1901.

NEW ZEALAND.

GEOLOGICAL EXPLORATIONS

(GENERAL REPORT FOR THE YEAR 1900-1).

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

Mr. ALEXANDER MCKAY, Government Geologist, to the UNDER-SECRETARY for MINES.

SIR,— Mines Department, Wellington, 10th June, 1901.

I have the honour to submit a summary of the work done, and the different examinations and reports made during the season of 1900–1.

The work of the latter part of the winter of 1900 was chiefly in connection with preparation and despatch to Professor Sollas, of the rock-samples of the Cape Colville Peninsula, the petrographical description of which should now be approaching completion. It is to be hoped that the results of Professor Sollas's work will come to hand shortly, as till then the various duplicate collections of the rocks of the Hauraki Goldfields cannot be distributed to the different Schools of Mines and other institutions as contemplated.

The work of Professor Sollas will be of great value as definitely fixing the nomenclature of the volcanic rocks of the district whence the greater part of the collections forwarded have been taken. The descriptions will probably be illustrated by micrographic drawings or photographs of the more important rock-preparations, and these will be of great value to the students to whom the duplicate set of rock-slices may be available. These preparations and the original rock-samples from which they were taken must be carefully preserved and retained in the possession of the department, as they constitute means for determining differences of opinion that, respecting these rocks, may arise in the future.

To make the petrography of the district of greater value to those engaged in mining on the Hauraki Goldfields, the ordinary illustrations accompanying a report of this kind should be supplemented by a series of photographs showing the rock-sample natural size, and various enlargements of the prepared rock-slice. By such means would be made clear, even to those who do not make a special study of the subject, the differences of rocks scarcely to be distinguished as hand specimens. For years I have been engaged in perfecting an instrument peculiarly adapted to this kind of work, and recent improvements made leave little or nothing more necessary for executing what is required in this respect. Not until the receipt of the results of Professor Sollas's examinations can the final report of the geology of Cape Colville Peninsula be written, and though some sections of this might in the meantime be written, it were better that from the first the whole of the material were available.

Since the 31st March, 1900, the following reports, memoranda, and notes have been written on the different subjects to which they apply :—

(1.) On Bradshaw's Reef, Preservation Inlet.
(2.) On Glass-sands in New Zealand, for Bottle-making.
(3.) On New Zealand Iron-ores.
(4.) On the Possible Occurrence of Coal at Dunback, Otago.
(5.) On Puponga and Pakawau Coalfield, Nelson.
(6.) On Boring for Coal at and near Dobson, Grey Valley.
(7.) On Coal at Mount Hamilton, Otago.
(8.) On Chrome at Croixelles Harbour, Nelson.
(9.) On the Probabilities of Coal near Hampden, Otago.
(10.) Remarks on the Character of the Main Mountain-chain of the North Island with reference to its Ore-bearing Character.
(11.) On Copper at Maharahara, Ruahine, Hawke's Bay.
(12.) On Deep Sinking for Coal at Waimangaroa, Westport.
(13.) On the Occurrence of Petroleum at Deep Creek, Kotuku, South-west Nelson.
(14.) On supposed Coal-seams in the Kaiata Range, Greymouth.

(15.) On Coal on Koiterangi, Kokatahi, Hokitika.
(16.) On Coal in the Valley of Coal Creek, Ross, Westland.
(17.) On Geology of the North Shore of Cook Strait and the Rimutaka Range.
(18.) On the Geology of the Kaimanawa Ranges, Hawke's Bay.
(19.) On the Oil-bearing District near Poverty Bay, Auckland (First Report).
(20.) On the Oil-bearing District near Poverty Bay, Auckland (Second Report).
(21.) On the Identity of the Quartz Lodes and Shoots of Gold East and West of the Moanatairi Slide, Hauraki Goldfield.
(22.) On a Copper-deposit in the Ruahine Range, West of Norsewood, Hawke's Bay.
(23.) On the Geology of the Ruahine Range, Hawke's Bay.
(24.) On Lignite-belts at Fitzherbert, Lower Manawatu District.

Of these, Nos. 1, 4, 6, and 8 are memoranda in answer to inquiries made, and No. 5 has already been published in the reports of the department for 1900. All the others are reports on districts examined during the year, and which have yet to appear in the annual volume of reports published by the department.

Puponga and Pakawau Coalfield.

On the Puponga and Pakawau Coalfield and its extension to the south and west, it may be remarked that the field is likely to prove a valuable one, in which bituminous and glance coals are found along the eastern margin of the field, while to the westward they gradually change to a more hydrous description of coal. Hitherto comparatively thin seams have been known and worked, but it is evident from the past year's work that thick seams, up to 8 ft. or 10 ft., are to be found along the eastern border of the field, while the more hydrous coals of West Wanganui are also of workable thickness.

Boring for Coal at Dobson, Grey Valley.

During the latter part of 1900 I visited Greymouth and Brunnerton for the purpose of locating sites for boreholes, intended to prove the coal-measures west of the fault-line that runs along the western boundary of the Wallsend lease. The problem of workable coal, and the depth at which it can be reached, is of great importance to the miners of Brunnerton and the shipping interests of the Port of Greymouth; and it is generally held that a valuable coalfield will be found under and west of Dobson Flat. I am not oversanguine in this matter, and therefore recommended boring at a point where the possible seam could be proved at a depth approximating 300 ft. from the surface. If coal of workable thickness should be passed through in the shallower bore, the cost of this might be disregarded, and another further west, near Dobson, put down to prove the extension of the seam in that direction.

On Deep Sinking for Coal at Waimangaroa Railway-station.

The question of being able to reach workable seams of coal in the hills and under the coastal plain between the Wellington Mine and the mouth of the Waimangaroa River being of great importance, at the instance of the Westport Coal-prospecting Association the locality was visited and reported on. I found that the high dip of the coal-seam in the Wellington Mine, and the continuance of this in the strata overlying to the westward, to reach coal at the railway-station would necessitate a depth of sinking not less than 1,500 ft., which may be regarded as being prohibitory at the present time. I had, therefore, to report unfavourably with respect to the particular locality; but this has raised the question of the reachability of coal at any point between the mouth of the Ngakawau River and Westport, and on this subject I am of opinion that coal could be reached at a moderate depth near the mouth of the Ngakawau River, and that generally the cover is less along the seaboard than midway between the coast-line and the foot of the ranges east of the break or fault-line. The opinion is based on the evidences there are of a synclinal arrangement of the strata, the western side of the syncline being seen between the mouth of the Buller River and Cape Foulwind.

Supposed Coal-seams in the Kaiata Range, Greymouth.

The reported coal-seams in this range proved to be a deposit of rolled fragments of coal forming a stratum of variable thickness near the base of the Miocene-Tertiary beds of the Kanieri series. The carbonaceous material varies from pieces 6 in. or 8 in. through to a fine sand, and the larger pieces are often found free in the beds of the creeks, and have led to the belief that the Brunner coal formation extends into this range. The presence of this coal conglomerate, derived by denudation from the coal-seams of the Brunner area, disproves this assumption, and shows clearly that prospecting for coal in this range and in these beds can lead to no satisfactory result.

Coal on Koiterangi, Kokatahi Plain, Hokitika.

The Kokatahi Plain and Koiterangi, or Camel-back, Hill were visited at the request of the Westland Pastoral and Agricultural Association. The occurrence of coal on Koiterangi has been known for many years, and recently fresh interest has been displayed in the matter of developments here and at Coal Creek, in the valley of the Kanieri River.

I determined the area of coal-bearing rocks on Koiterangi, and showed that they dipped to the eastward under the plain, but I was unable to see any of the coal outcrops. Previous reports show that the coal is not of more than workable thickness, and analysis proves it to be of a non-bituminous character. The coal in the Kanieri Valley is of a tender description, but of good quality. It occurs in thin seams standing at high angles, and may be regarded as unworkable at the present time.

Coal in the Valley of Coal Creek, Ross, Westland.

At the time I visited Koiterangi I was instructed to report on the prospects of coal in Coal Creek, Ross, and visited the locality for that purpose. I found the coal formation on both sides of

the valley of Coal Creek and the sequence of the rocks the same as in Koiterangi, but the reported coal-seam proved unworkably thin and of no value whatever. Between Kanieri Lake and the Mikonui River, along the line of junction between the granite and the slate and sandstones to the west, there is a series of patches of the coal formation either involved among the older rocks or occurring as but slightly inclined strata resting on the granite or slate. Such limited areas of the coal formation are found in the Kanieri Valley, on the Kokatahi Plain, and in Koiterangi, the south side of the Hokitika, and thence, by way of Constitution Hill, they extend across the Totara Valley to Ross, and for the time being terminate on the Mikonui River. Farther south on the same line continued there show other areas of the coal formation at the Paringa, at Abbey Rocks, and between the Haast River and the southern boundary of Westland. In all of these localities the area of coal is of a limited extent, although in the south some of them are considerable. All along the line the measures are apt to be disturbed, the coal crushed and standing at high angles.

Petroleum at Deep Creek, Kotuku, South-west Nelson.

Petroleum appears as oozings to the surface at four different places along the bed of Deep Creek. At the three lower places the escape is through the modern gravels of the creek-bed and its banks. At the fourth locality there is some evidence—not decided—that the oil is escaping from a breccia conglomerate that may be of Pliocene or older date, and a mile and a half to the eastward there are bluish-grey Miocene sands strongly charged with petroleum. These are all the facts that could be ascertained at the time the locality was visited, and it will suffice to remark that the appearances at the surface warrant vigorous prospecting of the district for oil. The lowest beds in which oil appears cannot have given rise to the oil itself, which, emanating from a more deep-seated source, simply finds storage in the higher beds. The oil is somewhat of a heavy character, not yielding a great percentage of illuminating oil; but this may in part be accounted for by volatilization of the lighter constituents on the oil reaching to and its exposure on the surface of the ground, or of the stream or pools in which it collects.

The Petroleum-yielding District North-west and North of Poverty Bay.

I have on two previous occasions examined the district, but more with reference to its general geology than having regard to the possibilities of oil being found in particular localities.

On this occasion the valleys of the Waipaoa, Mangatu, and Waikohu were explored, with special reference to the character of the rocks as producing or affording storage for oil. The Waipaoa was explored into its upper valley, the Mangatu to near its source, and the Waikohu to near the foot of the main range from which it takes its rise. An oil-spring at Dobbie's, to the south of the Waikohu Valley, was also visited. On completion of these examinations I still remained in doubt as to the conclusions I should arrive at. At two places only was oil met with, and at two or three places more emanations of gas are known; but these evidences can hardly be said to be sufficent to warrant a pronouncement respecting the probabilities of payable oil in the district, the more so as attempts already made, by boring to considerable depths, have failed, I, therefore, while indicating four or more localities as the more favourable at which to bore, do so without even implying that boring at these places will prove successful.

Copper at Maharahara, near Woodville, Hawke's Bay.

An examination of this mine made during the month of December last showed that, while copper-ore is generally present throughout the lode, the percentage is too low to constitute this a paying mine. During 1888 a bunch of comparatively rich ore was struck, and a bulk sample of this was collected by me, and shown in the collections of the Geological Department at the New Zealand and South Seas Exhibition. Since then no considerable patch of rich ore has been found.

Copper in the Ruahine Range, West of Norsewood.

Samples of copper-ore, yellow sulphide, were forwarded from this locality, and in the Colonial Laboratory gave a return of 12 per cent. of the metal. While in Napier during January last I learned from Mr. H. Hill, Inspector of Schools, who had visited the place, that a strong body of ore existed, and on my return from the Kaimanawa Mountains, about the end of February, I sent my assistant to examine this reported mountain of copper-ore. From his report it would appear that, while copper is not absent, both the size of the lode and the average of its yield in copper have been exaggerated. In its main features the lode resembles that at Maharahara, the best ore appearing at and near the surface, the lode pinching in both directions along the lode, and also underfoot, while the ore at the same time becomes of less value or totally disappears.

Geology of the Kaimanawa Mountains.

During January and February of the current year I made an examination of the upper valleys of the Ngaruroro and the Rangitikei Rivers, of the Kaweka Range, and the eastern Kaimanawa Mountains. The principal object was the verification of reported discoveries of gold in this region, such reports having been current for the past twenty-five years. After duly investigating the matter, and visiting most of the places at which gold was said to occur, I came to the conclusion that no encouraging prospects had ever been found. A colour of gold can be found both in the Ngaruroro and the Mangamaire, the eastern main branch of the Rangitikei, and traces of gold are to be found in some bands of cherty quartz that appear in the southern part of the range separating the Mangamaire from Kaimanawa Creek. The alluvial gold is found exclusively within the region over which æolian pumice-drifts extend, and, as in the Hinemaia River, draining the country to the north-westward into Lake Taupo, these igneous rocks may have to account for some portion of the gold.

The rocks of the eastern Kaimanawa and Kaweka Mountains, consisting chiefly of sandstones and subordinate beds of dark-blue slaty shales, are not much mineralised, and iron-pyrites or other

sulphides are rare in these rocks. Quartz lodes, of which so much has been spoken, are also nearly absent, only one true reef more than a few inches thick coming under my notice.

The district and its geology is in other repects interesting; more especially is this the case with regard to the recent covering of pumice that lies over a great part of the area. In the southern Kawekas there are thick bands of brown sandy shales, full of coarse plant-remains, which lead to the impression that coal may occur in some parts of the district over which these rocks extend.

Geology of the Rimutaka and Ruahine Ranges.

These were examined in part during the year by my assistant—the Rimutaka Range before the trip to the Kaimanawa Mountains, the Ruahine Range afterwards. The red and green jasperoid or calcareous rocks that distinguish the Rimutaka and Tararua Mountains are continued across the Manawatu Gorge, and are present throughout the whole length of the Ruahine Ranges, and to some extent are present in the Kaweka Range and yet further north. They are, however, absent from the Kaimanawa Mountains, which confirms me in the opinion that two formations are represented by the older sedimentary rocks of the Wellington Provincial District, the older of which is undoubtedly Palæozoic and the younger is probably of Triassic age.

Traces of copper in the younger formation are met with wherever the red and green rocks are, and the calcareo-argillaceous rocks sometimes pass into crystalline or fossiliferous limestones. A comparatively pure crystalline limestone (marble) occurs on the shores of Cook Strait, and copper is found both in the Rimutaka and Ruahine Ranges.

On the Identity of the Quartz Lodes and Shoots of Gold in the Country East and West of the Moanatairi Slide, Thames.

In this paper I discuss the relation of the rocks and quartz lodes east and west of the Moanatairi Slide, and show the improbability of the country on the foreshore and in the foot-hills west of the slide ever having had place as far to the east as Punga Flat; also that, assuming that this could have been the case, by no amount of reasoning could it be shown that the great shoot of gold in the country displaced downwards and westwards by the slide now finds its downward continuation in the lodes of the upper part of Moanatairi Creek and the vicinity of Punga Flat—a barren belt of country which west of the slide underlies the great shoot, and to the east appears at the surface interposing and separating this from the auriferous horizon of Punga Flat.

I have, &c.,

ALEX. MCKAY,

The Under-Secretary, Mines Department, Wellington. Government Geologist.

NOTES ON THE GLASS-MAKING SANDS OF NEW ZEALAND.

By ALEXANDER MCKAY, F.G.S., Government Geologist.

THE Agent-General having obtained a report on a sample of quartz-sand from Ashburton district, Canterbury, which was satisfactory has led to the compilation of these notes on the glass-making sands of New Zealand.

The sample reported on by Professor W. R. Dunstan, F.R.S., contained 93 per cent. of silica, 0·17 per cent. of ferric oxide, and 0·08 per cent. of calcium; and, "in order to obtain definite information as to the value of the New Zealand specimen, a sample was sent to one of the largest manufacturers of plate-glass in the country [England], who reports that if sand of the same quality can be regularly supplied it would command about 7s. 6d. delivered f.o.b. at St. Helens, Lancashire."

The sample in question was probably taken from the coal-measures skirting the western base of Mount Somers, where there are very considerable deposits of loose sands of different grades of fineness and degrees of colour. In 1872 I examined these sands along the course of Petrifying Gully, and have since examined similar deposits of different ages in all parts of New Zealand; and, as there are many deposits equal, even superior, in quality, and of far greater extent than those of the Ashburton district, some account of their character, position, and accessibility will be of interest, and may lead to the establishment of works for their utilisation. It is evident that at the price quoted above they would not pay for exportation to England.

There are, however, sands in the North Island of New Zealand that for quality, fineness, and freedom from all impurity are far superior to those of the Ashburton district, and would form, with but little preparation, the material for the production of white plate of the highest quality, and even the best optical glass. Such sands occur in abundance on the east coast of the northern district of Auckland, and should command a price that would enable the material to be sent to England.

Coastal sands, where not derived from schistose or granitoid areas, are usually of a grey colour, and, besides, are apt to contain calcareous and other impurities. The consequence is that along the east coast of the South Island the wind-blown sands carried inland from the tide-way would not be suitable for other than for bottle-making, &c. The west coast of the North Island also would not afford good glass-sands, on account of the presence of magnetite in them, the magnetite being often considerable and in many places the larger quantity. The same applies to many localities on the west coast of the South Island where otherwise the sands might be made available for glass-making purposes. Sandhills formed by wind-drift, if the material be otherwise

of good quality, would afford good sands comparatively free from iron; but with few exceptions the coastal sands recently accumulated may be disregarded.

The locality where such sands are of chief and very great importance is the long spit of sand connecting the insular hills of North Cape with the mainland of the northern district of Auckland north of Mongonui and Ahipara. Over this district the quantity of material is enormous, and the highest quality of sand appears in great abundance on the coast lying south of the entrance to Parengarenga Harbour. These sands are pure white, glass clear, and form the spit of land between the ocean and the southern arm of Parengarenga Harbour. They extend south along the shore of Great Exhibition Bay, and from this part of the district alone all the glass-making factories of the world might draw their supplies.

The material is clear, glassy quartz, without colouration or stain, except from organic impurities, the peaty soil inland often staining brown the upper part of the sands. This, however, does not affect the sands of the South Spit and the coast of Great Exhibition Bay, whence unlimited supplies can be obtained. Vast accumulations of such sands, but somewhat stained, are to be met with on the shores of Doubtless Bay. These sands are derived from the igneous rocks (quartz diorites) of the district, which are abundant north of a line between Hokianga and the Bay of Islands. These sands were first brought under the notice of the public by the late Captain Fairchild, and were more especially examined by me in 1892.

In the South Island, Cape Farewell Spit contains ample material of good quality for glass-making, but this is less pure and clear, and consequently not so well suited for glass of kinds requiring sand of great purity.

Of the sands that lie inland from the coast-line, the principal and perhaps the only important deposits are confined to the Cretaceous system and the coal-bearing formation of New Zealand.

The Post-Jurassic denudation of the schistose area of central and eastern Otago resulted in the production of vast deposits of quartz-sands, which are now found at the base of the coal-measures. Some of these deposits form gravel of moderate size, in which pieces of schist are to be met with. At other places the material is nearly all quartz, and much finer in grain, yet too coarse to constitute glass-sands. Often the material is simply crushed into an angular grit, the individual grains not seldom containing a bluish streak; but almost everywhere in the localities where the above are found there are beds of pure quartz-sand sufficiently fine in grain and sufficiently pure for the purposes of glass-making. Abundance of such material extends throughout eastern and central Otago and Southland, and occurs on the west coast of the Island within Inangahua, Buller, and Collingwood counties. Apparently drifted north from the Otago region, similar sands are met with along the foot of the mountains that bound the plains of Canterbury on the west.

The coal formation, as local patches, is found in the eastern mountainous parts of Canterbury, sometimes near to the foot of the main range, and these glass-making sands usually accompany. In the middle and northern parts of Canterbury Provincial District the glass-making sands are probably derived from the destruction of quartz porphyries that form a belt along the eastern margin of the mountain region between the Ashburton and Waimakariri Rivers. These quartz porphyries are of older date than the series of rocks containing the glass-making sands, and therefore the superior quality of the sands in the Ashburton district may have reference to these rocks adjacent to where the sands are found.

The farthest north to which these sands reach in the Canterbury District is the valley of the Ashley River, within which occurs, at a place called Glentui, a deposit of very fine absolutely pure, perfectly colourless sand. I noted these sands in 1870, and since then have seen nothing of the kind, so fine in grain and pure in colour, in any other part of the South Island.

It were to no purpose to point out all the localities at which sands suitable for glass-making can be found. It is enough to state that there is no scarcity of material; but generally this would require to be utilised within the country, as it is improbable that, except for special purposes, it would pay to export.

11th June, 1901. ALEX. MCKAY.

REPORT ON CHROME-DEPOSITS AT THE CROIXELLES, NELSON.

By ALEXANDER MCKAY, F.G.S., Government Geologist.

ON the 25th June last I visited the deposits of chromic iron situated on the south side of Croixelles Harbour, Nelson, which are being worked by Messrs. Tatton and Jackson, of Nelson.

The chrome-bearing rocks form a belt of soft serpentine immediately, or at no great distance, underlying the Maitai limestone, which latter is strongly developed on the southern shore of the harbour, about two miles inside of the south headland. The direction of the ore-belt is westerly, and from the landing-place a small stream leads in that direction, and takes its rise from a saddle, the waters from which flow westerly into Blind Bay. The height of the saddle is 1,200 ft. above the sea, and it is here that the chief workings for chrome-ore are situated.

The ore occurs as no regular, continuous lode, but as elliptic or lintel-shaped masses, sometimes nearly contiguous to each other, but sometimes, also, with a considerable space of non-productive ground between. Ore is reported on the west side of the valley leading to the saddle, but the chief and workable deposits begin just before reaching the saddle, and extend down its western side for some distance.

The principal excavation showing—also the most extensive development of ore—is on the saddle itself, where mined and in sight there may have been at the time of my visit (the 25th June) 150 tons of ore. Deposits of ore had been to some extent worked on down the west slope from the saddle, but these were of less consequence than that which showed on the saddle.

The western slope showed also considerable quantities of ore scattered about on the surface, more or less aggregated in distinct locations, as though masses of ore had been set free by the wearing-away of the softer serpentine, and by the action of variable temperature and moisture rent into a greater or lesser number of fragments. A considerable quantity of this ore had been collected into heaps, and was ready for transport to the shipping-place at Croixelles Harbour.

From the above description it will be readily inferred that from the surface, and near the surface, ore can be obtained which will probably pay those engaged in collecting or mining it. In the end, however, the surface ores will be exhausted or too distant from the port of shipment, and, owing to the irregular bunchy character of the ore *in situ*, the cost of mining must increase in depth till this also will greatly reduce the margin of profit. This latter contingency is, however, dependent on the facility or difficulty of mining, and the size of the ore masses, and the ease with which further masses can be traced and exploited. The amount of work done does not afford sufficient data to enable me to express an opinion on that point, but the ore in sight warrants its extraction and transport to a market, unless, indeed, the cost of road-making should prove greater than the ore in sight might warrant.

Since the above was written a considerable quantity of ore has been brought to the shipping-place in Croixelles Harbour and sent to market, and I understand that in the immediate neighbourhood of whence this was taken there is still a large quantity of ore in sight.

10th June, 1901. ALEX. MCKAY.

REPORT ON THE PROSPECT OF COAL AT WAIMANGAROA RAILWAY-STATION, WESTPORT.

By ALEXANDER MCKAY, F.G.S., Government Geologist.

BETWEEN the 10th and 13th of November last I visited Waimangaroa for the purpose of determining the probability of finding coal at a moderate depth at or near the Waimangaroa Railway-station. The data collected and the conclusions arrived at are contained in the report which follows:—

On the Mount Rochford plateau the coal lies at various heights between 1,700 ft. and 2,500 ft. above the sea. On its western margin the high land suddenly terminates, and a steep scarp is formed descending to the lower hills and coastal plain between Westport and the mouth of the Ngakawau River. This abrupt slope marks a line of fault which extends both north and south beyond the limits described. By the action of the fault the western extension of the coal-measures has been carried to a lower level, and they now appear as strata standing at high angles dipping west, and forming foot-hills immediately south of both the Ngakawau and Waimangaroa Rivers. Towards the sea the coal-measures are covered by more recent accumulations, in the south by Miocene beds followed by gravels both fluviatile and marine, and north of the Waimangaroa by the latter only. Under the coastal plain the dip of the coal-measures is at a less angle, and there is evidence of a reversal of the dip in this direction.

The examinations made from the railway-station along the southern bank of the Waimangaroa to where the coal-measures terminate, a little east of the Wellington Mine, had for their object to determine if at any reasonable depth coal could be reached in the front hills or under the gravels of the coastal plain.

The Wellington seam, exposed on the southern bank of the Waimangaroa River, strikes south 20° west, and dips west-north-west at an angle of about 40°. The coal where showing nearest to the river-bank and where worked is exposed as a seam of considerable thickness, much crushed and tender at the outcrop. It is overlain by alternations of dark shales and dark or lighter coloured sandstones, having the strike and dip already indicated. The seam has not been traced any distance to the southward, but should extend and outcrop along the foot-hills to where they terminate, and the low swampy plain reaches east almost to the line of fault.

Along the whole line of outcrop the dip of the coal will continue to be high, owing to the drag of the strata on the down-throw side of the line of fault. The high dip might be expected to lessen rapidly as the distance increases from the west side of the line of fault, but as a matter of fact it is maintained at a considerable angle as far west as observations can be made.

By following from the coal outcrop, the section of strata exposed along the railway, it is seen that the dip is not lessened, and that before the railway-station—430 yards from the coal outcrop—is reached a very considerable thickness of strata has been passed over. Yet further to the north-west, at the brick-kilns, the dip of the strata is even at a higher angle than at the Wellington Coal-mine; and, making allowance for the difference between the true dip and the line of section, it may be shown that at the brick-kilns coal could not be reached at a lesser depth than 1,000 ft. from the surface.

Between the brick-kilns and the schoolhouse the line of section followed turns more to the westward, and the rocks present are the mudstones and sandy marls that form the higher part of the coal-bearing sequence. Dips are rarely to be determined over this part of the section, but where the new road to Denniston begins to rise on the lower slope of the front hills rocks of a sandy nature are exposed striking south-east and dipping to the south-west at an angle of 25°, or nearly at right angles to the coal-measures in the lower part of the section. This change of strike conforming with the change in the direction of the section-line, the dip is at right angles to a line from the point of observation to the brick-kilns, and the distance to the kilns being about the same as from the kilns to the Wellington Coal-mine, it follows that, at least, despite the lesser angle of dip in the higher beds, some 500 ft. or 600 ft. of strata has to be added to that already noted.

The angle of dip considered—and, so far, there is in this section no evidence or indication of a reversal of the dip—and the fact that only one seam of coal (the Wellington seam) is known, war-

rants the conclusion that coal cannot be reached at a moderate or reasonable depth anywhere between the brick-kiln and the Waimangaroa Railway-station.

Theoretically, it is reasonable to conclude that the low grounds of the coastal plain from the Waimangaroa to the Buller River constitute an area over which coal-measures are present underlying Recent and Miocene deposits. This is shown, in addition to the facts here given, by what appears in the Cape Foulwind section and the section between Crane's Cliff and the mouth of the Ngakawau River; but coal, except where exposed standing at high angles along the eastern border of the depressed area, cannot be reached except at considerable cost.

The low grounds of the coastal plain should be tested by boring at or near the mouth of the Ngakawau, where there are evidences of a reversal of the dip, and where rocks of the lower part of the sequence are present. At and south of Granity the agglomerated rocks on the coast-line appear to be a friction breccia in connection with the great fault; and, owing to the nearness of the granite range to the coast, there can be but a narrow strip of coal-formation for some distance to the south. A small patch of the upper coal-measures lies at the foot of the range between the first tunnel and the coal-bins at Granity.

17th November, 1900. ALEX. McKAY.

REPORT ON SUPPOSED COAL-SEAMS IN KAIATA RANGE, GREYMOUTH.

By ALEXANDER McKAY, F.G.S., Government Geologist.

THE extension of the Brunner Coalfield to the south side of the Grey Valley and along the Mount Buckley Range towards and beyond the more proximate sources of Kaiata Creek has been the hope of many interested in the welfare of the district. This hope has from time to time seemingly been confirmed by the finding of stray pieces of coal in the beds of the creeks draining the north and north-west faces of the range, and while at Greymouth during November last, on the application of Mr. Smith, secretary of the Westland Coal Company, I was directed to examine a reported discovery of coal in one of the branches of Kaiata Creek.

The reported coal-seams in the range at the source of the creek proved to be a deposit of rolled fragments of coal, forming a stratum of variable thickness, appearing on the north face of the eastern end of the range at a height of 700 ft. above the sea. The formation present is not, and cannot be, the same as at Brunnerton, and with moderate certainty it may be determined as forming the lower part of the sequence of the Miocene formation as developed in the New River district.

The carbonaceous deposit where examined is about 2 ft. in thickness, and consists of rolled pieces of coal, the largest of which are about 6 in. in diameter, the lesser a fine gravel passing into grit and carbonaceous mud, mixed in varying proportions with arenaceous sands. As a coal-seam it is of no economic importance, and is of interest chiefly as showing that the rocks of the Grey Valley Coalfield were being denuded during or prior to the deposition of the Lower Miocene deposits along the east side of the Grey Valley and in the New River district.

Though thus disappointing in immediately practical results, the examinations made are of considerable importance in making clear the relation in which the beds containing coaly matter stand to the true coal-measures to the north and north-east.

In 1873 I examined this district on account of fragments of coal having been picked up in several of the creeks draining north-east into the Grey River. I noted the coal conglomerates which form the subject of this report, but at that time could not distinguish between the younger beds containing coaly matter and the true coal-measures of Brunnerton or the overlying beds of the same sequence, and I considered that the coal conglomerates occupied a position underlying the Cobden limestone. The notes made in 1873 bearing on this question are as follows:—

"15th December.—Went along the A.K. line, and observed that wherever the bed-rock is visible this is invariably the grey or black marls that overlie the dark-blue marls lower in the sequence of strata between Greymouth and Brunnerton. . . . Following the creek upwards I at length reached the locality to which I had been directed. Here I found masses of coarse grey micaceous sandstone (brown when decomposed) completely choked the watercourse, and on such patches of shingle as had formed in the bed of the creek small pieces of coal were stranded. The bed-rock I found to be the soft dark or grey crumbling marl that underlies the Cobden limestone near Greymouth; but the whence of the great blocks of micaceous sandstone as yet was unexplained. Nowhere was such sandstone to be found *in situ*, and this rock is not represented in the sections from the Cobden limestone downwards in the direction of Brunnerton.

"The banks of the creek were composed of angular *débris* mixed with clay, and I observed that many of the sandstone blocks contained streaks of coaly matter, sometimes as coal sand, and at times the carbonaceous material was of such size that where aggregated it might be termed and did constitute a coal or coaly conglomerate. Pieces thus included, in cases, were 1½ in. in diameter.

"Following the creek upwards for some distance, beds of the sandstone described began to appear, and at a particular place a bed of coal conglomerate was noted. At this point the bed of coal matter was not more than 6 in. thick, and the pieces of coal were small. I, however, saw blocks of sandstone in the bed of the creek that proved this coal conglomerate, or another band of the same, was sometimes 1 ft. in thickness. Other beds of sandstone became coaly to such an extent as to impart a dark colour and induce a flaggy character of the standstone, but nowhere, except in one particular bed, did the coaly matter form a conglomerate.

"These hard sandstone bands were interbedded with layers of soft marls, which, being easily removed, have caused great slips and landslides of the superimposed sandstones, and in this way is accounted for the huge blocks of sandstone found further down the creek-bed.

"As to the position which these beds occupy, there can be no doubt that they are intermediate between the beds that immediately underlie the Cobden limestone and the blue micaceous marls overlying the Island sandstone in the Grey River opposite Dobson Bluff.*

"The coal-conglomerate and sandstone beds lie along the western face of the range to the north of the upper part of Omotumotu Creek, and, as the slope of the range and the dip of the beds is not greatly different—15°—it (the sandstone) occupies the surface.

"The sources of Racecourse Creek on the east side of the range show masses of sandstone and occasional coal conglomerates associated, and from such source, or the rocks *in situ*, fragments of coal find their way down the creeks into the low grounds, where they are occasionally found, and lead to the assumption that solid coal-seams are to be found higher up.

"I have been informed that the pieces of pure coal are much larger near the north end of the range, and that the detached masses of sandstone are also larger in that direction. That this may be true receives confirmation on observation of the strike and dip of the beds. The strike is north 10° west in the left-hand branch of the Omotumotu, which, at an equal elevation, would bring the reported outcrop of these beds to where my informant describes it as present."†

Towards the northern end of the range, at the locality recently examined, the dip is east at an angle of 10°, and the rocks are such as have been described in the above extract.

The further light thrown on the relation of these beds to the coal-bearing series establishes unconformity between them, and removes the serious difficulty of having to account for the products of denudation of the lower beds appearing in the middle beds of the same sequence.

Due to palæontological considerations, Professor Hutton concludes that there ought to be unconformity between the Cobden limestone and the coal-measures of Brunnerton, and, while I had to admit in mid-section the presence of broken and rolled coal derived from the lower beds of the sequence, I was forced to admit that facts favoured that conclusion. Now, however, that the sandstones with coal conglomerate are referred to the lower beds of the Miocene formation the difficulty is removed, and the fossils of the Island sandstone, Mine Cliff (Brunnerton), and of the Ten-mile must, from a consideration of their Tertiary facies, be regarded as belonging to the same series as the Cobden limestone, their relative positions being the higher and lower parts of the same sequence.

ALEX. MCKAY.

7th December, 1900.

REPORT ON COAL IN KOITERANGI (CAMEL-BACK HILL), KOKATAHI PLAIN, WESTLAND.

By ALEXANDER MCKAY, F.G.S., Government Geologist.

ON Tuesday, the 20th November, from Hokitika, I went to the Kokatahi for the purpose of examining exposures of coal-seams reported as occurring in Koiterangi, or Camel-back Hill.

Prior to my visit, which was anticipated, a committee of the Westland Agricultural and Pastoral Association undertook the clearing of overgrown tracks to outcrops formerly discovered, and such other work as might prove necessary to a knowledge of the geology of the mountain which constituted the field of investigation.

On reaching the locality it proved, unfortunately, that the works contemplated had not been done, and the track to the first-discovered outcrop, examined by Inspector Binns in 1886, had proved so broken and overgrown that it could not be followed. Some attempt had been and was being made to trace the outcrop of coal on the northern face of the mountain, and coal at one place was discovered, but owing to the broken character of the mountain-slope, the thick and impenetrable nature of the bush covering, and the neglect to blaze a line leading thereto, the more recent find could not again be located. In the attempt to do this a third outcrop was discovered, from which samples were brought, but these the prospectors experimented with to ascertain the quality of the coal, and were consumed before I had opportunity of seeing them.

I examined, as far as was needful, the northern, eastern, and southern lower slopes of the mountain sufficiently to give me an insight to its geological structure, and enable me to indicate the area over which coal-seams may be reasonably sought for.

Geology of Koiterangi Mountain.

Maitai Rocks.—The western end of the mountain, and at low levels the whole of the southern face, is formed of rocks of the Maitai series of the New Zealand classification, corresponding to the Carboniferous formation of the Northern Hemisphere. These rocks are greenish slates and sandstones containing reefs of quartz. A reef of quartz is exposed at the east end of the southern face of the mountain on Mr. Bonar's property. This varies in thickness to a maximum of 2 ft., is said to contain gold, and is fairly good-looking quartz.

Coal-bearing Series.—Resting on the slate rocks, striking north to south and dipping east, the lowest member of the coal-bearing series is a coarse breccia, passing upwards into conglomerate at places, or retaining its subangular character throughout. This rock is largely of local origin, and is compacted and cemented so that it can only be removed or worked by aid of explosives. It

* This conclusion was in error, as it can now be shown that the strikes in the two localities are nearly at right angles to each other, and there are no rocks in the section from the Island sandstone to the Cobden limestone that correspond with the coaly sandstones above described; while the latter appearing in the New River area at the base of the Tertiary sequence of Miocene date proves in this way an unconformity which is confirmed by the presence of rolled coal derived from the horizon of the Brunner seam.

† Geological Reports, 1873-74, pp. 78-79.

shows along the eastern base of the hill for about half a mile from the Hokitika River. A road is being formed north to south along the east base of the hill, and it was thought that these breccias and conglomerates might be worked for the production of road-metal, but they proved much too strongly cemented to be excavated with the pick.

Dipping to the east these rocks rise on to the mountain, their junction line with the slates at the east end of the south side of the mountain taking a south-west direction to the crest of the mountain-ridge west of the main peak on which the trig. is situated.

Immediately west of the trig. peak is a saddle, on the further side of which is a rounded elevation, from which the mountain has received the name of Camel-back Hill. Through this lesser rounded elevation the breccia gravels probably extend, as on the intervening saddle small coal-seams are said to be found. These breccia gravels are of considerable thickness, being probably 300 ft. or more. While the lower part reaches well to the westward on the northern face of the mountain, the upper beds, from west of the saddle, owing to the easterly dip, descend to lower levels, and extend to the east along the middle and lower slope of this part of the mountain (the eastern part of the northern slope), till finally the breccias disappear at the level of the plain, being covered by recent shingle or swamp deposit.

Following these breccia conglomerates are the beds containing coal. These consist of sandstones and dark shales, reaching a maximum thickness of 400 ft., and, being conformable thereto their line of outcrop, follows the upper surface of the breccia conglomerates. There is some evidence that the beds are thinner on the south side than on the north side of the mountain, and it is likely that the thicker and purer coals will be found on the northern slope.

The highest beds in the series form a massive development of limestone resembling that of the Abbey rocks, or the Whangarei and Hikurangi limestone of the Auckland District. It is subcrystalline, but usually so fine in grain as to have an earthy appearance when seen in mass. This limestone covers two-thirds of the eastern face of the mountain, and may be some 200 ft. thick, but it is difficult to exactly determine its thickness by mere observation from the low grounds of the surrounding plain. It appears in the low grounds at the eastern end of the hill, and from the northern side is continuous for two-thirds the distance along the eastern face. It also appears to the north as a low isolated ridge on the plain about a mile distant from the mountain, much in the same manner as does a low ridge of the breccia conglomerate on the plain to the south-south-east of Koiterangi.

The coal-measures thus appearing between the limestones above and the breccia conglomerates below, and restricted to a narrow belt never more than a quarter of a mile wide, the field over which prospecting for workable seams may be carried is thus limited, and clearly bounded by easily recognisable rocks. So far as I could judge, the principal and perhaps the only workable seam lies high in the series, and at no great distance below the limestone; so that, passing over the limestone scarp, whether to the north-west, west, or south-west, search for coal outcrops should at once be begun, and, if at first unsuccessful, be continued till the breccia conglomerate is reached. This search should preferably be carried on along the beds of the numerous ravines and gullies that cut into the mountain-slope, unless the channel is too much choked with boulders, as sometimes will be the case. On the northern face of the mountain careful search should be made over the entire face, as on this I anticipate the coal-seams will be thicker, better, and more conveniently situated for working, and nearer to the likely market than on the southern end of the eastern face.

While on the ground I pointed out to Mr. McArthur, a member of the committee appointed to direct prospecting, what was required in the case, and over what ground it was most advisable to make search for coal-seams; and from what has been said above it will be readily concluded that the area is restricted and definitely bounded, so that no serious mistake should be made.

Regarding the seam already known, and to some extent prospected, Inspector G. J. Binns visited the outcrops in April, 1886, and of these he says: "The most likely one was a seam 3 ft. 6 in. in thickness, and occurring at a height of about 1,300 ft. above the flat. As this seam dips at 5° to the south-east, it may be found nearer the level ground, and, at my suggestion, the efforts of the prospectors will be directed to a solution of this problem."* From which it will appear that up to the present time no very strenuous or successful efforts have been made to discover coal at lower levels. A prospecting-drive was made on the lower slope of the hill, not far from the lime-kiln. This was examined by me in 1893, but from what I saw, not being able to enter the drive, I concluded that this was too close to the limestone, and, so far as I could at the time ascertain, was not commenced on an outcrop of coal.

ALEX. McKAY.

10th December, 1900.

REPORT ON INDICATIONS OF COAL IN COAL CREEK, ROSS, WESTLAND.

By ALEXANDER McKAY, F.G.S., Government Geologist.

ON the 22nd November, as directed, I went from Hokitika to Ross, and the following day examined the section exposed in the valley of Coal Creek, a branch of Donnelly's Creek. Fragments of coal have from time to time been picked up in the bed of the creek, and while its bed was being worked for gold a thin seam of coal was discovered. This led to some prospecting for coal, and a borehole was put down in the hope of cutting a thicker seam, but failed to do so. Recently an outcrop of coal was found on the left side of the valley, at a height of 130 ft. above the creek-bed. The discovery of this was the occasion of my visit, but on examination it proved to be of no value, the seam being not more than a few inches in thickness and doubtfully *in situ*.

* Mines Departmental Reports, 1886, C.-4c, p. 7.

The rocks showing along the banks of Coal Creek belong to the coal-bearing series, and the section reads much the same as that of Koiterangi, with the exception that the lower breccia conglomerates are absent, or have but a feeble development.

The lower beds exposed are gritty sands, sometimes greenish from the presence of glauconite grains. Above these are grey grit sandstone, followed by dark shales, with which are associated thin seams of coal. Limestone similar to that of Koiterangi closes the sequence. The whole is arranged as an anticline, the axis of which is deeply cut into by Coal Creek. The total area of these rocks is less than two square miles.

The occurrence of coal-bearing rocks at Ross is interesting as forming part of a line of such rocks that lie along the base of the higher mountains from Kanieri Lake through Koiterangi, and by way of Constitution Hill to Ross and the Mikonui River. Another patch of the same rocks is said to occur on or flanking Mount Fraser, towards the source of the Totara River; but this was not visited.

ALEX. McKAY.

11th December, 1900.

REPORT ON INDICATIONS OF PETROLEUM AT DEEP CREEK, LAKE BRUNNER, NELSON.

By ALEXANDER McKAY, F.G.S., Government Geologist.

In accordance with instructions, I went to Kotuku, Lake Brunner, for the purpose of examining the evidences of petroleum, reported as occurring in the valley of Deep Creek, near that place.

Indications of oil are to be met with over a distance of half a mile along the banks of Deep Creek, and samples of rock—a soft sandstone—obtained by Mr. Molloy from two miles to the eastward also gave indications of the presence of oil.

The first place visited, and where the strongest indications were met with, lies 60 chains north of Kotuku Railway-station and about 40 chains west of Molloy's homestead. At this place the oil rises to the surface on the left bank of a western tributary of Deep Creek, between which and the larger stream is a low alluvial flat. On the right bank of this lesser stream rise high terraces formed of gravels of older date, which, it may be, are the source of the oil at this place.

Oil rises from the bed of the stream and passes away with the current. A wing-dam, enclosing a narrow strip of the creek-bed, 12 ft. in length and about 2 ft. in width, impounds the oil oozing from the low bank and bed of the stream; and the water thus hemmed in was at the time of my visit covered to a depth of $\frac{3}{4}$ in. with a brownish rather fluid petroleum, but oil was escaping through the dam and passing away with the waters of the creek.

Several small holes 1 ft. in diameter and scarcely more in depth had been dug in the alluvial soil at distances 12 ft. to 20 ft. from the bank of the creek, and these invariably showed the presence of oil, though not to a greater depth than over the larger area hemmed in by the wing-dam. At this place there was no evidence as to what the primary source of the oil might be, and no attempt has been made to ascertain the nature of the rock underlying the gravels of the creek-bed.

About a quarter of a mile further up stream oil was again seen oozing from the bed of the creek at a point where this was bounded by an alluvial bank about 4 ft. in height. At this place no attempt had been made to sink holes or collect oil. A quarter of a mile yet further up stream, or half a mile above the locality first described, oil again appeared on the waters of the creek, and could be obtained from a solidified gravel showing on the left bank of the creek. This locality is known as the Sawpit. The solidified gravels closely resembled those of the "Old-man bottom" as seen on the south-east side of the Grey Valley, in the broken hilly country between Nelson Creek and Orwell Creek or Mount Napoleon. Resting on this, 10 ft. or 12 ft. above the creek, is a mass of sandstone, which at first sight appeared to be an erratic boulder, but on closer examination proved to be *in situ*, and to the north-west at the Sawpit was seen to break up into two or more beds, interstratified with gravel-beds and soft sandstone.

The coarser gravels underlying, on being broken into, showed the presence of oil, but, as oil floated on the surface of the pool in the creek, it was possible that the gravels had acquired the oil from that source when the creek was higher than at the time of my visit. The prospector who accompanied me as guide had no means, other than an old shovel, for digging a hole in these gravels, and with this instrument the surface could be penetrated a few inches only; yet as deep as could be reached oil appeared, and slowly oozed out of these gravels; and I concluded that the gravels yielded oil, and had not received it from the surface of the pool as above indicated.

I was informed that oil could be detected at places yet further up the creek, but the state of the weather did not favour penetrating a thick bush in search of indications no better than had already been examined.

North-east of Mr. Molloy's homestead, and about two miles distant, traces of oil are found in a bluish-grey soft sandstone, and samples of this were brought to me, but I did not visit the locality.

Geology of the District.

The formations present in the district are:—

(1.) *Recent.*—Gravels of the Arnold River and its various tributaries covering the low grounds and forming terrace of moderate height.

(2.) *Older Pliocene.*—"Old-man bottom." Coarse gravels, often subangular, and passing upwards into coarse breccia conglomerates.

(3.) *Miocene.*—(*a.*) Brown and grey soft sandstone associated with pebble-beds. (*b.*) Blue fossiliferous sands and sandy clays, at places marly, and downwards becoming glauconitic. (*c.*) Grey micaceous sands, sometimes a hard sandstone weathering brown, with pebble-beds, and at places containing bands of coal conglomerate and coal comminuted to a fine sand.

(4.) *Cretaceous.*—Coal-bearing series. This formation is present to the west and north-west, but there is no evidence that it directly underlies the surface-area over which the oil appears.

(5.) *Carboniferous.*—Maitai series. These rocks are largely developed on the Paparoa Range from the source of Moonlight Creek to Brunnerton, and south-west of the Brunner Gorge in Mount Buckley, and thence some distance along the range to the eastward. The eastern limit of this formation is a line drawn from the sources of Snowy River, a branch of the Little Grey, which, passing Bell Hill on its western side, is continued south-west to Kanieri Lake, Camel-back Hill on the Kokatahi Plain, Constitution Hill, and Mount Greenland. Between the Brown Grey and Lake Brunner these rocks are not seen at the surface, but there can be no doubt that they underlie the Recent and Tertiary strata, and form the fundamental rocks of the district over which indications of petroleum have been traced.

(6.) *Crystalline Schists, Gneiss, and Granite.*—These lie to the eastward of the oil-bearing area, and need scarcely be considered in this connection.

Probable Source of the Oil.

Formations 6 and 5 may be disregarded as being a probable source of the oil appearing at the surface, for, though the Carboniferous rocks might be considered capable of affording such, a careful examination of these rocks on the Paparoa Range throughout the Reefton district and along the east side of Little Grey Valley* showed no indications of either oil or gas springs.

The coal-bearing formation does not show north of Stillwater or east of the Grey River over any part of the district south of the Brown Grey, and, from the presence of much broken coal in the next overlying formation, it may be presumed that, even though once present, the coal rocks have been denuded over the area within which evidences of oil are present.

The Recent gravels, gravels of the "Old-man bottom," the brown and grey soft sandstones of formation 3 (Miocene), and the blue fossiliferous sands and sandy clays of the same formation, though capable of holding and storing oil, can hardly be considered as a likely source of the same; consequently there but remains the lower division of the Tertiary rocks, 3 (*c*), to which the source of the oil can reasonably be referred. This, it has been shown, contains considerable quantities of carbonaceous matter, the result of the breaking-up of coal-seams that formed part of the next older formation—the Cretaceous, or coal formation of the west coast of the South Island—and to this source the oil may reasonably be referred.

Rocks in which the Oil is found.

The gravels of recent date may be considered as merely admitting of the passage of oil, and as in no sense constituting storage-beds. With respect to the next underlying beds, which are more or less saturated with oil, there is some difficulty in determining their position and age. They present the normal appearance of the "Old-man" gravels as seen at the Sawpit in Deep Creek, and the soft sandstone and pebble-beds associated therewith as immediately overlying strata are not inconsistent with the assumption that the coarser material should be referred to the "Old-man" gravels, but the hard bluish-grey micaceous sandstone associated has not elsewhere been observed in connection with such rocks. This sandstone, however, appears in connection with the lower division of the Miocene group as above classified, and is in the range of hills between the Lower Grey and New River seen to overlie the bands of broken coal which have already been referred to.

The section from the Grey River across the front hills by way of Nelson Creek to Bell Hill supports the assumption that the rocks storing the oil lie at the base of the Miocene group, and do not represent the gravels of the "Old-man bottom" of Pliocene age. Along this line the gravels of the "Old-man bottom" form the lower slopes of the front hills and cap the hills to the eastward, the lower slopes of which and the valley-bottoms show the underlying brown sandstones and fossiliferous sands and clays. On the eastern boundary of these hills a steep scarp is formed, and the lower grounds to the eastward admit of the underlying beds, 3 (*c*), making their appearance. It has been stated there is some doubt as to the position of the gravels at the Sawpit, as to whether they should be referred to the "Old-man" gravels of Pliocene age or to the base of the Miocene sequence. Further examinations must determine this point, but in the meantime the evidence favours the conclusion that it is the coarser gravels associated with the lower Miocene beds, 3 (*c*) of the classification given above, that constitute the storage from which oil is escaping at the present time, and the only reasonable conclusion as to the source of the oil is that it is the product of the beds of coaly matter that lie at a greater depth in the same beds.

Prospecting.

Practically no prospecting has been done, and no prospecting-holes have been sunk to a greater depth than 2 ft., and these are all in the recent shingle or alluvial banks of Deep Creek. A series of holes should be sunk in the gravels at the Sawpit above the level to which the ordinary flood-mark reaches. If oil collects in such holes, then it may be fairly assumed that the oil has penetrated to near the surface from below. It will then be for those concerned to determine whether the oil should be collected in seepage-wells, or whether an attempt should be made by boring to reach oil under pressure at greater depth.

6th December, 1900. ALEX. MCKAY.

* Various geological explorations between 1874 and 1895 have been carried on over the districts mentioned by the Geological Survey and Mines Departments.

Samples of the oil from Kotuku were submitted to Mr. B. C. Aston, Analyst to the Agricultura Department, and the following report on these was furnished by him to the Mines Department:—

"*Crude Petroleum.*—This is a brownish-black liquid oil, having a specific gravity of 0·921. It retains its liquid state when subjected to a temperature of 15° C. On fractionating by distillation it yields the following: Below 150° C. (light oils and naphtha) trace; 150–300° C. (burning oil s.g. 0·863)=37 per cent.; 300–400° C. (heavy oil s.g. 0·884)=42 per cent.; above 400° C. (tarry residue in retort)=21 per cent: total, 100 per cent.

"The sample has a higher specific gravity than most American crude petroleums, but this and the absence of light oils or naphtha might be accounted for partly by the exposure of the sample to the atmosphere in thin layers before it was collected, entailing volatilisation of the lighter fractions, with possibly some oxidation of the remainder. The oil contained in the first fraction is rather heavier than is usually used for burning purposes. That in the second fraction would probably find best application as a lubricant. The tarry residue could be used for fuel.

"I enclose samples of the various distillates from the oil, and trust that further search may result in the discovery of a lighter oil, having a larger percentage of low boiling constituents."

REPORT ON THE KAIMANAWA RANGES, HAWKE'S BAY.

By Alexander McKay, F.G.S., Government Geologist.

As instructed, between the 7th January and the 18th February of the current year I made an examination of the eastern part of the Kaimanawa Mountains lying between the Ngaruroro and Rangitikei Rivers, and of the high-level plains and downs between the gorge of the Taruarau River and the Rangitikei below where it leaves the higher mountain district within which it takes its rise.

Prospecting.

The principal object of the expedition was to examine certain parts where gold had been reported as occurring: Firstly, in the Upper Ngaruroro; and, secondly, in the valley of the eastern main branch of the Rangitikei (the Mangamaire Stream), and at other places in Rangitikei and Taruarau Valleys.

For more than thirty years gold has been reported as occurring in the Kaimanawa Ranges, and when, in 1870–71, the district was examined by Sir James Hector prospectors were then engaged in both the eastern and western parts of the district, and traces of gold—a few colours to the dish—had been obtained.

In 1898 I partly examined the western part of the mountain region, the slopes of the south-western Kaimanawas, and farther north some parts of the Tauranga-Taupo and Hinemaia Valleys. I also saw at Tokaanu a considerable amount of rocky material, brought from the higher part of the western mountains, but neither these nor a study of the rocks *in situ* impressed me highly as to the auriferous character of the country.

Much of what had been collected as quartz was of too flinty a character to give promise of gold, and frequently calcite mixed with a greenish rock had been mistaken for quartz. In the latter cubes of yellow iron-pyrites formed an attraction, and, I suspect, were sometimes thought to be gold itself. Even during the recent trip such samples were shown to me as gold-bearing quartz, and the contained pyrites referred to as proof of the auriferous character of the stone. Sir James Hector was informed by a prospector engaged in examining the western mountains that "he frequently obtained the *colour*, especially above the gorges, but that on following the river (Tauranga-Taupo) into the slate country, in the upper part of its course, he never obtained any specs of gold in the wash" (Geological Reports, 1870–71, p. 162). What little gold I saw taken in 1898 in the upper valley of the Hinemaia River occurred in wash of a volcanic character, mainly a porphyritic trachyte. The sources of the Hinemaia and Tauranga-Taupo are partly in the slate and sandstone mountains of the northern part of the Kaimanawas proper, and in 1898 I supposed that the gold found in the rivers running west into Lake Taupo had its source in the slate country to the south and east. Sir James Hector indicates the pyritous reefs associated with the slates and sandstones as the source of at least some gold, and such also seems to have been the conclusion arrived at by the various prospecting parties who at different times have examined the country.

Since 1871 till the present time several parties of miners and prospectors have made search for gold in these mountains, but the results have never been more than a trace of gold—a few fine colours to the dish of stuff. And, as regards the eastern parts of the district within the Rangitikei and Ngaruroro watersheds, it was from Napier that the chief prospecting parties were despatched, and there the chief interest in hoped-for discoveries was displayed. A prospecting association was formed, but this, as time went on and no important discovery was made languished, and within the past few years was dissolved. During the existence of the Hawke's Bay Prospecting Association, and since, applications have been made to the Minister of Mines for a survey of the Kaimanawa Mountains, and as the outcome of these I was instructed to examine the country, which I did during the months of January and February of the present year.

Leaving Wellington on the 7th January, on reaching Napier I made preparations for the journey inland, and arranged to be accompanied by Mr. Robert Yuill, who had twice previously been engaged on prospecting parties to the Kaimanawa Mountains, and who claimed to have obtained prospects of gold at several places in both the Rangitikei and Ngaruroro Valleys. On the 11th January I reached Kuripapanga, where the road to Inland Patea crosses the Ngaruroro River. Here some delay took place, and it was not till the 16th that a start was made for Owhakao Station,

on the Taruarau River, from which on the following day the expedition started for the inner higher part of the mountain region, and from which it returned to Kuripapanga on the 12th February, and to Napier on the 14th February. A prevalence of wet and stormy weather interfered considerably with the work, and in the higher region work was twice interrupted owing to snowstorms which occurred on the 26th January and 7th February.

From Owhakao Station the first search for gold was made twelve miles distant in the Upper Taruarau Valley, but without any result. Mr. Yuill as prospector stated that on a former occasion he had obtained prospects in this valley. To me the general character of the wash was not encouraging. The outlines of the valley were such that in an auriferous country gold might be expected, but the high-level terraces were covered or formed of pumice gravel only. No sandstone and slate gravels are found except along the present channels of the river and its tributaries, and this is of a character scarcely favourable for the occurrence of gold. The sandstones are hard and of varying grain up to grit and fine-grained slaty breccia, into which they sometimes pass, and the more argillaceous rocks are almost without exception a dark-coloured slaty shale or mudstone, and show no sign of mineralisation, and quartz is nowhere to be met with, or, at least, is extremely rare. Six miles from the station I found one piece of quartz in the creek-bed of the stream which drains from the westward the range on that side of the Taruarau Valley.

About eleven miles up the valley the river flows over a greenish-blue angular breccia consolidated into a hard rock which might possibly be a source of gold, and the terrace on the left bank of the Twelve-mile Creek is formed of similar material—viz., the *débris* of the older rocks covered slightly with pumice. In the first instance we are dealing with a fan or slope deposit from the adjacent heights on the left bank of the river, in the latter case with the material rushed through the gorge of the creek and deposited in the main valley. It is possible that a colour of gold might be obtained from either of these deposits.

Higher up the valley to the source of the main branch of the river there is but little pumice, and the mountain *débris* brought forward by this and the lesser streams and deposited where favourable areas for lodgment occur, are unpromising in character, and in condition they offer little encouragement to the gold-hunter.

The only prospecting done was in the vicinity of the Twelve-mile Creek, and, no gold being obtained, Mr. Yuill declared that even when first prospected but little gold was found.

The range to the west was then crossed into the valley of Kaimanawa Creek, and in the meantime I had an opportunity of examining the upper basin of the Ngarururoro. Above the gorge by which the Ngarururoro breaks through the Kaweka Range the valley of the river widens, and two or three creeks from each side of the valley join the main stream. For two and a half to three miles above the gorge the river-valley presents the appearance of having at one time been the bed of a lake, the terraces on each side being nearly horizontal. The upper terraces are fully 100 ft. above the flat through which the river runs. From top to bottom the upper terraces are formed of pumice-drift, fine-grained in the lower part and coarse in the upper part, many blocks of pumice being 2 ft. in length and breadth. These terraces are not such as might be considered favourable for the occurrence of gold in them, and as much of the material has evidently reached its present position by flotation the presence of gold cannot be looked for.

The present bed of the river and its immediate banks is formed of sandstone and slate shingle, with a small proportion of acidic volcanic rocks, consisting of porphyritic trachytes, and fluidal rhyolite. I had no means of testing the river-bed for gold; but I came to the conclusion that payable gold was not likely to occur. I made search over a considerable area of shingle-bed for quartz, but found only one piece of grey flinty quartz of a most unpromising character. Three or four parties of prospectors have examined this upper valley of the Ngarururoro, and none of them have reported more than the finding of a mere colour of gold. I therefore concluded, and I think rightly, that, as far as alluvial gold is concerned, nothing payable will be found; and as respects the occurrence of auriferous reefs in the mountains of the neighbourhood the chances are not great. I saw but two pieces of quartz in this part of the district, one fair-sized piece in Golden Creek (the name is hopeful), and the piece already mentioned as having been observed on the shingle-bed of the Ngarururoro River. On rejoining Mr. Yuill I questioned him as to what prospects had been obtained by him, or his party, from the Ngarururoro Valley, and he asserted that the colour had been found.

In the valley of Kaimanawa Creek, the most eastern tributary of the Rangitikei, north of Owhakao Station, some prospecting was carried on over a distance of three miles in the middle part of the valley. Both the pumice, and slate, and sandstone gravels were tried, but not a colour of gold was obtained.

From Kaimanawa Creek hut the intervening range was ascended, and followed both north and to the south, and descents thence were made into the valley of Mangamaire Creek, the eastern main branch of the Rangitikei River. The range followed north for five miles brings one abreast of Makorako, the highest peak of the Kaimanawa Mountains, and it was in the bed of the Mangamaire, opposite this mountain, that the best and presumably paying prospects of gold had been found. Lower down the stream where its bed could be reached and tested no gold could be found; and so every effort was made to reach the locality where Mr. Yuill asserted ten strong colours of gold to the dish of stuff had been found. Some parts of the mountains were impassable for such pack-horses as we had with us, so to reach the Mangamaire at the place indicated the journey had to be done on foot.

This was finally done, and after a day's prospecting a few fine colours of gold were found in the sandstone gravels of the creek-bed, and in the crevices of the rock where this was exposed near the water-edge. The total of the gold obtained, had it been the product of one dish of stuff, would not have constituted a paying prospect in a sluicing claim, and fell far short of what I was led to anticipate.

The character of the gold was exceedingly fine, thin, and scaly and, though of good quality, was a light gold, and a great bulk of it would be required to weigh an ounce. The gold found had evidently travelled a considerable distance, and could not have had its source in the rocks of the immediate neighbourhood.

The valley of the Mangamaire has been choked with pumice-drift to a depth of 120 ft., and through this the stream has again cut its way to the bed-rock, leaving terraces of pumice material clinging to the hill-slopes; while at the level of the stream all pumice has been carried away, and no pumice appears except a stray piece washed out of the higher terraces. As in the Ngaruroro, a sprinkling of volcanic rocks of greater density than pumice appears in the shingles of the bed of the creek, and there is in the wash of all the creeks of the district considerable quantities of magnetic black sand.

Owing to the flooded state of the Mangamaire, the west or right bank of the stream could not be reached, and it was on this side that Mr. Yuill stated he had obtained his best prospects, and, as he explained, from a red gravel resting on slate rock. As but the width of the creek interposed, and as the red gravels were also exposed on the left bank, they were prospected, but no gold was found. One mile further down the stream a shingle beach was tried, but no gold was found, and half a mile higher up prospects were washed from a good-looking beach on the main stream, and also at the mouth of a tributary creek coming from the east, but without results.

This scarcity of gold was conformable with the character of the rocks in which the valley of the Mangamaire has been excavated. They consist, as usual, of hard sandstones and dark shales and mudstones, which are in nowise mineralised, are wholly destitute of iron-pyrites and other sulphides, and there is also a remarkable absence of quartz. The magnetic sands found in the wash of the different creeks have been derived not from the older rocks, but from the pumice and rhyolite fragments scattered over the country. These magnetic sands are found equally in the pumice of the mountain-tops and the reassorted pumice drifted into the valleys.

The eastern Kaimanawas have been reported as abounding in quartz reefs. This I found to be not the case. From Kuripapanga to the sources of the Rangitikei quartz of any kind is remarkably scarce. At Kuripapanga, where the Ngaruroro breaks through the southern end of the Kaweka Range, the rocks are well exposed in the banks of the river and in the road-cuttings across Gentle Annie, on the line of travel from Napier to Inland Patea. The rocks are thin-bedded sandstones and shales, and the joints of the sandstones are mostly covered by a white mineral, powdery or in thin films, which often leads to the impression that the thin-bedded sandstones are quartz. These rocks extend throughout the Kaweka Range and west to the valley of the Taruarau at Owhakao, and may thus have given rise to the reported frequent occurrence of quartz. Thin veins of calcite do occur in these rocks, more especially towards the west.

On the ridge of mountains between the upper valley of the Taruarau and Kaimanawa Creek there is one vein of grey flinty quartz, but this, not more than 8 in. thick, contains no pyrites, and otherwise looks most unpromising for gold.

On the southern end of the range, between the Kaimanawa Creek and Mangamaire Stream, there are two heavy bodies of grey cherty quartz identical with what may be met with, and has long been known to occur, in the Rimutaka, Tararua, and Ruahine Ranges. The larger of these lodes carries a fair sprinkling of pyrites, and, as usual with this stone, it may carry a little gold. Samples from this reef were sent to Wellington some years ago, and, on analysis, gave a return of 7 dwt. of gold to the ton of stone. This reef is 27 ft. across, and if the 7 dwt. return be maintained in the samples brought by me it is possible the reef may be worked to profit. The lesser body of stone lies a short distance to the westward, while more to the north there are lesser veins that strike more to the westward, and would therefore make junction with the larger of the two main reefs.

Two miles and a half more to the north, and on the same range, there are one or two small reefs of white and more crystallized stone, but these are of little consequence, being too small to work. Four miles to south-east there is another outcrop of quartz, white and crystallized. This I did not have an opportunity of examining, but Mr. Macdonald has kindly forwarded samples, which show that this is a stone likely to carry gold, although very little mineral of any kind is to be seen in the quartz.

These quartz lodes on the Mangamaire Range all lie towards the southern end of the range, between the Kaimanawa Creek and Mangamaire Stream, and near the junction of these with the Rangitikei. The strike of the larger bodies of stone is north-north-west, and the dip is to the west-south-west at high angles. The more crystalline lesser reefs strike more to the west, and thus, if continued, intersect the larger.

The larger bodies of quartz are evidently continuous outcrops for a very considerable distance, and this is the character of the rock elsewhere. When at Tokaanu in 1898 I learned that over and above the small leaders usually prospected (because more accessible and usually showing more pyritous mineral) there was a very large reef high on the mountains, towards the source of the Rangitikei River. It is in this direction, or possibly somewhat more to the east, that the larger reefs here described do strike.*

Altogether the results of the expedition in so far as concerned the finding of gold were somewhat disappointing.

Geology.

The rocks along the line of travel from Napier to Kuripapanga, and thence by the coach-road, to the Rangitikei River, of the Kaweka and Kaimanawa Mountains are in descending order, as follows:—

* An unavoidable delay has arisen with respect to obtaining analysis of the samples of quartz collected, and, since my return to Wellington, forwarded to Wellington, and thus their value cannot be stated at the present time.

Recent.— 1. *a.* Alluvial deposits; river-beds and river-terraces of modern date.
b. Special deposits of pumice along the river-valleys, consisting of pumice and pumice sands.
Pleistocene.— 2. *a.* Deposits of pumice on elevated and flat-topped areas.
b. Volcanic rocks at the source of the Rangitikei.
Pliocene.— 3. *a.* Upper or Puketapu limestone.
b. Sandy clays and pumice sands.
c. Lower or Puhoi limestone.
d. Sands and pebble-beds, with patches of shelly limestone.
e. Coarse breccias and conglomerates.
Triassic.— 4. *a.* Sandstone and carbonaceous shales forming the Kaweka Range.
Carboniferous.—5. *a.* Rocks of the Kaimanawa Mountains.

Carboniferous.

5, *a. Rocks of the Kaimanawa Range.*—These in the district examined consist chiefly of grey indurated sandstones and dark shales and mudstones. There is little variety in these rocks. The strike is usually north-west to west, and towards the east side of the area over which they occur the dip is easterly and more towards the centre of the mountain region to the westward. The sandstones weather to a light-grey, and often could be mistaken for quartz. Even the more sandy of the shales have a tendency in this direction. With these rocks are bands of slaty breccia consisting of small pieces of slate in a sandy matrix.

The trend of the principal river-valleys is partly across the strike of these rocks, the lateral lesser valleys being more in the direction of the strike; the result is that along the main valley of the Rangitikei and that of its principal tributary, the Mangamaire, the mountain heights are an apparently confused assemblage resulting from the greater resistance of the hard sandstones to denuding agents. Originally the whole has been an elevated table-land, but the present features were mainly determined prior to the pumiceous outburst of late Pliocene or Pleistocene times.

Towards the east on the Mangamaire Range, and between the Upper Mangamaire and the Ngaruroro, traces of this table-land still remain; and both this and the range between Kaimanawa Creek and the Taruarau Valley have a linear direction in a north-north-east direction, which distinguishes this part from the area more to the westward.

During Pliocene times the country was depressed 3,000 ft. lower than at the present time, and the southern part of the area was at and below sea-level.

The mineral wealth of these rocks is not great; gold does occur in the river-gravels of the district, but clearly not in quantity sufficient to pay for working the drifts, which themselves are not of great extent. Quartz reefs carrying a percentage of gold also occur on the southern part of the Mangamaire Range, but the real value of these has yet to be determined. (For fuller particulars *re* gold, see previous section of this report under heading of "Prospecting.")

As to the age of the rocks forming the Kaimanawa Mountains, they are here considered as Carboniferous, and correspond with the like rocks in the Ruahine, Tararua, and Rimutaka Mountains. No definite proofs of the age of these rocks have yet been obtained. Indistinct plant-remains do occur, and the fossil annelid of Mount Torlesse, Canterbury, is found at Cape Terawhiti; and, as the rocks of Mount Torlesse are generally regarded as of Carboniferous age, this and the certain knowledge that they are older than Trias, and do not resemble the known Devonian rocks of New Zealand, make it highly probable that the rocks of the central part of the Kaimanawa Mountains are of Carboniferous age.

Triassic.

4, *a. Rocks of the Kaweka Range.*—These form the eastern margin of the mountainous country, and rise abruptly from the lower country to the eastward, and which is formed of younger Tertiary rocks. The rocks of the Kaweka Range, and the continuation of the same south of the Ngaruroro River, are younger than those of the central higher part of the Kaimanawa Mountains, and are somewhat different in character, though still consisting of interbedded masses and bands of sandstones and shales, the sandstones considerably indurated. The thinner-bedded sandstones alternate with sandy shales of a light-brown colour, which are frequently crowded with obscure plant-impressions, and sometimes to such an extent that the shales might be regarded as coaly shale. The heavier beds of hard grey sandstone sometimes attain a thickness of 30 ft. or 40 ft., but are not continuous for any great distance, and as a rule are much jointed. The thinner-bedded sandstones having partings of shale between are always much contorted, and are as much jointed as the heavier-bedded rocks just described. The joints are filled with a white powdery mineral which, adhering to the surfaces, makes it appear as though the thin-bedded sandstones were quartz, and for such they have often been mistaken; otherwise it is difficult to explain the oft-reported occurrence of quartz in the Kaweka Range.

Calcite sometimes is found with these rocks, but always in thin veins and nests; and a common error of prospectors such as have explored the Kaweka and Kaimanawa Ranges is to mistake calcite as a form of quartz, but calcite as it occurs in these mountains cannot be made responsible for the reported thick reefs of quartz.

The brown sandy shales which have been mentioned as forming a part of these rocks are well displayed in the cuttings of the mountain-road that, west of Kuripapanga, crosses Gentle Annie. I spent some time endeavouring to obtain plant-impressions of a character such as might lead to an identification of the species to which they belonged, but the search was fruitless.

The Tutaekuri River takes its rise in the Kaweka Range, and the shingle-bed of that river shows here and there boulders of jasperoid quartz. These, I inferred, had been brought from the upper tributaries of the stream; but, though it is more than likely that the jasperoid rocks are

present in some part of the Kaweka Range, no trace of them is to be met with in the southern part, either in the Ngaruroro Gorge, the shingle of the river-bed, or anywhere along the road between Kuripapanga and the crossing of the Taruarau River. More to the south—west of Kereru—the flinty jasperoid rocks occur in the eastern part of the Ruahine Range, and they are practically continuous thence to the Manawatu Gorge. Towards the west, along the upper valley of the Taruarau, there and in the Upper Ngaruroro there is an absence of these red rocks, which is somewhat remarkable, seeing that they again make their appearance in Stony Creek, near Tarawera, on the Napier–Taupo Road.

In the Ruahine Range and farther south these red rocks and the massive bands of grey flinty quartz occur in the near vicinity of each other. North of the Ruahine Range they are separated by a considerable distance, or the red rocks are absent or but feebly developed in the Kaweka Range, and it is a question whether the jasperoid and grey quartz-rocks belong to the same formation. In the Kaweka Range the powdery-jointed sandstones and the plant-bearing beds are apparently distinct from the sandstones and black shales of the mountains farther to the west. Near Wellington the powdery-jointed sandstones are closely associated with rocks that yield the annelid of Mount Torlesse, and have hitherto been regarded as belonging to the Carboniferous formation. The plant-beds overlie to the eastward, and are well seen on the south shore of Porirua Harbour, at Ngahauranga, and in the north-east spur of Mount Victoria, Wellington.

I have described the rocks of the Kaweka Range as being of Triassic age, and as distinct from those of the Kaimanawa Range; and the evidence obtained in the locality will warrant this. How far the problem of their distinctiveness is borne out by evidence elsewhere obtainable must be judged by what is stated above.

Pliocene.

3, *e. Coarse Breccias and Conglomerates.*—The Tertiary rocks forming the high plateaux, downs, and hilly country of Inland Patea district, as a rule, have at their base a coarse breccia or more or less rounded conglomerate, usually derived from rocks in the vicinity of where such breccias occur. On the high grounds, 3,000 ft. above the sea, that lie between the Rangitikei and the Taruarau Rivers not a great thickness of sandy fossiliferous clays interpose between these beds and the overlying limestones (3, *c*), and it may fairly be inferred that the breccias and conglomerates are shore-line deposits derived from a mountainous country such as at present exist to the north and north-west of where the breccias have been deposited. At places, as in the Upper Taruarau Valley, the breccias and conglomerates are absent, the fossiliferous sandy clays resting direct on the slates and sandstones of Carboniferous age. Between the Taruarau and the western base of Gentle Annie these rocks are of great thickness, the upper part being a conglomerate, the lower a coarse breccia, and the rocks forming and represented in these are all derived from the older sandstones in the same neighbourhood. At places between Gentle Annie Saddle and the crossing of the Taruarau River these breccia conglomerates are some 200 ft. thick. On the table-land west of the Taruarau they have an elevation of 2,700 ft. above the sea. In the creek at the western foot of Gentle Annie they are about 1,700 ft. above the sea, but the same gravels occur on the Gentle Annie Saddle at a height of 2,250 ft.

These gravels follow the eastern slopes of the Kaweka Range, north and east of the Ngaruroro Gorge, and here assume the character of very coarse conglomerates. In this part they have a thickness even greater than to the west of Gentle Annie Saddle. They present the appearance of a very coarse river-gravel, and but for the fact that they clearly underlie the marine-beds next in the sequence they might be mistaken for river-gravels of Pleistocene or recent date.

From the Ngaruroro Gorge north-east along the eastern base of the Kaweka Range these beds are much disturbed, occupying nearly horizontal or nearly vertical positions within short distances. West of the Taruarau they are generally in a nearly horizontal position. On these beds between the Taruarau and the Rangitikei, Sir James Hector remarks: "Within a few miles of Mr. Birch's station, in the valley of the Rangitikei, the Tertiary strata can be observed to thin out against the mass of slate (*a*) rock [shown in section] at an altitude of 2,800 ft. above the sea-level. Gravel-beds occur with false-bedded layers and other characters that lead to the belief that there is preserved at this place the original shore-line of the Tertiary sea, the calcareous strata having been deposited among a group of slate islands, now represented by the Kaimanawa, Kaweka, Ruahine, and Tararua Mountains. Since the period of this deposit there must have been great inequality in vertical movement, as the same strata which round the last-mentioned range only reaches to less than 1,000 ft. above the sea are in the north found at more than twice that altitude."*

I have already referred to the disturbed state of these beds and the unequal heights at which they appear at localities not far removed from each other.

3, *d. Sands and Pebble-beds with Patches of Shelly Limestone.*—These beds appear both on the table-land west of the Taruarau and overlying the breccia conglomerates east of the Kaweka Range. In the latter locality they have a much greater development than in the western area, and cannot be short of 500 ft. thick. With the sands are pebble-beds, or fine conglomerates; and these are distinguished from the coarser breccia conglomerates that underlie by the presence of quartz pebbles and a bright-green slaty rock not found in the lower beds, nor known to occur in either the Kaweka or Kaimanawa Mountains. The sands are to some extent composed of pumiceous material, though no actual pieces of pumice are to be found in them. Patches and beds of shelly limestone, sometimes very impure, owing to contained pebbles, are found between the Blowhard and the eastern base of the Kaweka Range, and between Gentle Annie Saddle and the Taruarau River; and where the lower beds of the series are absent white sandy clay and patches

* Geological Reports, 1870–71, p. 161.

of shelly limestone are found resting on the older slate and sandstone rocks, as at Kuripapanga and more to the north-east. These beds show as nearly horizontal strata on the table-land west of Taruarau Gorge.

3, *c. Lower or Pohui Limestone.*—These limestones are found in the western part of the district under conditions described above in the extract made from Sir James Hector's report. They show on the northern side of the high downs west of the Taruarau Gorge, but are more fully developed to the west and south-west, towards the Rangitikei. However, the principal development is to the eastward of the Kaweka Range, in the Blowhard Range, and in Cattle Hill and Bonnie Mary, nearer the Ngaruroro. In the Blowhard Range a variable thickness of 3, *d*, underlies the limestone, resting on slates and sandstone rocks of the age of those forming the Kaweka Range, the lower beds (3, *e*) being absent. The limestones are variable in thickness, sometimes in one thick stratum and sometimes sandy beds between divide it into an upper and a lower limestone. This limestone is shelly, chiefly formed of oysters; large pectens are said also to occur, but I saw none of the latter along the line of the coach-road to Kuripapanga. This limestone strikes in the direction of Puhoi and the Mangaharuru Range, in which latter it attains a height of 4,000 ft. above the sea. It is most likely, also, the equivalent of the lower limestone in Scinde Island, and it is lower in the sequence than the Puketapu limestone, the section along the Tutikuri Valley showing this clearly. Some years ago Mr. A. Hamilton collected the fossils of the Blowhard Range, and, if I remember aright, he at the time informed me that he found many of the larger pectens of Scinde Island and *Ostrea ingens* in this limestone. Thus the evidence as to position, and the fossil contents, favour its correlation both with the Scinde Island and Te Aute limestones.

3, *b. Sandy Clays and Pumice Sands.*—The limestones of the Blowhard dip east, and at the foot of the range pass under a series of sandy clays, conglomerates, and pumice sands that, forming a belt of country that extends about six miles east to west, and stretches south across the Ngaruroro into the Kereru district and north to the Esk River and Rangipapa Hill. The middle and higher parts of these rocks are decidedly pumiceous, as shown in Kereru Stream, in the Tutaekuri and the Esk Valleys. In the Tutaekuri Valley thick beds of sandstone conglomerates occur in the middle part of the section. These correspond with the conglomerates of Rangipapa Hill, which in the Esk Valley are overlain by beds of clay and sandy clay rich in a great variety of Younger Pliocene fossils. They are also richly fossiliferous in Kereru Creek and at Petane, in which latter locality exhaustive collections were made by Mr. Hamilton.

In the Tutaekuri Valley the beds are also rich in fossils, but these have yet to be collected. To do so is scarcely needful, as there can be no doubt as to the identity and correlation of the beds in question in the localities named. The importance of the Tutaekuri section lies less in the abundance of the fossil contents of the rocks than in the clear and decisive manner in which they are seen to overlie the Blowhard limestones on the one hand, and underlie the Puketapu limestones on the other hand.

3, *a. Upper or Puketapu Limestone.*—These rocks from Puketapu stretch westward along the higher lands on each side of the Tutaekuri Valley for a distance of ten miles. The western exposure forms a bold scarp stretching away to the north, and which is less marked on the south side of the valley. The sides of the valley show this limestone covering up the pumice sands and fossiliferous clays that underlie it, and leaves no doubt as to the relative position of the two underlying rocks to the limestone above.

South, the Puketapu limestone is continued through the hills across and beyond the Ngaruroro into the Maraekakaho watershed, within, or beyond which, by the thinning-out of the sands and fossiliferous clays, it coalesces with the Te Aute limestone.

To the north it extends through Petane and east of the Lower Esk into the Mohaka watershed. It probably also constitutes the upper limestone in Scinde Island. The fossils of this limestone are almost wholly recent species, but they have not been specially collected to show this. As the lower limestone contains almost no extinct species, except *Ostrea ingens* and the group of larger pectens for which that horizon is famous, only recent forms could be expected from the upper limestone.

Pleistocene.

2, *b. Volcanic Rocks at the Source of the Rangitikei River.*—These I did not examine *in situ*. In the Upper Ngaruroro I found boulders of a rhyolite tuffs, none of which could be found among the pumice and rhyolite fragments covering the flatter parts of the mountain-tops. The same material was also found in the bed of the Mangamaire Stream, and more plentifully than in the Ngaruroro, while it was equally absent from the pumice deposits of the mountain-tops in that neighbourhood. On making inquiries, I learned from Mr. Macdonald, of Owhakao Station, that the material in question occurred in the solid in a western source branch of the Mangamaire Steam, close to the watershed leading into the main source of the Rangitikei River. This I intended to visit, but owing to the inclemency of the weather and other causes was unable to do so; but before leaving the district I requested Mr. Macdonald to forward to Wellington samples of the rocks described by him, and these have since been received.

The samples forwarded consist of fluidal rhyolite, such as is common on the east shore of Lake Taupo, and forming a large part of the great breccia that on the east side of the lake overlies the finer pumice sands and sediment. With these were also a pitchstone, containing crystals and blebs of sanadine feldspar, and the rhyolite tuff in question. These rocks do not cover any considerable area, but form a number of low rounded hills to the north of the creek-channel, and, as parti-coloured rocks, show in the bed and banks of the stream, and where exposed are partly decomposed, and so soft, barring the harder kernels present, that an ordinary walking-stick may be with but little effort pushed almost out of sight into these rocks.

There is thus here a deposit of rock that, consisting of rhyolite lava, rhyolite tuff, and pitchstone, must be considered as *in situ*, and occurs as a sort of outlier from the great development of

such or similar rocks that extend from the east shore of Lake Taupo to the sources of the Hinemaia on the south, and to within four miles of Tarawera on the Napier-Taupo Road towards the north-east. Whether this isolated area formed a centre of eruption or constituted the southern limit of lava-floes from volcanic vents further to the north cannot, with the information at hand, be determined; but it is clear that volcanic material, as tuffs and lava-streams, originated or did reach into the watershed of the Rangitikei, and the same may be said of the upper branches of the Ngaruroro River.

2, *a. Deposits of Pumice on Elevated and Flat-topped Areas.*—The existence of pumice fragments forming a covering more or less deep over a large area of the Hawke's Bay District, though often noted, has never yet received a full and sufficient explanation. This pumice-covered area has its southern boundary approximately along the line of the Napier–Inland Patea Road, from Kuripapanga, on the Ngaruroro River, to the western borders of the Kaimanawa Mountains. The northern limit lies beyond the Napier–Taupo Road, and the eastern boundary may be regarded as a line drawn from Pohui to the Ngaruroro at Kuripapanga. Fine pumice may extend beyond these boundaries, but within them the deposit is very noticeable. To the west the pumice-deposits of Rangipopo are not regarded as originating from the same source, and therefore may be for the present disregarded.

The Rangitikei, Ngaruroro, and Mohaka, and their tributaries, bring down great quantities of float pumice and pumice sands. Such pumice forms deposits on the banks of the rivers, or on the flood areas of the costal plains, or, as in the case of the Mohaka, where the costal plain is absent, is carried out to sea. This is the pumice that most frequently comes under observation, and will have to be dealt with under Recent formations.

The pumice now under consideration is the source of that which forms secondary deposits along the river-channels, &c. I first noted this pumice on the Maungaharuru Range, east of the Mohaka, below the crossing of the Napier–Taupo Road, and had difficulty in referring this to the same causes as would account for the pumice along the bed and terrace plains of the Mohaka River. Fragments of pumice several inches in diameter are found with smaller material at heights approaching 4,000 ft. above the sea.

During 1886–87 I reported on the eastern counties of the North Island, parts of the Provincial Districts of Auckland and Hawke's Bay, and, under the heading "Aeolian Pumice Deposits," stated what was then known of such deposits, as follows:—

"Over northern Hawke's Bay this superficial deposit is evidently derived in part from stratified beds of pumice sands in the marine Pliocene strata of the district, but by far the greater amount seems to have been spread over the district in a manner of which the late outbursts at Tarawera and Rotomahana may be said to furnish explanation and proof.

"Apart from the drift along the banks of the larger streams, this more general covering of pumice sand was first noted by Mr. Cox, late Assistant Geologist, in a report on the country between Poverty Bay and Napier, describing them thus: 'Post-Tertiary: Under this head are . . . . certain deposits of pumice sand and tufaceous beds, which attain their greatest development inland, occurring only to a small extent along the coast ranges' (Geological Reports, 1874–76, p. 97). 'Although these pumice sands overlie the marls [of Cretaceo-Tertiary age] they by no means obscure them, for the formation assumes the form of the plateaux which have been deeply cut into by the rivers which take their course from the back country to the sea' (*l.c.*, p. 98). Where they rest on Tertiary beds he describes the pumic-sands thus: 'Soon after the Taupo Road leaves the bed of the Esk River beds of tuff and pumice sand very similar to those occurring on the West Coast in the neighbourhood of Raglan appear, and cover a considerable area of country, the soil of which appears to be very barren' (*ib.*).

"Here Mr. Cox describes beds forming part of the fossiliferous Petane series of Pliocene date, corresponding with the beds 3, *b*, of the present report. Mr. Cox wrongly associates them with the drifting superficial pumice 2, *a*, and 1, *b*. of this report; but in recognising the presence of beds of tuff and pumice-sand in connection with the Younger Pliocene fossiliferous strata of Petane he noted an important fact, which some later observers have disregarded or entirely overlooked. Excluding 2, *a*, and 1, *b*, as above, it will be seen from the map accompanying Mr. Cox's report that the pumice sands described by him are confined to the area over which, according to Mr. Cox, Lower Tertiary and Cretaceo-Tertiary rocks are found—*i.e.*, Pliocene strata of this report.

"Touching this same subject Professor Hutton, writing in 1885, remarks, 'I could detect no pumice in any of these beds [belonging to the Petane series], but it occurs in abundance at Titiokura Saddle . . . and at other places in beds lying unconformably on the Petane series, as has already been pointed out by Mr. Cox.' (Trans. N.Z. Inst., Vol. xviii., p. 342.)

"In the geological reports for the year 1885, at page 191, I ventured remarks respecting the manner in which this deposit has accumulated over northern Hawke's Bay, and I considered it as a result of a wind-drift from the volcanic area to the west; but by far the most exhaustive and interesting account of the pumice-drifts covering this part of the North Island is given by Mr. Percy Smith, Assistant Surveyor-General, in a paper 'On the Geology of the Northern Portions of Hawke's Bay.'" (Trans. N.Z. Inst., Vol. ix., p. 565.)

At page 572 of the report referred to he says, "I have mentioned above the occurrence of pumice in this district. It is found nearly everywhere—on the river-terraces, the hillsides, and on the top of the highest mountains, covering the surface with a deposit of sand more or less deep, and in larger or smaller particles. During the course of the last five years it has been my duty to visit the tops of most of the higher mountains lying between Napier and Tongariro, and thence northward to the country under consideration, and in every case a deposit of pumice sand has been found, sometimes plainly showing, at others covered by vegetation. On Panikiri and neighbouring ranges around Waikaremoana it is found of a considerable thickness, whilst the lower lands along the lake are covered by it, sometimes to a depth of 3 ft. On the eastern side of the Mungaharuru

Range it is very thickly deposited, being often in the gullies 6 ft. to 8 ft. thick. The extensive terraces of the Lower Mohaka River (which contain as large a quantity of level land as is to be found in the district) are thickly covered with it, thereby rendering them unfit for cultivation. Towards the east the deposit gradually thins out, until approaching the vicinity of Poverty Bay very little of it is seen. The only spots that are free from it are the lower terraces of the rivers and the surface-slips; and, as the country lying along the coast is the most subject to these slips, as mentioned above, it is here that the pumice has in a great measure disappeared, thus allowing the grasses to spread.

"The general opinion appears to be that this pumice was ejected from Tongariro and the adjacent volcanoes, and was spread over the surface of the country by the wind; and there are certain considerations which favour this view, such, for instance, as finding the greatest thickness of sand on the lee side of the high ranges, where it would naturally accumulate, and also from the fact that the size of the particles appears to diminish as we recede from the supposed centre of distribution; but at the same time this will not account for all the facts. An examination of the sand seems to show that all the particles are water-worn or abraded, and that many of them are too large to be carried by an ordinary wind, being sometimes as large as walnuts, though the average size would be about an eighth of an inch in diameter.

"The only other hypothesis which would account for the presence of the pumice over such an extent of country is that it has been carried into its present position by water. No doubt many of the extensive pumice-drifts of the North Island do owe their origin to that cause, notably the pumice plains of Kaingaroa, near Taupo, which in places are regularly stratified, and often contain trunks of trees, lying in a horizontal position, converted into charcoal. But there is a great deal of difference between the pumice-deposits of Taupo, the Waikato, and the inland portion of Taranaki and those of northern Hawke's Bay. The former invariably occupy level plains or depressions which no doubt were at one time lakes. To my mind, a deposit of a light substance like pumice, which ordinarily floats on the surface of the water, is only possible in enclosed sheets of water which would not allow of its escape. If it once reached the open sea it would be carried far and wide by the winds and currents. There is one thing, however, which should not be forgotten, and that is that the enclosed air, to which pumice owes its buoyancy, might under pressure be driven out, in which case, of course, it would become water-logged and sink, and would then form regular aqueous deposits like sand or clay. That such deposits are sometimes met with I think every one must allow who has seen the Kaingaroa Plains, or the beds of white coarse sandstone near the Miranda Redoubt, which is, I think, without doubt, formed of pumice sand, consolidated under pressure, and the deep pumice strata found in the Tauranga district.

"I observe in the last volume of the Transactions of the New Zealand Institute that Mr. J. C. Crawford, of Wellington, in his paper on 'The Old Lake System of New Zealand,' has touched upon this subject, and comes to the conclusion that the great central pumice-drifts are lake deposits. In this I entirely concur, as far as relates to the country described by Mr. Crawford, but I think that the lake theory cannot be implied in this district. The large extent and great height of country over which the pumice is scattered precludes the idea that it is entirely due to the action of water, whilst the fact that the thickest deposits seem to be confined (in this district at least) to the northward of a line drawn in a due east direction from Ruapehu would add force to the argument that it was spread out by the prevailing westerly winds; and the water-worn appearance may be explicable on the supposition that it is due either to decomposition or to the attrition of the particles as they were ejected from the volcano. The amount of evidence, however, is not sufficient to come to a conclusion either way; nor are we justified in ascribing to Tongariro and its adjacent volcanoes the origin of the whole of this pumice until a thorough exploration of the mountainous Urewera country shall have proved that it did not emanate from some nearer source."

Mr. Cox was correct in stating that pumice sands occur in the marine strata of northern Hawke's Bay, and possiby correct as to the origin of a good deal of what he saw over the surface of the low grounds. Captain Hutton might have noted pumice sands elsewhere and in other beds than the superficial deposits on the Totokura Saddle, and Mr. Percy Smith overlooks the fact that part of the pumice-covered area described by him contained pumice derived from Tertiary marine beds which was necessarily to some extent "water-worn or abraded." He is quite correct in ascribing to the action of the wind the rounding of the pumice that could not have been derived from the Younger Tertiary rocks. Much larger pieces of pumice are found on the higher part of the Mungaharuru Range than fragments that might be equal to the size of a walnut. As to the position of the volcanic vents from which the pumice was ejected, none of these are located in the Urewera country outside the watershed of the Tarawera River and the eastern upper tributaries of the Rangitikei. It is possible—nay, it is highly probable—that in the mountainous region to the north-east of the Napier–Taupo Road, between Tarawera Hotel and the margin of the Kaingaroa Plain, the volcanoes of that part yielded pumice.

From the volcanic region east of Lake Taupo acid rocks extend across the Napier–Taupo Road from a point four miles west of Tarawera Hotel to the eastern edge of the Kaingaroa Plain, but if such rocks reach into the Whakatane watershed they do so only as capping the higher mountains with lava-streams and tuff-deposits.

Over the Inland Patea district and the Kaimanawa Mountains also from the line of road north to and over the greater part of the Waikato watershed, superficial pumice-deposits are met with, as originally deposited. On the open plains and downs of the southern part the deposit is not thick; the material is fine, and consists almost exclusively of pumice fragments, but when followed to the north, on reaching the base of the Kaimanawa Mountains, the pumiceous material is coarser, and small fragments of fluidal and spherulitic rhyolite are found mixed with the pumice. On the outer eastern range of the Kaimanawas there is very little pumice left in place, this having gravitated into the low grounds, and been deposited along the creek- and river-valleys. On the second

range of the Kaimanawas, between Kaimanawa Creek and the east branch of the Rangitikei, much pumice still remains, more especially on those parts where the top of the range is flat and of some breadth. From the steeper slopes of this range, whether to the east or the west, the pumice has been carried into the low grounds by the action of water alone, or accompanying the material resulting from the denudation of the older rock and the formation of the deep gorges and gullies that cut into both sides of this range.

As on the plains, so on this range the material gets coarser as the range is followed to the northward, and the fragments of fluidal rhyolite increase in size also. Abreast of the southern spurs of Makorako, 5,700 ft., the highest peak of the Kaimanawa Mountains, blocks of pumice up to a foot in diameter are found. This coarser pumice is for the most part seen in the saddles between the different peaks of the range, pumice being absent from the wind-swept peak itself. In positions more favourable for its retention, as on the plateau immediately north of Kaimanawa Hut, the pumice forms a covering up to 10 ft. in thickness; and here there is a good deal of carbonised timber mixed with the pumice and rhyolite fragments, and it is clear that the old surface was covered with trees, mostly of small size, which were buried under the pumice as it fell.

A study of the pumice-deposits on the plateau-tops of this mountain-range clearly shows that these accumulated in the same manner as, and as exemplified by, the deposits resulting from the eruption of Tarawera in 1886, the only difference being that in this case the material was mainly pumice. The gradual increase in the size of the fragments as the deposit is followed in a northerly direction in the Mangamaire and in the Ngarururo Valleys indicates some point on or near the water-parting between these rivers and the streams draining to Lake Taupo as being the centre from which, by explosive violence, perhaps supplemented by the strength and direction of the wind, the pumiceous material was scattered wide over the district to the south, east, and north-east. The rapid increase in the size of the pumice fragments led to the assumption that one or perhaps a number of explosive centres would be found on the eastern side of the main water-parting, and the occurrence of rhyolite tuffs in the gravels of both the Ngarururo and the Mangamaire, such tuffs not being found in the high-level pumice-deposits, seemed to confirm the assumption.

I did not reach to the very sources of either the Mangamaire or the Ngarururo, but the probability is that both the Ngarururo and the Mohaka reach through the slate and sandstone mountains, and take their rise from the volcanic region to the east of Lake Taupo.

In the Ngarururo Valley I collected samples of grey rhyolitic tuff, which also occurs in the gravels of the Mangamaire. This rock, not present in the pumice-deposits, had evidently its origin near the source of the river, but in that direction, as far as sight could determine, the mountains clearly were formed of slate; but from the head shepherd on the run I learned that near the source of the river a creek coming from the west cut through a peculiar formation answering to the description I had given him of the rhyolite tuffs both in the Taupo district and the Coromandel Peninsula. Not being myself able to reach the locality, he has, since my return, forwarded samples of the rocks from this west branch source of the Mangamaire, and from the description accompanying these it appears that the area of volcanic country is not great; but there is no doubt as to the existence of a volcanic deposit different from the dispersed pumice covering the mountain-tops. The area of deposit is but a few acres, and this seems to form an outlier from the great development of similar rocks within the Hinemaia watershed lying to the north.

In another report * I have noted the gradual increase in the size of the pumice boulders as the Hinemaia River is followed in the direction of its source, and the same remarks apply to the other pumice-carrying rivers that fall into Lake Taupo and come from the eastward. The Rangitikei and the rivers of Hawke's Bay that, carrying pumice to the eastern sea-board, have their sources in the range of the northern Kaimanawas show also an increase in the size of the pumice fragments as their beds are followed towards the sources of these rivers. These facts lead to the inevitable conclusion that the pumice had originated in the region to the north and north-west. It is, however marvellous, at least conceivable that, blown to a great height, the pumice drifted to the south-east and north-east, and was deposited as a covering more or less thick over the area described, and over a yet more extensive area within which such air-borne pumice is now obscured or has been washed away.

Within the watersheds of the Rangitikei and the Ngarururo it is evident that a heavy deposit of pumice was deposited as material borne through the air from eruptive centres on the northern borders of the district. This deposit accumulated rapidly, and was perhaps the result of a single eruption. Such light and loose material did not long remain on the steep slopes of a mountain region, and along all the valleys of the district terraces remain that indicate the height to which they were filled by the rapid translation of the pumice from the mountain-sides to the lower grounds.

In the upper valleys of the Ngarururo, Taruarau, and Mangamaire pumice suddenly accumulated to depths varying from 100 ft. to 120 ft., or more, through which the streams have again cut channels to the bed-rock, but leaving fringing terraces still indicating the height to which their valleys were filled. These terraces are formed exclusively of pumice, there being no slate or sandstone fragments present; and, what is perhaps more remarkable, the rhyolite associated with the pumice of the mountain-tops is not represented. This shows that the accumulation of the pumice was not a gradual process during which the lesser gullies in the older rocks were deepened, as otherwise, in spite of the difference in specific gravity of the material, heavier material would have been carried forward, and been mixed with or formed beds between the different thick beds of pumice. The gravels of these rivers do not at the present time show much pumice, pumice washed out of the terraces or off the mountains being carried away to beyond the mountain region; and this is another proof of the vast quantity and suddenness of the pumice-deposit that could have filled these mountain-valleys to a depth of 120 ft.

* Mines Reports, 1899, C.–9, pp. 16–31.

Such being the state of things in the Kaimanawa Mountains, it is not now difficult to understand the occurrence of deposits of less depth and finer grain over parts of the country that lie more to the east and north-east.

Recent.

1, *b*. *Special Deposits of Pumice along the River-valleys.*—These have already been referred to under heading of 2, *a*. Along the middle and lower courses of the rivers the pumiceous material often lodged at high flood-level, being of finer grain, is drifted away from the river-banks by the action of the wind, and in favourable situations has accumulated to deposits of considerable thickness. This is seen in the Ngaruroro Valley, at Kuripapanga, and at the crossing of the Taruarau River on the Inland Patea Road. The coarser pumice is carried farther by the current and lodged in the swamps of the low ground, towards the coast-line, or is carried out to sea.

1, *a*. *Alluvial Deposits; River-beds and River-terraces of Modern Date.*—The principal deposit of this kind is the Ahuriri Plain, mainly built up of the waste of the Kaimanawa, Kaweka, and Ruahine Ranges, covered by silt from the Tertiary strata, and in the more swampy parts by pumice. Below the gorge, and before it enters the Ahuriri Plain, the Ngaruroro has deposited on the northern bank a high-level terrace plain of considerable extent, but elsewhere deposits of this age and description are not important.

CONCLUSION.

Though the principal object—the discovery of payable gold-deposits in the Kaimanawa Mountains—has not been attained, the expedition served the purpose of learning something of a considerable area of country the geology of which was not known, or had only been guessed at; and, notably, it has enabled a definite explanation of the occurrence of much of the pumice that covers the mountains and hilly country of a large part of northern Hawke's Bay district. It has also shown that the beds 3, *b*, in so far as they consist of pumiceous material brought from the west side of the mountain-chain, had other means of reaching into the eastern sea than by way of the Manawatu Gorge. These pumice-deposits, as forming marine strata, occur on the highlands of Inland Patea, associated with limestones, and it is clear that pumice drifting south from the Lake Taupo region could, by way of the Inland Patea depression, between the northern termination of the Ruahine and the commencement of the Kaimanawa Mountains, find its way to the eastern area, over which marine deposits partly formed of pumice sands are now found. Thus it will be seen that the Manawatu Gorge was not the only means of reaching by water the east side of the mountains during the Pliocene depression of the North Island, and in this respect the statements made in the report of 1899 have to be modified. The geology of the district is shown upon the map accompanying this report.

25th February, 1901. ALEX. MCKAY.

REPORT ON THE PETROLEUM-BEARING ROCKS OF POVERTY BAY AND EAST CAPE DISTRICTS, AUCKLAND, NEW ZEALAND.

By ALEXANDER MCKAY, F.G.S., Government Geologist.

BETWEEN the 11th March and the 16th April last, as directed, I made an examination of the Poverty Bay district with the object of determining the position and character of the rocks yielding petroleum, and the localities at which oil or gas escapes at the surface, and the following report embodies the results of my recent and previous visits to the district:—

The Maoris were well acquainted with the occurrence of oil- and gas-springs over the region of the east coast of Auckland from East Cape to Mahia Peninsula; but it was not till 1873 that the attention of Europeans was seriously attracted and attempts to obtain oil in quantity began to be made. In March, 1874, the district north of Poverty Bay was geologically examined by the Director of the Geological Survey, Sir James Hector, whom I accompanied to the oil-springs east of the source of Oil-spring Creek, in the Waipaoa Valley, thirty-five miles north of Gisborne, and also along the coast as far as the mouth of the Waiapu River, near East Cape.*

At the time we visited the oil-springs thirty-five miles north of Gisborne a number of shallow holes had been dug, and the water in these and some natural pools was covered by a coating of oil, which was being collected from time to time. In the natural springs the oil was evidently coming up from some depth, but in the artificial holes it seemed to me that the oil was percolating from the sides of the excavations. After Sir James Hector left I continued in the district till the middle of May, and, during that time examined most of the area over which indications of oil are to be found.

Between 1874 and 1887 various companies were formed to prospect for oil, both in the Gisborne and Waiapu parts of the district, but were only partly successful in finding oil; and all of the companies have now ceased to operate. Shafts and shallow bores were put down where the oil showed at the surface a little east of the source of Oil-spring Creek. All of these failed, the shafts on account of the rapid accumulation of gas and the want of means for effective ventilation; the bores from the unstable character of the ground in which they had been started.

These difficulties might have been overcome, but eventually the South Pacific Company selected a bore-site some distance to the south-east of the oil-springs, in the valley of the

* See Geology of the District: Progress Report for the Years 1873–74; and reports relative to collections made in the East Cape district ("Geological Reports," 1873–74, pp. 116–164).

Waingaromia River, and here their principal effort to strike oil was made. This bore reached a depth of 1,360 ft., and oil appears to have been found; in fact, through escaping oil and gas the derrick was burned down, despite which there are some who believe that oil was not struck in the South Pacific bore in the valley of the Waingaromia. Be this as it may, the formations here and at the oil-springs near the source of Oil-spring Creek are different, the latter being sandy argillaceous beds of Tertiary date, while the former consists of indurated chalky limestone, white siliceous shales, often of a pink colour with beds of greensand, as shown in the section along Oil-spring Creek.

Six miles west of the South Pacific borehole is the Minerva borehole, situated in the valley of the Waipaoa River, a mile above the junction of the Mangatu with that river. This also is in Tertiary beds of character similar or identical with those passed through in the South Pacific bore. The bore was sunk to a considerable depth, something approaching 1,000 ft., but no oil was found, and a tenacious pug-clay, it is reported, proved a difficulty that, with others, led to the enterprise being given up. In the case of the Minerva the borehole is within 30 chains of the outcrop of the Cretaceous rocks which appear as a narrow belt crossing east and west the Waipaoa River, and to the eastward are continued along the valley of Oil-spring Creek to the oil-springs, and thence into the valley of the Waitangi, for which see map accompanying.

The Cretaceous rocks are continued north along the main range of this part of the Auckland District, but on the coast-line, and for some distance inland, Younger Tertiary beds are met with from the south side of Waipiro Bay to south of Tolago Bay, between which latter place and Gable-end Foreland for a short distance in Waitanguru Bay Cretaceous rocks are seen, and again at Whangara, and also, to a limited extent, on the north side of Poverty Bay.

North of Waipiro Bay the area between the Waiapu River and the coast-line is wholly occupied by Cretaceous rocks, and west of that river the mountainous region to the Palæozoic rocks skirting the Bay of Plenty is also formed of Cretaceous rocks. This constitutes the northern area, within which are numerous gas-escapes and evidences of the presence of petroleum. In this region boring for oil was carried on at Rotokaituku, on the west side of the Waiapu Valley. The deepest hole put down by the Southern Cross Company attained a depth of 1,700 ft., but oil in payable quantities was not found, and when last visited by me in 1887 the company had ceased operations, which have not since been resumed. At that time there was a powerful escape of gas from the pipe. The gas had been ignited, and was then burning with a flame some 4 ft. in height, and had done so for some considerable time.

In the southern part of the district oil is escaping from Tertiary rocks on Dobbie's Run, seventeen miles north-west of Gisborne. The springs are not powerful, but oil can be collected from one or two pools on the Pangihanga Block at a height of 740 ft. above the sea.

Although active operations in search of oil have ceased for a number of years, there have been persistent reports of the discovery of fresh springs and gas-escapes in the Poverty Bay district; and I was led to believe that an important discovery had been made westward of Oil-spring Creek, in the Waipaoa Valley, to examine which I was instructed to visit the district and report what the facts and prospect of such new discoveries might be.

I was accompanied from Wellington by Mr. R. Brett, who, in the interest of an English syndicate, is at present interesting himself in the matter of exploring for oil in various parts of the colony. Arrived at Gisborne, as soon as possible a start was made for Karaka, at the junction of the Waipaoa and Waikohu Rivers, and the valley of the latter stream was followed to Pohutu Accommodation-house, at the last crossing of the river on the Gisborne–Opotiki Road, and from that point were carried on yet further to the westward.

It was my intention to have followed the Gisborne–Opotiki Road across the mountain-range into the valley of the Motu River, in order to re-examine the lower beds of the Cretaceous sequence, which on the west side of the range are exposed under the higher calcareous beds, but the weather and the roads were alike execrable, and this part of the trip had to be abandoned.

Immediately west of Pohutu and north of the road-line, the Cretaceous rocks appear from under the Tertiary beds that on the south side of the valley continue further to the west, and, the appearance of these along the crest of the anticline being the principal thing sought for, it was by Mr. Brett considered unnecessary to proceed along the road further west; and I was anxious to see what fresh discoveries had been made in the Waipaoa Valley more to the north. Accordingly we proceeded to the Waingaromia Station, in the Waipaoa Valley, and next day followed the Waingaromia River to the site of the South Pacific borehole; and passing this, from the Waitangi out-station, in the valley of the river of that name, ascended the range to the west, and at a height of 1,460 ft. reached the oil-springs east of the source of Oil-spring Creek. I anticipated that I was being taken to something new—to a locality I had not before visited, and where the flow of oil was greater than had before been seen by me; and I certainly expressed surprise at being taken to a place well known to me, and which I had examined as far back as 1874, where oil had been sought for and the search abandoned years ago.

After spending some two hours at the oil-springs we proceeded north-west across the ranges to Muir and Finlay's station, at the upper end of the Waipaoa Gorge, and the following day, after examining the valley for a mile and a half above the station, followed the gorge downwards to the junction of the Waipaoa with the Mangatu.

It being necessary to return to Gisborne, the next work was an examination of the coast-line to within five miles of Tolago Bay, after which a return was made to the Waipaoa Valley, and the valley of its main tributary, the Mangatu, was examined nearly to its source. At a yet later date the district south of the Waikohu and west of the lower Waipaoa was examined, and the oil-spring at Dobbie's, on the Pangihanga Block, was visited, which closed the examination made on the present occasion.

Geology of the District.

Palæozoic Rocks.—There are no old Secondary or Palæozoic rocks east of the main range of this part of the North Island. Old rocks appear in the Motu Valley near the bridge on the Gisborne–Opotiki Road, and form the country westward to the shores of the Bay of Plenty, and are continued north to near Oreti Point, overlain to the eastward by Cretaceous rocks, and in the northern part by Tertiary beds.

Cretaceous Rocks.—The lowest beds of this sequence are well seen west of the main range on the Gisborne–Opotiki Road, and there consist of evenly bedded shales and sandstones dipping to the eastward. They rise to some height on the slopes of the mountain-range—to what height could not in 1887 be determined, the country being bush-clad, and there being no sectional exposures sufficient to determine this point. These lower beds may be a source of petroleum, and they are not too much compacted and indurated to prevent them supplying storage for oil. The same beds are seen on the banks of the Mata River, opposite Hikurangi Mountain, and they form the lower part of the south-east spur of that mountain. Here, however, they are somewhat different in character, being a moderately hard, greenish sandstone, full of broken plant-remains. South of the Gisborne–Opotiki Road the same beds should extend along the western slope of the main range for some distance, but they do not appear to continue into the Whakatane watershed. When in 1895 I examined the southern continuation of the formation in the Mungapohata Range I found the next succeeding division of the Cretaceous series resting on the Older Palæozoic rocks in the valleys of the Waimana and Waikari Rivers, which drain this part of the mountain-range to the Whakatane River. The thickness of this lower division of the Cretaceous rocks may be from 500 ft. to 800 ft. in either of the two localities where they are stated to be present.

Middle Division of the Cretaceous Rocks.—This consists of sandstones and dark shales, with calcareous concretions, and is found throughout the district from Mungapohata to the mouth of the Waiapu River. From Waipiro Bay north to the mouth of the Waiapu the district between the river and the sea, except on the south side of Waipiro Bay, is almost wholly composed of this middle division of the Cretaceous sequence, which, north of Hikurangi, also extends west, and occupies the eastern flanks of the higher mountains. These rocks at many places abound in fossils (*Inocerami*) of large size, but usually broken, being specially abundant at places. Thin bands of limestone of a yellow tint, full of fossils, occur a little inland of Waipiro Bay. A patch of Tertiary rocks occurs at Akuaku, on the coast-line north of Waipiro, but this is limited to the coastal hills, and is of no great extent. Escaping from these rocks are numerous emanations of inflammable gas; and at Rotokaituku, west of the Waiapu River, the bores of the Southern Cross Company were put down in these rocks.

In the basin of the Waipaoa River these rocks are present in the upper part of the Waitangi, and in the upper parts of the Waipaoa and Mangatu Rivers. In the first case the area of exposure is limited, the rocks to the north being overlain by Tertiary beds. In the Upper Waipaoa and Mangatu the beds are exposed along the eastern flanks of the main range, and in the hilly country to the eastward, where these rocks come to the surface in the cores of anticlines cut through by the rivers and larger streams. In the southern part of the area drained by the Waikohu these rocks are scarcely seen, the higher greensands and calcareous rocks occupying most of the surface over which Cretaceous rocks are found. Farther south these rocks are found west of the main range in the Whakatane watershed, where, as disturbed strata, consisting of shales and sandstones, they are present in Waikari Stream, below Mungapohata Pah. In this locality the rocks contain small concretions which often yield the fossil, *Inoceramus*, that characterizes these beds in the northern part of the district.

Upper Division of the Cretaceous Rocks.—These rocks consist in their lower beds of greensands and siliceous shales, resembling the chalky limestones that form the middle part of this division. Indurated chalky limestones, alternating with greensands, overlie, and these latter, the upper part of which is a marly limestone or a calcareous sandstone, alternate with beds of greensand. Fossils are rare in or absent from the lower limestone, and few or no fossils have been obtained from the greensands. The upper limestones, whether marly or partaking of the nature of a calcareous sandstone, abound in impressions of large fucoids, whether as rod-like stems or large radiating leaf-blades, and remains of *Echinodermata* are not rare in the calcareous sandstones. At some places the higher beds pass into a coral limestone. These beds extend along the mountain-range from Mungapohata in the south to Hikurangi in the northern part of the district, and probably extend along the higher mountains to the north of Hikurangi; but this part of the mountain region has not been closely examined. The greensands and chalky calcareous rocks are found near the coast, on the south side of Waipiro Bay, and from five miles south of Tolago Bay to near Gable-end Foreland, and at Whangara. Inland, within the Waipaoa watershed, the chalk limestone and associated or underlying white or pink siliceous shales extend in the north-east from the Waitangi River to the oil-springs, and along the valley of Oil-spring Creek to near its junction with the Waipaoa, before reaching which the Cretaceous rocks pass as a narrow belt from Oil-spring Creek into the valley of the Mangatu, and to the north and west the same beds occupy the whole of the mountain region north of the Gisborne–Opotiki Road to Hikurangi. In the district south of the Gisborne–Opotiki Road, and extending thence along the mountain-range to Mungapohata, the higher calcareous sandstones form the mountain heights, and near Mungapohata this becomes a coral limestone, underlain or partly alternating with beds of calcareous greensands, that show as large blocks of moderately indurated rock in all the larger streams flowing west from the mountain-range into the Waimana branch of the Whakatane. From these rocks petroleum reaches the surface at the springs near the source of Oil-spring Creek, and gas appears in at least two other places in the Waipaoa watershed, and in the Poverty Bay district they are specially regarded as the oil-bearing rocks.

Lower Tertiary Beds (probably of Lower Miocene age).—These extend throughout the district from its southern limit to Waipiro Bay and the Waiapu Valley, abreast of the eastern spurs of Hikurangi Mountain. The lowest beds in the northern part are a coarse conglomerate or breccia, consisting mainly of crystalline rocks, principally composed of hornblende, which often show a schistose structure. These rocks, between the Mata River and Tawhti Mountain, on the north side of Tokomaru Bay, are of great thickness. In this part they contain fragments of white limestone and spherical concretions derived from the Cretaceous rocks, proving the unconformable relationship of the two formations. The dark hornblendic boulders reach south into the valley of the Waipaoa above the junction of the Mangatu, and in the deep gorge above this junction the river-gravels show numerous hornblendic boulders up to fully 2 ft. in diameter. The Waipaoa Gorge has been excavated in sandy clays and sandstones belonging to this formation. In the gorge the source of the hornblendic boulders is not seen, but to the west, where this formation shows its lower beds resting on the upper division of the Cretaceous rocks, a thickness of the hornblendic breccia conglomerate is present, and by means of the tributary creeks *débris* from the same finds its way both into the Wapaoa and the Mangatu. A few boulders of the same rock are met with in the watershed of the Waikohu, but this seems to be the limit south of the hornblendic boulders.

The next succeeding rock is a great thickness of sandy and marly clays, with beds of grey or yellowish-brown sandstone, often fossiliferous; and near the base of this part a coralline foraminiferous limestone, which latter is seen on the hill forming the spur between the junction of Oil-spring Creek and the Waipaoa, on upper side of the creek, or between that and the Minerva borehole; and the same rock appears in the gravels of the Waikohu at and near the Pohutu Accommodation-house. Elsewhere this limestone has not been observed. The bulk of this formation in the southern part of the district is a marly clay, with segregations, in veins, of a more calcareous character. Near Dobbie's there is a proportion, sometimes considerable, of greensand grains in the more sandy rocks. These rocks strike north-east and dip to the south-east in the Upper Waipaoa. In the Waikohu the strike is more to the west, and the dip both to the north and the south, an anticline being thus formed, which runs along the low grounds of the Waikohu Valley.

Between Karaka and Dobbie's the section across these beds was not examined, but it is fair to assume from what was noted elsewhere that, the formation being of very considerable thickness and still dipping to the south, it does so throughout, and that there are no anticlines and synclines in the intervening space. It is true that the nature of the rocks at Dobbie's indicates the lower part of the beds, a considerable proportion of greensand grains being present in the more sandy beds. Near Dobbie's, as elsewhere, these rocks are much subject to slips at and near the surface, and this prevented the making-out of the true strike and dip of the beds.

On the coast-line between Poverty Bay and Tolaga Bay these rocks are thrown into a number of sharp anticlines and synclines, and are met with often standing at high angles, and as often at moderate or low angles; and this disturbed state of the beds probably continues across the intervening hilly country to the watershed of the Waingaromia. From the source of the Waitangi to Tokomaru Bay, except along the coast-line, these beds have not been examined.

Pliocene Rocks.—These consist of sandy clays and pumice sands, capped by limestones. They occupy a considerable area west of Poverty Bay and the lower Waipaoa River, and also on the east side of the valley north and south of Gisborne. The same beds are present at Gable-end Foreland, and farther north in the vicinity of Tolago Bay. Generally they are found resting at low angles, and form remarkable terraced country on the east side of the Waipaoa, above Karaka, and on the west side of the plain in the same neighbourhood a small area shows the presence of pure white pumice sands. The pumiceous beds form poor soils, but the farmers of the district do not apparently appreciate the cause, the pumice sands being classed with papa country, which generally forms good soil. The limestone forming the upper part of the formation is quarried at two places—near Ormond, and in the valley of Waikakariki Stream, west of Patutahi. At Ormond the limestone resembles the Scinde Island limestone, and is not more compacted. West of Patutahi it is denser, and forms altogether a better road-metal, for which purpose it is used in the neighbourhood, and is also, for the same purpose, carted to Gisborne.

Recent.—These rocks are found along the beach in places as littoral beach deposit and blown sands. Over the lower Waipaoa Plain and the upper plain above Karaka the alluvial deposits consist chiefly of the harder parts of the Cretaceous and Lower Tertiary formations; Palæozoic sandstones do not enter into the composition of these beds. The only very hard or crystalline rocks that enter into their composition are the dark hornblendic rocks that have been described as occurring at the base of the Older Tertiary formation. These, from their unyielding character, make a considerable display as far down the valley as Karaka.

The Cretaceous and Older Tertiary Rocks as a Source of Petroleum.

At many places in these rocks indications of mineral oil, whether as gas or oil-springs, make appearance at the surface, and therefore it would appear that the search for profitable oil-wells should be attended with success. The history of past undertakings with this object in view is not by any means satisfactory; but what the cause of failure, whether from an injudicious selection of the places where boring was carried on, or from an actual scarcity of oil in the strata, is as yet uncertain. At all the three principal places where bores were put down the strata was penetrated to a considerable depth, and the shallowness of the holes cannot be said to be the cause of want of success.

In the case of the Southern Cross boreholes, in the Waiapu Valley, strong indications of oil appeared near by. On the South Pacific Company's holding, in the Waipaoa, the most powerful natural springs of oil were at no great distance—about four miles—from where the deepest bore was put down; and several bores and shafts were put down at the springs, but none of these were of considerable depth, and the deepest did not pass through the disturbed ground and into solid rock.

The bore at the Minerva, in the Waipaoa Valley, was unsuccessful, from what cause cannot now be made clear—it is said from a difficulty connected with the sinking of the borehole only; and no attempt whatever has been made to obtain oil at or near the springs on Dobbie's Run.

From the examinations which have been detailed in the earlier part of this report the conclusion is that the oil mainly has its source in the Cretaceous rocks—presumably in the middle and lower divisions of that group; but, also, it may not be denied that the upper calcareous division may also give rise to mineral oil. But of these rocks it is not so much a question whether the oil has had source in them as their capacity for retaining it stored in the more permeable beds —*e.g.*, the greensandstones interstratified and underlying the chalky limestone, and the sandstones of the middle and lower divisions. The frequently shattered condition of the chalky limestones gives facilities for the escape of gas, and of oil converted to gas, and this, perhaps erroneously, leads to the impression that by such means stores of oil in the lower rocks may be lessened or depleted.

Of oil in the Lower Tertiary beds, this is only known at Dobbie's, but whether originating in these beds or escaping upwards from underlying Cretaceous strata is uncertain. The Tertiary strata at Dobbie's must be of great thickness and not much disturbed, and are of such a character as favours the holding and storage of oil; and the coralline limestone at the base of the formation may also be a source of the oil, and it is not therefore necessary to assume that the oil escapes from the Cretaceous formation.

The presence of oil in paying quantities not having as yet been proved, the recommendation of sites for future boring is a matter of some delicacy, and the selection of such must therefore be left to those whom it most concerns.

When at the springs east of the source of Oil-spring Creek, Mr. Brett seemed to favour, and asked my opinion as to, a bore-site on the ridge of solid ground that separates the little basin in which the springs are situated from the slope west into Oil-spring Creek, and which at the upper end of the basin curves round to the eastward. This certainly has the advantage of being in solid ground, and near the highest point oil is actually escaping from the undisturbed strata. Here there is little likelihood of failure, owing to continued displacement of sliding masses of rock, and the bore may be placed near, or half a mile from, where oil actually reaches the surface.

On the Minerva section a bore or boreholes may be put down on either side of the unconformable junction between the Tertiary and the Cretaceous rocks, as may be judged expedient. The Cretaceous rocks probably yield oil; they are also capable of storing it in the looser and less fractured strata; while the Tertiary strata, if they are not the source of the oil, should be capable of storing it. Owing to the considerable dip of the strata to the south-east, the Minerva borehole was placed perhaps a little too far from the south-eastern line of junction between the Tertiary and Cretaceous rocks.

In the Mangatu Valley any point may be selected, from Campbell's Station to or for some miles above Cooper's Station, care being taken that the bore at some depth shall reach a greensand stratum.

In the Waikohu Valley, west of the Pohutu Crossing and the accommodation-house, where the Tertiary Strata have an anticlinal arrangement, and at moderate depth are underlain by Cretaceous rocks, boring may be undertaken on the crest or north or south side of the anticline, as may be considered the most likely for reaching oil or convenient for bore-site. In this district there is no special locality that might be considered the most favourable. It is true that gas-springs appear on the north slope of the range on the north side of the valley, but this is outside the Waikohu Valley, and, with perhaps no better prospects, would be more difficult to reach.

More to the west, along the Gisborne-Opotiki Road, sites may be selected where boring would begin in the Cretaceous rocks.

At Dobbie's, where oil is escaping from Tertiary rocks, no special site other than what is convenient for taking on to the ground and erection of the boring plant need be indicated. The oil-springs are on a spur 300 ft. to 400 ft. above the valley in which the homestead is situated, and, as the presence of oil at the surface does not insure the success of a bore, it might be to no purpose to incur the cost and inconvenience of taking a boring plant on to the very site of the springs, even though there be no great difficulty in doing so.

With respect to a small area of Cretaceous rocks appearing on the shore-line between the mouth of the Turanganui River and the north headland of Poverty Bay, an area of the same rocks at Whangara, and yet another on the coast-line between Gable-end Foreland and Tolago Bay, these scarcely call for particular description in this report.

24th April, 1901. ALEX. MACKAY.

REPORT ON COAL AT FITZHERBERT.

By W. A. McKAY, Assistant Geologist.

I LEFT Wellington on the 5th November to examine the coal lately discovered at Fitzherbert, near Palmerston North, as directed. The reported coal is on the Fitzherbert East Road, at its junction with the Palmerston–Pahiatua Road, about half a mile from the Manawatu River and three miles and a half from Palmerston North.

The coal was discovered in sinking a well alongside the "Defiance" Butter Creamery, at a depth of about 25 ft., and was said to be 7 ft. thick. At the time of my visit the well was finished and the water allowed to rise to within 14 ft. of the surface, and the coal was under water. Some of it was lying about on the surface in small pieces, and in all respects it corresponded with an outcrop about half a mile to the south. At the well hard coal was reported to have been cut.

A small creek (unnamed) flows from the south and crosses the road at the well, and, as the coal was too deep to be cut by the stream, the bed was followed up, and the same seam was found half a mile distant (as mentioned above) and on the left bank. At this point it was exposed by a small landslip, and was seen to be dipping at an angle of 10° to the east. In thickness it varied from 2 ft. to 4 ft., and the seam was distinctly laminated. The lignite showed the presence of numerous plant-remains and much wood in process of carbonization, the latter 8 in. and 10 in. long, sometimes more.

A little prospecting had been done at this point, but no hard coal seems to have been found, and the material taken to the creamery furnace refused to burn. Exposed to the weather, its laminated character completely disappears, and the whole disintegrates, becoming a clayey mass. Its colour changed from its normal dark-brown to a dirty grey, leaving only the pieces of wood standing out of the heap.

The plant-remains also penetrate the underlying blue clay, but in the overlying beds they are absent. The upper beds have the same dip and strike, and are composed of clays, sands, and conglomerates of varying thickness.

Examining the strata at the well of the creamery and along the Fitzherbert East Road, the same beds are found as overlie the coal above mentioned. They differ, however, in lying perfectly flat, and in the conglomerates being of much greater thickness, and at places occupying almost the whole of the section. In the opposite direction (south-west from the well) they are much thinner, and are made up of clays, sands, and conglomerates, as in the outcrop in the creek. All these beds pass under the swampy land and more recent river-flats of the Manawatu, on the edge of which the well at the creamery is sunk.

12th November, 1900. W. A. McKay.

Note by the Government Geologist.—The lignite and beds described appear to be a continuation to the south of the pumice sands and lignite beds of the Pohangina Valley, and the sandstone conglomerates overlying are probably separated by an unconformity. As a fuel the material is worthless, and seems decidedly inferior to the Pohangina lignite. The beds extend as far to the south as Shannon, but it is only to the north of the Manawatu Gorge that the lignites are of importance. Along the course of the Pohangina, and in the district adjacent to the west, the deforesting of the country will tend to make these lignites of value for local purposes. Along the Pohangina the beds of lignite are extensive, and often 20 ft. to 30 ft. in thickness.

Alex. McKay.

REPORT ON A COPPER LODE IN THE RUAHINE RANGE, NEAR NORSEWOOD.

By W. A. McKay, Assistant Geologist.

As instructed, I have the honour to report on the outcrop of copper-ore situated in the Ruahine Range, near the source of the Makaretu River, opposite Norsewood :—

The locality of the lode and the associated rocks is at the extreme head of the right-hand branch of the Makaretu River, and on the dividing-ridge which separates it from the left-hand branch of the same river. The height of this spur is 3,900 ft. ; but the main range is still further west, separated from this by the deep gully of the left-hand branch. This secondary range forms a junction with the main range about three-quarters of a mile north of the lode, at the water-parting of the Tukipo River and the left branch of the Makaretu.

The exact position of the copper lode is on a short and precipitous spur on the east slope of this ridge, between two small creeks, tributaries of the right branch. Three great landslips, from 600 ft. to 900 ft. in height, have been the cause of the exposure of the reef and the associated mineral belt. About midway on the length of the precipitous spur above mentioned, the reef crosses at right angles at a height (the lowest point) of 3,100 ft., and rises to 3,250 ft., at which point it becomes covered by the scrub. The total height of the lode exposed is therefore 150 ft.

The strike is 30° west of north, while the dip is to the east at a very high angle—about 85° from the horizontal. As a true reef, with walls containing sulphide of copper and iron-pyrites, the vertical exposure is 50 ft. in height, and on its strike it is seen for about the same distance. Below the slip the lode is obscured, but it has been intercepted by crosscutting at the creek-level 100 ft. below, where it is seen as a pug-vein 14 in. to 15 in. in width. On the other side of the creek, at a distance of about 50 ft. or 60 ft., the same mineralised pug is seen in the face of the big slip, and occurs at the same level, coinciding in strike, dip, and in width. Although the land-slide has laid bare the rocks for several hundred feet above, this vein is not seen to be continuous to the northwards, and on this side it does not rise more than 10 ft. from the creek-level. As mentioned, the pug-vein was cut at the creek-level by trenching; but, previous to doing this, Mr. Thompson put in a small drive for about 12 ft. on the strike of the lode, and about 10 ft. or 12 ft. above the trench, and he tells me that a pug-vein, 15 in. wide, was cut, containing copper. The drive proving unsafe, it was discontinued, and the entrance was walled up with stones. He then drove in a longer tunnel from the hanging-wall side at a distance of some 40 ft. from the lode, at an angle of about 35°, and 5 ft. below level of lode. The total length was 24 ft. ; but at this distance it had not pierced the green rocks which form the wall of the reef at this level.

The width of the ore-body is comparatively regular, averaging about 16 in., excepting at one "blow" on the uppermost part, where it is 5 ft. in width. As a pug-vein the reef gets narrower, and in the creek it ranges between 12 in. and 15 in. The quality of the deposit varies, and, as a lode, is seen to be very bunchy in character. The stripping on the outcrop exposes small pieces

of both excellent and medium copper-ore and iron-pyrites. The largest block *in situ* of sulphide ore of good quality was 12 in. by 4 in., walled in by 12 in. of iron-pyrites on the one side and the country-rock on the other. In this way there occur several small patches of medium and good ore throughout the deposit. Where the reef is 5 ft. wide the iron-pyrites preponderate greatly, and the copper-ore is poor, the whole being interspersed with country-rock, both with and without copper. While the reef is small the walls are regular and well defined, but on gaining the larger dimensions they become very uncertain, more especially the foot-wall, and the lode gradually passes into the ordinary country-rock.

The associated red rocks continue on the strike noted, both to the northward and southward; but the copper-deposits do not extend in either direction outside a distance of 200 ft. But at right angles to its strike copper shows outside the reef (proper), and occurs in the reddish-black rocks, and as a surface stain in the form of a silicate of copper. Where the reef is largest this country-rock, impregnated with copper, is seen to be a mixture of sulphides of copper- and iron-ores, yellow copper-ore, and iron-pyrites, mixed indiscriminately. Including everything, at this point the deposit is fully 20 ft. in width; but the dimensions gradually get less and less as it is followed to lower levels, where also the cupiferous country-rock separates itself from the true reef, when that body gets to its narrowed limits of 18 in. between the two walls. At a still lower level this impregnated country ceases on the hanging-wall, and is so reduced on the foot-wall that, with reef included, it is about 10 ft. in width. Below this the reef proper disappears, and, as observed in the trench and on the opposite side of the creek, its continuation is seen to be the mineralised pug-vein of about 14 in. The walls of this pug-vein are without copper in any form, and consist of green rocks on the hanging-wall and stratified red rocks on the foot-wall. The green silicate of copper occurs throughout in greater or lesser quantities, but it is most abundant about the centre of the reef.

Regarding the deposits as from 20 ft. to 15 in. in width, it is seen to be bounded by greenish sandstones, interspersed with a few patches of red rocks on the east. The green rocks are full of quartz, but with no regular reefs, or even lengthy stringers, the patches of quartz having linearity in all directions. The strike of the beds is 45° west of north, and the dip 40° to the eastward. The bedding is thin—from 2 in. to 4 in.—well defined, though somewhat contorted. On the west the lode, together with the country-rock permeated with copper, is bounded by well-stratified red rocks, having a strike of 40° west of north, and a dip of 45° to the eastward. The thickness between the bedding is about 4 in., and much twisted. The colour is lighter than the same rocks nearer the lode, and the texture is finer. These beds follow the copper-deposits for their whole length, and from the creek-level continue up the sides of the spur to the top, passing over into the small gully adjoining, and thence on to the main ridge. To the south they cross a high spur, and into the several creek-valleys of the right-hand branch of the Makaretu which lie in that direction. These rocks can in all cases be distinguished from the overlying beds affected by copper, on account of the absence of stratification in the former and darker colour of the latter. The greenish sandstones occupying the east side of the lode are overlain with soft shales and sandstones at a distance of about 200 yards from the outcrop. Their strike is 20° west of north, and they dip to the eastward at 40°.

To the west of the copper reef, and underlying the stratified red rocks, is a body of the ordinary coarse sandstone of the Ruahine Range, interstratified in places with shales. The strike coincides with that of the lode and other rocks in their general direction, being 45° west of north, while the dip is to the eastward, at an angle of 40°. These sandstones extend west until within 300 ft. of the ridge, where they are seen to overlie another rib of red rocks belonging to the mineral belt, which continue to the top and cap the ridge without descending into the gully on the west. The strike is about 40° west of north, while the dip is not so well seen, but is about 40°, and to the eastward. This belt is approximately parallel to the rib in the gully below, but on following the ridge to the southward this upper rib gradually approaches the lower one and forms a junction with it as it rises out of the gullies to top the ridge.

In the underlying belt of red rocks some prospecting has been done, and a tunnel 14 ft. in length has been driven, and also some trenching, but so far without results. No sign of copper-deposits was to be seen. These beds are peculiar, and distinguishable from the rib carrying the lode, from the fact of the great quantity of thin black veins forming a casing to the red rocks, the result of pressure and slickensiding. The rocks of the parallel rib also possess this peculiarity, but to a much lesser extent.

The various creeks and the ridges were traversed with the object of tracing the continuity of the copper-deposits. Five creeks in all were examined, and, although in each case red rocks occurred in profusion, nothing of the reef, either as a solid ore-body or as a pug-vein, was to be found. The spur, on the north side of which the copper is located, rises on the strike of the lode 300 ft. above the lowest workings, and, although the belt of red rocks passes up and over this spur into the creek-valley beyond, nothing of the lode could be seen. It crosses this small gully, rises on to the main ridge, and passes over into the watershed of the left branch of the Makaretu River, where, however, it disappears without reaching the bottom of the gully.

To the northward the creeks are full of the rocks of the mineral belt, both as *débris* and in the solid. The gullies were examined in this direction for copper-ore, but without results. By following the ridge around the belt could be seen to strike in the direction of the Tukipo River. The loose stones and blocks of the underlying rib situated on the ridge disappear as the upper valley of the source of the Tukipo is neared. Exposures of rock could be seen corresponding to the rib overlying that carrying the lode, in the extreme north branch of the Makaretu, on the spur dividing it from the Tukipo. The valley towards the source of this has no red rocks, the strike of the easterly belt carrying it more towards the plains, while the westerly rib disappears before the Tukipo is reached. As red rocks are reported to be very plentiful in the Tukipo River where it

leaves the ranges, it is evident that the rib mentioned on the spur dividing that river from the Makaretu occurs in the valley of the river, and it must be a considerable distance from the source.

Report on Quartz in the Mangatawainui Creek, Ruahine Ranges.

In the Mangatawainui Creek, a tributary of the Manawatu River, some reefs were said to have been found, and on the 6th April I examined the locality. The reef is on the face of a precipice, over which the creek falls in a drop of 150 ft., and at a height of 2,200 ft. above sea-level. The position is about half a mile from the source of the creek, at about eight to ten miles from Norsewood, while the main ridge of the Ruahines could be no more than 800 ft. above.

The rocks belong to the mineral belt, and consist of red rocks, which, however, are a little darker than the bright-red-coloured rocks seen elsewhere. No greensandstones, shales, &c., were seen; but, as the country is heavily timbered, and with but few rock-exposures, it is possible that they are in the vicinity. The strike of the rocks is due north and south, while the dip is almost vertical, and to the west. The bedding is thick—from 3 ft. to 5 ft. in width; while the reef is simply one of these beds, containing small stringers and irregularly shaped pieces of quartz—nothing longer than 3 in., and averaging about 1 in., or even less. The total quantity of quartz would not make a 2½ in. reef, while the whole is spread over a width of 4 ft. or 5 ft. in the ordinary red rocks. Outside this particular bed the quartz becomes less until it ceases, and consequently the strata, dotted with quartz veins, gives an appearance of direction and continuity. The stringers and pieces of quartz have no general direction, and even when these are 3 in. in length the strike is seldom the same in any two pieces. Of a necessity, the "reef" or "lode" has the same trend as the country-rock—namely, due north and south—while the dip is almost vertical, and to the west. The quartz is considerably mineralised, containing iron-pyrites pretty freely. The deposits could not be followed, on account of their disappearing over the precipice in one direction and into the bush in the other.

W. A. McKay.

REPORT ON THE GEOLOGY OF COOK STRAIT FROM PENCARROW HEAD TO THE RUAMAHANGA RIVER, AND OF THE EASTERN SLOPES OF THE RUAHINE MOUNTAINS BETWEEN THE TAMAKI AND MAKARETU RIVERS.

By W. A. McKay, Assistant Geologist.

On the 29th October, 1900, I received instructions to proceed to the shore of Cook Strait between the entrance to Wellington Harbour and the mouth of the Ruamahanga, and make an examination of the strata showing on the coast-line and adjacent thereto as far as the interior parts can be reached in a day's journey from the coast.

The piece of country under consideration is occupied by the southern extremity of the Rimutaka Mountains and the various subsidiary ranges. The main range lies between the Orongorongo River and the westerly shores of Palliser Bay, terminating in Cape Turakirae. The Rimutakas here maintain their height, and at Mount Matthews it is 3,079 ft., while Papatahi is 2,957 ft., and Kotuma is 2,578 ft. On their eastern slopes they descend abruptly to the coast-line, but further north, abreast of Onoke Lake, the mountains are flanked by lower ranges and terraces until the lower country is reached.

A parallel range of considerable height lies between the Orongorongo and the Wainuiomata River, forming a junction with the main ridge at a point some seventeen miles from the mouth of the Orongorongo River. It is less rugged than the main ridge, and in height it rises to between 1,000 ft. and 1,500 ft. Further west another and lesser ridge occurs between the Wainuiomata and the eastern shores of Wellington Harbour, with an average height of between 700 ft. to 800 ft.

Thus the Rimutaka Mountains in their southern extremity are divided into three long and parallel ranges, of about fifteen to twenty miles in length, with two important rivers dividing them, and flanked by lower hills and terraces on the east towards the Onoke Lake. Excepting a narrow strip from Cape Turakirae to Pencarrow Head, and the terraces to the west of Onoke Lake, the whole of the country is, or was, heavily timbered.

The chief rivers are the Wainuiomata and the Orongorongo, entering the sea near Baring Head, and the Little Mukamuka, Mukamuka, Wharekauhau, and Wharepapa, draining the east slopes, while the Ruamahanga, from the interior, empties itself at the Onoke Lake.

The formations presented within the district are:—

1. Recent.
2. Pleistocene.
3. Old Secondary or Palæozoic.

Within the area described in this report no outcrops of fossiliferous Pliocene rocks were observed, though it can hardly be doubted that rocks of that age, well seen on the east side of the Lower Wairarapa Valley, extend under the more recent deposits on the west side of the valley. As regards the older rocks forming the Rimutaka Mountains, although these have often been referred to and classified as being of Carboniferous age and referable to the Maitai series of the New Zealand Geological Survey classification, it would at the same time appear that possibly Old Secondary rocks are also present. These younger rocks are not easily separated even by those who have studied them more than the present writer, and therefore no attempt has been made to do so in this report.

1. *Recent: Alluvial Deposits, Raised Beaches, Blown Sands.*

Of the alluvial deposits the most prominent is the spit which backs up the waters of the Ruamahunga River and forms the Onoke Lake on the coast at the head of Palliser Bay. In

length it is two miles, and from 300 to 500 yards in width. It is composed chiefly of well-rounded gravels, the bulk of it being shingle, very little of it being over 1 ft. in diameter. The highest part is about 25 ft. above the high-water mark.

Where this spit abuts against the mainland to the west a raised beach can be seen. The length is about half a mile, with a width of 600 yards. The earthquake of 1845, which was the cause of the raised beaches along this coast, according to the old settlers, did not affect the spit. The height of these raised gravels is considerably lower than the adjoining bar of Onoke Lake, parts of it being barely above the tide. In character and contents they are much the same as the spit, of well-rounded gravels and sand, chiefly the detritus of the adjacent Pleistocene terraces, consisting of sandstone, shales, red and green rocks.

Continuing along westward a considerable development of blown sands is to be seen piled up against the vertical precipices of the gravel terraces to a height in places of 100 ft. or more. At a point about two miles north of the Mukamuka River a small length of raised beach is seen. It continues for about half a mile, and in width it is about 200 yards. It covers the rocks of the main range, the mountain-side rising abruptly from the beach to heights of 2,000 ft. or more. The material composing the beach is much coarser than the example near the spit, having a much greater quantity of small boulders. Being in the immediate vicinity of the mineral belt, and by the immense landslips in the vicinity exposing the rocks, a much greater proportion of the red jasperoid slates and green rocks are contained in these gravels. The height above the tide is about 10 ft.

A much greater and very fine example of the effects of the 1845 earthquake is the raised beach stretching without a break from a point three miles and a half eastward of Cape Turakirae to the mouth of the Wainuiomata River, fully four miles to the westward. In width it varies from 200 ft. to 300 ft. on the eastern and western extremities to three quarters of a mile at Cape Turakirae.

In all the three cases of raised beach the effect of the earth-movements has been to throw up a ridge (the old beach) of large boulders and gravel, between which and the hills or high ground is found a lagoon and swamp, which is scarcely above the tideway. In this raised beach at Cape Turakirae the whole surface from end to end is littered with big boulders from 2 ft. to 6 ft. or 8 ft., together with the small water-worn gravels of the old beach. Besides this, there are exposures of the water-worn rocks *in situ* projecting through the boulder-beach. The old beach-line keeps near to the hillsides, at a distance of about 300 yards to half a mile. Of a necessity the line of the old beach of these raised gravels forms the boundary of the dry ground that was elevated and of the sea-bottom that was raised to its present position. On both sides of the cape the boulders get smaller and smaller as this is left behind, and on the western side of the Orongorongo the character of the beach changes very much, the size of the boulders being much less.

The valley of the Wainuiomata varies in width from a few hundred feet to three-quarters of a mile wide. The lower valley is twelve miles long, and is occupied by heavy beds of shingle and clays, and a top soil forming terraces and flats.

Under the head of "Recent" must be placed the vast landslips which have occurred on both sides of the main range of the Rimutaka east of the Orongorongo. These huge slides are confined to this range, and are much greater on the western slope than on the eastern. The slips have come down from the highest points, and the uppermost part of most of the slips must be at least 2,600 ft. above the sea. In all, there must be thousands of acres, for they descend to the river-bottom in most cases at a height of only 500 ft. above the sea. In their descent they have carried away hundreds of acres of bush in each case, burying and piling it up in utter confusion.

2. *Pleistocene: Terraces and High Level Gravels.*

At the base of the recent deposits of gravels on the western shore of Onoke Lake, and immediately overlying the older rocks of the main ranges, are the gravel terraces of Pleistocene age. They occupy the coast from the spit to the lower portions of the main ridge, and penetrate inland for two miles up the Wharekauhau Creek and five miles up the Wharepapa Creek. Their general height is about 250 ft., but nearer the ranges they are found at a height of 300 ft., and adjacent to the lake as low as 70 ft. To the sea they present a line of vertical precipices for three miles and a half, and these are cut completely for their whole height by the Wharekauhau and the Wharepapa Creeks.

The terraces consist of thin and well-stratified beds of conglomerates and clays, which at the base become thicker and more indurated. These lower clays have wood- and plant-remains. The whole have on the coast-line a very slight and almost imperceptible inclination towards the west, which causes the beds containing the plant-remains and coaly material to disappear in that direction.

The materials of the conglomerates do not differ in any way from the beach-gravels and the alluvial of the spit. They consist of water-worn boulders and gravel of the rocks forming the adjacent ranges, including grey sandstones, breccias, shales, red and green rocks belonging to the mineral belt, and boulders from the reefs of calcite. The size of the included pieces is not large, 1 ft. being the maximum. At the lower beds the conglomerates are 5 ft. in thickness, and have undergone considerable induration. They form the banks of the Wharepapa in places, and are able to resist well the denudating effect of the stream; moreover, a smart blow of the hammer is necessary to obtain a specimen. In the upper beds the same beds will not stand carriage. They differ also in their having a much greater quantity of clay as a matrix, and also in the greater variation in the size of the stones, the lower conglomerates being almost a mass of small stones. The beds of clay are thicker at the base, and the coaly matter and wood- and plant-remains are confined to one thick band, which occurs on both sides of the Wharekauhau Creek and at the foot

of the cliffs along the coast right up to the Onoke Lake. These carbonised deposits are mostly composed of pieces of wood, some of it being 8 in. and 10 in. long and 3 in. in diameter, together with smaller pieces, and other material.

The Wharekauhau cuts through these Pleistocene terraces for a distance of about two miles, at which point the clays and conglomerates give place to the blue shales of the adjoining ranges. The same shales are on the coast-line, at which point the junction is seen to better advantage.

The Wharepapa Creek, further to the eastward, also traverses these beds for a distance of about five miles. The creek has cut the gravels to sea-level, leaving cliffs, which, however, are not so high as elsewhere. The section thus exposed shows the same thin beds, 6 in. to 12 in. of clays and conglomerates, in the upper layers, and thicker and more indurated beds, together with wood- and plant-remains, at their base. At a point five miles up the Wharepapa from the coast these Pleistocene deposits are seen to cover the coarse grey sandstone and dark shales of the Rimutaka, the blue- and greenish-coloured shales which the same gravels cover in the Wharekauhau and on the coast being absent.

On the western shore of the Onoke Lake the cliffs are 40 ft. to 60 ft. in height, and expose sections which correspond with the beds elsewhere. The lower beds containing the wood- and plant-remains are some 14 ft. above high-water mark.

Overlying the blue shales to the westward of the Wharekauhau are horizontal beds of Pleistocene age about 30 ft. to 40 ft. in thickness. They continue at intervals all along the coast for a distance of six miles till the Little Mukamuka Creek is reached. Near the Wharekauhau their elevation is about 300 ft., and further to the southward, where they cover the red rocks, the height is still greater. At the Little Mukamuka Creek they are found at an elevation of less than 190 ft. At Baring Head, three miles to the eastward of Pencarrow, they are capping the ordinary grey sandstone at a height of 400 ft., forming, with the underlying beds, the precipitous face of the coast. Their thickness here is about 6 ft., made up of small-sized pebbles, nothing larger than 1 in. The matrix of this conglomerate is very little, and the whole is held together chiefly by the compacting influence of pressure to which they have been subjected.

3. *Old Secondary or Palæozoic.*

About one mile to the west of the Wharekauhau Creek is seen a considerable development of bluish, soft, crumbling shales. They continue along the coast until a small creek (unnamed) coming down from Mount Matthews is reached, a distance of about three-quarters of a mile. In height they rise from 400 ft. on the eastward to 700 ft. at various places more to the westward. The stratification is not good, the bedding being thin and irregular and much contorted. In thickness the individual beds are never much more than 6 in., and in places they are less. The general strike is more regular, being 10° west of north, while the dip is high, 70°. Throughout the beds calcite veins run in all directions, and some of them are fully 6 in. in thickness and 20 ft. in length. Besides these veins, small threads of the same mineral occur throughout the rock. On the left bank of the small creek (unnamed) the bedding seems more regular, and improves further up the creek.

Near the head of the Wharekauhau, where the beds disappear eastward under the Pleistocene terraces, the strike is due north and south, and the dip west at an angle of 40°. The stratification is much better than on the coast, although contorted in places. At a height of 500 ft. on this creek these rocks are divided by a band of greenish sandstone, the strike of which corresponds with the blue shales, being north and south, and the dip is to the west and at an angle of 45°. This rib is not more than about 75 ft. across, and gives place to the shale at a height of 600 ft. The latter rocks at this height strike 10° east of north, and the dip has increased from 40 ft. to 70 ft. from the horizontal. The band of greenish sandstone does not continue to the southward to cut the creek, nor to the northward to cross the Wharepapa. The blue shales are characterized by their extreme friability and softness, and make a very feeble resistance to denudation, but, notwithstanding, form vertical precipices several hundred feet in height. Following up the creek (from Mount Matthews) the blue shales soon give way to the overlying coarse sandstones, slaty breccias, and shales. At the junction the strike is north and south, and the dip 40° from the horizontal.

The rocks immediately overlaying them are peculiar, owing to the great development of calcite. It differs, however, from the same mineral in the blue strata in that it occurs in bands. At the junction the cliffs, 500 ft. to 600 ft. in height, are exposed six or seven parallel bands of calcite, varying from 6 in. to 2 ft. in thickness. In breaking these beds they are seen in many cases to be the ordinary grey rock encased in a shell, or even a stain of calcite. In places this casing is very pure, clean lime; in others it is arenaceous, and can scarce be determined from the enclosed sandstone. These bands are remarkable for their continuity and their uniformity in width, varying only in character of the calcite.

Six miles to the south the purity of the deposit of calcite in these beds becomes very much less, and the reef-like appearance is scarcely distinguishable. At the north, where they form a junction with the blue shales and where they are associated with the jasperoid rocks, the sheen of the white beds can be seen some miles away. As mentioned, these rocks continue southwards for six miles or more, to within two miles and a half of Cape Turakirae, and to the northwards past the Wharekauhau and Wharepapa Creeks. The bed of the creek (from Mount Matthews) is littered with all sizes of calcite boulders up to 10 ft. in diameter. In many cases these huge water-worn rocks are wholly of calcite.

At a height of 500 ft. on the slopes of Mount Matthews the grey sandstones are interstratified with fine black well-bedded shales. Their strike is at variance with the containing beds, being due east and west, and the dip is to the north and at almost vertical angles. At the base of these black shales a quartz-reef was seen, varying from 6 in. to 2 ft. in thickness, in the side of the

cliff. The strike was north and south, and the dip was to the west and at an angle of 40° from the horizontal. The quartz was hard, pure, and white, not visibly crystalline, and with no sign of pyrites or other minerals.

With these deposits of grey calcareous sandstones and shales is a large development of red jasperoid rocks, green breccias, pyritous and greenish slates. The chief development is seen on the coast-line, one mile and a half north of the Mukamuka River. In strike they coincide with the associated strata, being north and south, while the dip is to the west at very high angles. The band varies from 40 ft. to over 100 ft. in thickness, and is continuous for fully one mile and a half. The sea terminates its linear extension towards the south, the band running out to sea at the point on the left bank of the Mukamuka. Its northerly end strikes 20° east of north, which causes it to take a direction away from the coast. The creek (from Mount Matthews) does not expose the band. At its southern end it is a few feet above sea-level, but at the other extremity it has been exposed by a great slip, and is seen to rise some 500 ft. or more in precipices overlooking the shore-line, and the *débris* of the slide covers the beach.

This mineral band is composed of purple-coloured limestones, nearly pure, and probably of value for hydraulic lime, also a purple breccia cemented with lime as calcspar and leek-green breccias, which are also calcareous, together with a fine grained slate with pyrites and sandstone crystallized quartz adhering.

Four distinct localities containing the rocks of the mineral belt were found in this range, but the best example is this place to the north of the Mukamuka Creek.

Immediately overlaying this development of calcareous rocks and the mineral belt is a series consisting of decomposed slates, fine-grained grey sandstone, slaty breccias and very fissile slates, and greenish round stones. The strike is pretty regular, being about 15° to 30° east of north, but the dip varies from 45° to the vertical, and in all cases the inclination is to the west. The breccias occur freely in various places in this locality, and the included pieces are seen varying from 6 in. to small inclusions no larger than a pin's head. Following up the Mukamuka River these beds are passed through, and the ordinary grey sandstone, containing lime in small quantities, takes their place. The dip is 45° to the west, while the strike is north and south. Further up the creek, at an elevation of 150 ft., the strike is 10° west of north, and the dip varies between 40° and 60° from the horizontal, while at places the strata is vertical and somewhat contorted. These beds are overlain by bluish crumbling shales, containing reefs and stringers of calcite, which reach to a height of 300 ft. above sea-level, and to a distance of one mile from the sea. They are identical in all respects with the beds lying to the west of the Wharekauhau. The bedding is thin—not more than 6 in. in thickness—and are much crumpled. The strike is 20° west of north, and the dip is high, being to the west and 60° from the horizontal.

Passing through this belt of shales the grey sandstones again occur, and overlying these is seen a black and bluish slate, interstratified with grey sandstone, standing vertical, while the strike is 45° east of north.

At the point on the right bank of the Little Mukamuka Creek another and a larger development of the jasperoid rocks and limestones occur. They are separated from the lower and parallel belt just described by the series of brecciated slates and fine-grained sandstones on the coast at the mouth of the Mukamuka River. The red rocks and limestones are about the same thickness, varying between 50 ft. and 100 ft., while the length is about a mile. In strike it coincides with the more northerly belt. Towards the south its trend carries it seaward, and into the gorge of the Little Mukamuka Creek to the northwards, to a point about three-quarters of a mile from the sea. It is overlain by a development of calcareous sandstones, in which the lime occurs, as elsewhere, in seams and reefs running quite parallel. The width of these calcareous beds varies from 6 in. to 5 ft. or 6 ft., being much thicker than the beds associated with the mineral belt north of the Mukamuka River. The limestone is, however, very arenaceous, and the beds are not as prominent as in the examples elsewhere. The same applies to the limestone forming a part of the mineral belt. The jasperoid rocks are much lighter in colour. The leek-green rocks, breccias, and pyritous slates are absent. The strike is north and south, and the rocks stand vertical. These rocks do not reach inland very far after crossing the Little Mukamuka River, for none of the branches of the Mukamuka River further north show any detritus of this kind.

The overlying sandstones and calcareous rocks continue southward to within four miles of Cape Turakirae, at which place they are seen to be overlain by a coarse, grey, gritty sandstone, the strike of which is 20° east of north, and the dip 60°, and to the west. They are thick-bedded in all cases, and until the cape is reached they vary very little in strike and dip; the lowest angle noted was 45° from the horizontal. But on rounding Cape Turakirae, and at a distance from it of about a quarter of a mile, the rocks are seen to dip east and the strike north and south, and in places the dip is south with an east and west strike. This locality is important as being the first instance of a permanent change in the dip and strike of the rocks along the coast. This variation is intensified as Pencarrow Head is reached.

In these rocks occurs a small exposure of the red rocks. They occur at a height of 350 ft. above sea-level, and on the cliffs overlooking the coast, at a distance of about a quarter of a mile west of the cape. It consists of red and green rocks, together with some very soft fissile shales. The rocks contain blebs of lime. In length the outcrop is about 100 yards, and the width is about 25 ft., the exposure being caused by a very recent "wash-out." The strike is a few degrees to the west of north, showing that it is a parallel rib to the two exposures of the same rocks on the east side of the range. It, however, dips to the east instead of the west, the angle being about 45° from the horizontal. It is seen that this third band of the jasperoid rocks coincides with the dip and strike of the containing beds, whereas the same beds elsewhere plunge at a different angle to the adjoining strata.

The third development of the mineral belt is seen in the series of great slips on the west side of the Rimutaka Range, in the valley of the Orongorongo River, about seven miles from the river. From the river-bed at least three exposures can be seen, while the river-bed is littered with jasperoid and calcareous rocks. The height of these exposures would be about 1,700 ft. to 2,000 ft., and in places even more. The detritus in the creeks show calcite as blebs in the red rocks, but the seams of calcite in the sandstone running in parallel lines are absent on this side. The rocks closely associated with the red rocks elsewhere—as the green breccias, pyritous slates, &c.—are not on this side.

As the stream brings down red rocks as detritus at points above this exposure, the same rocks must occur elsewhere up the valley. As the strike of the two ribs on the east side of the range would carry them into the head-waters of the Orongorongo Valley, it is possible that a small quantity of *débris* of red rocks finds its way from such a source. This last exposure on the Orongorongo is undoubtedly the same as the small rib showing on the west of Cape Turakirae, but no dip or strike could be taken by instruments, as the exposures are in the face of the great slips; but from the way the rocks weathered it could be seen that they were dipping to the east.

The three parallel ribs exposed in six different places are all the localities actually seen of the mineral belt, but at a point about six miles up the Wharepapa Creek, on the east side of the range, the loose boulders in the creek shows the proximity of the mineral belt. This will either be a fourth and parallel rib or a continuation of the development on the north of the Mukamuka River. The creek was traversed till a height of 1,300 ft. above sea-level was reached. The ordinary rocks of the range were found in the solid, consisting of slates and sandstones, the dip of which varied between due north and south and 40° east of north, while the dip was in all cases high and towards the west. Rocks in the solid were, however, scarce, and the rocks of the mineral belt were not reached, but the *débris* in the creek-bed was similar to the breccias of the coast, with the difference that instead of being leek-green they were grey. The jasperoid rocks were not so prominent, while pyritous slates were present, but not in the solid.

The irregularity of the sedimentary rocks on the west side of Cape Turakirae does not continue up the Valley of the Orongorongo, the dip being generally eastward; at times the rocks stand vertical. They consist of rather coarse sandstones of a grey colour, interstratified with dark shales. At a point half a mile up the Orongorongo the strike is 10° east of north and the strata is standing vertical, and one mile up the dip is to the west at an angle of 45°, while the strike is north and south. At this locality—one mile from the sea—the sandstones and shales are finely bedded, while at other places they have undergone a good deal of contortion. Still higher up the valley the same fine-bedded shales are standing on edge. Six miles up the valley from the coast and abreast of the great slips there occurs a very fine exposure of soft, black shales, much crumpled, the strike of which is 15° west of north, and the dip 45° to the west.

From the mouth of the Orongorongo River to Pencarrow the coast-line is occupied by a series of slates, coarse, and fine-grained sandstone, and brecciated slates. The dip of these rocks is extremely irregular, varying in a few feet, while in places some of the rocks are very much contorted. At the mouth of the river and on to Baring Head the rocks are a coarse, gritty, grey sandstone, having a strike of 70° east of north, and a northerly dip of 40° from the horizontal. In all respects they are a continuation of the beds at Cape Turakirae. At Baring Head they become interstratified with slates; the dip is here very high, being 80° from the horizontal and to the west, while the strike is due north and south. A little further to the west and on the same point the same beds are standing vertical, while the strike has altered to 10° west of north. The rocks here are thin-bedded and well stratified. Overlying these in Fitzroy Bay is a blue shale which has undergone much movement. Still further west the coarse sandstone of Baring Head comes in, but in place of the regular and thin bedding it is here 4 ft. in thickness and standing vertical, while the strike is 45° east of north. These beds contain a good deal of calcite in stringers. About midway between Baring Head and Pencarrow the strike is 10° east of north, and the sandstones with calcite are here interstratified with a black fine-grained sandstone. In this way the rock continues, alternating between coarse thick-bedded sandstone and sandstone with shale and slate partings. Nearing the entrance to Wellington Harbour the irregularities in the strike and dip become so great that it is quite impossible to determine the direction of the beds. In one place, a little to the south of Gollan's Creek, the rocks have undergone, in a distance of 30 ft. to 40 ft., a complete inversion. Leaving these crumpled rocks to the east, the beds nearing Pencarrow are coarse thick-bedded sandstones of a purplish colour, which are overlain at the Heads by a very fine example of slaty breccia of considerable thickness, which rises up into precipices about 200 ft. in height or more. The inclusions of slate are of a very fine-grained quality of a black colour. They occur in pieces from the size of a pin's head to fully 9 in. and 10 in. in length; the average size is from 4 in. to 5 in. The containing rock differs in no way to the underlying beds of coarse sandstone. The dip in both cases is to the west, and at an angle of 75° and the strike north and south.

Ruahine Range.

Within the same season—1900—a portion of the Ruahine Ranges was examined for deposits of copper, and the geology of the country was noted at the same time.

The Ruahine Range is a continuation of the same mountain system to which the southern extremity of the Rimutakas belong, and the piece of country which was more or less examined lies between Dome Mountain and the sources of the two branches of the Makaretu River, together with the adjacent foot-hills and low lands to the eastward. The main range is heavily timbered up to 3,000 ft. or more in elevation, above which point the vegetation consists of stunted scrub. From 4,000 ft. and upwards the mountains are clear and open. The total height goes over 5,000 ft. in several places, and the range increases in elevation and ruggedness towards the north.

The chief rivers are the Mangatawaiiti, Mangatawainui, Manawatu, and Makaretu. The first four rivers find their way into the Manawatu at different points, and the latter is a tributary of the Tukituki, which empties itself in Hawke Bay.

Recent Deposits.—These are practically absent, the rivers being mountain torrents, which have cut deep and narrow beds in the Pleistocene terraces to depths from 50 ft. to 500 ft., which leave as little room for these deposits to accumulate in the gorges of the ranges from where they have come.

Pleistocene Deposits.—These are considerable. They flank the ranges for the whole length, and form the valley between the Ruahine and the ranges opposite and to the eastward. They form terraces, rolling country, and moderately sized hills. In all cases they are or have been heavily timbered. As soon as the country rises into the main range they cease, and the sandstone of the ranges take their place. Gravels and clays are the component parts of these beds. The gravels consist of well-rounded water-worn rocks of grey indurated sandstone and slates, from pebbles up to boulders of 12in. in diameter, together with occasional pieces of pumice. Of the latter, pieces were seen fully 7 in. in length on the road-cuttings on the left bank of the Mangatawainui three miles south of Norsewood.

The clays in places contain wood- and plant-remains well defined in bedding of the strata. They in no way differ from the same deposits in the Pleistocene beds at Palliser Bay. They are seen very prominently one mile to the north of Mangatera on the main road. They are seen here to have an easterly dip of 45°, and a north-and-south strike. These gravels and clays almost everywhere are laying horizontal, and it is very seldom that they are inclined. The thickness of the individual beds is not great, averaging about 1 ft., seldom going over 2 ft., while at places they are as small as 6 in.

Old Secondary or Palæozoic.—These rocks occupy exclusively the ranges, and nowhere do they protude through the overlying gravels as far as was examined. They rise immediately from under these Pleistocene beds. They consist of coarse sandstones, shales, slates, and moderately fine sandstones, brecciated sandstones, and several members of the mineral belt, including greenish sandstone, jasperoid slates.

As seen in the *débris* of the Tamaki River, rising at the Dome Mountain, the rocks consist of coarse and indurated sandstone and slates, which are also brecciated. Very little lime is seen in the rocks, and there is no evidence to show that the mineral belt traverses the ranges within the watershed of this river.

The Mangatira is some three miles to the northward of the Tamaki, and takes its rise in the mountain of that name, while the Mangatawaiiti River is seven miles from the Tamaki River in the same direction, and neither of these streams give any evidence in their *débris* of the rocks of the mineral belt. But the Mangatawainui Creek, three miles to the south of Norsewood, brings down small quantities of jasperoid rocks. This stream was traversed to its source, some ten or twelve miles, with the object of examining these rocks *in situ*. The gorge is heavily timbered, and but few rock exposures could be seen. But at a height of 2,200 ft. a development of jasperoid rocks come in. They are bedded with coarse grey sandstone, and strike due north and south, while the dip in both rocks was almost vertical, but slightly to the west. The jasperoid rock was of a dull red colour. Its thickness could not be determined, due to the heavy bush, but it seemingly was not associated, as far as could be seen, with the usual greenish slates and breccias. The bedding was very thick, being about 4 ft.; and one of these bands was studded with quartz in small pieces, none of which were longer than 2 in. or 3 in. The absence of quartz in the adjoining beds gave this development of quartz an appearance of continuity, and the whole had been taken for a quartz lode. The amount of quartz was so small that it would, if put together, have not made a lode of moderate size.

The Manawatu River, to the northward, does not cut this or any other rib of the mineral belt, the *débris* not showing anything but the ordinary sandstones and slates. On the other hand, the Makaretu River, one mile and a half to the north, is littered with red and green rocks belonging to the mineral belt, and at the extreme head of the right-hand branch of the river, on the eastern side and top of the ridge dividing it from the left-hand branch, is a great development of these rocks. The series is cut by all the creeks of the right-hand branch, but a parallel rib occupies the crown of the ridge, which unites with the lower one as it rises out of the creeks; the augmented deposit then crosses the ridge, but disappears before the left-hand branch of the Makaretu is reached. The strike is 30° west of north, and this carries the lower rib down into the gullies as it is followed northwards until it shows on the ridge dividing the Makaretu from the Tukipo. The uppermost rib keeps the main spur for three-quarters of a mile, and then it disappears.

The beds of this mineral belt consist of jasperoid rocks, with copper and iron sulphides, greenish sandstones, grey sandstone, quartz and black shales. Pyritic slates and the leek-green breccias are absent. Of these the most important rock is the jasperoid rock, containing iron-pyrites and sulphide of copper in the form of a well-defined reef. The locality is near the southern extremity of the development, at a height of 3,100 ft., and 800 ft. below the crest of the range. The lode varies from 15 in. to 5 ft. in thickness, and is traceable for 150 ft. to the southward, where it is covered by the scrub; towards the south it disappears as a pug-vein 15 in. or less. The quality of the copper-ore is excellent in one or two places, but the percentage of iron-pyrites throughout the whole is very large. The strike coincides with the containing rocks, but in dip it is almost vertical.

Outside the reef the red rocks are permeated by copper to a width varying from 20 ft. in the top to 14 in. in the bottom levels.

The beds are overlain to the eastward by greenish sandstones, in which are a few patches of red rocks. The green rocks are full of quartz, but with no regular reefs, or even lengthy stringers, are to be seen; the strike 45° west of north, and the dip 40° to the eastward. The bedding is thin, from 2 in. to 4 in., well defined, though somewhat contorted.

On the west side the lode, together with the country-rock permeated with copper, is bounded by well-stratified red rocks, having a strike of 40° west of north, and a dip of 45° to the eastward. The thickness of the bedding is about 4 in., and much twisted. The colour is lighter and the texture finer than the same rocks nearer the lode.

Underlying these red rocks to the westward is a body of ordinary coarse sandstone of the Ruahine Range, interstratified in places with shales. The strike and dip coincide with the overlying rocks. The beds extend west until within 300 ft. of the ridge, where they are seen to overlie the parallel rib of red rocks belonging to the same belt, which continue to the top and cap the ridge without descending into the gully on the west. The strike of this second rib of red rock is 40° west of north, while the dip is to the eastward and at an angle of about 40°. This parallel rib shows no sign of iron or copper sulphides, neither does the rib in the gully outside the deposit examined. The rib on the ridge is peculiar, from the great amount of slickensiding characterising it. As mentioned before, these rocks do not descend on the western side of the ridge, and the rocks bounding them on the west are the ordinary coarse grey sandstones and dark shales. This rib is not associated with the other rocks of the mineral belt. The rocks to the westward, in the left branch of the Makaretu, are twisted and irregular. Their strike is east and west, and the dip nearly vertical and to the south.

Going back, and continuing the section from the copper lode, and thence to the eastward down the valley of the Makaretu, the greenish rocks overlaying the jasperoid rocks are seen to be covered by very soft sandstones, shales, and sandstones, at a distance of about 200 yards from the outcrop, the strike of which is 20° west of north, and the dip is to the eastward at 40°.

The Makaretu Valley is heavily timbered, and the outcrops of rock are few. More to the eastward, at a height of 2,500 ft., or 600 ft. below the copper lode, the very soft sandstone shales are lying almost horizontal, while three to four miles further down the creek, at a height of 1,625 ft., the rocks consist of sandstone, with black shale partings. The former is coarse, and grey in colour. The bedding is irregular, being from 2 ft. to 2 in. in thickness. The strike is 45° west of north, while the dip is to the south, at 40° from the horizontal.

The creek now takes a turn and trends south, and the section now goes over a high range to the westward which rises to fully 3,000 ft. On the western slope of this range, at a height of 2,200 ft., the sandstones are seen to be much finer in grain. In strike they trend 10° west of north and are standing in a vertical position. The bedding is thin and very regular. Half a mile to the westward the strike and vertical position is just the same, but the rocks are coarse, thick-bedded irregularly stratified sandstones and shales. The shales and slaty partings disappear on the eastern slopes, and until the beds disappear under the Pleistocene terraces and low grounds the rocks continue as a coarse, thick-bedded, grey sandstone, standing almost vertical, with a general north and south strike, and a dip to the eastward.

25th May, 1901. W. A. McKay.

REPORT ON THE CORRESPONDENCE OF THE SHOOTS OF GOLD EAST AND WEST OF THE MOANATAIARI SLIDE, THAMES GOLDFIELD.

By Alexander McKay, F.G.S., Government Geologist.

As affecting the prosperity of the Thames Goldfield there is no problem of greater importance than the determining the correspondence of conditions that exist in the parts of the district east and west of the Moanataiari Fault or Slide. This is the principal and, at the same time, the best known of the different dislocations that affect the area over which gold-mining at the Thames is carried on. Two other principal faults have been mentioned by some writers, and are popularly understood to be present in this field—the Beach Slide, running along the flat between the foothills and the east shore of the Frith of Thames; and the Collarbone Fault, described as springing from the Moanataiari Fault at the point where it crosses Karaka Creek, and thence taking a somewhat sinuous course nearly north across Punga Flat, Tinker's Creek, and Ohio Creek (30 chains above where the latter joins Tararu Creek).

With respect to the Beach Slide, there are no proofs other than to show that a steep shore-line suffered depression, and that subsequent deposits in the Frith of Thames tended rapidly to obliterate the inequality; so that this is of the nature of an unconformity separating deposits o different ages, and cannot be considered as a displacement by fracture.

The Collarbone Slide probably consists of a number of minor displacements having no direct connection with each other. In the southern part, from the saddle at the head of Collarbone Creek to Karaka Creek, it shows all the evidences of a series of landslips moving down the gully and grinding against the solid rocks on the eastern side. Though the rocks in motion may have a considerable depth, the whole of this part is of a superficial character, and is a slide affecting the surface rather than a fault dislocation reaching to great depth.

Recently proposals have been before the Government in which considerable stress is laid on the influence which the Moanataiari Slide has had in determining the position of the richer parts of the Thames Goldfield. In these it is contended that the displacement downwards and to the west of the rocks west of the line of fault makes it probable that the deep-seated continuations of the reefs west of the slide are to be found in the hills east of the slide in the neighbourhood of and even east of Punga Flat, and on this matter, my opinion being sought, the following is my reply to the question:—

Re parts of the Hauraki Goldfield west of the Moanataiari Slide or line of fault, and the probability of tracing the reefs of the front lower hills and Grahamstown Flat in the country east of the slide, the following facts and the reasonable inferences therefrom have to be borne in mind:—

First, that the strike of the reefs and their dip is almost the same in both areas, and, the strike being nearly at right angles to the average trend of the slide, it is fair to assume that the reefs to the west and east of the slide, before the dislocation took place, formed the higher and lower parts of the same reef systems; but it must also be borne in mind that shoots of gold, having a low angle of inclination, would be wholly displaced and carried bodily to the westward of the slide, and that gold found, or to be found, in the reefs to the eastward of the slide belongs to a lower horizon than the main gold shoot on the west side of the slide, except it may be in the near vicinity of the slide itself, which shoot of gold might find its continuation along a limited belt of country on the east side of the slide and adjacent thereto. Beyond the first 500 ft. east of the slide any gold in the reefs is not likely to have formed part of the great shoot of gold worked in numerous claims on the west side of the Moanataiari Slide.

The hope, therefore, that the gold shoot of the reefs west of the Moanataiari Slide will be found in the back hills between Point Russell and Punga Flat is not well founded, and the same may be said of any line of section parallel to that mentioned between Shellback and Hape Creeks. Apparently, the opinion is entertained that the shoot of gold so richly productive in the foreshore and front hills should also be found east of the Moanataiari Slide, but the likelihood of this is disproved by the experience of the miners within the area west of the slide.

This shoot of gold affected many reefs, and may be somewhat incorrectly described as a band or thick stratum of country within which all reefs between certain levels were gold-bearing. The lower limit of this productive band was found to be at different levels, according as it was proved at various points along a line bearing N.W. to S.E. In this way the shoot of gold-bearing country emerging to the surface in Kuranui Hill deepened, and took on a covering of barren country as it was followed to the south-east, and in the Queen of Beauty the lower plane of gold-bearing country, which appeared at the surface in Kuranui Hill, was not passed through in the principal shaft of that mine at 748 ft. from the surface: at least, it is stated gold continued for the full depth to which the shaft was sunk.

Below this great shoot of gold there appears to be a considerable thickness of rock, in which the reefs are not, to any extent at least, payably auriferous, and deep sinking in the northern part of the area west of the Moanataiari Slide has not been successful. This is in accord with what may be seen at the surface between Kuranui Hill and the lower part of Shellback Creek, which is the emergent end of the barren country underlying the gold-bearing belt between Kuranui Hill and the Queen of Beauty shaft. Over this area, west of the fault-line, but little gold has been found, although reefs are not absent, and much prospecting has been done. And here the question arises, Are the lower rocks and their contained reefs auriferous over this western part of the field? By actual trials, so far as made, the answer is No; and the same conclusion is arrived at on an examination of the surface between Kuranui Hill and Shellback Creek. Yet this country has been displaced westward from its original position beyond the Moanataiari Slide, and before displacement took place there was interposed between the upper shoot of gold and the yet lower gold-bearing portions of the reefs between Point Russell in Moanataiari Creek and Punga Flat a belt of poor or barren country now seen between the fault-line and Point Russell. This belt of barren country is represented under the shoot of gold to the west of slide.

That in shallow workings, and at levels of greater depth, gold was found right up to the Moanataiari Slide does not affect the question of the presence of an underlying barren belt of country. A portion of the upper shoot of gold seems to have been left on Messenger Hill, the barren belt lying below and to the eastward of that, and the same thing seems to have taken place on the western face of Una Hill.

Second, it has to be considered what was the original state of things before the fracture of the country and the formation of the Moanataiari Slide took place. The plane of the Moanataiari Slide dips to the westward at an angle of 45°. The popular idea at the Thames, that the country now lying westward of the fault once stood to the eastward vertically over Punga Flat, would result in a mountainous pile approaching 9,000 ft. in height. Punga Flat is at an elevation of 1,200 ft. above the sea, and the plane of the slide thus projected into the air would, in the vertical of Punga Flat, be 7,200 ft. above the sea; from which it would appear that since the formation of the slide denudation has reduced the land over this part by 6,000 ft., and the rocks thus carried away find their counterpart or continuation between Point Russell and the Moanataiari Slide on the one hand, and in the deep ground west of the slide on the other. The barren country thus interposed, separating the upper shoot of gold from that at lower levels, has been worked in various mines on and west of Punga Flat.

The sketch herewith shows the line of fault with the yet-in-place rocks that, moved downwards and to the west, are now found in the front hills and Grahamstown Flat west of the line of fault.*

The result of the restoration, as shown in Fig. 1, being the production of a mountain 9,180 ft. in height, this has been lowered by the slide 1,980 ft., and since denuded by the amount of 6,000 ft. This seems altogether unreasonable, and yet such a restoration is necessary on the assumption that the lodes and principal shoot of gold worked on the west side of the fault find their continuation and deeper-seated parts in the country east of the Moanataiari Slide back to Punga Flat.

This assumption must therefore be discarded, and a scheme of restoration adopted that will do less violence to what is reasonable and the probabilities of the case. It will satisfy most minds to assume that the Moanataiari Slide did not displace the rock more than 1,000 ft. horizontal and vertical. The effect of such a movement is shown in Fig. 2 of the illustrations accompanying. The consequent result of such a movement is that only a limited linear extent of the reefs on one or other side of the line of fault finds its equivalent in a higher or lower part on the other side, and according to the assumption it is impossible that rocks as far to the eastward as Punga

*See separate sheet for illustrations of this.

Flat that had a less elevation than 5,000 ft. above the sea could by any means be found on the west side of the line of fault. The converse of this is, that near Punga Flat it is vain to look for the downward continuations of those parts of the reefs that at low levels lie to the west of the slide.

No reef passes through the Moanataiari Slide, though the reefs on both sides have approximately the same strike and dip. Thus, it may be contended, and without question it is to some extent true, that the reefs to the east of the fault-line are the eastern continuations of those on the west side; and, if to within 1,000 ft. of the fault the reef-outcrops belong to a lower horizon than the portion moved by the action of the fault, and now found to the westward of the fault-line, as this is to be traced on the surface of the ground, as a consequence the gold shoots could not have been the same.

Therefore there is no probability of finding either the actual parts of the reefs originally vertically underlying the portions worked west of the fault at or in the vicinity of Punga Flat, or at any point east of Point Russell, or eastward of any point of equal distance along the line of fault; and, further, in as far as the shoot of gold affecting the greater number of the reefs to the west of the Moanataiari Slide has been worked out, or at all events passed through, the gold of the reefs in the hills to the eastward of the slide cannot be a continuation of the same.

The Upper Moanataiari Creek valley and the neighbourhood of Punga Flat, and extension of the same belt to the north and south, is therefore to be considered an auriferous area quite independent of that lying to the west of the Moanataiari Slide, except in so far as the lodes may be a continuation in strike of those to the west of the fault. Be that as it may, this eastern area must be prospected without reference to anything found on the western part of the field, and its past history must serve as incentive and for guidance of future prospecting endeavour. How much is to be hoped for is shown by the success which has attended prospecting and attempted developments since 1895; and I am not oversanguine of better results in the future.

7th May, 1901. ALEX. MCKAY.

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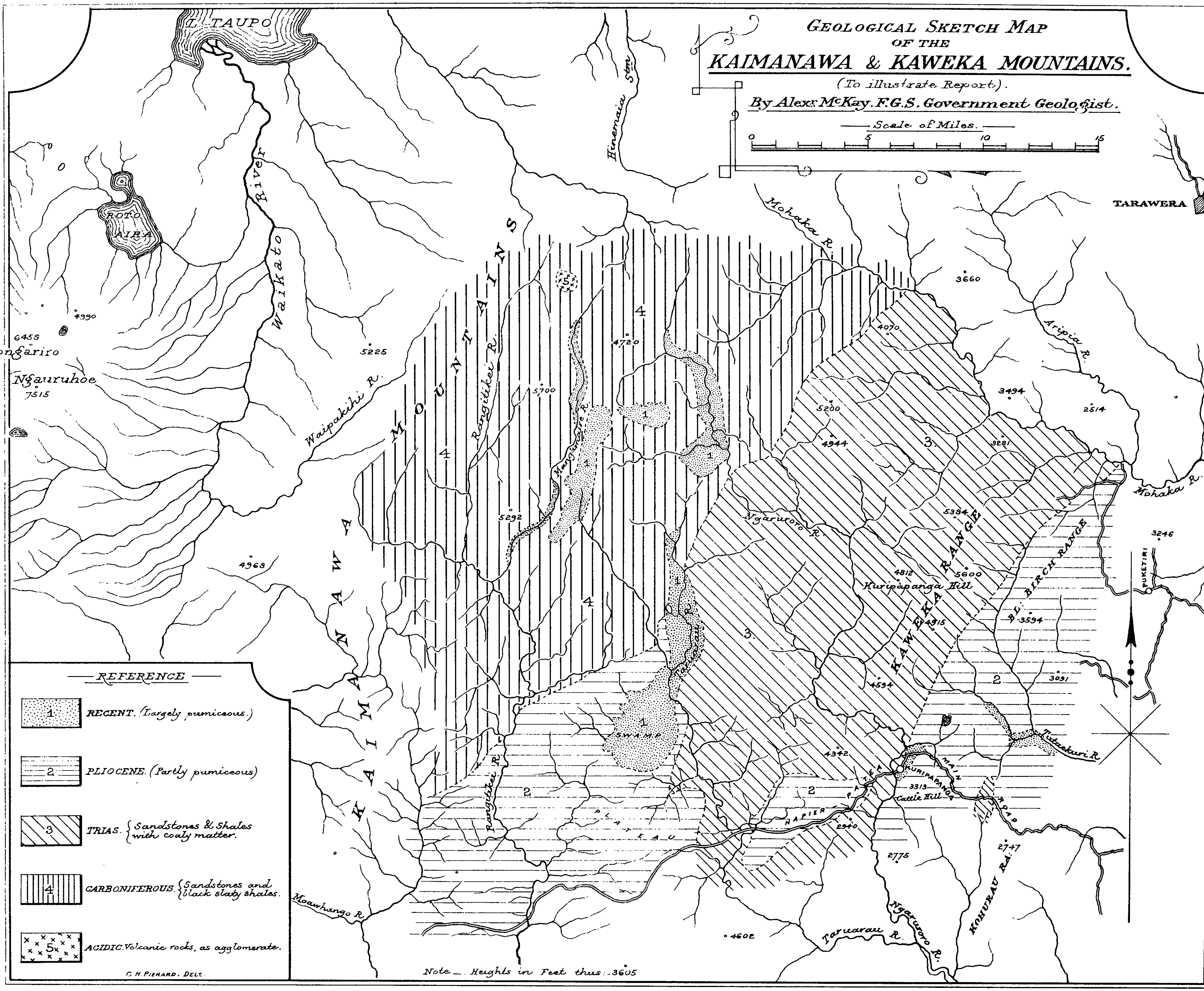
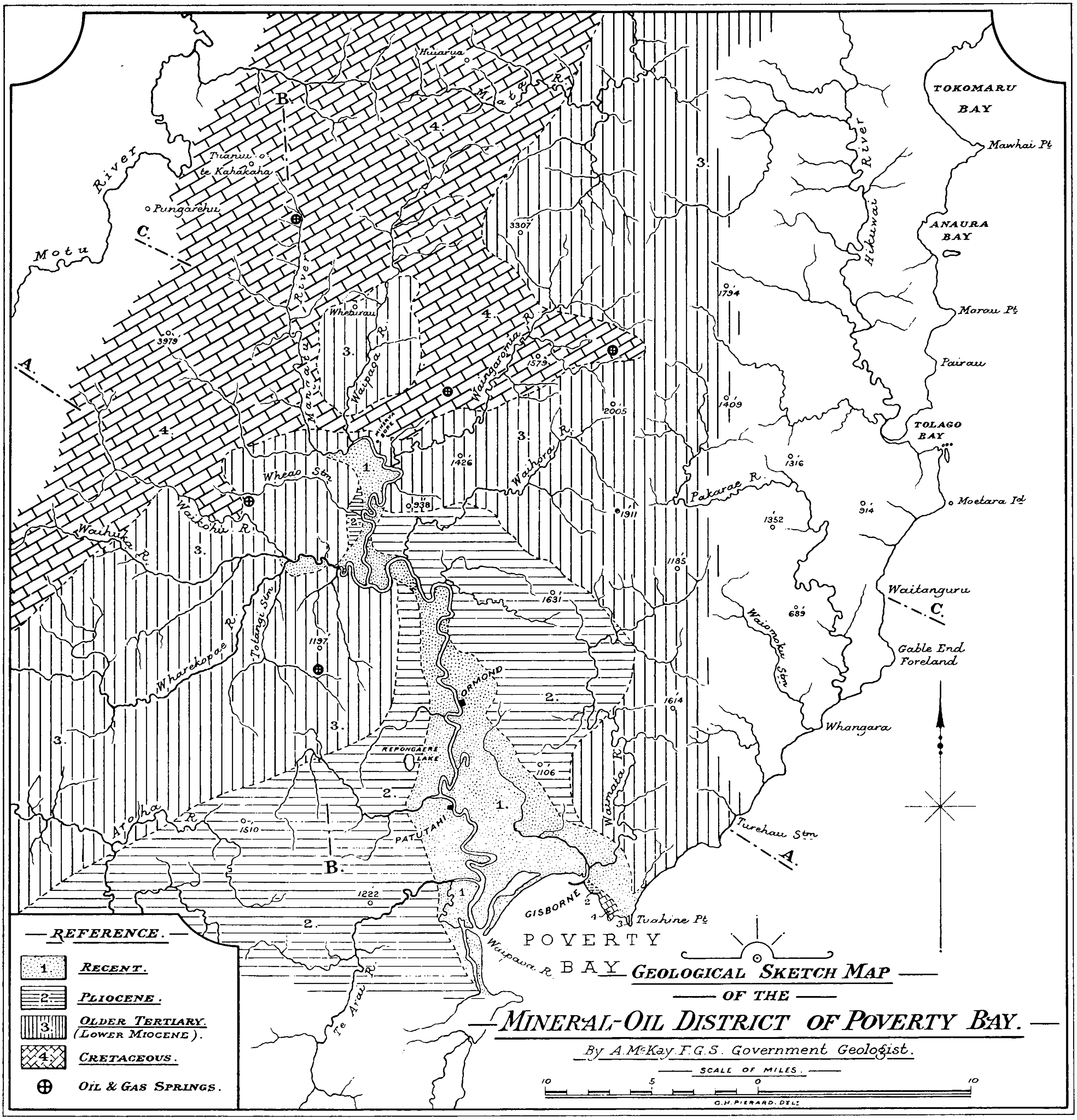
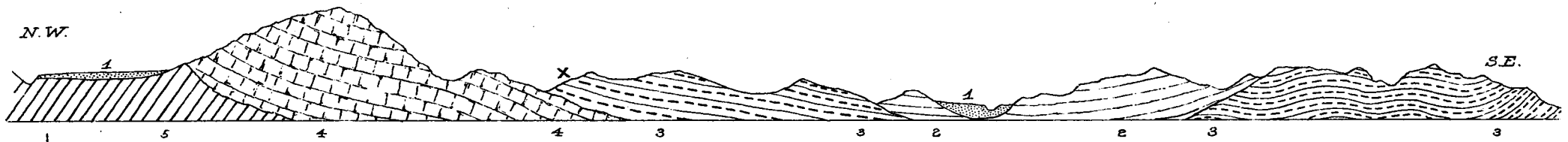

GEOLOGICAL SKETCH MAP
OF THE
KAIMANAWA & KAWEKA MOUNTAINS.
(To illustrate Report).
By Alexr. McKay, F.G.S. Government Geologist.
Scale of Miles.
0 5 10 15
REFERENCE
1 RECENT. (Largely pumiceous.)
2 PLIOCENE. (Partly pumiceous)
3 TRIAS. { Sandstones & Shales with coaly matter.
4 CARBONIFEROUS. { Sandstones and black slaty shales.
5 ACIDIC. Volcanic rocks, as agglomerate.
C. H. PIERARD. DELT.
Note _ Heights in Feet thus: 3605
L. TAUPO
ROTO AIRA
Tongariro
Ngauruhoe
Waikato River
KAIMANAWA MOUNTAINS
Waipakihi R.
Rangitikei R.
Hinemaiaia Stm
Mohaka R.
TARAWERA
Aripia R.
Ngaruroro R.
KAWEKA RANGE
Kuripapanga Hill
BL. BIRCH RANGE
PUKETIRI
Tutaekuri R.
SWAMP
PLATEAU
NAPIER PATEA MAIN ROAD
KURIPAPANGA
Cattle Hill
Moawhango R.
Taruarau R.
Ngaruroro R.
KOHURAU Rd.


GEOLOGICAL SKETCH MAP
OF THE
MINERAL-OIL DISTRICT OF POVERTY BAY.
By A. McKay. F.G.S. Government Geologist.
SCALE OF MILES.
10 5 0 10
C.H. PIERARD. DEL.
REFERENCE.
1 RECENT.
2 PLIOCENE.
3 OLDER TERTIARY. (LOWER MIOCENE).
4 CRETACEOUS.
OIL & GAS SPRINGS.
TOKOMARU BAY
Mawhai Pt.
ANAURA BAY
Marau Pt.
Pairau
TOLAGO BAY
Moetara Id.
Waitanguru
Gable End Foreland
Whangara
Turehau Stm.
Tuahine Pt.
GISBORNE
POVERTY BAY
Waipaoa R.
Te Arai R.
PATUTAHI
ORMOND
REPONGAERE LAKE
Hikuwai River
Waiomoku Stm.
Pakarae R.
Waimata R.
Waihora R.
Waingaromia R.
Waipaoa R.
Mangatu River
Mata R.
Huiarua
Tuanui
te Kahakaha
Pungarehu
Motu River
Wheturau
Wheao Stm.
Waitohi R.
Waihuka R.
Wharekopae R.
Tolangi Stm.
Arakihi R.
3307
1794
3979
1579
2005
1409
1316
1426
938
1911
914
1352
1185
1631
689
1197
1614
1106
1510
1222
A.
B.
C.

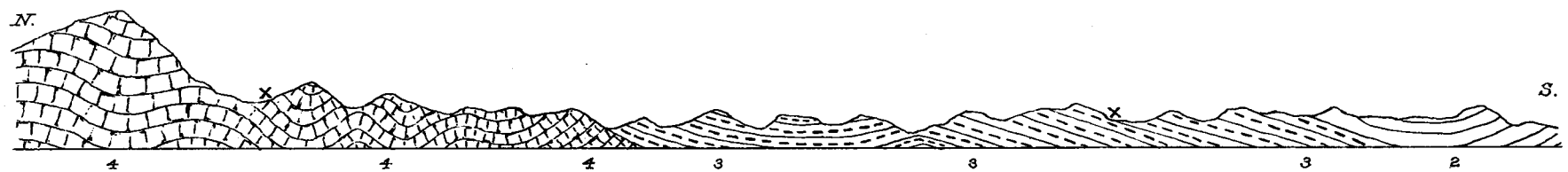
Sketch Geological Sections of the Mineral-oil District, Poverty Bay.

by A. McKay, F.G.S. Government Geologist.



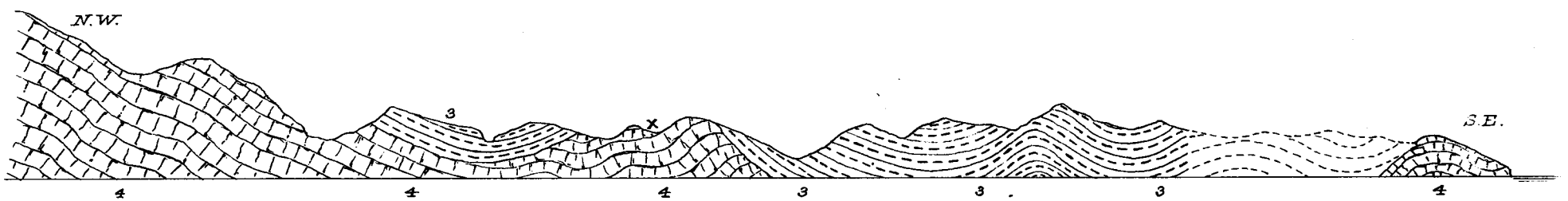
Sketch Section on Line A.A. N.W.–S.E. Motu R. to east coast near Turehau Stream.

1. Recent. Alluvial. 2. Pliocene. Limestones, & Pumice sands.
3. Lower Miocene, or Upper Eocene. Grey, marly strata.
4. Cretaceous. Chalky Limestones, & Greensands.
5. Palæozoic. X. Oil or Gas Springs.



Sketch Section on Line B.B. N.–S. Tuanui-o-te-Kahakaha to Gisborne – Ngatapa Road.

2. Pliocene. Sands & Limestone.
3. Lower Miocene, or Upper Eocene. Grey, marly strata with Coralline Limestone.
4. Cretaceous. Indurated chalky Limestone, Greensands, Shales, & Sandstones; with Concretions near base of formation.
X. Oil or Gas Springs.



Sketch Section on Line C.C. N.W.–S.E. From Pungarehu to Sea-coast at Waitanguru.

3. Lower Miocene, or Upper Eocene. Grey, marly strata.
4. Cretaceous. Chalky Limestones, & Greensands.
X. Oil or Gas Springs.

C.H. PIERARD. DEL.

To illustrate Report on the

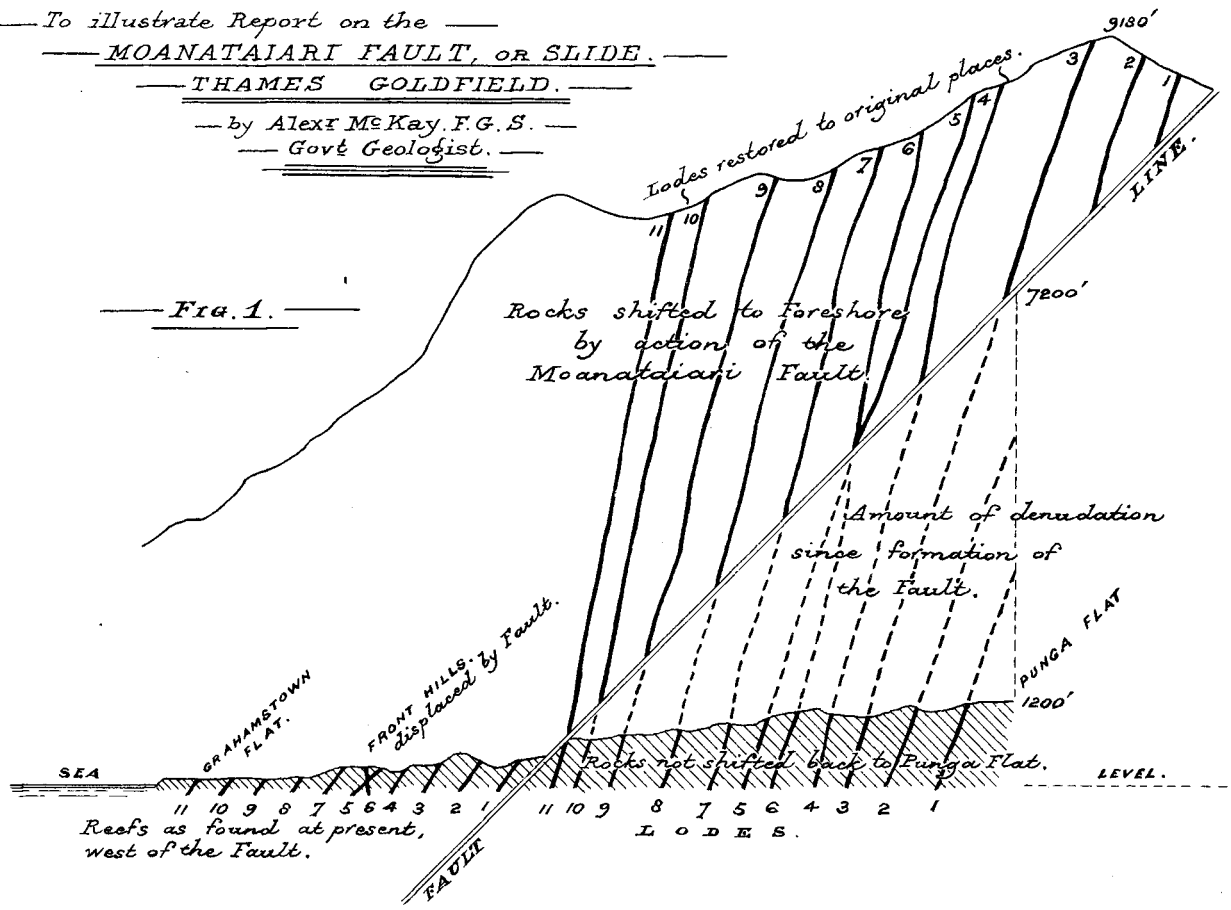
MOANATAIARI FAULT, OR SLIDE.

THAMES GOLDFIELD.

by Alexr McKay. F.G.S.

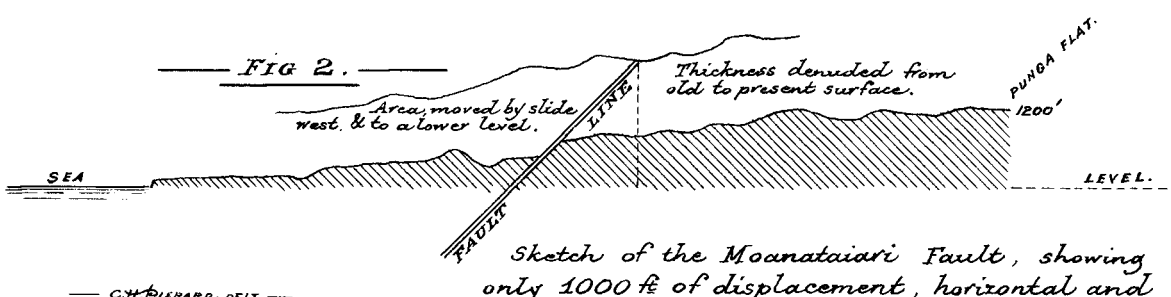
Govt Geologist.

FIG. 1.



Sketch showing position of the Lodes in the Front Hills & Grahamstown Flat, west of the Moanataiari Slide, or Fault; & the same restored to their original position, assuming No3 Lode to be = to Dixon's No1 on Punga Flat.

FIG 2.



Sketch of the Moanataiari Fault, showing only 1000 ft of displacement, horizontal and vertical. (To same scale as Fig 1.)

C.H. PIERRARD. DELT.