slaty shales. Dogtooth and nailhead spar in scalenohedra are common in the Scotty reef in the Kapanga area. Argentine, a pearly lamellar calcite, is found in the Tribute reef, Tokatea.

Aragonite.—Found in stellate needles in Scotty's reef, and may indicate a deep-seated origin of the gangue of the reef. More probably, however, the rhombic form is due to the presence of impurities.

Glauber's Salts.—Occurs in minute quantities in old drives and workings.

Epsomite.—Long rhombic silky prisms occurring as an efflorescence on walls and roofs of old drives and workings.

Quartz.—The matrix of the gold. Generally finely crystalline, or crystallized in small prisms terminated by pyramidal faces. Sometimes amethystine in Tokatea area.

* Trans. Aust. Assoc. Adv. Sci., Vol. I., 1889.

Chalcedony, Carnelian, and Jasper.—Common in fissures in the slates.

Wood Opal and Semi-opal.—Abundant in the Miocene tuffs and breccias.

Felspars.—Orthoclase occurs in the Miocene trachytic dykes and plagioclases in all the solid lavas, as also do the amphiboles and pyroxes. These have already been dealt with microscopically in Chapter VIII.

Kaolin.—This is the "pug" of the miners, and is abundant in the reefs, resulting from the decomposition of the felspars in the country rock.

Glauconite.—Occurs staining the Kathleen tuffs at the 345 ft. level, resulting probably from the decomposition of the ferro-magnesian silicates.

B.—*Metallic Minerals.*

Pyrolusite and Wad.—Occur in limited quantities in the reefs generally, but are more especially characteristic of the Tokatea Range, where the quartz is often stained black from the presence of these oxides.

Native Arsenic.—Occurs throughout the auriferous belt, and is one of the best local indicators for gold. Occurs massive in the Kapanga reef and in the Wynyardton Mine. In the Tokatea Consols it occurs as reniform nodules. Colour of freshly broken surface grey and shining, but face soon tarnishes on exposure, becoming a dull black. Geodes often 6 in. to 9 in. in diameter, and enclosing thread gold.

Arsenolite (As_2O_3), *Orpiment, Realgar.*—I have collected specimens of these minerals from the Tokatea Hill, but am rather inclined to the opinion that they are artificial products arising from a fire having been lighted near or on a reef containing native arsenic. They were found as an incrustation on the exposed wall of a quartz reef.

Antimonite or Stibnite.—Occurs in fine rhombic prisms, and also as an impalpable powder in the pug of reefs in the Blagrove's and Hauraki North Mines. It also occurs as longer needles in the Matawai district. It is, next to native arsenic, one of the best indicators for gold on the field.

Kermesite ($Sb_2S_3 + Sb_2O_3$).—Occurs in cherry-red fibrous crystals as an incrustation on the reef in the Hauraki North Mine.

Galena.—Occurs in considerable quantities in reefs in the Tiki and Matawai districts together with ores of copper. It is argentiferous, but not highly so.

Hedyphane (a variety of Mimetite).—Occurs in clay partings near the slaty shales, with, however, the greater part of the lead replaced by calcium. Lustre resinous; colour pale-yellow.

Magnetite.—Occurs in microscopic crystals as described in treating of the rock-sections under the microscope.

Hæmatite.—Earthy forms common in the Miocene breccias, resulting probably from the ultimate decomposition of the hornblendes common in those rocks.

Limonite.—Occurs also under the same conditions.

Pyrites.—Exceedingly common throughout the field, both in reefs and in the country rock. Reefs of pyrites up to 1 ft. in width are not uncommon. Pyrites is considered a very good indicator for gold. Occurs in cubes with striated faces, in pyritohedrons and combinations of the pyritohedron and cube faces.

Chalcopyrite or Copper-pyrites.—Abundant on the field, weathering in many cases to erubescite. Forms part of the galena lode in the Karaka Creek.

Marcasite; Mispickel.—These sulphides and sulph-arsenides are common in quartz reefs in the Matawai district, and it is to the presence of these, together with antimonite, that the Matawai ore owes its refractory nature.

Melanterite or Copperas.—Occurs in small stalactites in the Hauraki Mine. Found only in dry places. Abundant in mine-waters. The presence of this mineral necessitates the use of untanned-leather boots in the mines, as otherwise the $FeSo_4$ unites with the tannic acid of the leather to form an ink which stains the feet black.

Vivianite.—Occurs in small quantities as a whitish-blue incrustation on bones, generally in swampy places or in localities that have previously been swampy.

Ilmenite or Menaccanite.—Occurs massive as rolled pebbles in the Waikoromiko Creek. Colour black, lustre submetallic, streak brownish-red. Acts strongly on the magnetic needle.

Native Copper.—Found in small grains in the galena lode in the Karaka Creek. Grains rather finely arborescent. Associated with the copper-pyrites in this lode are the following copper-ores: Bornite occurs as an iridescent film on copper-pyrites. Malachite and azurite, the green and blue carbonates, are found as incrustations at the outcrop of the lode.

Argentite.—Occurs sparingly in black bands through some quartz reefs in the Matawai district.

Pyrargyrite.—Found as small cochineal-red crystals in the Golden Pah Mine. I have, however, obtained only a single small crystal.

Kerargyrite.—Occurs in the Waikoromiko Creek district. Here several pounds were obtained some ten years ago. Brown on surface, and waxy-grey interior.

Native Gold.—The occurrence and properties of this mineral have been already described.

XVI.—Future Prospects of the Field, etc.

On the majority of goldfields it is not a difficult matter to prognosticate with some degree of accuracy the future of the field for several years in advance, but in the case of the Coromandel field this is well-nigh impossible. The auriferous deposits are so extremely irregular both in position and extent that no data can be obtained for a calculation of this nature, and, speaking generally, there are no reefs in Coromandel with a uniform ore-value such as exist on the Ohinemuri goldfields, in the south of the Hauraki Peninsula.

Reasoning from past experience, it may certainly be assumed that the goldfield is very far from being worked out. As already related, the rich ore-shoot on the cap of Scotty's reef was not discovered until 1862, ten years after the opening of the field. Seven years later the auriferous reefs on the Tokatea Hill were discovered, and after a further period of three years the Green Harp shoot in the Hauraki area. All the above are within a radius of two miles from the first-discovered gold. Again, as we have seen, the Hauraki patch, worth over £300,000, lay perdu for more than forty years, though levels had been driven and work carried on within a comparatively short distance from it. In all these cases there was nothing to lead up to the gold—no indicators that could be followed. Hence mining in Coromandel must necessarily be conducted in a more or less haphazard manner, and can never partake of the nature of a commercial business with a regular percentage of profit on the capital employed.

The prospects of obtaining payable returns from mining at great depths do not appear to me to be very bright, since the volcanic auriferous rocks are everywhere underlain by the Palæozoic slaty shales; and while it is true that reefs in the slaty shales in the Tokatea area are undoubtedly auriferous, yet they appear to become impoverished as they descend. In the deepest level worked in these slates, which is yet 650 ft. above sea-level, the reef was valueless. It is probable, therefore, that the gold came not from below through the slates to the surface, but downwards by percolation through fissures from the overlying volcanic rock, and must necessarily be of limited extent in the slates.

It is quite possible that the large low-grade reefs now being worked at Opitonui, some four miles to the north-east of Castle Rock, may be continued along the eastern slope of the main range towards the headwaters of the Waikoromiko Creek, in which case permanent mining-works would result. In any case, the amount of dead-work done during the last three years by British and colonial companies in opening up the reefs throws open a wide field to tributers, and it is probable that many of these will receive substantial returns for many years to come.

The alluvial deposits on the foreshore have recently been exploited with fairly satisfactory results. The obstacle here, however, is that already referred to—viz., the difficulty of primary mechanical separation owing to the non-disintegration of the reef-quartz.

The galena and copper lode in the Karaka Creek would, at the present market values of lead and copper (£14 and £76 per ton respectively), certainly pay to work provided a cheap local method of concentration were adopted. The concentrates could then be shipped to Australia for smelting. At present, however, the rapid fluctuations of the market values of these metals precludes the erection of costly concentrating machinery.

In conclusion, I am of opinion that, though the field will probably never give employment to a great number of men, and though it can hope for nothing from improved metallurgical processes, for it possesses no low-grade auriferous reefs, yet the reefs are by no means worked out, and will afford a livelihood to a limited number of miners for many decades, with always the possibility of that livelihood becoming affluence.

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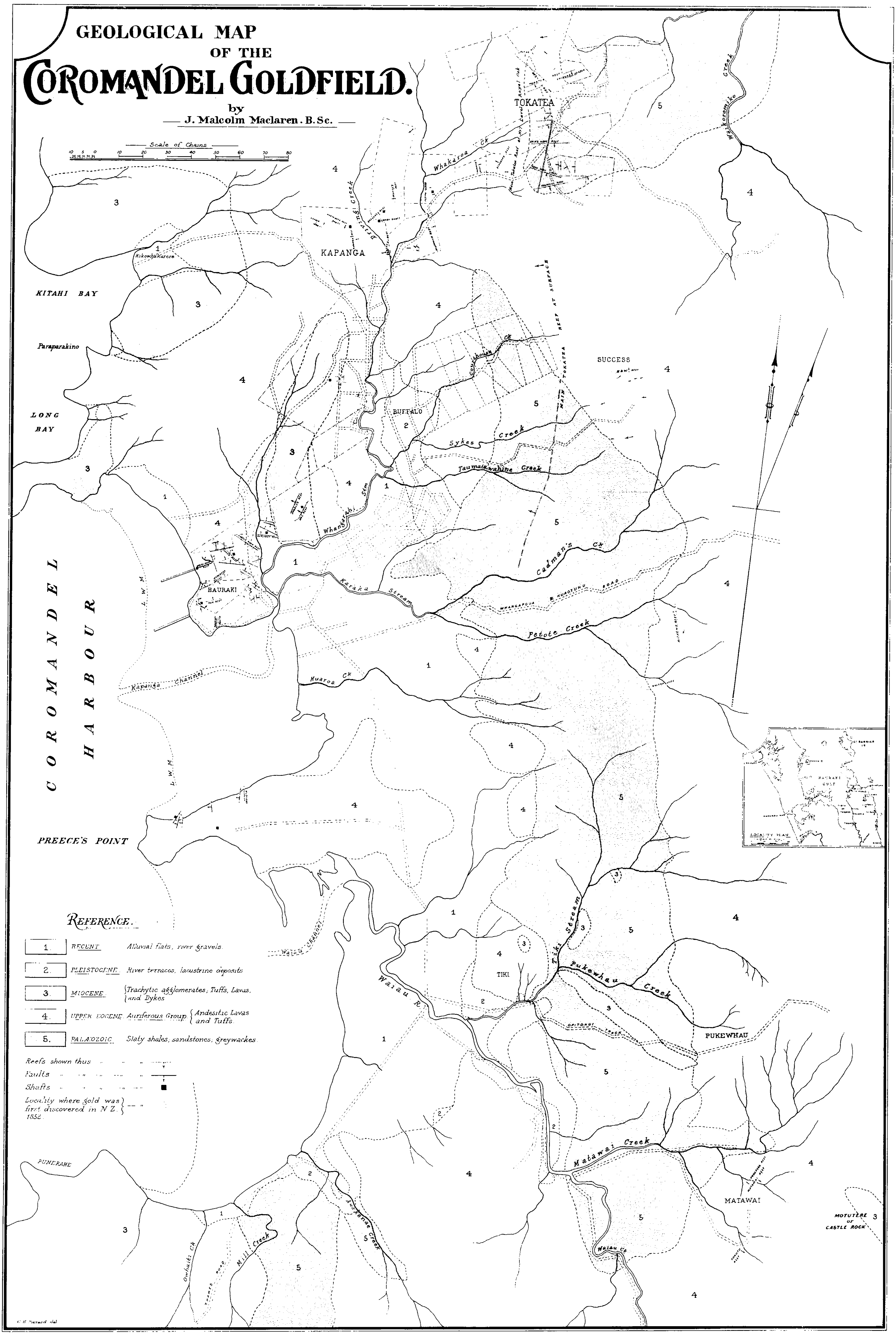
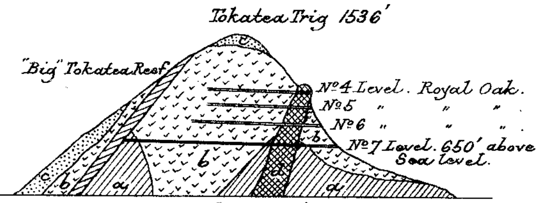
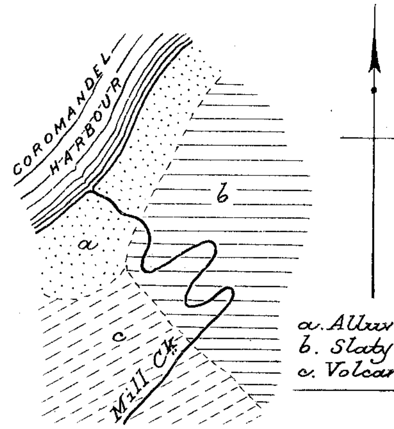

GEOLOGICAL MAP
OF THE
COROMANDEL GOLDFIELD.
by
J. Malcolm Maclaren. B.Sc.
Scale of Chains
10 5 0 10 20 30 40 50 60 70 80
TOKATEA
KAPANGA
Whakaroa Ck
Waikoromiko Creek
Driving Creek
KITAHI BAY
Kikowhakarere
Paraparakino
LONG BAY
SUCCESS
BUFFALO
Coughtown Ck
Sykes Creek
Taumatawahine Creek
TOKATEA MAIN REEF AT SURFACE
Whanganahi Stm
HAURAKI
L.W.M.
COROMANDEL
HARBOUR
Kapanga Channel
Karaka Stream
Cadman's Ck
WHANGAPOUA & KUAOTUNU ROAD
Petote Creek
Huaroa Ck
PREECE'S POINT
Waiau R
Tiki Stream
TIKI
Pukewhau Creek
PUKEWHAU
OPITONUI TRACK
Matawai Creek
MATAWAI
MOTUTERE OR CASTLE ROCK
Waiau Ck
PUNERAHE
Owhaiti Ck
THAMES ROAD
Mill Creek
HAURAKI GULF
LOCALITY PLAN
REFERENCE.
1. RECENT Alluvial flats, river gravels.
2. PLEISTOCENE. River terraces, lacustrine deposits
3. MIOCENE. Trachytic agglomerates; Tuffs, Lavas, and Dykes
4. UPPER EOCENE. Auriferous Group. Andesitic Lavas and Tuffs.
5. PALAEOZOIC Slaty shales; sandstones; greywackes.
Reefs shown thus
Faults
Shafts
Locality where gold was first discovered in N.Z. 1852.
C. H. Pierard del.



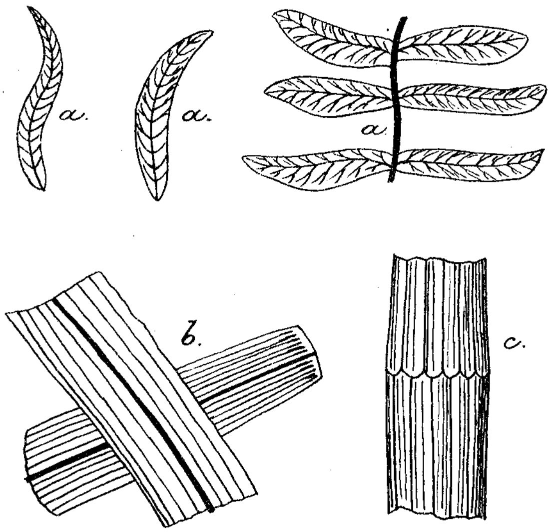
a. Slaty Shale. b. Ceratophyres & Felsitic tuffs. c. Andesites. d. Quartz porphyry dyke.

Fig 1. Section across Tokatea Hill.



a. Alluvial.
b. Slaty shales.
c. Volcanic rocks.

Fig 2. Beds at Mill Creek.



a. Blechnum priscum.
b. Flabellaria sub-longirachis.
c. Bambusites australis.

Fig 4. Fossil Plants from Carbonaceous Clays. Waiaro.

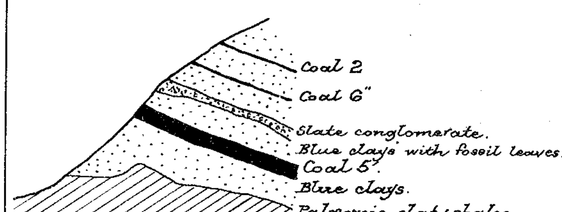


Fig 3. Section shewing Sedimentary beds at Waiaro.

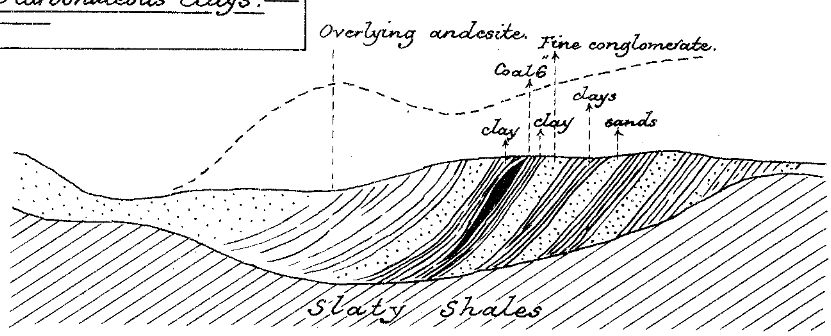
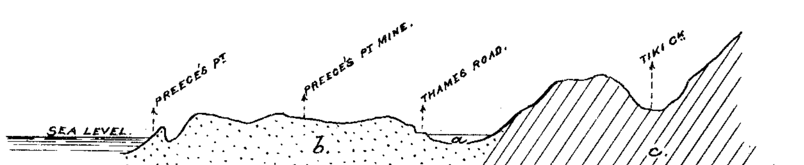


Fig 6. Section across Lacustrine beds, road to Success Mine.



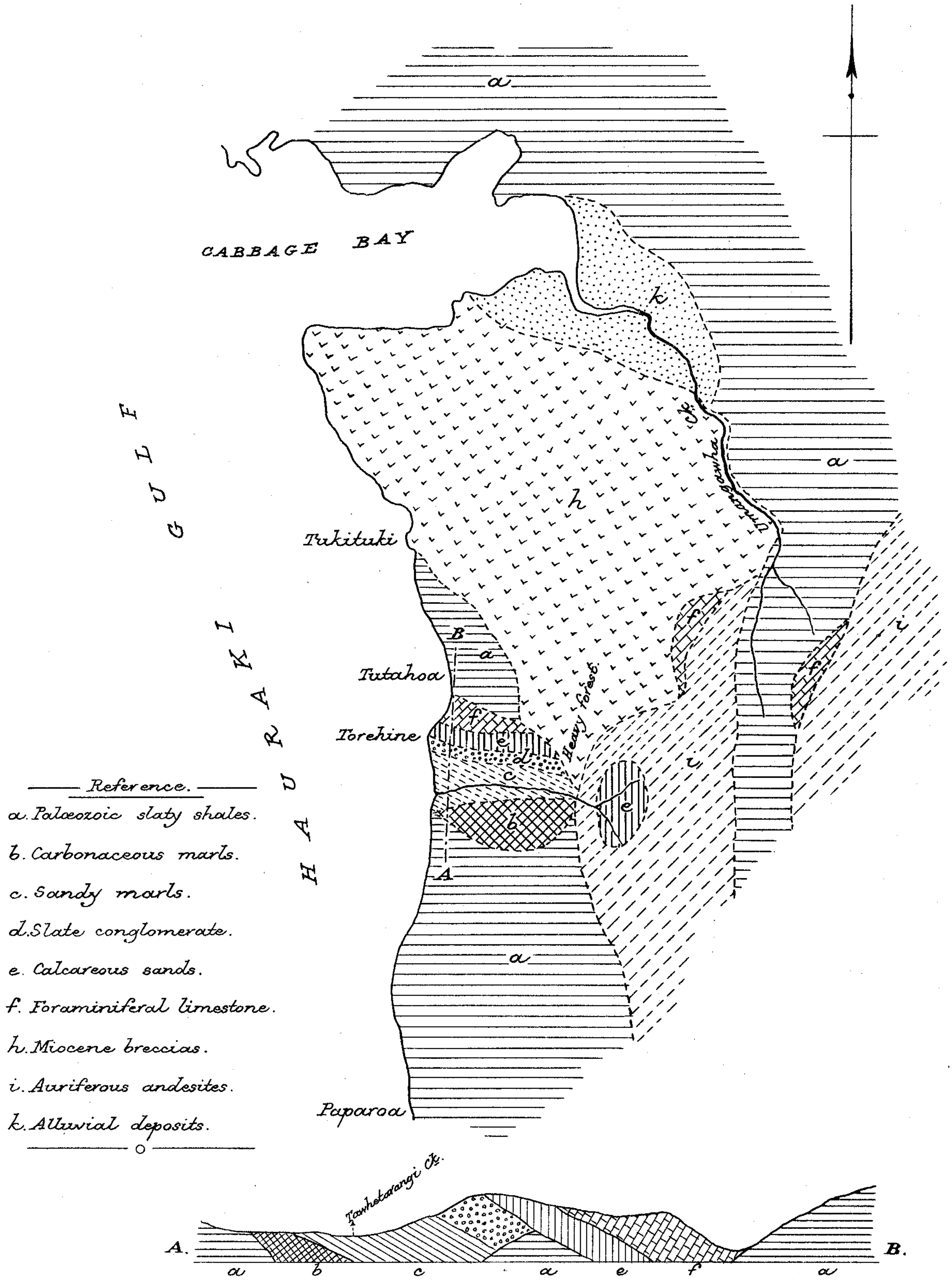
a. Alluvium. b. Andesites (decomposed). c. Slaty shales.

Fig 7. Section from Preece's Point to Main Range.

To illustrate Report on the Coromandel Goldfield. by J. M. Maclaren. B.Sc.

C.H. Pierard. lith.

Plate 2.



Section on line A.B.

SEDIMENTARY BEDS. TOREHINE.

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Plate 3.

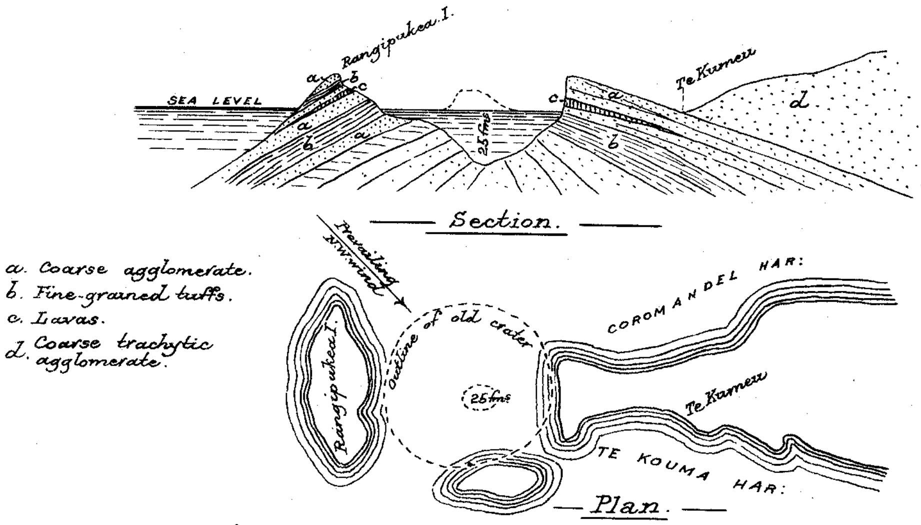

Fig 8. Entrance to Coromandel Harbour.

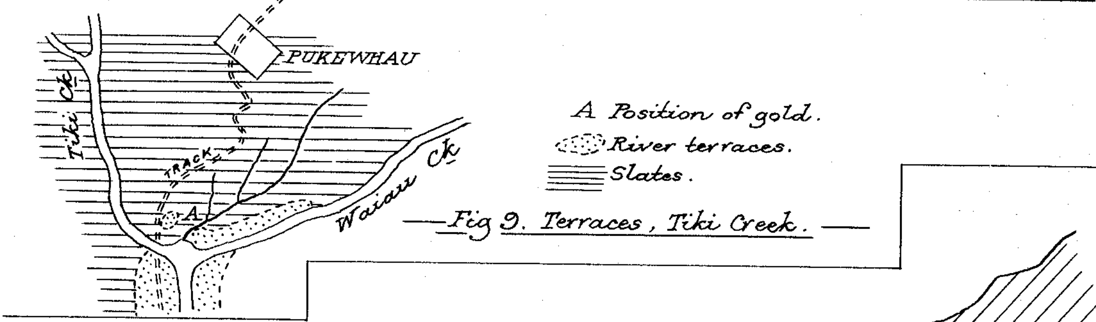

Fig 9. Terraces, Tiki Creek.

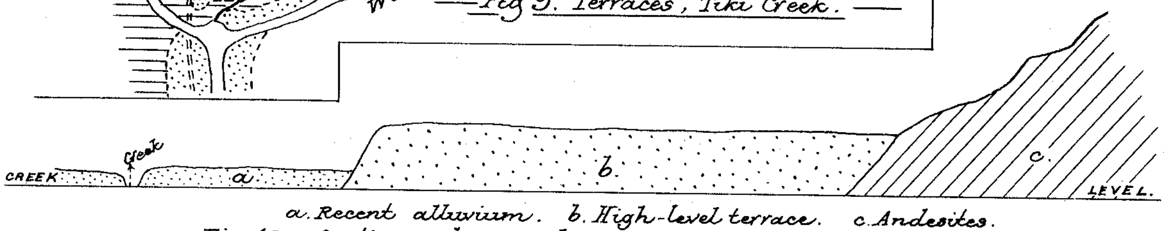

Fig 10. Section showing high level gravels.

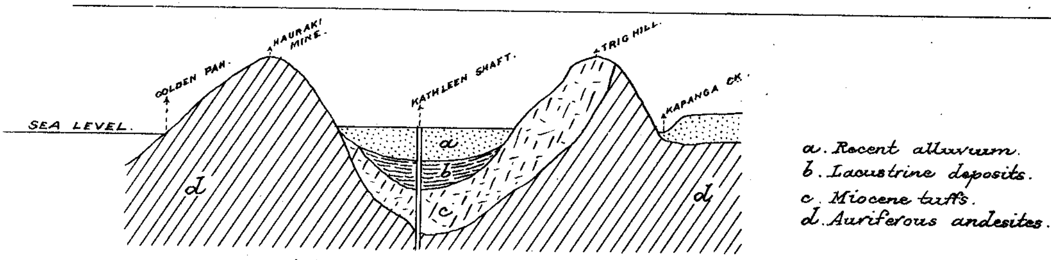

Fig 11. Section across Kathleen Mine.

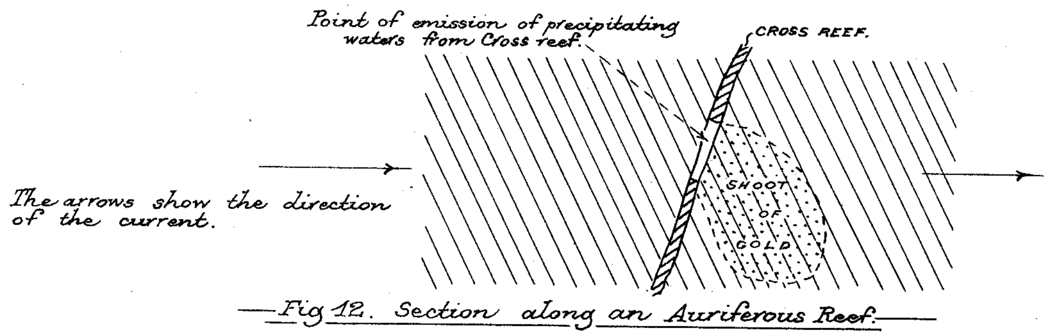

Fig 12. Section along an Auriferous Reef.

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