1899.

NEW ZEALAND.

GEOLOGICAL EXPLORATIONS

MADE DURING 1898-99.

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,— 29th April, 1899.

During the winter and spring months of the year just expired I was in part engaged with the preparing and printing of reports relating to the work of the previous year; also, in preparing rock and mineral specimens for exhibit at the then forthcoming Auckland Exhibition.

Towards the end of August I was sent to New Plymouth to examine the various borings obtained by the New Zealand Petroleum Company, and to ascertain if possible the source of the oil hitherto obtained and the likelihood of oil being found in the wells then in progress. The result of this work will form the subject of a special report, and here only the conclusion arrived at need be stated.

I was led to consider that the oil is derived from rocks at a very considerable depth from the surface, and that such oils as have been found exist as secondary deposits in strata and fissures of a formation of younger date; that such storage is of a limited amount, and exists at two horizons—first, at about 900 ft.; and second, at between 1,900 ft. and 2,000 ft. from the surface—and that, despite the many escapes of inflammable gas between Inglewood and the Sugar Loaves at New Plymouth Breakwater, the probability of finding oil is confined to a narrow belt of country, the greater part of which is deeply covered by ejecta from Mount Egmont or other volcanic vents along the line.

While in the Taranaki District I paid a visit to the Patua Range, forming the outer hills flanking Mount Egmont on the west side. In this range there exist considerable bodies of thermal quartz, which appear as terrace accumulations at the surface or as bodies of greater or lesser magnitude, disposed as reefs confined between walls of volcanic rock.

For a long period of years prospecting for gold and other minerals has been carried on in these rocks, and I was induced to visit two localities where such prospecting is being carried on at the present time. The prospects were said to be favourable, and I selected samples of quartz from one locality at the base of the range and from another mine at an elevation of 1,200 ft., but on having these tested at the Colonial Laboratory only traces of gold were found.

During the later part of December I made an examination of a lode of rhodochrosite (carbonate of manganese) that for some years past has been known to exist in the vicinity of Paraparaumu, at a convenient distance from the Manawatu Railway. When first discovered, owing to the dense forest clothing this part of the district, the tracing of the lode was a matter of difficulty. This has now been done, and the determination of a regular lode 6 ft.–10 ft. thick is the result. This ore at the time of the discovery was supposed to be valuable, but recent information states the price of good ore as not more than £2 per ton. This low price is said to be due to recent discoveries in Spain, from which country it appears large quantities are being shipped to England. The present value of the ore would not enable the profitable working of the lode at Paraparaumu, and therefore interest in it is for the present lessened.

From the middle of November till the 15th December I was engaged at Auckland in connection with the display of rocks and minerals constituting the exhibit of the department at the Auckland Industrial Exhibition, 1898–99.

On the 3rd January, 1899, I left Wellington for the purpose of examining the country east of the Ruapehu and Tongariro ranges and on the east and west shores of Lake Taupo, and thence along the course of the Waikato River on the route of travel to Rotorua and the Hot Lakes district, with the object of collecting siliceous deposits, possibly containing gold.

At Taupo I was instructed to examine certain deposits to the east of Lake Taupo that, located on Native lands, have for the past two or three years been prospected by Mr. A. Campbell. At first the Natives were averse to my seeing the reported discovery, and it was only after a considerable delay that finally I was permitted to examine the ground. The event showed that no payable prospect had been found, but indicated the existence of gold in some way associated with the extensive field of acidic rocks developed to the eastward of Lake Taupo, and forming the western slopes of the northern part of the Kaimanawa Range.

In the meanwhile I had visited Te Puke, for the purpose of examining the cement deposits some time since discovered on the eastern slope of the coastal range north of Fleming's Hill and Clark's. This I found associated with, and lying between, heavy beds of pumice-sand, and in itself consisting mainly of a coarse subangular wash, fully one-half of which is of a rhyolitic character, the rest being andesic material. The area of this auriferous deposit never exceeded 5 or 6 acres, and such of it as has escaped destruction through the cutting-down of the creek valley is less than 2 acres in extent. The amount of gold present is far too little to pay for working the cement band, which would require to be driven out and sluiced by suitable arrangements in the open of the creek channel.

Had this and the like deposits to the east of Lake Taupo been proved to contain gold in payable amount, a vast field of similar deposit would ere this have claimed the attention of the prospector, as over the pumice-covered region between the Rangitika Valley, through Rotorua to the height of the watershed draining into the Bay of Plenty, there are many areas, large and small, over which the same material is to be found, and within which colours of gold are reported to have been found.

These investigations occupied me till the 10th February, on which date I went from Rotorua to Auckland, for the purpose of repacking specimens on closing of the Exhibition, but on its being decided to keep the Exhibition open till the end of February I employed the interval, according to your instructions, in examining a reported gold-discovery at Wade and certain prospecting operations for gems which are being prosecuted near Riverhead.

On the repacking and despatch to Wellington of the exhibits shown by the department, as requested I visited Waihi, Ohinemuri County, for the purpose of examining the seams of coal or lignite recently discovered in the hilly country bounding on its south-west side the Waihi or Upper Ohinemuri Plain. This work has been effected, and the result is the ascertainment of the existence of a number of seams, two of which are of a workable thickness, and—though the coal is not of high quality—in view of the rapid disappearance of timber from the neighbourhood of Waihi and Karangahake and other gold-bearing centres of the Upper Thames District, likely to be of considerable value in the near future.

The Assistant Geologist was engaged during the winter and spring months in matters connected with the preparing for show and cataloguing of the bulky collections of the previous year, and in preparing copies of maps to enable the production of a geological map of the colony showing the work done to the most recent date of publication of detail maps.

During the month of November he was sent to Manaroa, Pelorus Sound, to examine and collect from the rocks of that district, interest having been aroused by the receipt of a slab of rock from Manaroa by Professor Hutton which showed the impression of the foot of a struthious bird of such size that it was considered to be that of a moa. My assistant, however, failed to find rocks of the age indicated in Professor Hutton's letters to me, and subsequently to the Hon. the Minister of Mines, the rocks met with being, excepting modern sea-beaches and coarse alluvial deposits of creeks, of Palæozoic age. Information since received points to the existence of Tertiary rocks some distance further up the sound, and when a further opportunity of examining this part occurs the source of the original boulder showing foot-markings may be ascertained.

On the 15th December the Assistant Geologist was directed to make a survey of the Trooper Range, on the east coast of Wellington, to determine the nature and age of the formations present, and to collect rock-samples, more especially of the igneous intrusions that are known to occur in that range, some of which are of considerable interest to petrologists.

Subsequently the same officer was directed to continue this survey of the coast-ranges of the east district of Wellington South to the gorge of the Pahau River. This work is now in progress, and so far the results show a complex and interesting development of interstratified, sedimentary, and igneous rocks that, important in themselves, are likely also to help to a right understanding of the time when some of the more important gold-bearing rocks of the Cape Colville Peninsula made their appearance.

During the latter part of April I was directed to examine the eastern part of the Mokau Coalfield, that part of it north of the Tangarakau River, and east of the water-divide, between the Mokau and Wanganui Rivers. In connection with this matter I proceeded to Stratford, and there saw the member for the district and such others as were interested in the matter of the application for a survey which had been made. I pointed out the difficulties of carrying out their wishes, especially at this late season of the year, and agreed to make an effort to ascertain the southern limits of the coal-bearing area. With this object I reached into the head-waters of the Tangarakau River and within twelve miles of the outcrop from which samples had been sent to Wellington. As far as the Tangarakau River the rocks are of Tertiary age, while the rocks of the coalfield to the north are supposed to be of older date. The boundary is, therefore, to the north of the point to which I reached and outside the limits of Stratford County.—I have, &c.,

The Under-Secretary, Mines Department. ALEXR. MCKAY.

REPORT ON A DEPOSIT OF RHODOCHROSITE AT PARAPARAUMU, WELLINGTON.

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

SEVERAL years ago I visited Paraparaumu and, accompanied by the general manager of the Manawatu Railway Company, made some exploration of the ranges lying immediately to the east. In what was at the time heavy forest, we came upon an area of rocky soil, with many black boulders of considerable size interspersed. These, on being broken into, showed a pale rose-colour, and the weight of the specimens indicated a metallic mineral. The mineral proved to be rhodochrosite, and on analysis specimens afforded over 80 per cent. of carbonate of manganese. At the

time the mineral was supposed to be of such value as to make it worth while to search for it *in situ*, the blocks on the surface indicating a massive lode. The Manawatu Railway Company induced prospectors to endeavour to trace the source of the blocks on the surface, but this they failed to do, and it was not until the hillsides in the neighbourhood were deforested that the lode was found.

For a number of years no interest was manifested as to the development of this find, and not till last winter did I pay a second visit to the district, which I did for the purpose of tracing the lode and ascertaining its size, which could not easily be done when the mineral was first found. The original sample was found on the lower slope of the range, on to the east side of the valley running south from Paraparaumu, and drained by the small stream that passes on to the coastal plain at Paraparaumu Railway-station. When and where first found the locality of the discovery was either a tangle of fallen timber or heavily covered with standing bush, and it was not easy to make out the probable direction of the outcrop. Ore as large blocks was plentiful on the surface, and from such loose blocks it was that the first samples were taken. These assayed 82 per cent. carbonate of manganese, and the price then quoted for the mineral induced the proprietor and the Wellington–Manawatu Railway Company to search for the lode at greater heights, and to the north-east on the western slope of the range. As a result of this prospecting, further samples were forwarded to the Colonial Laboratory, but these proved much inferior to the original, and, there being some difficulty in locating the lode, interest in the discovery ceased, and not till some time after was the lode found. Ten or twelve years having elapsed since the discovery, during the interval most of the timber has been cleared off the range, and there is now a fair opportunity for tracing and following the lode.

At the date of my last visit I found that further prospecting had been carried on in the meantime. Four or five pits had been sunk on the outcrop, but apparently the workmen did not apprehend that they had to do with the actual lode. The first of these openings is situated about half a mile to the north-east of where the first specimens were found, and the outcrop of ore shows on the right bank of a small creek, and at an elevation of 500 ft. above the sea. The ore appears at the surface a deep black: this, however, is due to the formation of a hydrous oxide, a result of the decomposition of the carbonate of manganese forming the great bulk of the lode. The carbonate, being a pale-grey or slightly flesh-coloured mineral, was rejected by the prospectors as quartz, and, as the dark oxidized part was soon passed through in this first opening, it was abandoned, and another commenced on the line of the lode more to the north-east, and higher on the spur on that side of the creek. The results here were the same as at the creek-level, the black manganese soon being passed through, and the grey or flesh-coloured mineral entered upon. Two other holes on the line of outcrop were made farther to the north-east, and in all the change from the black to the grey or flesh-coloured ore was only the matter of a foot or so; but, so long as dark joints and partings appeared, the prospectors had seemingly hope of coming on a deposit of pyrolusite or manganite. In this way the lode was proved through a vertical depth of 200 ft., and over a distance of from 5 to 7 chains along the lode. The thickness of the ore-band varies from 3 ft. to 10 ft., and the ore itself is a compound of carbonate and silicate of manganese, with about 14 per cent. of carbonate of lime, 4 per cent. of carbonate of iron, and traces of magnesia and water.

Manganese-carbonate is quoted as bringing at the present time 16 to 20 cents per pound. The deposit at Paraparaumu should therefore pay to work, provided there be a sufficient demand for the mineral to enable the working of the deposit on a large scale and continuously. There is, however, no ready means of information as to the requirements of the market, and to what special uses the ore is at the present time being applied. The following copy of Mr Skey's analysis of a sample of the ore recently collected is appended:—

	Per Cent.
Carbonate of manganese	63·03
Silicate of manganese	18·23
Carbonate of iron	4·00
Carbonate of lime	14·48
Carbonate of magnesia	Trace.
Water	0·26
	100·00

July 28th, 1899. ALEXR. MCKAY.

REPORT ON PETROLEUM AT NEW PLYMOUTH, TARANAKI.

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

THE occurrence of petroleum at Moturoa, Taranaki, was known to the Maoris before the settlement of the district by Europeans, and though known to the settlers at an earlier date, not till 1865 was any attempt made to sink wells and collect the oil for commercial purposes. In 1866 (Dr.) Sir James Hector, as Director of the New Zealand Geological Survey, made an examination of the Taranaki District, and reported on the prospects of the district near New Plymouth as a field for the occurrence of petroleum in quantity. At that time boring for oil was in progress, and the belief was general that an oil-field had been discovered. Three wells were bored to a maximum depth of 650 ft., but the results not being what were anticipated the works were discontinued, nor again resumed until 1888. In 1888, Mr. Samuel, solicitor, of New Plymouth, became interested in the matter of the discovery of oil in paying quantities, and since that date until the present has been the leading spirit in all matters connected with and relating to that object.

The past history of endeavouring to find petroleum at Taranaki is summarised in a letter from Mr. Samuel, managing director of the New Plymouth Petroleum Company, to the Hon. the Minister of Lands. Mr. Samuel describes what has been done up to the 13th March, 1898, as follows :—

"Indications of petroleum have been seen at Moturoa for many years past, and, as far back as 1865, efforts were made by boring to obtain oil. Three wells were sunk in 1866–67, but no greater depth was reached than 650 ft., and no oil in large quantity being reached, and the appliances being somewhat primitive, operations were discontinued and the wells finally abandoned. My own connection with petroleum-boring dates from 1888, when I was associated with the Hon. Sir Julius Vogel in the enterprise. After some difficulty a company was formed in England, a plant and drillers sent to New Plymouth, and a site chosen near the root of the Breakwater. A bore was drilled to between 900 ft. and 1,000 ft., when oil was struck. But mainly, I think, on account of the broken strata met throughout, and the falling-in of hard boulders from the uncased part of the bore, accidents were of frequent occurrence, and the drilling tools got jammed in the bore and the drilling-poles broken. Thus much money was lost (a great deal, I am convinced from my recent experience, through the want of personal supervision of one with money invested in the venture), and the English shareholders—much of whose money also went in the London office expenses and payments to directors and others—got disgusted and ceased to supply the funds. The head driller, Mr. Booth, who had considerable experience on the oil-fields of America, in an official interview with me (on the 19th June, 1891) made the following statement, which I forwarded to the directors in London :—

We are down over 900 ft. now and are in oil. It is the most valuable oil I have ever seen yet. Without going deeper we could now pump up about four barrels of oil each day—that is 160 gallons per day. The success of the company is now certain. It would pay well to pump four such wells and refine the oil, but the more wells the better. I am sure twenty such wells can be bored so near the present one as to be pumped with the same engine. If wages are paid I intend to go down another 200 ft., if I do not sooner come to a lighter oil which rises freely, and I am expecting that every foot deeper I go. It will take about three weeks to sink another 200ft. I say again, that unless I am stopped, the success of the company is certain. I recommend sinking the present bore another 200 ft., then sinking some five or six other wells in the vicinity of the present one to what I find the necessary depth. These would cost from £500 to £600 each, to a depth of 1,200 ft. each. Five such wells, even if we do not improve the flow of oil, would certainly yield twenty barrels a day, which would pay well to refine; and as success is a certainty, a refinery should be erected and a refinery plant procured, so as to get a return on the outlay. The smallest plant I ever saw would do to begin with, and I never saw one less than a three-still plant, which would run off 3,600 barrels a week. This, I think, would cost from £3,000 to £4,000. The company must get a man who understands refining, as I do not profess to do so. Machinery for pumping the wells, if necessary, can be got in the colony for about £300, I think. I cannot give you any advice or help about funds. The men will not work beyond Saturday next if they are not paid, and if they stop I must stop also. I do not understand what the directors are about.

"Immediately after this the drilling tools got jammed and one of the poles parted. The result was that, as funds were not forthcoming, work was suspended; and, after some months' delay, the men were paid off and the works shut down. For a time the drillers were retained, in the hope of funds being again raised or a new company being formed in England, but nothing came of the efforts made in London (no doubt partly because of the commercial crisis in 1892 and 1893), and New Zealand creditors took proceedings with a view to the sale of the plant. Towards the end of 1893 I visited England, and endeavoured to prevent the sale of the plant, which I felt sure would cause the undertaking to be abandoned altogether. In the end I arranged for raising a loan in New Zealand, on security of the company's assets, to pay all the New Zealand debts, and secure six months' time during which to raise capital. The time elapsed, and the company being unable to do anything, I formed a small syndicate at New Plymouth of men who were interested in the welfare of the district, and who were willing to spend a little money in the hope of developing the wealth which we trusted was lying dormant here. We procured drillers, reopened the works, and attempted to clear the bore, but our efforts were unsuccessful. I then met Mr. R. E. Fair, of Sydney, one of an Australian firm of artesian-well-borers, who had succeeded in sinking wells to great depths, and who had previously had some experience in oil-boring in America and Roumania. Mr. Fair was very sanguine of success, and proceeded with me to Australia, where he induced some persons with whom he was acquainted to join him in arranging with me (representing the New Plymouth syndicate) to bore to the depth of 1,000 ft., in consideration of an equal share with us in the assets. Mr. Fair then took charge of operations, supplied some new plant, and sunk a bore near the abandoned one to the depth of about 1,000 ft. Oil was struck at about 905 ft., but water had not been shut off, but I understood from Mr. Fair that the water in the bore rose and fell with the tide—showing that there must be some fissure communicating with the beach below high-water mark. The New Zealand syndicate then formed a company; but, recognising the tendency which those engaged in mining exploration of every description have to exaggerate the chances of success, we did not place any shares in the market, but issued only the shares applied for by the members of the syndicate. For some reason, which has never been explained (probably because he thought the yield too trifling, and that to leave a bore open, with water not shut off, might spoil the oil in the vicinity), Mr. Fair (who was appointed managing director) had the bore which he had drilled (called No. 1 bore) plugged up, most of the casing drawn, and abandoned. Mr. Fair then selected a site about a mile off in a southerly direction, and sunk a bore there to a depth of 1,534 ft., without getting any oil or gas. He abandoned this also of his own instance. Mr. Fair then selected another site, to the south-east of No. 1 bore, and there drilled the third bore. In this oil, in quantity at least ten barrels per diem, was struck at about 905 ft. This was, however, found to be a mud-vein with papa above, which constantly fell in and choked off the oil. What followed up to 1897 is correctly stated in the 'New Zealand Trade Review' of the 2nd September, 1897, page 8, a copy of which I forward herewith :—

[Extract from the New Zealand Trade Review.]

In our issue of the 19th March, 1896, we gave a sketch of the boring operations conducted at New Plymouth to that date. We now continue the account of the work thus carried on to the present time. While we compliment our Taranaki friends upon the pluck and perseverance which they have shown we greatly regret that their enterprise has so far met with so little reward.

Three bores near New Plymouth Breakwater, out of four sunk to over 1000 ft., resulted in finding in each a quantity of oil at between 900 ft. and 1000 ft., but in conjunction with "papa"—a sedimentary deposit which, although it had at that depth hardened by pressure and exclusion of water, became soft as soon as it came into contact with either water or oil, and thus frustrated all the attempts of the company's staff to bring the oil to the surface.

After several weeks spent in testing the quantity of oil and mud, and finding the latter inexhaustible, drilling was continued in the fourth bore in February, 1896, and was proceeded with to a depth of 1976 ft.

In the course of its operations, the company met with great difficulties and losses, the drilling-tools frequently becoming detached, and connections parting owing to the great depth and the peculiar strata passed through, which, though for the most part "papa," contained small pieces of hard rock which, after being passed by the drill, fell in and jammed the tools in the bore. At 1,358 ft., 1,392 ft., and 1,675 ft. gas and oil were met with, but it was not until 1,976 ft. that any large supply of oil was reached. The "papa" at about 1,865 ft. gave place to soft sandstone, in which also it was found most difficult to "sut off" the water which followed the bore down on the outside of the casing, the result being that after the first explosion of gas and oil in the seam at 1,976 ft. the water in the bore flowed into the oil-seam and effectually forced back the oil and prevented it from flowing or accumulating in the bore so as to permit of it being pumped out. At intervals, however, the gas forced the water out and brought up pure oil to the surface, and it being apparent that there was a very large quantity of oil below, the directors were encouraged to carry on extensive operations by "packing" with a view to "sutting off" the water.

Meanwhile the derrick in which the work was carried on was frequently filled with gas (which was used also instead of fuel), and the floor and sides were constantly drenched with oil. One night there was an explosion, caused by the gas igniting through coming in contact with a lighted lamp at some distance from the bore, and in a moment the whole of the derrick was in flames, and the oil which had accumulated in the shaft outside the bore, and near the derrick, and which was at that time slowly flowing from the bore itself, burned fiercely until the works were completely destroyed. Undismayed by this disaster the directors repaired such of the machinery as was not rendered useless by the fire, and procured other necessary plant, and re-erected the works, the bore being meanwhile plugged up. Mr. Fair, who had hitherto been managing director, finding it necessary to return to Australia, Mr. Samuel, the chairman of directors of the New Zealand Board, succeeded him, and the operations of the company have since been carried out under his superintendence.

When the works were reinstated, the previous operations to free the bore from water, and effectually keep it clear, were resumed. These usually succeeded temporarily, and each time resulted (after a few days spent in pumping from the oil-seam below the water which had entered it from the bore) in a supply of pure oil at the rate of about eight barrels (336 gallons) per diem, but in every instance the strata proved too friable and soft, and the water from above worked round the "packer," and again flooded the bore below and the oil seam. In all, about seventy barrels of oil were obtained, which found a ready sale at 15s. per barrel (barrels being supplied to the company). The Railway Department and other manufacturers of gas found the crude oil most suitable for their purposes, and orders poured in which, however, the company found it impossible to supply.

At length in March, 1897, the directors reluctantly relinquished their efforts, and, leaving the bore still cased, abandoned it and moved the engine and most of the plant in order to commence a new bore about a hundred yards off. This, the fifth bore that has been drilled, was continued with great expedition (electric light being used to prevent risk of explosion), and oil and gas were again encountered between 900 ft. and 1,000 ft.; but the rock, as before, consisted of "papa," and therefore again rendered ineffectual all attempts to exclude water, and caused the bore itself to cave in and fill with oil-mud. The directors have now abandoned all hope of success at this level, and are proceeding to drill deeper with the hope that when the limit of papa is passed, and the lower oil seam between 1,900 ft. and 2,000 ft. is reached, some strata of sufficient hardness and durability will be found to enable them to bring the oil to the surface.

The present company has, in all, bored over 5,600 ft. in its four bores, in three of which oil has been found in quantity which would be payable were it not for the soft strata above and around it. The depth of the present bore is 1,140 ft. We understand that if better results are not obtained from the present bore at the lower level, the directors will abandon their efforts, so far at any rate as the vicinity of the Breakwater is concerned, unless they re-erect their machinery at the last bore, from which the gas continues to rise, and brings a continuous small stream of water with oil in it, of which the company saves about 60 gallons a week regularly.

The oil itself is of the most valuable quality. Professor Boverton Redwood states that: "The oil was of a rich brown colour and quite free from any disagreeable odour. Its specific gravity was ·840 (at 60° Fahr.), its flashing-point 62° Fahr. (Abel test), and that the following are the percentages by weight of the commercial products which the crude oil yields:—

Petroleum spirit	Nil.
Petroleum oil (kerosene), sp. gr., at 60° Fahr., ·811 flashing-point, 78° Fahr. (Abel test), equal 50 per cent. by volume	48·25
Intermediate and heavy oils with solid hydrocarbons (paraffin)	51·25
Coke and loss	0·50."

The Professor concludes a lengthy report by remarking: "The crude oil must therefore be regarded as of an exceptionally valuable description, and the commercial importance attaching to the discovery of such an oil in the locality is undeniably great." Mr. William Skey, the Analyst to the New Zealand Mines Department, in a report on the oil, after describing the results of the tests, remarks: "These results clearly show that this petroleum is of excellent quality and greatly resembles those of the east side of this island, also some of the best American petroleums that are very largely distilled for kerosene;" and he also adds that it has a high commercial value.

It is probable that in any event the company will, before abandoning operations, sink a bore somewhere inland, but in any single bore at a distance from where the oil has already been found there is considerable chance of no oil being struck. Fortunately those directing the destinies of this company have steadily repressed any attempt to "boom" the shares or cause them to change hands for speculative purposes, and therefore they have been hitherto able to continue their operations and retain the absolute confidence of the shareholders, but it can scarcely be expected that the comparatively small number who have provided the funds for this enterprise will continue their expenditure unless some remunerative return is before long obtained. It would be a most deplorable thing in the interests of the district and of the colony if the present company should be compelled to wind up and to discharge its efficient staff and sell its plant, probably to find its way to Australia, where it can be utilised in artesian well boring. As, without any aid from the Government, private individuals have expended some £9,000 to such good effect, so far as boring is concerned, and as they have proved that oil in large quantities does exist in the district, we think that the Government should in the interests of the colony give them some substantial aid to enable them to continue their operations. Probably £1,000 would go far to sink another bore, and we know of no better use to which such a sum could be put by the Government.

"Although No. 3 bore (with a depth of 1,976 ft.) is practically abandoned, and has a set of drilling tools near the bottom, it has for the last year continued to yield water and oil, brought up by gas-pressure below, from which we have regularly saved about 30 gallons of petroleum per week. We bored No. 4 bore to a depth of 2,050 ft., and succeeded (for the first time at any depth over 1,500 ft.) in practically shutting off water, but the result showed that we were off the oil-strata which we had struck in the No. 3 bore, and, although we got oil, it was in very small quantity. We have, accordingly, ceased operations there, but the bore is securely cased and protected and the plant left in position, so that drilling can be resumed at once should it be thought wise to sink deeper. We have now, with a new plant, commenced to sink a bore about

four miles inland, towards the south-east of No. 1 bore, but, not unnaturally, the shareholders cannot afford to provide further funds for an enterprise which, however hopeful, and although very successful recently as far as drilling is concerned, has, from a pecuniary point of view, proved a series of failures.

"The company was formed in Sydney with the expectation that the capital would be more readily obtained there, and therefore the head office is there, together with one-half of the directors, but the Australian shareholders, whilst they hold nearly half the shares and are liable for more than half the uncalled capital, are very few in number. Calls fall heavily on these, as well as on several, at any rate, of the New Zealand shareholders, and the present position may be gathered from a letter just received from the manager:—

* * * * * *

"The site (about four miles inland towards the south-east of No. 1 bore) chosen by me is an excellent one, and in the direction recommended by Mr. Gordon (who has specially inspected the locality). It is unquestionably in the proper direction, and within a mile of a spot where gas is now issuing from the ground. If we now, for want of funds, abandon the undertaking, it is practically certain that all hope of any other attempt to get oil will be at an end—for many years, at all events. It seems clear from the results of the old Petroleum Company's bore, and No. 1 bore and No. 3 bore, that there is oil in large quantities somewhere in the vicinity of New Plymouth. It is ascertained that this oil is of great commercial value, and would, if obtained in quantity, enormously increase the wealth of the colony as a whole. Our present organization has deserved well of the colony, and expended many thousands of pounds and bored many thousands of feet, whilst its recent performances in drilling compare most favourably as respects cost and depth with any drilling operations in the world. The management rests with those whose experience now fits them to conduct operations efficiently . . . . and we possess plants of the most improved design, and two Canadian drillers, who are probably second to none in the world in experience and knowledge in practical drilling. I therefore venture to urge that the Government should prevent this undertaking failing by giving such moderate assistance as may be necessary to enable us to sink the new bore to such a depth as will be some fair test of the strata below. . . . . —13/3/98."

As a consequence of this communication from Mr. Samuel, I was directed to proceed to New Plymouth, and ascertain what had been done and what the prospects were of the ultimate success of the New Plymouth Petroleum Company's undertakings. I examined the sites of the various bores and the gas and oil exudations at several places, and, so far as I could, determined the nature of the rocks at the surface and those that had been passed through in the different bore-holes that had been made. From the bores more recently made samples of the rocks passed through had been preserved, and these were of considerable importance, as showing the nature of the strata penetrated by the bore-holes and the character of the beds from which oil had been obtained. And whatever assistance lay in his power was afforded me by Mr. Samuel; but, as my investigations did not extend beyond the region covered by volcanic *débris* from Mount Egmont, in order to a right understanding of the conditions under which petroleum occurs in the district, I had to consult Sir James Hector's report, already referred to, and that on the Taranaki District by Mr. James Park, F.G.S.; and was aided by subsequent observations made by myself in the district adjacent to the eastward.

Shortly after the investigations by me were made, the following report on the subject of petroleum at Taranaki was addressed to the Under-Secretary for Mines:—

"I have the honour to report that, as directed, on the 23rd August I proceeded to New Plymouth, and during the week following collected evidence bearing on the past history and the present prospects of boring for petroleum in the Taranaki District.

"Respecting the discovery of, and the earliest efforts to obtain, oil, little or no information could be obtained other than that in the reports by Sir James Hector published in the 'Abstract Report of the Progress of the Geological Survey of New Zealand' during 1866–67. At a later date boring was carried on to greater depths, the maximum depth in one of the two bores situated near the landward end of the Breakwater being 900 ft. From these bores oil was obtained, but apparently not in sufficient quantities to warrant the further prosecution of the works at that place; and I could not learn what was the nature of the strata at 900 ft. from the surface, or whether the oil obtained from that depth originated from that or from a higher level.

"Subsequently the New Plymouth Petroleum Company determined upon a site half a mile more to the eastward, and here two bore-holes were put down to a depth of 2,000 ft., and, as these proceeded, approximately correct records of the strata passed through were kept.

"In No. 3 bore the superficial sands and underlying volcanic agglomerate proved to be 275 ft. thick, below which sandy papa was entered upon and continued to a depth of 810 ft., when a bed of rather coarse quartz-sandstone was encountered. This passed, fine quartz-sand containing oil was met with at 915 ft. This was not an abundant supply, and the bore was continued to greater depths, care being taken to exclude the water and oil of the higher levels from the lower parts of the well as the bore was proceeded with.

"Between 1,900 ft. and 1,996 ft. oil and gas were again struck, and this time in such quantity as seemed to afford hope of the ultimate success of the undertaking. To obtain the oil, pumping had to be resorted to, and then it was found that the supply was intermittent. The failure of continuity of the yield of oil arose from one or other of two causes, viz.: First, material sucked into and around the foot of the pipe, and thereby preventing the access of oil to the well; or second, the drawing away of the looser sands of the porous oil-stratum, and the coming together of impervious strata above and below the oil-bearing bed. It need not be here inquired which of these two suppositions is the correct one. It will suffice to say that an accident happened whereby the derrick was destroyed by fire, and the well has since been closed down, except occasionally when the accumulated gases and some oil are allowed to escape, the latter being collected in tanks prepared for that purpose.

"On the destruction of the derrick at No. 3 bore, the company procured fresh plant and commenced putting down No. 4 bore. This being only about 4 to 5 chains south of No. 3, passed practically through the same strata at the same depth, the difference of surface-levels considered.

"At the 915 ft. horizon of No. 3 bore traces of oil were obtained, but the amount was considerably less than in No. 3 bore. At the greater depth of between 1,900 ft. and 2,000 ft. no oil was obtained, and thus discouraged, No. 4 bore was, for the time being, abandoned, and a site was chosen some distance further to the eastward, where a bore put down some 300 ft. failed, owing to the incoherent nature of the volcanic agglomerate passed through at that depth. The last effort of the company, the present bore (No. 6) is situated on a flat terrace a short distance west of No. 5 bore. This has been successful so far as the piercing of the volcanic agglomerate to the depth reached—about 140 ft; but in this locality it has yet to be ascertained whether the thickness to be bored before reaching the papa rock will be much greater than at Moturoa.

"About five miles east of the Breakwater, and nearly in a line between the Breakwater and the township of Inglewood, numerous gas-springs escape from a stratified formation composed of alternations of fine and coarser sands and volcanic *débris*, in distinct layers that have evidently been arranged under water. Other gas-springs exist in the district, as, for instance, at and near the township of Inglewood; but these were not visited.

"In No. 3 bore, and in all subsequent bores, due precautions have been taken at proper intervals to prevent leakage of oil or water to the lower depths of the wells, and thus in No. 3 bore, while the oil is escaping slowly from the oil-stratum at 900 ft., this does so outside the sheathing, while in the inner pipe inside the sheathing the accumulated gas and oil are under considerable pressure. Ample evidence of the great pressure under which the gas and oil from the deeper part of the well accumulates, and its non-connection with that at 900 ft. was afforded by slightly opening the valve and allowing a portion of the gas and oil to escape.

"Samples of the borings from different depths of No. 3 bore, and now in the company's office, were examined and determined and, as showing the nature of the rocks passed through, the catalogue of the samples examined is here given.

"*New Plymouth Petroleum Company's No. 3 Bore.*—Sample 1, from 50 ft.: Very fine sand with scales of mica. Sample 2, from 100 ft.: Volcanic fragments, same as the Sugar Loaf; solid ash. Sample 3, from 150 ft.: Subangular fragments of volcanic material. Sample 4, from 200 ft.: Subangular fragments of volcanic material. Sample 5, from 250 ft.: Subangular fragments of volcanic rock, more felspathic than No. 2; solid flow. Sample 6, from 300 ft.: Fine sand (papa) with a little magnetite. Sample 7, from 350 ft.: Same as at 300 ft. with clear crystals of quartz. Sample 8, from 400 ft.: Arenaceous clays (papa), not marly, very fine without sand-grains; a deposit in moderately deep water. Sample 9, from 450 ft.: Similar to No. 8, with broken crystals of augite or hornblende. Sample 10, from 500 ft.: Very fine quartz-sand. Sample 11, from 550 ft.: Same as No. 10. Sample 12, from 600 ft.: Extremely fine sand. Sample 13, from 650 ft.: Same as No. 12, with black grains added. Sample 14, from 700 ft.: Same as No. 12. Sample 15, from 810 ft.: Coarse quartz-sand with scales of mica. Sample 16, from 850 ft.: Same as No. 12. Sample 17, from 915 ft.: Very fine quartz-sand; smells strongly of oil. Sample 18, from 950 ft.: Very fine sand with spangles of mica. Sample 19, from 1,000 ft.: Same as No. 18. Sample 20, from 1,100 ft.: Same as No. 18. Sample 21, from 1,150 ft.: Same as No. 18, but finer. Sample 22, from 1,250 ft.: Similar to No. 18, but more clayey. Sample 23, from 1,300 ft.: Similar to No. 18, but more clayey. Sample 24, from 1,350 ft.: Fine sand; similar to No. 18. Sample 25, from 1,400 ft.: Fine sandy clay. Sample 26, from 1,450–1,500 ft.: Fine sand with scales of mica. Sample 27, from 1,550–1,600 ft.: Fine sand. Sample 28, from 1,680–1,750 ft.: Very fine sand. Sample 29, from 1,900 ft.: Moderately coarse sand; oil at or about this horizon. Sample 30, from 1,976 ft.: Moderately coarse sand with mica.

"Somewhere between 1,000 ft. and 1,400 ft. the beds passed through were fossiliferous, broken marine shells forming part of the borings. These were small bivalves that could scarcely be identified, but resembled much a similar shell-bed found at Strathmore, twenty miles north-east of Stratford. The sequence of the rocks passed through in No. 3 bore also corresponds with that of the rocks seen between Toko and Strathmore, with the exception that the coarse shell-limestone of the Toko–Strathmore section is absent in the bore. No. 15, 810 ft., is so similar to 1,900 ft. and 1,976 ft. that the borings cannot be distinguished.

"As regards the prospect of successful boring for oil in the Taranaki District in the vicinity of New Plymouth, this is not of the most hopeful kind; and yet it is perfectly manifest that there exists a source of oil apart from what may be derived from the lignite deposits of Younger Tertiary or Post-Tertiary ages.

"The facts in connection with the sinking of No. 3 bore show that the oil obtained from it is not derived from a superficial source, or from a deposit comparatively near the surface. No oil was found in the upper sands or volcanic agglomerate, and more than 600 ft. of papa rock had been pierced before the first indications of oil were met with. After this first oil-bearing stratum at 915 ft. was passed, no oil-bearing beds were met with till a depth of 1,900 ft. was reached, whence a much stronger flow of oil than from 900 ft. was obtained. The primary source of the oil lies at greater depth than yet reached, or at a distance from any of the wells yet bored. At 900 ft. and 1,900 ft. the oil exists merely stored in the strata, since to a depth of 2,000 ft. there are no beds that in the first instance could have given off the oil, and it does appear that a further 1,000 ft. might be bored without reaching carbonaceous beds likely to afford or capable of yielding the oil stored at higher levels. But it is hardly a question of reaching the carbonaceous strata from which the oil has been derived; much more important is it to determine an abundant supply in the storage-levels at 1,900 ft. and 900 ft., or at lesser or intermediate depths.

"The supply of oil has not proved over-abundant, and the temporary abandonment of the different localities and particular bores that have engaged the present company's attention are certainly discouraging facts. Meantime the New Plymouth Petroleum Company has located and is proceeding with their No. 6 bore at a moderate distance from their former bores, Nos. 3 and 4, and it is to be hoped they will be able in this to reach the stratum equal to 915 ft. in No. 3 bore, at which depth, should oil not be struck, it might be matter for consideration whether boring should be continued."

In 1866, Dr. Hector examined the district along the coast to the White Cliffs, and the following description has been taken from his report on the progress of the Geological Survey of New Zealand during 1866-67 :—

"The geology of this interesting locality can only be understood by following the natural section shown along the sea-coast for thirty miles north of New Plymouth, . . . which gives the succession of the strata from the White Cliffs to the Waitara River. The White Cliffs (600 ft. to 700 ft. high) are composed of Older Tertiary marls containing a few marine shells and corals, and marked by lines of calcareous septaria dipping to the south-west, and visible along the coast as the lower part of the sea-cliffs* as far south as Omera, which is five miles north of the Waitara River. At this point they are overlaid unconformably by Newer Tertiary clays, the junction being marked by a stratum of rolled septaria derived from the older marls, intermixed with quartz-gravel and broken shells. As the overlying clays differ only very slightly from the older marls, if this conglomerate bed were not present, it would be very difficult to detect that a different and newer formation had been entered upon. The newer clay (Pliocene Tertiary) rests horizontally on the bed of conglomerate, and in the course of a few miles from where they first appear, they acquire a brecciated structure from the presence in them of angular fragments of volcanic rocks, indicating that the deposition of these clays was contemporaneous with volcanic eruptions in the neighbourhood, which, judging from the interposition among the angular breccias of beds of rolled conglomerate, were evidently of an intermittent character. . . . South of the Waitara, this clay breccia passes into a tufaceous agglomerate, in which both the matrix and the embedded fragments are of volcanic origin, probably indicating a near approach to the centre from which the eruptions took place.

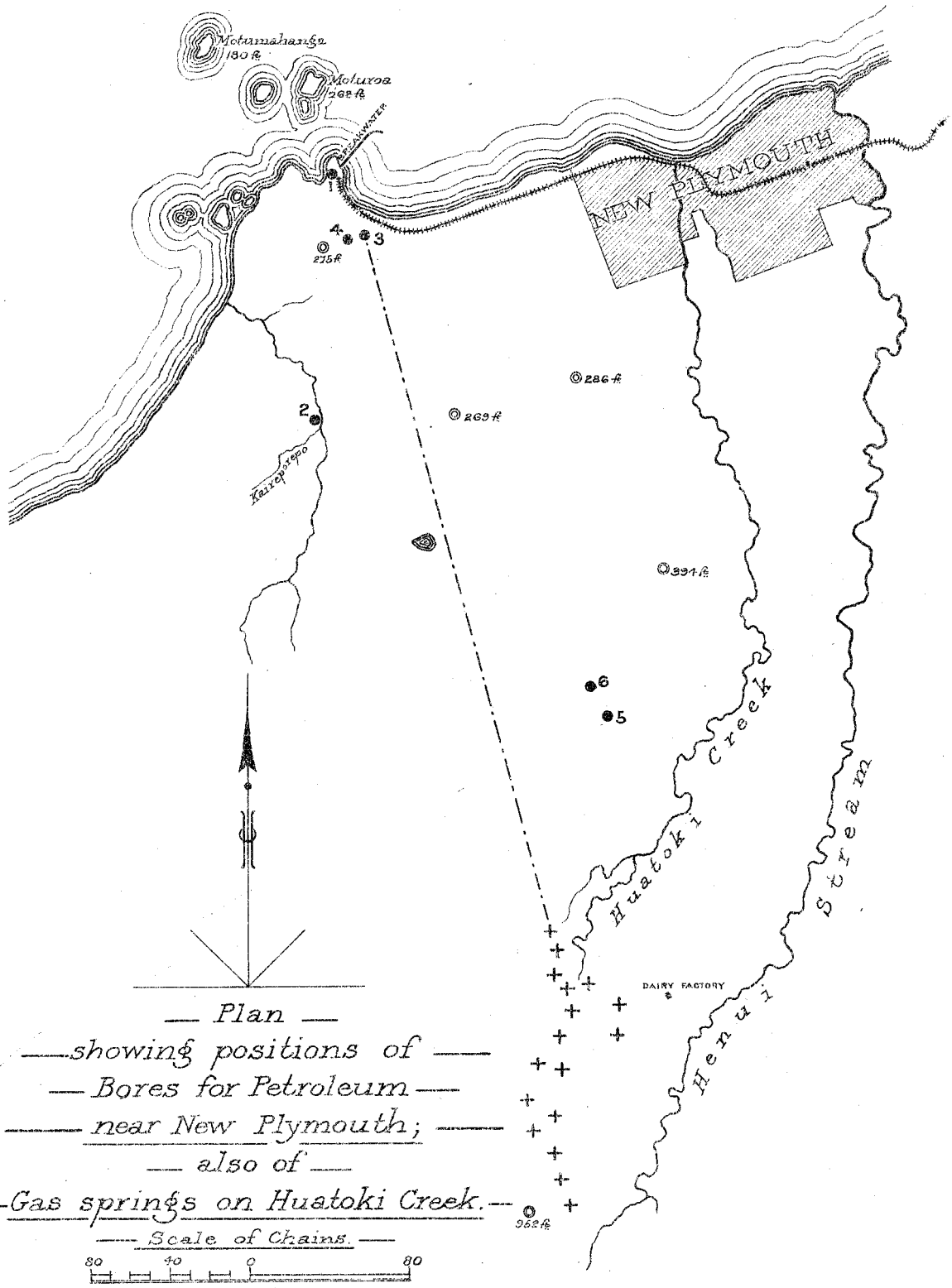
"At Sugar Loaf Point a break occurs in the section, owing to the intrusion of a dyke-like mass of trachyte porphyry. This dyke, which is 300 ft. wide, lies in the magnetic meridian, and forms the main Sugar Loaf and the Island of Moturoa. It appears to be of earlier date than the tufaceous agglomerates, having probably stood as an island ridge in the sea in which the latter were deposited. South of the Sugar Loaf the agglomerates again prevail, but at Fort George they form only the lower part of the cliff, being overlaid by newer volcanic tufas from the Mount Egmont centre, which are probably the equivalents in that locality of the beds next to be described.

"There are Pleistocene deposits consisting of stratified gravels and sandrock (not hard enough to be termed sandstone) with beds of lignite. This formation, corresponding in age and stratigraphical position with certain of the auriferous gravels in the South Island, is highly charged with oxide of iron, forms the upper part of all the cliffs along the coast north of the Waitara, and is readily distinguishable by its deep red colour. These gravels do not extend far inland nor to a greater altitude above the sea than 150 ft., so that they must be regarded as in some way connected with an ancient coast-line, and from the circumstance that at the base of this formation in many places, and underneath the lignite seams, there is a layer of rolled broken shells of existing species, we may infer that these gravels have been deposited in lagoons parallel with the coast-line during a gradual elevation of the land, and that they have been overtaken, as it were, by the encroachment of the sea, and exposed in sea-cliffs after they are 80 ft. to 100 ft. above the present level of the tide. As, during the interval which must have elapsed, there was time for the formation of beds of lignite 8 ft. to 10 ft. thick, we have thus an indication of the extreme slowness with which changes of level are taking place, even in an area of such marked volcanic action as that around Mount Egmont. . . . . The only other formations observed are superficial deposits still in progress, such as a rich brown loam in the district around Mount Egmont, derived from the decomposition of volcanic tufas and sand-dunes along the coast, which latter are sometimes extremely consolidated by the infiltration of iron as to resemble a sandstone formation of much higher antiquity. In the foregoing section [and as here described] we may safely conclude, owing to the deposition of the strata, that we have somewhat the same succession of formations which would be encountered in a vertical line in the Sugar Loaves, namely: (*a*) volcanic breccia, 250 to 350 ft.; (*b*) newer tertiary clays, 400 ft.; (*c*) conglomerate and quartz cement,† 100 ft.; (*d*) older tertiary marlstones, 900 ft. The foregoing estimates of the thickness of the strata to be passed through are taken from the coast sections, and are therefore only very approximate.

"The rock in which the borings for petroleum are in progress is the breccia in the above section. This breccia or agglomerate consists of a variety of trachyte and basaltic fragments, cemented by a tufaceous clay and calcareous marl or ash of various shades of red, yellow, and green colours, but sometimes there occurs a thick bed of tufaceous clay of green tint with but few included fragments. Between the innermost island and the north headland the fragments of this breccia, where the stratum has been denuded by the sea, form a natural causeway, which is dry at low water, and it is on this causeway principally, but also round the shore of the headland, that the indications of the presence of petroleum are found. Masses and seams of a ferruginous

* The balance of opinion is in favour of a somewhat younger age for these beds, and Park, in his classification of the rocks of the district, places them as not of greater age than the Upper Miocene period. I am inclined to agree with Mr. Park in this matter.

† Local.



— Plan —
— showing positions of —
— Bores for Petroleum —
— near New Plymouth; —
— also of —
— Gas springs on Huatoki Creek. —

— Scale of Chains. —

80 40 0 80

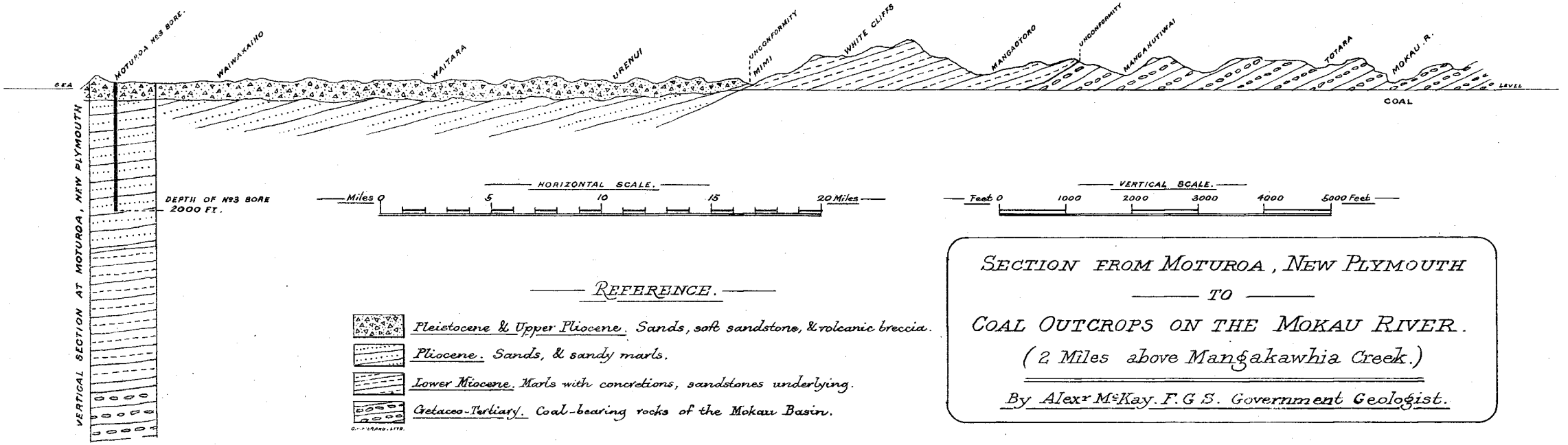
To illustrate Report by Alexr McKay. F.G.S. Govt Geologist.

— REFERENCE. —

● ● Nos 1 to 6 Bore Holes for Petroleum. + + Natural-gas springs.

·—·—· Line along which Petroleum is found or supposed present between the Breakwater and Natural-gas springs on Huatoki Creek. S-S.E. 6-6¾ miles from Breakwater.

C.H.P. Lith.



REFERENCE.

- Pleistocene & Upper Pliocene. Sands, soft sandstone, & volcanic breccia.
- Pliocene. Sands, & sandy marls.
- Lower Miocene. Marls with concretions, sandstones underlying.
- Cretaceo-Tertiary. Coal-bearing rocks of the Mokau Basin.

SECTION FROM MOTUROA, NEW PLYMOUTH
TO
COAL OUTCROPS ON THE MOKAU RIVER.
(2 Miles above Mangakawhia Creek.)

By Alexr McKay. F.G.S. Government Geologist.

tufa or clay ironstone, which intersect the tufaceous clay in the neighbourhood of the great dyke, yield oil when broken; but whether these indicate the outlet of fissures which are vents by which oil escapes from a deep-seated source, or whether they are merely masses of bituminous ironstone, has not been ascertained.

"At the time of my visit [October, 1866] borings were in progress at three places. . . . Close to the main Sugar Loaf and to the foot of the cliffs is the Taranaki Company's bore, No. 1, ... which has been sunk with much trouble to a depth of 300 ft. The derrick stands at 10 ft. above high water, and for some time the water-level in the bore maintained this level, but after a time it sank suddenly to 32 ft., which would appear to indicate the existence of subterranean channels communicating with chambers where there is less than the external atmospheric pressure, owing, perhaps, to the condensation of oil-vapours. At 254 ft. a patch of grey ferruginous tufa, like those seen at the surface, was passed through, charged with oil, which was the only result. In this bore some patches of hard basaltic rock were encountered, but, on the whole, there was no decided change in the character of the agglomerate.

"The Taranaki Company's bore, No. 2, is on the island off the north headland, and is commenced on a shelf 20 ft. above the water-level. This island consists of ferruginous sands 50 ft., false-bedded like the sand-dunes at New Plymouth, and resting on 40 ft. of red tufaceous sand, which, again, rests on the agglomerate. In the section which is shown in the lower part of the cliffs of this island, the agglomerate is seen to be very distinctly interstratified with beds of indurated tufa and waterworn fragments of rock. The bore was, in October [1866], sunk to a depth of 145 ft., being 10 ft. in the sandstone, 95 ft. in the agglomerate breccia, 30 ft. in consolidated tufa, and a few feet more into the agglomerate again. A few oil-patches have been passed through, but no appreciable quantity has been obtained.

"The third bore is that of the Alpha Company, which is situated a short distance from the north headland. It is from this locality that most of the oil which has been chemically examined has been obtained. At 10ft. above high water, and close to the boulder-covered shore, into a high sandy cliff a shaft was sunk 60 ft. in the agglomerate, from the sides of which, at 44 ft. from the surface, oil was found to ooze. This shaft was continued by a bore-hole to a depth of 180ft., oil being got at 80 ft. and again at the extreme depth. When allowed to stand at rest, a considerable quantity of oil collected both on the surface of the water in the well, and also in the bore-tube, accompanied by the escape of gas. This oil was pumped into a tub along with the water, from the surface of which it was afterwards skimmed off. Recently, the well has been pumped more regularly, and yields, I am informed by the directors, about 50 gallons a week.

"The escape of gas in large quantities from under the sea at various spots among the islands would seem to indicate that the oil described as occurring in the ironstone seams is only a secondary deposit; and as we know, from what has been observed respecting the occurrence of bituminous products on the East Coast, that the inflammable gas and oil escape from the surface in localities where the most superficial bed is the marlstone [or lowest in the section as read in the Taranaki District] we must conclude that its source is from some more deep-seated stratum than any that have been [here] described, and that its reaching the surface at Sugar Loaf Point through the superincumbent formations must be dependent in some way upon the dislocations in the neighbourhood of the great igneous dyke.

"As there is every appearance of the formations *a*, *b*, and *c*, being more recent than the eruption of the dyke, and therefore not dislocated by it, it is just possible that the oil and gas may have escaped upwards as far as the base of these formations, when in that case it would be collected in reservoirs at a depth, I should surmise, of from 500 ft. to 700 ft. below the surface, although by following fissures such as those marked by the ironstone veins, it may rise in small quantities to a much higher level and even to the surface.

"What I would wish to impress with regard to these oil-wells, as I did in my former report on the subject, is, that there is no indication in the Taranaki District of the occurrence near the surface of the regular alternations of sandstones and shales which characterise the best oil-bearing formations. Under the marlstone formation, judging from analogy with other parts of the colony, there probably occurs a thick group of ferruginous clay and sandstone, which again rests on the same coal formation as on the West Coast of Nelson. Great interest will therefore attach to the investigation of the geology of the Mokau District, and of the country lying between the range of hills terminating on the coast at the White Cliffs, as in that area the underlying formations may be expected to occur, and I think it very probable that among them extensive carbonaceous strata will be discovered."*

Mr. Park, in his report on the Taranaki District, concisely describes the rocks from New Plymouth to Waitara, and thence to the White Cliffs, mentions little that was not previously noted by Sir James Hector, nor is there mention made of the occurrence of petroleum near New Plymouth in this or in a report of the following year, by the same author. See "Geological Reports," 1886–87, pages 24–73, and pages 167–182.

The later-made bore-holes put down by the New Plymouth Petroleum Company show clearly that at nearly 2,000 ft. from the surface the Miocene rocks of the White Cliffs were not passed through, and judging from a study of the borings preserved by the company I conclude that only the higher part of that formation has been passed through.

Comparing the material from the two bores at Moturoa, I conclude that the tertiary sedimentary strata of this part are in nearly a horizontal position, the evidence relied on being that similar rocks were obtained from equal depths below sea-level. The tertiary sands and marls over a wide district to the north and east of Mount Egmont lie at low angles, and dip generally to the south or south-west, and it is clear that between New Plymouth and the mountain the deeper-seated strata have been but little disturbed. Sir James Hector estimates the thickness of these

* Progress Reports, Geological Reports, 1866–7, pages 2–7.

tertiary marls and sandstones at 900 ft., but as the present company sunk its No. 3 bore to 1,975 ft., and for between 1,600 ft. and 1,700 ft. through papa, the total thickness of this formation probably exceeds considerably the total depth of the bore-hole. There is therefore little or no hope of a depth being reached sufficient to enter upon the coal-bearing formations of the Mokau Valley should these chance to be present under the tertiary deposits of the district.

The tertiary rocks met with in the deeper parts of the bore-holes, as they consist of arenaceous sands and sandy marls, and are not highly fossiliferous, are regarded as unlikely to be the actual source of the oil found any more than the volcanic breccias that overlie, and hence the assumption that the Mokau coal-formation underlies these, and that the carbonaceous beds of this, acted upon by volcanic heat and kindred causes, have in the first instance yielded the gas and oil that, rising into superincumbent strata, have had storage in the looser sandy beds of the Miocene formation, or risen into yet higher beds, or escaped at the surface. Nothing can be said against the reasonableness of this assumption, but it is without proof, and is likely to so remain: and the simple fact remains that gas and oil appear at the surface, and have been traced downwards through superficial deposits and volcanic breccia some 300 ft., and after that found at 900 ft. and nearly 2,000 ft. from the surface.

The lignite formations of the superficial Pleistocene formation, described by Sir James Hector, and certain marsh deposits seen in connection with the volcanic breccias, might be held accountable for some of the oil at and near the surface, and some years ago I thought the oil at shallow depth near the Breakwater might be accounted for in this way.

At the northern base of the Sugar Loaf south of the Breakwater a section is exposed, which shows clays full of plant-impressions covered by volcanic agglomerate. Every trace of plant-substance has been removed from these clays. They dip northward towards the Breakwater, in which direction the volcanic breccia, or agglomerate, is overlain by loose, or more or less compacted, sands. These sands and the volcanic breccias underlying the latter, or both, interstratified with peaty deposits, changed to lignite, altered or wholly removed, might reasonably be regarded as the primary source of the oil found in the same strata, or as oil or gas escaping to the surface.

Knowing the nature of the older Pliocene and Miocene strata that underlies, and the very considerable thickness of these formations, the likelihood did not seem great that the oil and gas at the surface were derived from an inferior underlying formation; the more so as all the oil and gas might be accounted for as proceeding from the the upper lignite-bearing formations.

The operations of the New Plymouth Petroleum Company have shown that there is a deeper-seated source of oil than the volcanic breccias and Pleistocene formations overlying the Miocene sands and marly clays, and it may be well, therefore, to try to determine the probable source of this oil. The sections that may be studied—first, from Stratford to the Tangarakau River; second, along the coast from New Plymouth to the Waitara River; and third, of the coal-bearing strata in the Mokau Valley, show that, unless the higher part of the coal-formation has been denuded away, some 5,000 ft. of beds overlie the coal in the vicinity of New Plymouth. In the District of Taranaki and the west coast of Wellington, south of a line east from the mouth of the Waitara River, there is no evidence of the presence of Cretaceo-tertiary coal-measures underlying the tertiary sands and marls of that region, the lignites of the Pohangina and the western slopes of the Ruahine Range, according to Park, of newer Pliocene date, north of which to the southern end of the Kaimanawa Range only tertiary rocks are met with along the junction between the Palæozoic rocks and the younger formations to the west and south. Over great part of the district south and west of the boundaries indicated it is probable the coal-formation was once present, but presumably they have been removed prior to the deposition of any tertiary strata.

In 1878 Sir James Hector made a further examination of the coast-line north of New Plymouth, and continued his explorations into and along the valley of the Mokau, and the following extract from the report descriptive of this work, as it supplements that of 1866, may be here given: "A few miles north of the Waitara the volcanic rocks of the Mount Egmont system, and superficial rocks derived therefrom, disappear, and from beneath them a great formation of clay marls of Lower Miocene age (Pareora series) rise to the surface and form a very broken range of hills that terminate on the sea-coast in the White Cliffs. The change to the next formation is marked by a band of shell breccia, beneath which the strata are formed of soft argillaceous sandstones, which form the northern portion of the White Cliffs. . . . In ascending the Mokau River . . . the base of this formation is found in the nummulitic limestone (Middle Eocene) which again rests unconformably upon the grey marls and the chalk marls which belong to the Cretaceo-tertiary formation. These in turn rest on greensands, passing downwards into the brown concretionary sandstones of the coal formation."*

From this I gather that there are two unconformities in the section described, and that the Miocene-tertiary deposit is of great thickness, beneath which the upper part of the coal-bearing formation is of great thickness. The carbonaceous part of the Cretaceo-tertiary formation must lie at great depth below the town of New Plymouth—that is, if it has not been removed by denudation—and to reach this by boring would be utterly impossible. The true source of the oil, therefore, if not the Miocene beds, can never be known, and it is useless to speculate thereon.

The plan herewith shows the position of the different bore-holes that subsequent to 1866 have been put down by the present or former company since 1888. The natural-gas springs between Moturoa and Inglewood are also shown, the map in so far being a copy of a plan accompanying a report on the various bores put down by the New Plymouth Petroleum Company, by Mr. Strauchon, Commissioner of Crown Lands and Chief Surveyor, Taranaki. The sections are compiled from the descriptions given by myself or others in this or former reports.

10th April, 1899. ALEX. MCKAY.

* "Geological Reports," 1878–79, p. 21.

REPORT ON THE AURIFEROUS DEPOSITS OF THE HINEMAIA VALLEY, TAUPO DISTRICT, AUCKLAND.

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

For the past twenty-five years there have been reports of the finding of gold in the Taupo district, and despite the fact that throughout this long period up till the present time nothing more tangible than a few colours has been found, residents and prospectors finding their way into this part hold firmly to the conviction that for gold-mining the district will yet become important.

Tokaanu, at the south-west corner of Lake Taupo, is so placed as to be a convenient centre from which prospecting may be carried on west and north-west round the sources of the northern tributaries of the Wanganui River, or in the valleys of the lesser streams falling into the lake; or south-east among the older rocks of the Kaimanawa Mountains; or east of the lake along the valleys of the several rivers falling into Lake Taupo; or on the northern shore of the lake towards Western Bay. In all these directions prospecting for gold has been prosecuted, in some cases with persistent diligence, and always without sufficient results. West of Lake Taupo and in the neighbourhood of Tuhua Mountain, prospecting has been carried on for a considerable number of years. Slate country occurs in this part of the district, but to a very limited extent. Gold, however, is obtained, but at such considerable distances that it cannot well be considered as having its source in reefs occurring in the slate.

In some of the streams falling into Lake Taupo from the west, the colour of gold is found, the wash being of a volcanic character. Beyond the water-parting and on the fall leading into the Wanganui, the gold is reported as occurring in a conglomerate that rests immediately on fossiliferous clay marls, generally spoken of as "papa." The nature of this conglomerate I was not able to determine, but I take it to be the trachyte breccia and tuff of Hector and Hochstetter, which thus appear to yield traces of gold.

From Tokaanu, during the past season, it was intended to penetrate into this country, but at the time when this could be done the weather was so bad as to render such an expedition at the time impracticable and certainly unadvisable; beside which suspicion and jealousy would, in any case, have prevented anything like prospecting for gold on Native lands.

In the Kaimanawa Range there are numerous reefs in sandstones and dark slates that are probably of Devonian age. These have often been prospected, and in numerous instances a little gold has been obtained or reported as having been obtained. I saw a collection of such rocks at Tokaanu, but this did not impress me strongly as to the auriferous character of the country from whence they came. Many of the so-called quartz leaders proved to be thin veins of calcite in a greenish slaty rock. Heavy bodies of quartz are reported to exist, and one very large reef of quartz is spoken of. It appears, however, that interest in the prospecting of these reefs has died out, and during last January I could only learn about what had been: there seemed to be no proposal or preparation being made to further prospect these mountains. It must be admitted that prospecting in these rocks in the Tararua, Ruahine, and Kaimanawa Mountains has been disappointing; and, while it is yet quite possible that a payable or even a rich reef may be struck, it is also true that such are usually found early in the search.

Quartz-reefs also occur in an isolated volcanic hill close to the northern shores of Lake Taupo. In this, tunnelling has been carried on intermittently for some years, but was suspended for a time; its continuance was resumed during the past two years. Thermal quartz charged with iron pyrites was found, but as yet not in a regular lode; and so far, it would seem, no attempt has been made to ascertain the auriferous character of this quartz.

During the past two years the chief interest has centred in the district to the east of Lake Taupo. The various rivers on this side of the lake take their rise in the sedimentary formations of the Kaimanawa Mountains, or from the igneous rocks that form the mountain-ranges where lie the north-east sources of the Hinemaia River and other streams to the north-east, as far as the Napier–Taupo Road.

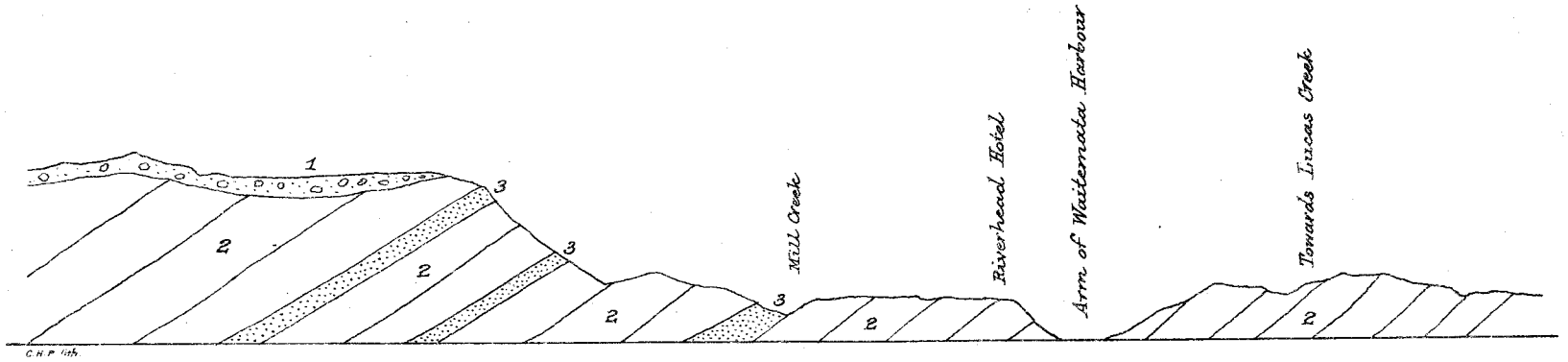
Whether borne by one or other of these rivers or derived from the heavy breccias that lie upon the pumice deposits cannot be determined, but on the shore of Lake Taupo was found a boulder of quartz which, tested in Auckland, gave a rich, almost a fabulous, return of gold. The Natives searched this beach above high-water and below for other boulders of quartz, hoping that these also would be rich in gold. It does not appear that any others rich in gold were found, and the mystery of the whence of this rich boulder of quartz has exercised the minds of Natives and Europeans alike.

About three years ago Mr. Archie Campbell commenced prospecting along the terraces bounding the lake on this side, and, as would appear, got indications of gold that led him to suspect the source of the gold lay further to the east in the direction of the Upper Hinemaia River. Having obtained permission of the Native owners to prospect on their lands he at length reported having found gold at several places, and especially on the first southern branch of the Hinemaia. Having so far succeeded, the Natives retracted their permission to prospect, while at the same time Campbell believed that he had hit upon a deposit that would pay to work for gold. The Natives, through some of their chiefs, applied to the Government for an examination of the district by an expert; and being at the time about to proceed upon a trip through the interior part of the North Island I was directed to make the examinations required. Accordingly, as instructed on the 11th January, 1899, I had an interview with Mr. A. Campbell, prospector, with reference to the work done by him within the watershed of the Hinemaia, and I had also an interview at Taupo with the three Natives who forwarded to the Government the request that an expert be sent to examine the district within which Mr. Campbell reported the presence of gold. I found the Natives who had met to discuss the question distrustful of Mr. Campbell, and mutually jealous of each other—anxious to exclude

Campbell from participating in the results of anything that had been or might be found, envious of those on whose land the gold was supposed to exist, and generally apprehensive that in some way wrong and injustice would be done to them. A meeting was held, at which it was decided to leave the matter in the hands of Te Heu Heu, the principal chief in the district, who the day following refused his consent, and in consequence I proceeded by the first opportunity to Rotorua, and thence on the 21st January to Te Puke.

At Te Puke I remained for a week, at the end of which time I received further instructions with respect to the examinations to be made in the country to the eastward of Lake Taupo, and returning accordingly I reached Taupo Township on Saturday, the 28th January, and, armed with a proper authority, with Mr. Campbell set out for the Upper Hinemaia the following day. For the night we stopped at Tauranga Taupo, and by noon of the following day reached Wairoa, a small Native settlement on the southern branch of the Hinemaia River. Near here the principal prospecting-works carried on by Mr. Campbell were situated, and these were reached about midday. In the afternoon several prospects made with the dish were panned off, but nothing like a payable prospect of gold was found; and next day was spent in prospecting this locality, with a like result. Many Natives assembled to ascertain the results of the examinations being made, and several of these washed numerous prospects, with no better results than were obtained by Mr. Campbell and his mate. I also panned off several dishes of washdirt, but was not more fortunate than the others had been, and eventually I was forced to the conclusion that at this place, at least, there was not sufficient gold in the wash to make it payable to work. Wednesday was spent in endeavouring to trace the auriferous wash into or under the terrace on the right bank of the stream, and in an endeavour to prove an extension of the wash in this direction, but the results were not as satisfactory as could be wished. On Thursday, with Mr. Campbell and his mate, I went to see the other localities within the Hinemaia watershed whereat he asserted gold had been obtained by him. To do so we followed down the branch stream on which we were camped to its junction with the main river, and by the way prospected the gravelly banks of this tributary where the bottom could be reached, and at higher levels the terraces where these, showing the presence of coarser gravels, had been cut into by the lesser streams crossing them to join the larger creek. Gold was obtained from wash at the higher levels indicated, but as a colour only, and, though bottom (a rhyolite rock) was reached at two places along the main stream, no gold was found. Reaching the Hinemaia River at a point a little above the junction of the first southern branch, which had been followed from Wairoa downwards, here the left bank of the river showed the presence of a dark wash, mainly formed of volcanic material, but containing also a percentage of sandstone derived from the ranges to the east and south-east, the principal source of the Hinemaia being in that direction, among the higher peaks of the Kaimanawa Range. Doubtfully was the presence of gold determined at this place, and the wash could not be bottomed owing to its being in part below the level of the river at the place where gold was said to have been found. The rock-bottom shows a few chains up the river, and is overlain by a gravelly wash, which also was prospected, but without the result desired; also, two other places in the same vicinity. I was next taken about a mile down the main stream to where a gorge, by the action of the river, has been formed in the solid rhyolite rock. Here various pot-holes and fissures were cleaned out, as it was here Mr. Campbell relied on for the finding of coarse gold, which I was informed had been obtained on a previous occasion. No trace of gold, after a prolonged search, could be found, and after prospecting the river-bank at two other places, further endeavouring was abandoned, and we returned to the camp at Wairoa. I was then informed that I had seen the different localities relied on as being gold-bearing, but, over and above this, gold had been obtained on some of the bars of the Upper Hinemaia River, which possibly might lead to further discoveries. I was not asked to see these, possibly from the fact that I had very plainly hinted that what I had already seen in no way supported the assumption that payable alluvial gold would be found further up the valley. Mr. Campbell expected that I would stay to see the results of further stripping and trenching at the locality, near Wairoa, first described. I did so till it was plain that the wash along the bank of the river abutted against the pumice-sands overlying the rhyolite rock, and forming the terraces on both banks of the stream. This done, I left on the Friday afternoon, reaching Tauranga Taupo the same night, and Taupo Township the following day, the trip having thus occupied seven days.

As regards the source of the gold, all that can be said is that in the first southern branch of the Hinemaia, near Wairoa, the precious metal is associated with volcanic rocks only, there being neither sandstones nor slates represented in the wash. A few stray pieces of quartz are occasionally present, but these may have been derived from either a sedimentary or a volcanic formation, and there is thus nothing to show that the gold has had its source in the Kaimanawa Range, and been drifted west and north to the position in which it is now found. On the other hand, dark fluidal rhyolite is not, according to all experience, a favourable rock for the occurrence of gold. This rock, however, forms the bulk of the wash in which the gold is obtained, and in some way an explanation of this association has to be found. This rock exists to the east of Lake Taupo under most peculiar conditions, and, except in some doubtful cases near Taupo Township, it never occurs *in situ* as far to the eastward as my explorations have extended. For some twelve to fifteen miles to the east of Lake Taupo the crystalline rhyolites showing at several places along the shores of the lake and in the Upper Hinemaia are overlain by some 500 ft. of fine pumiceous sediment. This may have accumulated in a former extension of the lake, or it may be of marine origin, but this need not be discussed here and at this time. Towards its upper part these beds of finer grain are interstratified with well-rolled gravels of dark volcanic rock 2 ft., 4 ft., or 6 ft. in thickness; and, finally, overlying the uppermost of the fine pumiceous sediments is a heavy bed, variable in thickness from 10 ft. to 20 ft. or more, which is composed of angular pieces of fluidal rhyolite, pitchstone, and rocks approaching the character of obsidian. This breccia is composed of pieces of all sizes from a few inches to 10 ft. or 12 ft. in diameter. It occupies all the higher lands between



— Sketch Section showing position of beds being prospected for gem-stones —

— near Riverhead. Auckland —

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

— REFERENCE —

1. Superficial deposit with large boulders of Andesite.
2. Rhyolitic sands, often micaceous.
3. Pebble-beds, or Conglomerate-bands — being prospected.

NB. The lowest band is the coarsest, and yields the largest so-called gems.
The beds strike E.W. and dip South.

the different river-valleys from Taupo Township to the Tauranga River, and especially on each side of the Hinemaia River to the first branch going to the south-east. Above the forks of the Hinemaia these gravels and great part of the underlying pumiceous sands have been removed, pulled down, and reassorted by the action of the streams in cutting down their valleys, and owing to the proximity of such streams (the Hinemaia and its tributaries) the whole country has been worked over, and nothing more remains of the high-level breccias in this part of the district. The product of reassortment, however, is found in the shape of rhyolitic gravel along the beds and banks of the different streams, and forming the upper surface of the different terraces formed by the principal river or lesser streams. Grinding, removal, and concentration of the denser material has thus been carried on, and, as a result, here and there a fine colour of gold is sometimes to be found in the concentrates over the lower grounds and terraces. To this breccia of volcanic rocks and the concentrates of the same I refer the gold found in the Hinemaia, rather than to the rocks of the Kaimanawa Range, which, though reaching into this watershed, are yet but feebly represented in the gravels of the streams discharging by the Hinemaia into Lake Taupo. The whence of this great body of rhyolitic breccia has not been ascertained. It is distant from where it is now found north or south of the lower Hinemaia River, and probably lies in the wooded mountainous country to the eastward, in the direction of the north-east sources of the river. The grey quartz trachyte, as distinguished from this dark fluidal rhyolite and pitchstone, forms the fundamental rock of the district examined, and seems to be largely developed in the upper valley of the Hinemaia, before the river begins to trend to the south, into the higher part of the Kaimanawa Range. If this be the source of these breccias—and there seems to be none other—from this direction also the gold must have come; but only further prospecting and careful intelligent search will make this clear.

28th July, 1899. ALEX. MCKAY.

REPORT ON THE SUPPOSED GEM-BEARING FORMATION NEAR RIVERHEAD, AUCKLAND.

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

SIR,— 28th March, 1899.

Between the 25th and 28th of February last I visited Riverhead, one of the upper reaches of Waitemata Harbour, for the purpose of examining the beds from which it has been reported gem-stones of various species have been obtained. Originally Henderson was prospected for precious stones, and it was claimed that diamonds had been discovered in that locality. Samples of the stones obtained were submitted to Mr. Pond, analytical chemist, Auckland; but that gentleman informs me that he was unable to determine the presence of diamonds or gem-stones of any value in the material submitted to him, and that the stones submitted to him were altogether too small to be of value.

Subsequent to my going to Riverhead I met, in Auckland, the prospectors who are engaged in the search at Riverhead. They informed me that they had commenced at Henderson, but soon satisfied themselves that what they sought was not likely to be found in that locality; but, tracing indications, they were gradually led eastward, towards Riverhead, where for some time they have been located, and where they believe they have good prospects of finding what they seek for. The prospectors at Riverhead have applied for, and been granted, a prospecting license for minerals (other than gold and silver) and precious stones, and have done a fair amount of work in the shape of sinking and driving at various points on the south-east face of the plateau that lies to the north-west of Riverhead. These varied works I examined, and though none of them were of an extensive character, they were sufficient to show the nature of the material being excavated and to indicate the formation being prospected. I also had some of the concentrates supposed to contain stones of a valuable kind submitted to me for inspection. The stones were all very small, all of them under a tenth of an inch in diameter, and most of them I could determine as quartz, in part the detritus of quartz trachytes, or a rhyolite formation, of which there were evidences to be obtained in the beds of coarser grain, and breccia conglomerates interstratified with the sands of finer grain constituting the great bulk of the formation. I pointed out the improbability of getting stones of any considerable size in the beds of finer grain, and indicated some conglomerates in the vicinity as more likely to yield what was sought for. This advice was followed, and in one of the conglomerate-bands referred to transparent stones of larger size were found. A parcel of these has been forwarded to the department, and the Government Analyst's report is to the effect that all the stones tested proved to be quartz.

The formation thus prospected is the same as seen on the shores of the Waitemata Harbour from Auckland to Riverhead; at Devonport, and thence along the west shores of the Hauraki Gulf to the mouth of the Okura River, beyond which it recedes inland, the boundary-line between this and the cretaceous rocks of the Wade, passing across Dairy Flat in a north-west direction. West and south from Dairy Flat they form the country on the north side of the upper part of Manukau Harbour, and across Lucas Creek past Riverhead to the western base and slopes of the Hunua Range. The beds, as developed near Auckland, have been often described, and a great diversity of opinion as to their geological age has been expressed.

I have dealt with the question of the age and relations of these beds in the reports of the Geological Survey for the year 1883–84, page 101, and I clearly point to unconformity between the beds over and underlying the Parnell grit. The higher beds are those that concern us at the present time. In the report above referred to, the age of the trachyte sands is stated to be Miocene. They are certainly not older than the Younger Miocene, and might be considered as of Pliocene date. The fossil evidence is nowhere of a decisive character, and it is abundantly clear that the first outburst of acidic volcanic rocks of late Tertiary date had begun before the lowest of the sedi-

mentary rocks from Auckland to Riverhead were laid down. That they are unconformable to the coal-bearing series and the limestones of Wade and Mahurangi is proved by the presence in the upper beds of material derived from those lower. The exact age of these overlying trachyte or rhyolite sands may, however, be matter for doubt, as there has evidently been two periods in late Tertiary times at which such rocks appeared, but it is to the elder of these that the Riverhead rocks must be referred. There are no vents or volcanic cones in the immediate neighbourhood, and the nearest that are, in the direction of Auckland, show only rocks of a basic character. Though largely formed of volcanic material, the beds themselves are purely sedimentary, and their source must have been at a considerable distance from where they now lie, but whether the material was brought to its present position by way of the lower Waikato, or forms part of the deposits filling the Thames Valley and at one time was continuous along the inner part of the Hauraki Gulf to Auckland, and, as a consequence, to Riverhead, matters little, since the source in either case was probably the same.

ALEX. McKAY.

The Under-Secretary, Mines Department.

REPORT ON LITHOGRAPHIC LIMESTONE, MANGONUI COUNTY, AUCKLAND.

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

THE mineral resources of the Northern District of Auckland were well represented at the Auckland Industrial and Mining Exhibition, held at Auckland, 1898–99; but there was manifest oversight in that there was no exhibit of samples of the cretaceous limestone so strongly developed within Mangonui County, north of the Mangataniwha Range. This was pointed out to a number of settlers and business men interested in the district, who usually remarked that they were unaware of the existence of such stone in their district. Among these Mr. J. H. Mackie particularly interested himself as representing an association that specially aims at the development of the resources of this part of Auckland. For further information on the geology of the district, he was referred to the Mines Department, and, accordingly so applied; but it was found that the general reports did not afford in a consecutive manner the information needed or even what was available. To supply the need thus arising the following account has been compiled, in the hope that it may lead to a thorough prospecting of the district to ascertain the value of the limestone at different places, more especially within Mangonui County.

Limestones of a cretaceous or non-crystalline character are abundant along the west coast of Auckland, from Kawhia, in the south, to Ahipara, Mangonui County, in the north, and reach to the east coast of peninsular Auckland at Wade, Mahurangi, Whangarei, and Kawakawa. South of Whangarei and the Upper Wairoa watershed these rocks usually assume the character of broken, much-jointed, indurated, fine-grained limestones of a light colour, or, as at Mahurangi, of a friable marly limestone, which is there worked as hydraulic limestone by Wilson and Co., of Mahurangi and Auckland. In Limestone Island, Whangarei Harbour, and along the shores of different arms of the Kaipara Harbour, it is often of a more flaggy character, and might in places be found suitable for lithographic purposes; but the proportion of spoil and rejected rock in all known localities south of Hokianga would probably be so great that it is hardly likely a quarry would be found which could pay to work. Even on the south side of the Hokianga River the limestones of this age and character are thin-bedded, highly tilted, broken, and contorted, and are hydraulic rather than lithographic limestones.

It is only within the limits of Mangonui County, stretching along the northern slope of the Mangataniwha Range, and thence spreading over the lower grounds to the north on both sides of the Kaitaia Valley, that the limestone occurs under conditions such as enables it to be worked and used as a lithographic limestone. Here it is thick-bedded and free from joints so far as to enable the raising of it in blocks of any size likely to be used in lithography. In the hilly country, on the south side of the Middle Kaitaia Valley, there appears to be an abundance of such rock.

During my survey of that district, carried on in 1892, I found this limestone being quarried for road-metal, and on examining the quarry I pointed out to the men engaged the true nature of the rock, and took a small slab of the same for the purpose of having its quality tested on my return to Wellington. This I faced and polished and set in a bed of cement, and Mr. Pierard, draughtsman to the department, placed thereon some shaded drawings, which, on being printed off, proved the stone free from blemishes and defects, and in every way suitable for ordinary lithographic work. The member for the district was then applied to, and in due course a larger block was sent to the Survey Department. This was so unskilfully taken from the quarry, being blasted out with some explosive, that so quarried it showed rents in various directions which did not orginally exist in the rock, and therefore made it unsuitable for the purposes of a lithographic stone. However, it was faced, but no attempt was made to square or size it as regards thickness. A map was traced upon it, and some copies struck off. It was reported as being unsuitable for the purpose for which it was sent, owing to the numerous rents in the stone, the larger of which showed on the prints. How these originated I have explained. Since then no interest has been shown in the matter of lithographic stone within the limits of Mangonui County until the present application for information by Mr. J. H. Mackie.

The road-quarry whence the samples experimented upon were obtained lies about thirteen to sixteen miles from Mangonui Township and Port; and in the hills on the south side of the valley stone of good quality might be got at a lesser distance from the shipping-place.

Various qualities of stone, from hard to soft, are likely to be found in the hilly country on both sides of the Kaitaia Valley, but for some reason or another great indifference has been displayed respecting the further prospecting for or development of this stone at known localities. The limestone is perfectly non-crystalline and free from iron impurities or minute shells, which

have detracted from the value of such stone in other parts of the country. The stone in the quarry referred to is rather soft than hard, but as induration and excessive hardness are what is most common and most to be feared, if we have regard to other localities where this rock is found, this softness is, on the whole, a favourable circumstance. What remains to be done is to prospect the district for different varieties of the stone, have slabs raised in a proper and workmanlike fashion, and fairly tested as to quality and the purposes for which the different varieties are most suitable.

Rocks of the nature of lithographic stone are abundant throughout both Islands of New Zealand, usually closing the sequence to which the coal rocks belong. Younger Tertiary limestones in places have been altered in the near presence of volcanic rock to a kind of lithographic stone, as, for instance, at Oamaru; in some parts of the Amuri district of Nelson; and in the Chatham Islands. But all such deposits are local, irregular, and unimportant.

Lithographic stone occurs at Abbey Rocks, South Westland, and for a time was quarried for the purpose of its being placed upon the market. The undertaking was abandoned owing in part to the difficulty of shipment, but much more on account of defects in the stone itself, which was not wholly of an earthy character, but often contained minute foraminiferal shells, thin veins of calcite filling joints, and minute crystals of iron pyrites disseminated through the stone.

Earthy limestones are found along the east coast of the South Island from Stonyhurst to Cape Campbell, and at places they are flaggy and could be raised of such size as would make them suitable and fit for lithographic purposes; but usually they labour under the defects that have been referred to as disqualifying the Abbey Rocks lithographic stone. The same class of limestone is largely developed along the east coast of the North Island from Cape Palliser to Castlepoint, and at places might be found suitable for lithographic purposes. In the north-east district of Auckland limestone of the same age occurs abundantly, but is usually broken and uneven in its bedding. In the valley of the Motu River, falling into the Bay of Plenty, there is a great development of limestone of this class; and, judging from what appears in the river-bed where crossed near the sea, there is a likelihood of its being massive and even in grain in the mountains on each side of the lower gorge of the river.

The considerable market for, and the prices paid for lithographic stone, should stimulate prospecting for stone of high quality, or stone that would have a commercial value, and the different localities above mentioned have been cited in the hope that those having opportunity will collect and have tested samples of the rock occurring in their neighbourhood.

July 26, 1899. ALEX. MCKAY.

NOTES ON THE AURIFEROUS IRON-SANDS OF NEW ZEALAND.*

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

AURIFEROUS iron-sands (chiefly magnetic oxide) are, for the most part, confined to the west, south, and south-east coasts of the Middle Island of New Zealand, commonly known and hereafter to be spoken of as the South Island.

The titanic iron-sands of the west coast of the North Island, though mixed with magnetite, are not usually gold-bearing, and south of Auckland have not been ascertained to contain gold in sufficient quantity to pay for working such deposits. For the most part, these sands have been derived from volcanic rocks of young Tertiary date, associated with which, except on the western flanks of Mount Egmont, there are no lodes carrying gold.

On the east coast of Cape Colville Peninsula, at Mercury Bay, there are deposits of black sand that contain gold, and which it has been proposed to work for the precious metal. Possibly, also, there are other similar deposits on the west shore of the Bay of Plenty, where such sands have been derived from auriferous rocks. The magnetic and titanic iron-sands of the North Island are, however, not usually regarded as a repository of gold in paying quantities.

On the west coast of the South Island, from near Cape Farewell to Preservation Inlet, the sea-beaches, formed of material of moderate fineness of grain for the most part, show the presence of magnetic iron-sands, and often such sands form a considerable part of the total material of the beach between high- and low-water mark. Such sands are at almost all places auriferous, and for the past thirty years have been worked for gold. At first these deposits were extremely rich, and were worked again and again, as often as the material was acted upon by a heavy surf during storms, or rearranged more slowly by the ordinary action of the tides. Often the auriferous sands would be covered by a variable depth of grey quartz-sand, which, if not too deep, would be removed to reach the auriferous layer; but as frequently they would appear at the surface, varying from a few inches or a mere skimming to a foot or more in thickness. Such deposits, when formed, were treated as rapidly as possibly, or, at all events, removed beyond the action of the tide, as they are apt to be suddenly swept away by a change in the direction of the wind or by a varying force or direction of the tide and sea-currents. Gradually, in the course of years, these beach deposits became less auriferous; but they still yield, on all the more important beaches, a profitable return to miners expert at this form of mining.

Beach workings of this description are carried on from thirty miles north of the mouth of the Buller River to the southern extremity of the Island, and east along the northern shore of Foveaux Strait and the south coast of Otago to the mouth of the Molyneux River, and along the east coast in a northerly direction to the boundary of the Otago Provincial District.

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* These notes on the auriferous iron-sands of New Zealand were written in reply to a request for information by Messrs. Angus Macdonald and Co., of Victoria, British Columbia. Mr. Macdonald states that he is the inventor of a process of extracting gold from black sand and other earthy bodies, whether the gold lies free or coated with iron, and he wished to obtain data about the gold-bearing sands of New Zealand, having been informed by Mr. Partridge, of London, that on the West Coast they are in abundant quantities.

Usually, where magnetic iron-sands are found on the beach, deposits of the same kind, now no longer acted upon by the tide, are present on the higher grounds inland, or lie buried under grey sands between tide-mark and the foot of the first terrace. These beach leads have been a great source of gold at many parts on the west coast of the South Island. At many places, near the mouths of rivers and large creeks, the ground is wet, and by dredging or other means it is that considerable areas have yet to be worked. The first horizon above or inland of tide-mark has deposits of iron-sand in all favourable situations along the west and south coasts of the Island, and these are notably developed near the mouths of the larger rivers. Usually they have proved very rich in gold, and but for difficulties such as have been alluded to most of them had already been worked out. At many places they are covered by flood-deposits from rivers or by æolian sands drifted back from the beach, and thus it is that discoveries are likely yet to be made.

At higher levels successive terraces of auriferous iron-sands are met with, principally between the mouths of the Buller and Hokitika Rivers, and some of the larger rivers of South Westland. These have been more particularly described in the "Geological Reports" for 1892–93 and 1895–96, and the descriptions of the blocks reserved for mining purposes, for which see joint report by Messrs. Gordon and McKay. Here it will suffice to mention Addison's Flat, Charleston, and Brighton; Darkie's Terrace and Rutherglen, near Greymouth; Ballarat Hill, in the Waimea Valley; and the Houhou Lead, near Hokitika.

On Addison's Flat and at Charleston the iron-sand deposits are developed on a most extensive scale, and have yielded, and still yield, great quantities of gold. At both places further oxidation of the magnetite has taken place, and rusty-coloured iron-sand cements are the results. This fact has entailed an enormous loss of gold to the claim-holders working the cement, as the gold coated with iron-oxide escapes being caught by the means employed for that purpose, and, finding its way into the tailing-channels and streams, a part of such escaped gold is again recovered by various contrivances placed so as to intercept it, and a part carried to the seaboard tends to enrich the black-sand deposits within tide-mark. Between Charleston and Brighton these deposits rise to a height of 600 ft. above the sea; more to the south they gradually attain to lesser elevations, and south of Hokitika are but little above sea-level.

On the shores of Foveaux Strait, it is only at Orepuki and near the mouth of the Waiau River that these deposits reach any distance inland, or more than a very moderate height above the level of high-water mark. East of the Bluff, and from the vicinity of Dunedin to the northern boundary of the Otago Provincial District, the auriferous black-sand deposits are confined to the limits between high- and low-water mark, or to less than 25 ft. above that.

Along the East Coast, within the Canterbury Provincial District, it is only between Lake Ellesmere and the mouth of the Rakaia River that auriferous sands payable to work are found. These, however, do not contain notable quantities of magnetic iron-sand, but for the most part they are grey or garnetiferous sands. North of Christchurch, while at places it is evident that great elevation of the land has (in modern times) taken place, and old beaches can be traced up to at least 400 ft. above the sea, only traces of gold have been found, and black sand does not abound.

The great richness in gold of these sands enabled them to be worked with profit when the means employed were both costly and of a rude description. At many places the yield was phenomenal, and thus there has been impressed on the New Zealand miner the full importance of the deposits, and black-sand claims are still in favour. Many deposits are rich only in particular parts, or are poor generally, and any means that tends to lessen the cost of extraction of the gold would be a boon to the black-sand miner, and should be hailed accordingly.

28th July, 1899. ALEX. MCKAY.

REPORT ON THE PUMICE-STONE DEPOSITS OF THE MIDDLE PART OF THE NORTH ISLAND.

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

INTRODUCTORY.

THE North Island of New Zealand is distinguished for the variety and extent of its igneous rocks. These are in great part eruptive and for the most part belong to a late tertiary period. Intrusive rocks are found on a large scale in the extreme north of the Auckland district and there, as diorites, probably belong to a Palæozoic age. More to the south igneous rocks appear in connection with Palæozoic and Old Secondary rocks in the main chain of mountains commencing between East Cape and the Bay of Plenty and continued south-west to the shores of Cook Strait. Tuffs and solid igneous rocks also appear in connection with the Younger Cretaceous strata of the East Coast of Wellington.

Cape Colville Peninsula, to the east of the Hauraki Gulf, in the Auckland district, presents a vast assemblage and a considerable variety of volcanic rocks, the oldest of which probably made their appearance in Cretaceous times. The youngest, belonging to the Pliocene period, are mostly acidic and are often pumiceous. The volcanic rocks of this region are characterised by the great preponderance of tuffs and fragmental ejecta.

Volcanic rocks supposed of Miocene age cover a considerable area of peninsular Auckland, south of Whangarei, and extend, though not continuously, along the West Coast as far south as Kawhia Harbour, but all these in area and extent fall short of the vast development of volcanic rocks to be met with, covering and obscuring the older sedimentary rocks of the central part of the North Island. The volcanic rocks of the central part of the North Island are in age from Younger Pliocene to Recent: some vents, such as Ngauruhoe and White Island, being active at the present time, while the terrible spasmodic eruption of Tarawera, in June, 1886, showed that the volcanic forces are far from being exhausted, and that mountains apparently extinct may burst forth afresh at any time.

This region of volcanic activity extends from Ruapehu on the east side of the Wanganui watershed fifty miles from the shore of Cook Strait in Wanganui Bight, north to the shores of the Bay of Plenty and through this to White Island, a total distance north and south of 150 miles, and if the younger acidic rocks of Cape Colville Peninsula are to be considered as of this age the distance of these at Mercury Bay would be 170 miles. East and west fragmental ejecta, chiefly pumice, extend from the sources of the Waipa and Mokau Rivers over the southern part of the volcanic zone and the Kaimanawa Mountains to the eastern watershed and almost to the shores of Hawke's Bay. Pumiceous deposits abound in and cover the greater part of the Middle Waikato basin as far as the Taupiri Gorge and are spread over the extensive plains along which the Waihou (Thames), Waitoa, and Piako Rivers make their way to the Firth of Thames—the inner portion of the Hauraki Gulf. The pumice found within the Lower Waikato basin must be considered as drift pumice carried forward by the river.

The pumice-covered highlands between the sources of the Mokau and Wanganui to the south, and the rivers falling into the Waikato to the north, superficially appears as though it were ejecta showered widely over the land and so accumulated; but this is the case almost at all places where heavy deposits of pumice are found. Assuming for the present that the pumice of the higher plateaux unaffected by the present streams has been so accumulated, the greatest breadth over which are found volcanic rocks of young Pliocene age may be roughly estimated at about eighty miles, supposing the eastern limit to be within the Tarawera Valley four miles north-west of Tarawera Township.

Within the eastern half of the area covered by volcanic rocks, and running from Ruapehu north-north-east to the Bay of Plenty, is a belt of country designated by Hochstetter "the Taupo Zone," within which are situated the most prominent volcanic cones and the line of present thermal activity. The breadth of this is greatest towards the north, to the south it is comprehended in the base upon which Ruapehu itself stands. To the north the rocks are almost wholly of an acidic type; to the south, in Tongariro and Ruapehu, semi-basic rocks make their appearance, the rocks of which Ruapehu is built up being, according to Park, dolerite, trachy-dolerite, phonolites, porphyritic and vesicular trachytes, bosses of pitchstone, and masses of agglomerate.* No pumice seems to have originated from this southern part of the zone of activity.

Although there is considerable activity along the line, eruptions of lava seem to have ceased. The outbreak of Tarawera in 1886 was explosive and not accompanied by any fluid matter whatever. The crater of Ngauruhoe, though emitting vast volumes of steam and sulphurous gases, can hardly be said to be otherwise active. The same may be said of White Island at the opposite extremity of the line. Intermediate between these two points hot water, steam, and geyser displays are almost everywhere, and constitute the wonderland of the North Island of New Zealand.

The Abundance of Pumice.

During a journey through the central part of the North Island, if proceeding from the south by way of the Rangitikei Valley, pumice first begins to attract attention on arriving at the southern part of the Murimotu Plains east of the Wangaehu River. Here pumice-sands or coarser pumice much decayed first appear in the road-cuttings; at first the pumice forms but a thin layer resting on volcanic breccias or the slates and sandstones of the Kaimanawa Range. As the route of travel is followed north to Tokaanu the amount of pumice increases, but yet is not in such quantity as excites astonishment till Tokaanu is left, and the eastern margin of Lake Taupo is followed to the Township of Taupo at the northern end of the lake. At Tokaanu there is no pumice on the low swampy levels near the settlement or over the delta of the Tongariro River. Passing the Tongariro River the swamps and low flats bordering the lake are covered with blocks of pumice, and pumice fine or coarse as sand and gravel forms the lower hills bordering the lake, or caps the trachyte or rhyolite of which these may be mainly composed.

On reaching the Tauranga River, near its inlet to the lake, the pumice-formation begins to be of importance, and beyond this point to the north-east and east the pumiceous sands and gravels form high table-lands between the different streams falling into the lake. These table-lands terminate in steep cliffs overlooking the lake, or the low flats over which the lake once extended, and the sections that are thus exposed and seen in the like precipices that bound the narrow valleys of the different rivers finding their way from the eastward to the lake show equally well the great depth of pumiceous deposit.

North, north-east, and north-west of Taupo, with the exception of the higher ranges, the whole country is covered with pumice. Generally speaking, this forms terraces along the banks of the rivers or higher flats and table-lands, from which material is supplied to lower levels and a greater distance from the source of the pumice.

To the east of the Waikato, in the Kaingaroa Plain, the pumice-deposit is of great depth, and for many miles is unbroken otherwise than by deep cañon-like gulches that run back some distance into the plain. North of Rotorua and Rotoiti Lakes, the pumice-formation is developed on a grand scale, and forms broken hilly country gradually descending to the shores of the Bay of Plenty. West of Rotorua, the Patetere plateau, in part, the extensive Waitoa Plains, and great part of the Middle Waikato basin show the presence of heavy deposits of pumice, and the volcanic plateau west and north-west of Lake Taupo is equally so characterised.

This excessive abounding of pumice is the astonishment of every traveller, and, by almost common consent, all agree that the whole of it has originated from Lake Taupo. Hochstetter, indeed, refers the pumice of the Middle Waikato basin to an older series of volcanic rocks whose vents lay along the coastward range west of the Waipa and Lower Waikato,† but this opinion is almost forgotten, and it may be doubted whether in the first instance the reference was correct.

* "Geological Reports," 1886-87, pp. 70-71. † "New Zealand," by Hochstetter, p. 66.

The amount of pumice to the eastward of where it must have originated is very great. There is a thick covering of drift-pumice on the Kaimanawa Mountains and over a large part of the Urewera country, and over many of the hills on the slope from the main water-parting to the shores of Hawke's Bay. The greater part of these pumice-deposits, as far as they can be studied at and near the surface, give evidence of a rude arrangement such as might be expected from their having accumulated as ejected material during times of eruptions, or the after-effects of strong winds on the same, or their partial assortment in lakes of limited extent, or by the action of rivers. This applies to the surface only; when the deposit is of considerable thickness the lower part usually gives evidence of a considerable regularity, and indicates distinct stratification under water. This is particularly the case on the east side of Lake Taupo, and there are good reasons for supposing that the general surface of the Kaingaroa Plain owes its even regularity to the action of the sea.

The probability that much of the pumice over the northern and western areas, already described, has been deposited under water, and probably on the bottom of a shallow sea, will appear in a yet stronger light on it being shown that large deposits of pumice are interstratified with and form part of the young Pliocene formation of the west coast of Wellington and Hawke's Bay districts. This pumice is so evidently due to the activity of volcanic vents within the Taupo zone that no one has ever thought of endeavouring to show that it had other origin than that here indicated.

Marine fossiliferous pumice-sands on the East Coast were first studied in 1874–75 in the neighbourhood of Gisborne and within the southern district of Hawke's Bay. In 1874 I accompanied Sir James Hector in a trip along the east coast of Auckland from Poverty Bay to East Cape. During various explorations, fossiliferous beds, containing more or less pumice (pumice sometimes predominating), were found on the shores of Poverty Bay, and inland at Ormond, and at many places along the shore-line as far as the hills of the mainland opposite East Cape. In the Pliocene strata the pumice occurred usually as fine sands, and thus the real nature of the material was sometimes overlooked, or referred to as rock matter of another description. Its importance in this connection was not then apprehended.*

Towards the close of 1874 the writer examined the southern part of the Hawke's Bay district and found moderately coarse pumice-sands in Pleistocene strata of the cliffs along the south side of Hawke's Bay, and in beds of older date in the neighbourhood of Waipukurau, and as far south as Dannevirke in the Seventy-mile Bush. Subsequent examinations in the same district showed heavy deposits of pumice-sands on the range immediately north of the Manawatu, and at the same time in the low grounds of the Pohangina Valley, on the west side of the Ruahine Range. At that time the greater part of the district between Woodville and Norsewood was covered with dense forest, and the nature of the rocks could only be determined where exposures took place along the banks of the streams. So that, although pumice-deposits might be observed at many places, the relation of these to the Pliocene beds of a different character was not made out, and all the pumice of the district was referred, not very determinately, to a covering of pumice overlying the youngest marine beds.

In 1886-87 the writer made an extensive examination of northern Hawke's Bay, the East Cape District of Auckland, and the Urewera Country, and determined definitely that while a great deal of pumice formed a covering, usually of no great thickness, over large areas of the district examined, there also were heavy deposits of pumice, both coarse and fine, interstratified with the Younger Pliocene strata from the Manawatu Gorge to Tolago Bay. And, at the same time, it became evident that this pumice had reached into the eastern sea by way of the Manawatu Gorge and the lower mountain heights immediately to the north and south. These pumice deposits were, in the Esk Valley, clearly seen to underlie the limestone of the coast-range in the same district and west and north-west of Napier to add greatly to the average thickness of the formation in which they occurred. At the same time the high cliffs of the coast-line at Gable End Foreland, north of Poverty Bay, were ascertained to be formed of pumice-sands, and similar deposits were found in the East Cape hills and inland amongst the mountains separating the East Coast from the shores of the Bay of Plenty.

Mr. James Park, formerly an officer of the Geological Department, and late director of the Thames School of Mines, in a report on the geology of the western part of the Wellington Provincial District,† describes the Newer Pliocene formation of that district as largely consisting of pumice, gravels, and sands, which are absent from the Older Pliocene and Miocene limestones and clays of the same district. The Newer Pliocene rocks do not extend, as shown in Mr. Park's map, north-west of the mouth of the Waitotara River. Their absence in the district more to the northward is probably due to their removal by denudation, but, as it is, they still extend over a wide area, and are practically continuous with the like deposits of the same age that stretch along the east side of the main chain of mountains through the Hawke's Bay district. The pumice-sands of this formation are described at length at pages 62 and 63 of the report above referred to.

Between the northern boundary of this formation and the southern base of Ruapehu, there is a broad stretch of country extending from the west flanks of the Ruahine Range to Mount Egmont and New Plymouth, over which Miocene tertiary deposits appear at the surface, the Newer Pliocene deposits, once present, having been removed by denudation. The amount of pumice thus present in these beds in Wellington, Hawke's Bay, and East Cape district of Auckland is very great, and shows how violent and extensive were the eruptions within the Taupo zone during the earlier periods of activity.

This wide distribution of pumice, both superficial and as forming part of marine strata, shows how difficult it is to say what the limits of deposit from the Taupo zone may have been, and it justifies the assumption that in great part, if not wholly, the like deposits over the low grounds of the Middle Waikato basin, and the plains through which flow the Waihou and other rivers to the Firth of Thames, had a similar origin within the bounds of the Taupo volcanic zone.

* "Geological Reports," 1873–74. † "Geological Reports" of 1886–87, pp. 24–73.

In the matter of the classification of the volcanic rocks of the North Island, Hochstetter, who even now must be regarded the chief authority on this subject, distinguishes but two periods of volcanic activity: First, an old Tertiary period, and second, a younger (Recent) period.* With the older group he associated the volcanic rocks of Cape Colville Peninsula, and the bulk of opinion is still in favour of regarding all the igneous rocks of the Peninsula as Tertiary. Recent investigations tend to show that the younger acid rocks are of Pliocene age, and Park believes them to be contemporaneous with those of the Taupo zone.† The writer believes them to be older, though not of a very different date. The oldest group of volcanic rocks in the Peninsula may also belong to the Cretaceous period.

It has been shown that the earliest emanations of volcanic matter from the Taupo zone were of an acidic character, and largely consisted of pumice, great volumes of which were spread over the sea-bottom adjacent, and to very considerable distances from the points of eruption.

Marine Character of the first Eruptions.

The acidic products of the later eruptions on the Cape Colville Peninsula were poured out on land or deposited in lakes of fresh water, and in point of time preceded the commencement of activity within the Taupo zone. Hochstetter expresses the opinion that the first eruptions were submarine, and both Park and the writer have collected facts that go far to confirm this view; and the depressed state of the North Island at this time (Middle Pliocene) is affirmed or incidentally alluded to by many writers on the geology of New Zealand.

The physical features of the Taupo zone are described by Hochstetter, from whose work on New Zealand‡ the following has been taken: "The name Taupo reminds me of the grandest natural sceneries I have seen. [p. 360.] Hoping to have a view of Tongariro and Ruapehu, which we had approached by this time to within a distance of twenty-five miles, and in order to execute another series of observations, I ascended the Ngariha. . . . At the top we found ourselves amply rewarded for our toil by the view now presented to our eyes. . . . There lay the volcano Tongariro before us, all clear from foot to top. The still active cone, called by the Natives Ngauruhoe, with its regular and conical form, rises majestically from the midst of a circular range shutting it in all round, and open only on the south-west, similar to Vesuvius encircled by the Somma. The funnel-shaped crater at the summit of the cone could be distinctly seen, indeed almost looked into, the west side of the crater being much lower than the east side. Consequently the crater presented itself to us in the form of an ellipse, from which continually dense white steam-clouds arose, which sometimes enshrouded the whole peak, and at other times were driven southward by the wind, which afforded us a view of the blackened edge of the east side of the crater. . . . . Farther north on the slope of the mountain a briskly-steaming solfatara was visible. The Tongariro was entirely of snow. But to the right of Tongariro arose the towering mass of Ruapahu, its summit wrapped in dense clouds, and below the cloud-cap the snow-fields of the peak were seen to reach down as far as an absolute height of 7,800 ft. At the base of these mountain colossi dark forests extended; but in the foreground mountains with sharp edges and deeply fissured-precipices, and at our feet the valleys with their long-stretched terrace-lines. Thus we beheld in one glance the effects of fire and of water on the grandest scale in one and the same landscape. [pp. 353 and 354.] Tuhua mountain is the most prominent point in the whole country north of Tongariro, about 3,400 ft. high, with a broad platform and a steep descent on its south side. At the bend of the river (Mangakahu) I counted no less than eight terraces on both sides. Trachyte rock prevails. Leaving the valley, and following a southerly direction over terraces and woodless hills, the track leads with a steep ascent on to the table-land Pokomotu, 1,386 ft. above the level of the sea, at the western foot of the Tuhua mountain. This plateau is literally covered with pumice-stone. [p. 355.] The distance from Petania to Lake Taupo is estimated a two days' journey. The road, however, is extremely difficult; it leads up and down from valley to valley, from mountain to mountain, across the ridges springing from Tuhua Mountain in a southerly and south-westerly direction, and through dark primeval forests. It traverses the sources of the Wanganui, and ascending higher and higher, it finally reaches the watershed between the Wanganui and Lake Taupo. We were three whole days in passing over this route. On the fourth day, after a most fatiguing passage through deep ravines cut into pumice-stone gravel, we crossed the Takaputiraha Range—1,534 ft. high—and encamped on the left bank of the Pungapunga River. . . . . We had now to scale the Puketapu. This mountain is the most remarkable point on the road from Tuhua to Lake Taupo. . . . . The height of the mountain is estimated at 2,073 ft. As the summit was covered only with young underwood, I ordered the same to be cut down, and thus gained an interesting view of the sources of the Wanganui, over a sombre mountain country and wood landscape, in the background of which the Ruapahu loomed up in all its majesty, its peak wrapt in clouds. South of Ruapahu, another volcanic cone 3,000 ft. high was visible; it was pointed out to me as Hauhanga. To the north-west and west the Tuhua Mountain and the Hikurangi cone were the most prominent points. . . . . The Puketapu is, moreover, especially remarkable for the circumstance that, in the midst of a landscape, in which everything is covered by volcanic tuffs and pumice-stone, it is composed of clay-slate of exactly the same description as that at the Taupiri on the Waikato." [pp. 357 and 358.]

"After leaving Puketapu . . . at length we came to a small creek flowing in a direction different from that of all the other creeks we had hitherto passed; it was the source of the Kuratao, running in a north-east direction towards Lake Taupo—a sign that we had crossed the watershed. . . . . Of the lake, however, the sight of which we had expected . . . . . there was as yet nothing to be seen; but in its place two beautiful mountain-cones, Kuharua and Kakaramea, rose before us. We had reached a pumice-stone plateau, called by the Natives Moerangi, and I was greatly surprised at finding the result of my barometrical observations to show a height of 2,188 ft. [p. 358.]

* "New Zealand," by Hochstetter, pp. 66-67. † James Park, "The Geology and Veins of the Haurak Goldfields." ‡ "New Zealand," by Hochstetter, English edition.

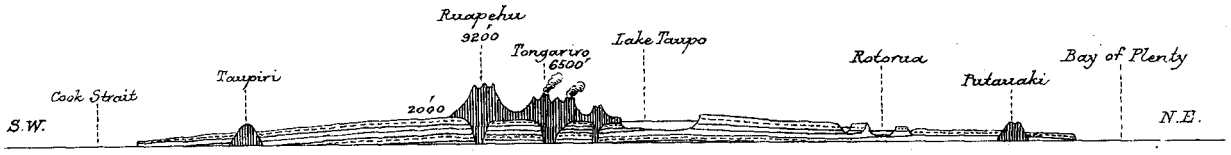
"Lake Taupo is a real inland sea, twenty-five miles long from south-west to north-east, its greatest breath about twenty miles, and of a depth as yet not fathomed. It lies 1,250 ft. above the level of the sea. . . . . The lake is everywhere surrounded with volcanic formations. Quartz-ore, trachyte lavas—which of late have been distinguished from the common trachyte by the name of rhyolite—in the most different modifications of structure and colours (crystalline and vitreous), together with huge masses of pumice-stone, are the prevailing rocks. They form round the lake a high table-land from 2,000 ft. to 2,200 ft. above the level of the sea, upon which numerous volcanic cones arise, built up of trachyte, phonolite, trachy-dolerite or andesite, and partly also of basalt. The lake itself evidently owes its origin to a break in the plateau, and seems to be of an extra-ordinary depth, especially in its western half. The west shore of the lake is formed by vertical bluffs or rocks, which, near Karangahape, at a promontory projecting far into the lake, attain a height of more than 1,000 ft. Upon that side of the lake a landing is practicable only at the few points where little rivers empty into the lake. The long-stretched wooden ridges of Rangitoto and Tuhua Mountains, rising to a height of 3,000 ft. above the level of the sea, shut out the horizon in a north-westerly direction, and only one point attracts the attention by its rather singular form—I am speaking of the Titiraupinga Mountain, from the summit of which a bare pyramid towers up, resembling a ruined castle. The east shore, in its greatest part, is flat and formed of a broad sand-beach, upon which the road leads along the lake. Widely gleaming white pumice-stone cliffs border the strand. Above them extend pumice-stone plains covered with grass and bushes, which rise in terraces up to the foot of a high wooded range, which, under the name of Kaimanawa, forms the continuation of the Ruahine chain in the Province of Wellington, and, together with this chain, is to be considered as a continuation of the Southern Alps of the South Island. The foot of the range is ten to fifteen miles from the east shore of the lake. Behind the wooded ranges rocky pyramidal peaks tower to the sky, which attain a height of 6,000 ft. more above the level of the sea, and present, with their rugged alpine character, a picturesque contrast to the regular conical shape of the volcanic mountains on the south side of the lake. Further to the north-east the mountains are growing lower and bear the name of Te Whaiti. The range, in its whole length from Cook Strait to East Cape, was, and for the greater part still is, a *terra incognita*. And if there is anywhere upon the North Island a prospect of finding gold, silver, and other metals, it is in those unexplored mountain-chains. . . . . In that range all the numerous and partly considerable rivers rise which empty into the lake from the east. The detritus which they carry with them consists mostly of bluish slate and of grey sandstone. At the north end of Lake Taupo the beautiful cone of the Tauhora points out the region where the Waikato leaves the lake as a stream of quite considerable size.

"By far the most attractive parts, however, are the southern shores. They are bordered by a successive series of picturesque volcanic cones, behind which the Tongariro and Ruapahu rear their lofty heads. From the south shore itself these two giants are not visible; but from the east and north shores they are everywhere seen towering high above the lower mountain-cones, by the Natives so well designated their wives and children. Their names are Pihanga, Kakaramea, Kuharua, Pukekaikiore, and Rangitukua. Pihanga, the eastern one of those cones, is also the highest. I estimate its height at 3,500 ft. above the level of the sea. Only its topmost peak, cleft by a deep chasm, is woodless, and displays already from afar a crater open towards the north; likewise the Kakaramea, the summit of which is of a red colour, bears probably a crater. Both craters are deemed extinct, but the volcanic forces below have by no means been as yet lulled to their final repose; for on the northern declivity and at the foot of the Kakaramea it steams and bubbles and boils in more than a hundred places. . . . . The whole northern side of the Kakaramea Mountain seems to have been boiled soft by hot steam, and to be on the point of falling in." [pp. 365–367.]

"The fertile lowlands about Tokaanu are . . . . to be considered as part of the extensive delta of the Waikato River, which here, at the south-east side, flows into the lake. The river in its delta is divided into four branches. . . . . It is formed by two rivers uniting at the foot of Pihanga, the one coming from the south bearing the name of Waikato, the sources of which are at the Tongariro and Ruapahu; the other rising in the Kaimanawa Range, and, as it seems, the larger branch, retaining the name of Tongariro. . . . . The foot of Tongariro [Mountain] is about twelve miles distant from the lake. Between the volcano and the Pihanga and Kakaramea Mountains lying before it, there intervenes a broad valley with the beautiful Lake Rotoaira, three miles long. The outlet of this lake, the Poutu, is one of the principal tributaries of the Waikato." [pp. 370–371.]

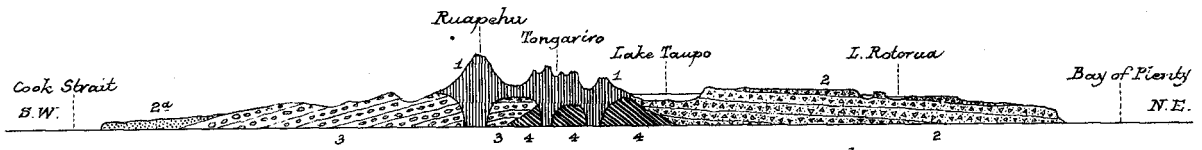
"Tongariro is not a single mountain like Ruapahu, but is composed of a whole group of mountain-cones. The beautiful cone towering high above the other parts of the group is distinguished by the special name of Ngauruhoe. It bears a funnel-shaped top-crater, the principal active one of the Tongariro. The Ngauruhoe, together with the grand circular range, from the centre of which it rears its head, forms the southern portion of the Tongariro system. It is a cinder-cone of the most regular conical shape, with a slope of 30° to 35°. The height from the base to the top I estimate at 1,600 ft. It overtops the highest points of the other parts of the system by about 500 ft., and attains probably an absolute height of 6,500 ft. above the level of the sea. The outer circus, shelving off inside with steep walls, and from all appearance forming a grand mountain amphitheatre with rocky precipices of 1,000 ft. in height, is opened to the west side by a broad chasm, and no doubt it is through the chasm, from the atrium between the cone of cinder and its circumvallation, that the chief source of the Wanganui River flows. This seems also to be the only side from which the cone is accessible. . . . [pp. 372–373.]

"The Ngauruhoe crater . . . seems to be at present in the state of a solfatara, throwing out, continually, large masses of steam and other kinds of vapour. The Natives know nothing of lava-flows, yet from time to time the crater is said to eject cinders and hot mud, and during such



Section through the North Island. S.W. to N.E. (New Zealand. Hochstetter. p 379.)

As Dr Hochstetter did not, in his journeyings, reach south of Tokaanu, his description of the lower grounds south of Tongariro and Ruapehu is almost necessarily imperfect. Succeeding examinations of the country have shown that the section should be represented thus :—



Section through the North Island.—Cook Strait to the Bay of Plenty.

1. Volcanic rocks of Ruapehu and Tongariro.
2. Volcanic rock, Lake Taupo to Bay of Plenty, consisting of Trachyte and Rhyolite floes, and fragmental pumice deposits.
2a Younger Pliocene. Marine strata, largely consisting of Pumice, & abundantly fossiliferous.
3. Miocene. Sediments containing no volcanic material.
4. Carboniferous, or Upper Devonian. Slates and sandstones, forming the western foot of the Kaimanawa Range, and appearing west of the Tongariro Range, and within the Wanganui watershed.

NOTE. There is no evidence of Miocene sediments anywhere within the Middle and Upper Waikato Watersheds, and the presence of a Palaeozoic barrier between the Tertiary sediments on the fall to Cook Strait, and the slope Lake Taupo to the Bay of Plenty is assumed on grounds sufficiently reasonable.

—— Geological Sections by Alexr McKay. F.G.S. Govt Geologist. ——

—— To illustrate Report ——

—— on ——

—THE PUMICE DEPOSITS OF THE NORTH ISLAND.—

eruptions, now and then a fiery shine is said to be visible over the mountain. . . . . The Ngauruhoe does not reach the limit of perpetual snow, yet the Natives assured me that, in winter-time, when the lower parts of the mountain are covered with snow, the latter would not stick to the Ngauruhoe, so that the whole cone seems to be heated from within.

"The Ngauruhoe, however, is not the only crater in the Tongariro system. Bidwill mentions that, from the top of Ngauruhoe, towards the north, he noticed, upon another part of the Tongariro, a circular lake. This remark most probably has reference to the truncated peak immediately north of the Ngauruhoe, which the Natives designate as Ketetahi, the crater of which acts periodically. . . . To the north-west of the Ketetahi there is a third cone, likewise truncated, and nearly 6,000 ft. high. Concerning the condition of its top, I am unable to give any positive information. I merely suppose that it also contains a deep crater. On its northern side, at a height of about 4,000 ft. above the level of the sea, a fissure is to be seen, from which, as from the Ngauruhoe crater, dense clouds of steam are continually streaming forth. This seems to be a great solfatara. . . . A fourth cone north of the Ketetahi, or north-east of the last-mentioned cone, shows on its north-western slope, at a height of about 3,500 ft. above the level of the sea, a crater apparently entirely extinct. From the east shore of Lake Taupo to the right of the Pihanga, the dark black hole can be plainly seen. Although this grand volcano, with its various craters, has, within the last centuries, as far as it is known, not had any eruption of lava, yet I would not venture to assert that such might not suddenly recur again. . . .

"South of Tongariro rises the Ruapahu. The feet of the two mountains gently slope together, forming a plateau about ten miles wide and about 2,200 ft. above the level of the sea. Upon this plateau four lakes are said to lie, two of them about three miles long, the other two smaller. . . [pp. 375–377.]

"The Ruapahu has the shape of a truncated cone, towering up into the regions of perpetual snow. No one has ever ascended or explored it. [This was prior to 1867.] Nevertheless, there can be no doubt as to its volcanic nature, but it seems to be perfectly extinct; there is no trace of a solfatara to be discerned in the distance, either at its sides or at the top; and it is totally unknown whether the broad summit forms a plateau, or whether it contains a crater. The mountain is but rarely free from clouds; and if once the weather happens to be clear, large snowfields are seen covering the summit, and running down along the fissures by which the slope of the mountain is channelled, as though they terminated in glaciers. The limit of perpetual snow in the latitude of Ruapehu (39° 20'), is at a height of 7,800 ft., and to judge by the colossal extent of the snow-fields even in midsummer, the mountain appears to reach a height of 9,000 ft. to 10,000 ft. above the level of the sea. At any rate the Ruapahu is by far the highest mountain of the North Island. A portion of the mountain bears the name of Paratetaitonga. At the eastern declivity of the Ruapahu rises the southernmost source of the Waikato. It forms a waterfall, according to the statement of the natives; and fifty yards from the source of the Waikato, the source of the Wangaehu is said to lie, which flows south and empties into Cook Strait east of the mouth of the Wanganui River. Its water, the natives say, has a milky colour and a bitter astringent taste.

"The pumice-stone plateau, upon which the Tongariro and Ruapehu rear their colossal heads, assumes on the south-east side of the Ruapahu, where it forms the watershed between the Waikato and the Wangaehu, the character of a sandy desert. The natives call the plateau Rangipo, and the sandy desert Onetapu. The road from Lake Taupo to Wanganui leads over it, and the Natives have driven pegs into the ground in order to point out the direction of the road.

"From the southern foot of the Ruapahu, the country slopes gradually towards Cook Strait in the same manner as from the north end of Lake Taupo towards the Bay of Plenty. It consists on both sides principally of pumice-stone tuffs* and rhyolitic lavas, and it can be justly said that the foot of the two volcanic colosssi reaches from sea to sea.

"Consequently the Taupo volcanoes arise upon a huge flat cone, which was formed by the first submarine eruptions, and rose only gradually by the upheaving of the land above the sea. In close connection with this rising is the terrace-formation in all the river-valleys of that cone, a phenomenon which is very characteristically marked on the shores of Lake Taupo. The first terrace is at Pukawa, about 100 ft. above the present level of the lake. It is covered with sand and boulder alluvium of the lake, and so characteristic that even the Natives could not help noticing it. They say that in former times, before the breaking-through of the Waikato to the north, the lake had stood at that height. The second terrace is 300 ft. to 400 ft. above the lake, and forms extensive plains round about the lake. Yet it is only the third stage that leads on to the pumice-stone table-land 700 ft. to 800 ft. above the lake. The formation of the terraces is most perfect in the Kuratao and Waikato upward from the lake, and along the eastern side of the lake. [pp. 378–380.]

"From the table-land, upon which, on the north shore of Lake Taupo, the picturesque Tauharu arises, there extends in a north-easterly direction, with a gentle slope towards the Bay of Plenty, the Kaingaroa Plain, an extensive plain, fifteen miles wide and channelled by numerous valleys. Vast quantities of pumice cover the almost treeless plain, the scanty soil of which produces only a meagre growth of grass and low shrubs. It appears as though in olden times a powerful stream had taken its course over the plain to the sea. On the east side the plain is bordered by the Te Waiti Range, striking in the direction of East Cape; on the west side by a volcanic table-land cut up and broken by faults and dislocations into a thousand hills and mountains, which separate the sterile pumice-stone plain from the wood-clad Patetere plateau. . . .

"The whole distance from Lake Taupo to Maungatautari the river is innavigable on account of its numerous rapids. The land on both sides consists of trachyte tuff, of pumice-stone, and of partly vitreous, partly crystalline rhyolitic lavas, the flow and extent of which is to be traced to

* It has been shown, and will further be, that the superficial pumice on the southern slope is confined mainly to the Rangipo plateau, the plain on the west side of Ruapehu and the river valleys.

the volcanic centre of Tongariro and Ruapehu Mountains. While the deep-terraced valleys are the result of long-continued erosion by water, we see, on the other hand, the effects of volcanic fire displayed in an immense number of hot springs, in which the country abounds. If we suppose two parallel lines to be drawn from Lake Taupo, touching its east and west shores, and extending in a north-east direction as far as the Bay of Plenty, then these two lines, including the range of hills and mountains situated between the Kaingaroa Plain and the wooded Patetere plateau, border likewise the space upon which, from more than a thousand places, hot vapours arise, calling forth all those phenomena of boiling springs, fumaroles, mud-volcanoes, and solfataras for which the North Island of New Zealand, and especially the 'Lake District,' is so remarkable. The southern point of this wonderful zone of hot springs, which by far exceeds all others in the world in variety and extent, is the Tongariro volcano with its solfataras, and the northern end is marked by the ever-steaming Island of Whakari [White Island], in the Bay of Plenty, a distance of 120 sea-miles. [pp. 389–390.]

"Through a small side valley, called Rotoparu, we ascended the right bank of the Waikato, crossed a fern-hill, and came into the Rotoreka Valley, a dreary and swampy plain, with here and there an isolated *ti*-tree. Towards the west the valley is bordered by low, woodless hills; towards the east a high rocky bluff ascends almost vertical, extending in the direction N. 24° E. in a straight line. Above the steep precipice numerous rugged cliffs tower up, and in the middle of the rocky wall a high wooded peak Pairoa [or Paeroa] projects towards the west. After this prominent peak, I have called the whole extent of the bluff the Pairoa Range; and it is easy to be seen that along this range an immense dislocation took place, that the almost perpendicular western side of the range is caused by a 'fault' corresponding to a deep fissure in the earth-crust, and that the low lands between the Pairoa Range east and the Patetere plateau west were produced by a breaking or sinking of a large part of the volcanic table-land. In a most remarkable manner the fissures and lines of dislocation are also indicated by the numerous hot springs issuing along the Pairoa Range, at the foot of the precipice, on its slopes, and even above on the heights. [pp. 400–401.]

"Having thus given a description of the principal ones of the thousands of *puias* and *ngawhas* on the North Island, I will now say a few words about general features and about the origin of the springs. We can distinguish three parallel lines of springs, striking in the direction N. 36° E. One line connects the two volcanoes, Tongariro and Whakari. On this line are situated the hot springs of Lake Taupo, the fumaroles of the Kakaramea Mountain, and the hot springs round Rotomahana. The second line is the line of *puias* of Orakeikorako and of the Pairoa Range; and to the third line belong the hot springs of Rotorua and the solfataras of Rotoiti. . . . . Both kinds of springs [intermittent and permanent] owe their origin to the water permeating the surface and sinking through fissures into the bowels of the earth, where it becomes heated by the still existing volcanic fires. . . . . The rocks from which the silicious hot springs of New Zealand derive their silica are rhyolites and rhyolitic tuffs containing 70 and more per cent. of silica; while we know that in Iceland palagonite and palagonitic tuffs with 50 per cent. of silica are considered as the material acted upon and lixiviated by the hot water. By the gradual cooling of the volcanic rocks under the surface of the earth in the course of centuries the hot springs also will gradually disappear." [pp. 441–434].

The above extracts show that Hochstetter was of opinion that the earlier and greater eruptions within the Taupo zone were on the site of the high volcanic mountains that lie between Kakaramea and the southern end of Ruapehu, and that the first outbursts were submarine. Also Hochstetter seems to have been of opinion that great part of the solid rocks north of Lake Taupo to and beyond the Waikato after it turns to the north-west were emanations from the volcanic cones of the Tongariro and Ruapehu systems, and that the Kaingaroa Plain gives evidence of currents of water flowing towards the Bay of Plenty. As regards the submarine condition of the earlier eruptions reasons have already been given in support of this theory. The evidence, however, is not in favour of the assumption that the bulk of the pumice emanated from vents situate on the southern part of the Taupo zone, and this neither in the earlier nor the latter phases of eruptive activity.

Hochstetter's impression that the southern slope from Ruapehu to the shore of Cook Strait was covered with volcanic ejecta in like manner as is the slope from the northern end of Lake Taupo to the shores of the Bay of Plenty proves to be erroneous, Older Pliocene and Upper Miocene marine sediments forming the bulk of the rocks appearing at the surface in that direction. The flat cone as indicated by a section from the shore of Cook Strait to that of the Bay of Plenty may, indeed, be due to gradual upheaval of the land since volcanic activity began, but, contrary to what we might expect, Ruapehu and the Tongariro Range are not built up on a basement of eruptive matter giving evidence of deposit in the sea and of being mainly pumiceous in character. To the contrary there is evidence that the earliest emanations from these vents rest on Palæozoic and Tertiary rocks of a sedimentary character, and, it may be, to the west of Tongariro, on coal-bearing strata. And yet it is evident that by way of the southern part of the Taupo zone much pumiceous matter found its way into the Pliocene sea occupying the area now drained by the Wanganui and rivers eastward to the Ruahine Range. Older Pliocene rock on the Kaimanawa Mountains at heights exceeding 3,000 ft. above the level of the sea shows that the southern part of the Taupo zone shared in the depression that then prevailed and gives evidence of the probability that there was a continuous and broad water-way through the middle part of the North Island connecting what are now Cook Strait and the Bay of Plenty.

Volcanic eruptions probably first commenced in the north, towards the Bay of Plenty area, and floating pumice was carried south and deposited in the Pliocene sea, over the areas within which pumice-sands and gravels are now found in connection with beds of that age; also, thick deposits of pumice must have probably accumulated over the southern part of the Taupo zone. The farther the distance from the eruptive source the finer the pumice would become, and hence

the character of such deposits in the valley of Pohangina and the neighbourhood of the Manawatu Gorge, in the Hawke's Bay district, and along the east coast to East Cape. And the bulk of such deposits is fine, although floating pumice of considerable size found its way into the eastern sea. Near the centres of eruption, pumice, both coarse and fine, might be expected, and such actually we find to be the case. Vast deposits of finely-comminuted pumice are found along the eastern shore of Lake Taupo, but much coarser pumice occurs here than anywhere south of Ruapehu, and the same has to be said of the area of the Kaingaroa Plain and the slope generally from Lake Taupo district to the shores of the Bay of Plenty.

Granting a depression that would thus facilitate the distribution of pumice to the south through the Manawatu Gorge and along the East Coast, as already described, the district to the west and north of the northern part of the Taupo zone must also have shared in the depression of the land, and been fitted to receive pumiceous deposits in like manner to the southern and eastern districts, and accordingly we find the Middle Waikato basin and the Waitoa Plains to the shore of the Firth of Thames covered with pumice.

There can be no doubt that the pumice over these districts belongs to the same period, even if it did not emanate from the same vents as of that which was carried to the south. As the earlier eruptive vents become inactive or exhausted, fresh ones appeared, and these latter generally to the south of the former. And now we must suppose that the land began to rise, and there was no longer water-connection between the Bay of Plenty and Cook Strait. Denudation would proceed rapidly where it affected such loose and easily-moved material as unconsolidated pumice-sands. The highest lands that now are within the region affected would probably be the first to appear, would be the most rapidly acted upon, and necessarily, for the longest period. Thus, as might be expected, the area constituting the water-parting between the rivers flowing south to Cook Strait and north to the Bay of Plenty would, or might, become completely denuded of its pumice; and as to the south lay, not hard Palæozoic rocks, but comparatively loose Tertiary sediments, these also being strongly denuded, the escarpment or slope of younger Pliocene rocks containing pumice-sands would recede rapidly to the south and leave a broad area over which pumice was only to be found in the river valleys, as is the case at the present day.

While this was going on on the southern slope of the great dome, the northern slope towards the Bay of Plenty was rising also. But besides being the much longer slope, volcanic cones situated on it were still yielding pumice, and the lower marine deposits as they emerged into dry land received additions as terrestrial deposits.

The continued upheaval of the land to the south of Lake Taupo did not result in the production of a flat dome, as might be inferred from the section drawn from Cook Strait to the Bay of Plenty. The section at right angles indicates rather the elevation of a broad side or plateau proceeding west from the southern and middle parts of the Kaimanawa Range to the present coast-line between the mouth of the Mokau River and Kawhia Harbour. (See section west to east from near mouth of Mokau River to Hawke's Bay, and section from Albatross Point across Tongariro to Cape Turnagain, neither of which convey the idea of a dome-shaped elevation on the higher part of which the great southern volcanoes have been built up.)

Appearance of Terrestrial Volcanoes.

On the denudation from this of the pumiceous products of the earlier volcanoes, and while these were too distant, or perhaps in a quiescent state, the more basic volcanoes of the south part began to be built up. It were perhaps vain to speculate as to which of these are the earliest, but it might be not unreasonable to assume that Ruapehu was the first. Its greater height and mass and apparent extinct state would seem to favour this assumption, as would the present activities of the volcanic cones situated farther to the north. Be that as it may, they do not appear to have been erupted through or to rest on a pumice cone of prior production, or the result of the earlier eruptions from their southern vents.

The purely acidic eruptions of the district north and east of Lake Taupo were continued or began afresh, and spread vast quantities of pumice over the high lands to the south of the Middle Waikato and west of Lake Taupo, the southern edge of which being eaten into by the Mokau and northern tributaries of the Wanganui, the valleys of these rivers received large deposits of drift pumice, which terrace the sides of the valleys at the present day, and are gradually being carried forward to the sea. None of this pumice, however, can be referred to the Tongariro or Ruapehu group of volcanoes; nor can that which is found along the high valley between the volcanoes to the west and the southern part of the Kaimanawa Ranges, or on the Kaimanawa Mountains themselves.

There seems to have been a tendency of the pumice-producing volcanoes to appear progressively in a south-east direction, and finally to make a tremendous display to the eastward of Lake Taupo, and it was here, and over the area of all but the western part of Lake Taupo, that the last great eruptions of pumice took place. From volcanoes so situated sub-aërial deposits of pumice were accumulated over the lands already emerged from the sea—*i.e.*, those to the west of the lake and south and south-east as far as superficial pumice now extends. The higher lands to the north-west and west seem also to have been elevated prior to the eastern part occupied by the Kaingaroa Plain, and the continuation of that south to where the table-lands terminate along the Tauranga River.

This eastern side of the northern slope from Taupo to the Bay of Plenty being the latest to emerge from the sea explains the appearance noted by Hochstetter—that the Kaingaroa Plain presented an appearance of having been washed, and, presumably, its surface arranged, by heavy currents of water. Undoubtedly such appearance is due to the sea. The western margin of the plain has been much eaten into by the tributaries of the larger streams flowing towards and falling into the Waikato, and probably a considerable part of the plain has thus been destroyed. In this destruction of the west side of the plain the streams were aided by numerous hot springs and

fumaroles, which still abound in the district. Certain classes of these may be termed migratory, disappearing in one place to appear in another; and in places they pull down and destroy terrace-lands, as though they were maintained by the continued combustion of a layer of decomposable substance not far from the surface.

As an instance of this, outside the west border of the Kaingaroa Plain, north of Tauhara, is situated Rotokawa Hot Lake. This lies in a depression, which at first sight appears to be due to subsidence, and though in part this may be so, yet the terrace-lands to the north, outlying fragments of the Kaingaroa Plain, are being continually eaten away and lowered in level by the action of boiling pools and steam and sulphurous emanations. On the north side of the lake this action now going on has broken up and lowered the original terrace over an area of fully half a mile square; and beyond this, another group of boiling springs and steam-holes is gradually eating away the terrace-lands to the south of them, and now but a narrow strip of original terrace is left between the two areas of action. How the material of the terrace-lands is disposed of is a mystery, but the operation and the evident lowering of the ground can be seen in process at the present time. But whether lowered or not by such action, the surface of the ground is broken up and the rocks reduced to a pulpy state, easily carried away by running water. And by the aid of these two agents the western part of the Kaingaroa Plain has been carried away, and a long line of escarpment indicates the limits to which such action has been carried. Otherwise, the general level of the plain is but little affected by the action of water on its surface further than the formation of many deep ravines, which in the general view from south to north are not observable.

As seen between the outlet of Lake Taupo and the Tauranga River, which from the east falls into the upper part of the lake, the thickness of the pumiceous deposit above the level of the lake is in places not less than 800 ft. And this constitutes a continuation south of the Kaingaroa Plain. Over this part this continuation is broken through by three or four considerable rivers taking their rise among the mountains to the east and thence flowing west to the lake. These have cut deep narrow valleys through the pumice-deposits, and show well the nature of the material and the manner of its arrangement. Ten to twelve miles east of the lake, owing to the convergence of the several branches of the rivers, the whole of the high levels have been worked over and reduced considerably, if not totally reduced, to the rhyolite rock that forms the basement rock of the country. This is especially the case in the upper valley of the Hinemaia River.

Along the east shore of Lake Taupo these pumice-deposits also form high vertical cliffs, which also descend below the level of the lake, and in general do not, although well stratified, convey the idea of having been deposited in an extension of the lake. That the pumiceous accumulations over this part are lacustrine and deposits within Lake Taupo at a time when its area was much greater than at present, is the prevailing idea. But it is not appreciated that neither to the north nor the north-east are there bounding heights that could have retained the waters of the lake at the levels required, and in the case of the Kaingaroa Plain none such could at any time have existed.

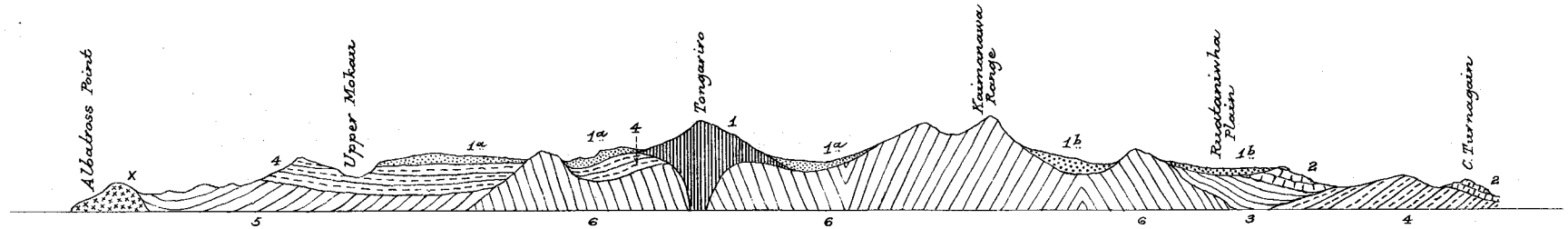
Lake Taupo is popularly supposed to be the source of most, if not all, the pumice that forms the surface of the adjacent country; but the cubic contents of the lake-basin, to a considerably higher level than that at which the waters now stand, would not equal in measurement even a part of the pumice that has to be accounted for. The pumice-stone deposits on the east side of the lake give little evidence of ever having proceeded from it. The lowest deposits seen are fine-grained pumice-sands, clearly stratified, and resting in a nearly horizontal position. Between the Hinemaia and the next river to the north these deposits specially show as cliffs on the shore of the lake, rising, bare of vegetation, to a height of 300 ft. or 400 ft. above the level of the lake.

Towards the upper part, the pumice-sands have bands of well-rolled gravels, mostly composed of volcanic rocks. At places deposits of black sand (magnetic iron-sand) have been formed, and the whole is finally covered by a very coarse breccia of volcanic rocks, consisting of dark rhyolite and glassy obsidian. This remarkable deposit abounds in blocks, 6 ft. to 10 ft. or 12 ft. in diameter, and for the most part even the smallest fragments show no sign of being water-worn. Yet the rocks have evidently consolidated elsewhere, been broken up in their original position, and from a distance been conveyed to their present position by some agency that did not involve grinding and trituration, and the production of rounded boulders, gravels, and sand.

Except where covered locally by loamy deposits, this coarse breccia, rightly spoken of as an agglomerate, extends over all the high lands to the east of Lake Taupo north of the Tauranga River. I could not determine the whence of the material. In different localities there is a variation in the nature of the material, but in every case more than 90 per cent. of it is volcanic and volcanic rocks of the character described. It suggests, by the angular character of the material, a possible morainic origin, or more probably berg-matter from floating ice. It cannot have been due to explosive violence of a volcanic nature breaking up consolidated lavas and scattering the material thus produced to great distances over the country, because not even the rudest arrangement of the material has been effected, and such, to some extent, must have happened should these breccias have been due to the latter cause.

The higher levels east of the lake, formed at the surface of the breccia-agglomerates just described, are from 2,000 ft. to 2,300 ft. above the level of the sea, and, as before stated, their height is such that it is difficult to imagine these can be deposits in any conceivable extension of Lake Taupo. The lake has certainly stood at a considerably higher level than at present. The bench-terraces conclusively show this to have been the case, and the erosion of the valley of the Waikato gives a sufficient explanation of the lowering of the lake to the present level of its waters.

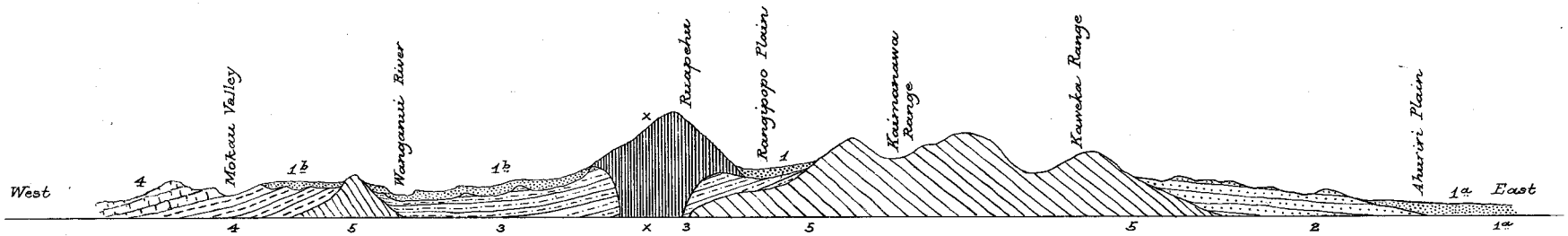
The area to the east of Lake Taupo is the source of the fields of coarse pumice that now lie stranded over the lower terraces of the lake or in places are piled upon the beaches of the south-eastern shore. The Hinemaia River brings into the lake great quantities of such coarse



—— Section from Albatross Point Kawhia Harbour, across Tongariro, to Cape Turnagain. ——

1. Volcanic rocks of Tongariro.
1a. Pumice & fragmental volcanic ejecta E. & W. of Tongariro.
1b. Gravels of the Ruataniwha Plain &c.
2. Te Aute limestone.
3. Pliocene. Wanganui & Kereru beds, with pumice.
4. Cretaceo-Tertiary. Waipa & Kawhia limestones, shales & coal.
5. Middle & Lower Secondary.
6. Carboniferous, or Upper Devonian. Rocks of the Kaimanawa Range. &c

x. Intrusive rocks of Albatross Point. (Middle Secondary?)



—— Section West to East. From near Mouth of Mokau River to Hawke Bay. ——

x. Volcanic rocks of Ruapehu.
1. Fragmental and other deposits of Rangipopo Plateau.
1a. Recent deposits of Ahuriri Plain.
1b. Pumice deposits along Wanganui & Mokau Rivers & tributaries.
2. Upper Pliocene. Strata on East Coast, containing Pumice. (Marine).
3. Lower Pliocene & Miocene. Deposits of Wanganui Valley. (Marine).
4. Cretaceo-Tertiary. Rocks of the Mokau Coalfield.
5. Carboniferous or Devonian. Slates & Sandstones. Kaimanawa Range. &c

—— Geological Sections by Alexr McKay. F.G.S. Govt Geologist. — To illustrate Report on ——

THE PUMICE DEPOSITS OF THE NORTH ISLAND

C.H.P. lith.

pumice, and this, carried some distance into the lake, seems unable to pass the current described by Hochstetter as passing south to north along the middle part of the outlet. The floating pumice is then, by the prevailing strong north-west winds, carried to the south-east and stranded on the beaches in that direction. The comparatively extensive low grounds on both sides of the entrance of the Tauranga River into the lake is covered deeply with such blocks of pumice, and is the principal source of such when used as building-material. None of this pumice reaches the south-west side of the lake, and the pumice-blocks used in building chimneys and other parts of houses in the Township of Tokaanu are all brought from the south-eastern shore of the lake and from the neighbourhood described.

Along the banks of the Hinemaia River large blocks of pumice are frequently found; and in the upper valley of that river beyond where the high-level terraces extend to, during the past year solid blocks of pumice-stone 5 ft. in diameter were met with. Beyond this, toward the east and north-east, must be the source of the coarse pumice carried into the lake by the rivers draining to the lake from the eastward.

Between Taupo and Rotorua, along the lines of travel by coach, the country in the low grounds is thickly covered with pumice-drift, the higher ranges being formed of trachyte and rhyolite, the lower hills and downs being often a pumice breccia, more or less consolidated. North of Rotorua and the Hot Lakes district to the shores or low land along the Bay of Plenty the country is hilly and broken, and almost everywhere shows a great depth of pumice-drift of a coarser description than is met with in the cliffs bounding Lake Taupo. This is usually rudely stratified, and contains deposits of rhyolite gravels, not usually of great extent but of frequent occurrence. To the eastward the coarser pumice gravels descend to sea-level, but toward the north-west in the Te Puke Range the pumiceous material resting on the underlying rhyolites is as fine as that forming the cliffs on the east shore of Lake Taupo.

The drift-pumice of the Middle Waikato, Waiho, and Piako basins, it cannot be doubted, has originated from volcanic vents of the Taupo zone of activity or belongs to areas contiguous, and active at the same time. Indifferently, from the Taupo zone or other source much pumice found its way into the west and north-west of the Taupo zone, firstly, as being spread over a shallow sea-bottom, and latter, as carried thither by running water or wind-borne.

Conclusion.

The vastness of all these deposits forbids the idea that all this pumice originated within a limited district, extensive even as that of Lake Taupo; and, as the southern end of the Taupo zone does not appear to have been a pumice-producing area, the district between Lake Taupo and the shores of the Bay of Plenty must be considered as having yielded the bulk of the pumice. The volcanic monntains of this district for the most part are formed of rocks of the acidic type, but it is very curious that pumice is rarely found on the slopes or higher parts of these; and this can hardly be explained away by supposing that the light pumice has been removed by gravitation to the lower grounds, seeing that loose pumice covers large areas of the slopes and higher parts of the Kaimanawa Mountains, of the mountains of the east coast within the Hawke's Bay district and the Urewera country. In the case of Tauhara, east of the lower end of Lake Taupo, this mountain, though surrounded on all sides by a great and unknown depth of pumice, holds no pumice on its slopes or higher part. Its rocks are formed of trachyte and porphyritic rhyolites, and though it might have been expected to show evidences of having thrown out pumice, as has been said, none are to be found on the mountain at the present time. This is also the case with several other mountains and ranges of volcanic rocks in the district to the north and west.

The conclusion seems to be warranted that the vents chiefly concerned in yielding pumice have been covered up; and of greater age in some cases, but generally younger, the more solid acidic rocks appear through the pumiceous deposits. It is only to the east, to the lower end of Lake Taupo that solid pumiceous rocks are likely to be found. From what may be seen in the valleys of the Hinemaia and the Waitahanui this is rendered highly probable, but such rocks *in situ* have yet to be discovered. Whatever its source, the quantity of pumice distributed over the middle part of the North Island from Ruapehu to the shores of the Bay of Plenty and the upper end of the Hauraki Gulf, in the Middle and Lower Waikato, and east and west from the sources of the Waipa to the East Coast and Hawke's Bay is enormous, and may well excite curiosity and prompt speculation as to the origin of the same.

Alexr. McKay.

21st June, 1899.

REPORT ON THE OCCURRENCE OF COAL NEAR WAIHI, AUCKLAND.

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

Sir, 16th May, 1899.

I have the honour to report that, as directed, between the 19th and 21st of March last, I visited Waihi, Ohinemuri County, for the purpose of examining some seams of coal or lignite recently discovered in the hills bounding on the south-west the Waihi or Upper Ohinemuri Plain. At Waihi I was met by Mr. McLean, of the Waihi Consolidated Company, who, with Mr. Morgan, of the Waihi School of Mines, accompanied me to the locality where the outcrops are. Three seams of workable thickness and some smaller seams were examined. Their value as a fuel had already been ascertained at the Waihi School of Mines, and my business chiefly lay in determining the formation in which the seams of coal or lignite occurred.

Coal as anthracite, bituminous coal, brown coal, or lignite, occurs at many places on the Cape Colville Peninsula; but in the southern or Upper Thames district, within Ohinemuri County, it is known only in two horizons—first, in connection with the Beeson's Island group of rocks; and second, associated with the acidic group of younger date.

The rhyolites of the Waihi Plain, where they become tufaceous, frequently contain buried timber carbonized or completely altered by silica and other minerals, but it is only near the junction of the Waitekauri with the Ohinemuri and on the left bank of the latter that are seen clays and stratified deposits that might be expected to carry seams of lignite. These rhyolites are the younger of the group of rocks to which they belong. To the eastward of the Waihi Township the hills towards the sea are formed of spherulite and spherulitic rhyolite, evidently of older date, and to the south four or five miles beyond the limits of the Waihi Plain rises Hikurangi Mountain, of which the middle and higher parts are rhyolite that agrees in character and probably corresponds in age with the rhyolite forming the hills to the eastward of Waihi.

North-west from Hikurangi Mountain along broken hilly country a narrow belt of rhyolite and rhyolite-tuff is traceable to the edge of the bush, east of the saddle crossed by the Waihi-Tauranga Road where it begins the descent from the plain to the sea-level by way of the Waiau Stream. This projection to the north-west of the acidic rocks of Hikurangi does not stop short at the edge of the bush as shown on the map of the district by me to accompany report on the Cape Colville Peninsula (published with the Mines Reports, 1897), but is continued north-west through the bush for some distance.

Two miles north of the saddle leading into the Waiau, a district road leads from the Tauranga Road to the edge of the bush, whence a tributary of the Ohinemuri flows north across the open plain to join the main stream. On the banks of this stream, near the bush, solid rhyolites are met with, and near the edge of the bush rhyolitic tuffs and breccia are seen, forming the last of the fern-clad hills. On entering the bush and following the stream towards its source, andesic boulders mainly are met with. But a quarter of a mile into the bush rock-exposures are seen in the bed of the creek. The rocks exposed here and higher up the stream are rhyolite and rhyolite-tuff, passing into clays and shales derived from, or interbedded with, the acidic rocks. Higher up, and on the right bank of the creek, a carbonaceous clay, or lignite of poor quality, is cut in a shaft sunk within a yard or so of the creek-bank. This appears to be lying nearly horizontal. Higher up the creek, a 4 ft. seam and a 10 ft. seam of considerably better quality are exposed crossing the creek, and in the walls of the gorge within which the creek is confined at that place. Both these seams are standing nearly vertical. The roof of the thicker seam is rhyolite-tuff, the shale or under-clay not being clearly discernible at where the seam is exposed. Less than a quarter of a mile higher up the stream a fourth seam, 6 ft. in thickness, is exposed crossing the creek in a north-west direction. This seam has a dip of 30° to the east-north-east, and, as far as dip and the disposition of the associated beds affects it, is quite workable. The seam is so disposed that it rises into the ridge of hills to the south-east, and offers considerable facilities for being mined in that direction.

As to the quality of the deposit, it is certainly not a high-class fuel; but the ash is low, and without question this lignite will be a valuable asset in time to come, when, as must certainly happen, the hills in the neighbourhood of Waihi are denuded of timber, and the need of fuel for steam and domestic purposes is greater. Mr. McLean had 10 tons mined and taken to the saw-mill at the entrance to the bush, where its steam-raising qualities were tested, as he writes me in the following manner with the results as here stated: "The seam has been driven on for 60 ft., and as driven on continued to improve in quality; while a 3-ft. seam 800 ft. distant to the north [this has been discovered since my visit] is of yet better quality. From this, 10 tons which were mined and its steaming powers tested at the adjacent sawmill, proved that each ton of lignite was equal to 2 tons of rata-wood used for the same purpose." There thus appear to be four seams, of a thickness varying from 3 ft. to 10 ft., and as Mr. McLean purposes boring, others of a workable thickness may yet be discovered.

It is undeniable that this discovery is of great importance as a source of fuel to the mining district of Waihi and the township of that name. The enormous quantity of firewood consumed bids fair within a year or two to denude the timber from all accessible places on the adjacent ranges, and the cost of fuel for all purposes would in consequence be greatly enhanced. Although this discovery of coal in the neighbourhood may not greatly retard the disappearance of the forest, it will at all events tend to keep down the price of fuel, and, as a consequence, in working mines will enable stone to be treated that otherwise would not afford a margin of profit. Clearly, in time a railway must be built from Paeroa to Waihi, so that Waikato coal may find a market at Waihi. This, as yet, is in the future; and meanwhile, whether conveyed by tramway or cartage, the transit of this coal to Waihi in cost need even now scarcely exceed the cost of cartage on the firewood used.

The Under-Secretary, Mines Department. ALEXR. MCKAY.

REPORT ON AURIFEROUS CEMENTS AT TE PUKE, TAURANGA COUNTY, AUCKLAND.

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

BETWEEN the 22nd and 29th of January last, I paid a visit to the Te Puke Goldfield, specially with the purpose of making an examination of the reported alluvial or cement deposits that have been prospected on the range to the north of Fleming's Hill.

When I visited Te Puke three years ago, this alluvial or cement deposit had been discovered, but the limited time at my disposal and other circumstances prevented my visiting the locality. During the month of January last, I was engaged in investigating the occurrence of gold in connection with the volcanic rocks lying between the Bay of Plenty and the Lake Taupo regions; this naturally brought me to Te Puke. Three years ago, I was shown a sample of rather coarse gold said to have been obtained from the deposit here to be described, and during the past season, there were on show at the Auckland Industrial and Mining Exhibition samples of the cement, and

of the gold which it produced. The gold was comparatively pure, and might be worth £3 17s. 6d. per ounce; and on examination the material of the cement proved to be wholly volcanic in its character, and consisted of a moderately coarse breccia-conglomerate, mixed with a percentage of clayey matter, serving to bind the whole together. The gold derived from this matrix was evidently alluvial, and the position of such a deposit—on the side of a steep range—naturally excited my curiosity, and I therefore took the first opportunity of examining the conditions under which it occurred.

The lower and middle slopes of the range north of Clark's Hill and the Sisters Claim are formed of rhyolite up to about 800 ft. above the sea. Here the range is cut into by a deep gorge that carries the waters of a small creek to the low grounds. Where the rhyolite ceases the stream divides into two branches, the main branch continuing east directly for the higher part of the range, while the lesser branch turns to the north, and rises on a saddle about a mile distant, being fed and augmented by lesser streams from the range to the east. At the source of this stream on and near the saddle a good deal of prospecting has been done by sinking and driving, and by channelling along the bed of the creek.

The rhyolite rock is here of a highy felspathic character, and, near the surface, so much decomposed that holes may be sunk in it to a considerable depth without having recourse to blasting. Much of the partly disintegrated rock, on being thrown to the surface, resembles a coarse sand, other bands are of a more clayey nature. Holes and drives were made in this formation under the belief that it was an alluvial deposit, and gold, it is said, was obtained from some layers of the decomposed rhyolite. This statement, however, could not be verified, yet, from the amount of excavation made, there would seem to have been some inducement to continue the work.

Where the first eastern tributary joins this northern branch of the creek, alluvial gold was obtained, and the bed of the stream has been sluiced for about two chains. Gold was obtained here, and it is more than probable that most of the gold from this part of the range was obtained here. The wash in the creek-bed is mainly andesic, and is supplied by the tributary already spoken of. It is, however, peculiar that gold could not be traced in the eastern tributary along which the andesic wash had come. Below this, along the northern branch of the main creek, rhyolite rocks continue, and in these a small vein of quartz carrying a little cinnabar is seen on the left bank of the creek, opposite the junction of the second tributary coming from the east.

Crossing two ridges and a gully on the east side of the north branch, the main eastern branch of the creek was reached at a height of 950 ft. above the sea. The creek here flows along a deep valley, almost a gorge, cut in pumice-sands, that, resting on the rhyolite rock, form a soft sandstone, and are seen to continue for some distance up the creek, and probably continue to the crest of the range.

At the point where the bed of the creek was reached is a waterfall some 15 ft. in height, beneath which, and in the precipitous banks of the creek on both sides, a stratum of coarse dark gravel-cement is exposed. On the right bank of the creek the most westerly (down creek) exposure of this is about 8 ft. in thickness, it thins out rapidly towards the east, and under the waterfall a thickness of not more than 2 ft. can be seen. About midway in the distance mentioned a drive has been put in towards the south, and here there is evidence that the cement is divided into two bands by a bed of pumice-sand (soft sandstone). As the cement, followed to the south some 20 ft., gave evidence of thinning out, the drive was turned to the eastward, and driven to nearly abreast of the waterfall; but in this direction also there was distinct evidence that the cement would shortly thin out. Divided in two by the band of pumice-sand, and there being a low dip of the beds to the east, the lower band of cement in the farther part of the drive passed underfoot. The upper bed of cement becoming thin, of finer grain, and yielding no gold, a winze was sunk in the floor of the drive to cut the lower bed of cement, but, as I understood, failed to do so.

Where thickest, and not divided by pumice-sandstone, the cement is composed of rather coarse material, boulders 10 in. or 1 ft. in diameter not being uncommon; and it was from this part that the best prospects of gold were obtained. As the bed thinned, and the material became finer, the gold gradually disappeared. I washed two dishes of stuff from the coarser part of the cement, whence it was said the best prospects were obtained, but I failed to get gold. At the same time I carefully examined the nature of the material of which the cement is composed. This might at first sight be judged of as being dark andesite, but at least two-thirds of it proved to be rhyolite.

On the opposite (north) bank of the creek the cement, where exposed abreast of the thicker part of the south side in the face of the cliff, showed from 2 ft. to 3 ft. in thickness. A short drive was put in to the north-east, at the inner end of which the cement had totally disappeared and only pumice-sands were driven on. I did not learn that gold had been obtained from the commencement or any part of this tunnel. Altogether, in neither branch of the creek has payable gold been got from either the recent alluvial wash or from the cements, and more particularly in the cements the prospects obtained were poor.

From the manner in which the cements died out to the south, to the east, and north-east, although possibly more than half of it has been washed away, the cement deposit at no time was other than of limited extent, and what remains of it may be estimated as little more than an acre in extent. None of it is payable, and, so far as proved, but a small part of it is gold-bearing. How much cannot be said, as I found no gold, and none was shown me when on the ground.

The alluvial gold found in the north branch of the creek is probably derived from a like or similar deposit of rhyolite and andesite gravel to that which has been prospected in the east branch, as such patches of coarse dark gravels abound in the pumice-sands that form the country between the shores of the Bay of Plenty and Rotorua Lake. These Te Puke cements are interest-

ing to the student of geology, but practically they are of little consequence to the gold-miner, at least in so far as their value has yet been proved. In similar gravels, report has it that gold in small quantities has been obtained over a wide area between the shores of the Bay of Plenty and the southern end of Lake Taupo. It would be rash to say that, though all were tried, none of these would prove payable. Yet, up to the present time, though gold has been obtained from Taupo to Te Puke, in no case has the amount been sufficient to pay for working the deposit. What is curious is that these deposits are generally without quartz, and no sedimentary rocks of any kind are present as a part of them, and that almost exclusively the material is composed of rhyolite. As to the source of the gold in these Te Puke cements, it cannot reasonably be referred to the reefs to the south-east, in Fleming's Hill and that vicinity, since thus could not be accounted for the gold in distant inland parts; and it does appear that the gold in these rhyolite gravels and cements should be referred to a common origin.

Wellington, 16th May, 1899. ALEXR. MCKAY.

REPORT ON THE DISTRICT BETWEEN STRATFORD AND THE TANGARAKAU RIVER.

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

SIR,— Wellington, 26th April, 1899.

As directed, between the 10th and 22nd instant, I made an examination of the country along the main line of road and proposed Stratford route of railway, from Stratford to the Tangarakau River. My instructions directed the making of a detailed survey of the eastern part of the Mokau Coalfield, that part of it lying within the Wanganui watershed and is developed towards the head-waters of the Tangarakau, Heao, and Ohura Rivers, within the valleys of which streams several outcrops of coal are known to exist.

The position of these outcrops in rugged mountain-country, and the lateness of the season, rendered it improbable that the work suggested could be effectively carried out, at least until the fine weather that may be expected during the coming summer sets in. This was represented to those interested in the making of the survey required, and finally it was arranged that I should make an endeavour to ascertain the southern limit of the coalfield which it was hoped might lie within the bounds of the County of Stratford. This arrangement I endeavoured to carry out, and on the 14th April I went from Stratford to Whangamomona, and the following day to Sladden's Camp, one mile from the Tangarakau River. Here I learned that it would be difficult to reach any of the coal-outcrops reported to occur in the valleys of the affluents of the Wanganui draining the west side of the upper part of the Wanganui watershed. It had been reported to me that I could reach the nearest of the coal-outcrops three miles beyond Sladden's Camp. When I reached there I found that the nearest outcrop was twelve miles distant, and that a good deal of difficult country lay between the camp and the coal-outcrops. Not being provided with the means of camping out nor with a guide, after reaching and following some distance up the right bank of the Tangarakau River without having seen the coal-outcrops, I determined to return, as it was clear that, single-handed and alone, I was not likely to reach even the nearest of the coal-outcrops. In consequence I returned to Stratford, and thence to Wellington.

REPORT.

The town of Stratford is situated south-east of Mount Egmont, and on the main line of railway thirty miles south of New Plymouth. West and north of Stratford fragmental ejecta and solid lava streams form the low grounds, or build up the volcanic cone of Mount Egmont and the flanking ranges connected therewith. Volcanic matter at the surface extends east of Stratford to Toko—a distance of seven miles—and the eastern boundary of the volcanic rocks; thence runs north to the coast-line near the mouth of the Urenui River. To the eastward of these volcanic rocks, the country west of the Wanganui River is formed for the most part of Tertiary sediments of Pliocene or Miocene age in the southern part and within the limits of the County of Stratford. Beyond this, to the northward, and within the district drained by the western tributaries of the Wanganui, is the supposed eastern extension of the Mokau coalfield. Several outcrops of coal are known to occur in this part of the district, and as these are at no great distance from the proposed route of railway from Stratford to connect with the south extension of the Auckland railways, an importance has been attached to these coal-outcrops which, otherwise, they might not have had for many years to come.

There has, hitherto, been no certainty as to the position of the southern limit of the coalfield within the Wanganui watershed, and, naturally enough it was hoped to be much nearer Stratford than proves to be the case. There is little likelihood of coal being found to the south or south-west of the Tangarakau River. If coal-seams are found in this part of the district, they must lie at the base of the Tertiary sequence, and be connected therewith. Whether or not this would prove such coal-seams of a different age to those of the Mokau Valley remains to be seen, and there are no present means of determining this question.

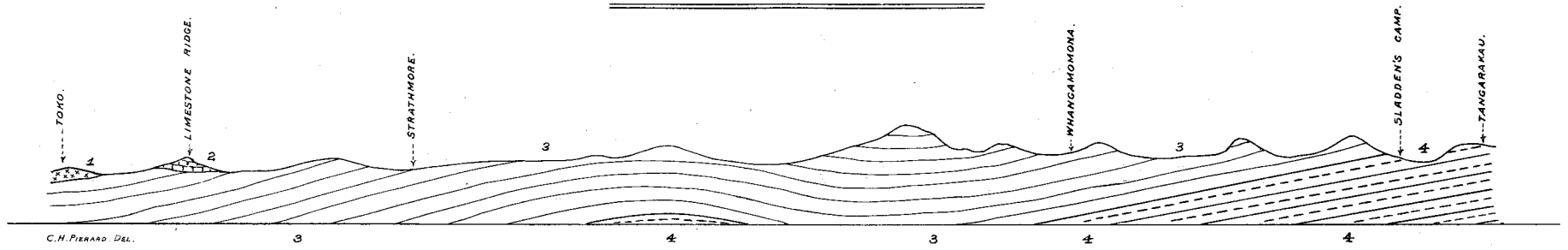
The highest and youngest sedimentary rocks between Stratford and the Tangarakau River are soft sandstone beds—often loose sands—that contain a percentage of ironsands as ilmenite or as magnetite. These sands appear at and extend four miles to the east of Toko, beyond which, as reported, shelly limestones appear to the east and north-east. The actual age of these sands might be matter for debate, as they do not well agree with the Putiki series of Hutton as developed on both sides of the Lower Wanganui. In the higher beds they are not richly fossiliferous, nor are they largely formed of pumice-sand and coarser grit, as are the rocks of Younger Pliocene age in different parts of the Wellington and Hawke's Bay Districts. In that they are associated with shelly limestones that resemble those of Scinde Island, and appear to

Sketch Section by Alex.r McKay. F.G.S. Government Geologist.

To illustrate Report on

THE DISTRICT BETWEEN TOKO AND TANGARAKAU.

(STRATFORD COUNTY.)



REFERENCE.

1. Volcanic.
2. Shelly limestone.
3. Brown sands, & blue, sandy, or marly clays.
4. Soft brown sandstone, bluish or greenish when broken into.

—o—

be the same as those of Kaiwhaiki, on the Wanganui River, which are referred by Park to the Older Pliocene or Upper Miocene formation.* Though possibly of younger date, for the purposes of this report they may be regarded as of that age. These younger beds on the line of route travelled, first appear at Toko, seven miles from Stratford. Beyond Toko they extend some four or five miles to the eastward, beyond which distance to the east and north shell-limestones are reported to cap or form ranges of hills in that direction.

From Toko the road to Strathmore turns to the north, and for the first five miles the rocks seen are mainly the brown sands referred to. At five miles from Toko the road crosses a ridge of hills at a height of 760 ft. above the sea, the hills to the south-east being capped by a thick shell-bed, forming a limestone which is reported to have a considerable development to the south-east, and also extends from the saddle in a north-west direction, though how far could not be ascertained. This limestone is at the present time used as a road-metal, and forms excellent roads, and is likely in the future to be valuable for other purposes—as a mortar-lime and in its application to the land. The limestone and underlying beds in position are nearly horizontal, the slight dip being to the south-west. Towards the south-west it either thins out or is covered up by the volcanic deposits of Mount Egmont that lie in that direction. North, towards Strathmore, the limestone is not again seen, the lower sandy beds appearing in that direction; and before crossing the next ridge of hills, which the road does at a height of 825 ft., there are beds of coarser grain, in part composed of small, well-rounded quartz pebbles. Beyond this second ridge of hills, which also trend to the north-west, lower and yet lower beds of an arenaceous character appear, alternating with beds of blue sandy clay, which, at and near Strathmore, contain abundance of shells, yet not in such abundance as in any sense would constitute a limestone.

On leaving Strathmore for Whangamomona, beyond the first two miles the rocks are again brown sandstones, but this development lies in a lower part of the series to that already described as being closed by the shell-limestone five miles from Toko. With these lower sands are associated bands of sandstone conglomerate, some of the boulders in which are 6 in. or more in diameter. There are two or three such bands of conglomerate, and then farther north and lower in the sequence, a very considerable thickness of brown sands underlies and forms a range of hills that, striking north-west, is crossed by the road, the saddle being 875 ft. above the sea. The beds here form an anticline, and north of this ridge the dip is to the north-east, at low angles, and this dip continues till nearing the crest of the next range of hills, which rise to a height of 1,050 ft. above the sea. The beds showing in this range are alternations of brown sandstones with blue sandy or calcareous sandy clays, with occasional bands and concretionary masses of cement-stone. The change of dip again to the south-west takes place on the south-west side of the saddle, about six miles from Whangamomona, and on this resumption of the south-west dip the same is continued to the north-east, but always at low angles as far as the Tangarakau.

From the Whangamomona Township the road follows for the first six miles the valley of the Whangamomona Stream, and the rocks, so far as seen, are a succession of soft brown (at the surface) sandstones and sandy clays more or less marly. The formed road terminates on the saddle leading into the valley of the next stream farther to the north, and thence a bridle-track leads to within a little more than a mile of the Tangarakau River, seventeen miles from Whangamomona.

Before reaching Sladden's survey camp, one mile from the Tangarakau, a high range of hills has to be crossed, which exposes marly clays with concretions. At the northern base of this range marly clays appear in which there are a considerable number of fossils—mainly marine shells, but corals belonging to the genus *Flabellum* are also present. Near Sladden's camp a change takes place, and brown sandstones are exclusively found to the Tangarakau and as far up stream and along the banks of the river as was reached by me. The last rock-exposures showed a dip still at low angles to the south-west.

So far as I reached, the strata everywhere must be referred to as Tertiary rocks, and I concluded that the rocks associated with the coal in the Tangarakau Valley must be of a different age and character. From what I learned at Sladden's camp it would appear that no change takes place, the rocks adjacent to and overlying the coal being described as similar to those passed over between the camp and Whangamomona; also there seemed strong reasons to believe that the quartz pebble-beds described as occurring some miles to the south of Strathmore are present towards the source of the river, as such pebbles are found plentifully on the banks and in the bed of the Tangarakau. Also, I could learn nothing as to the presence of the Mokau limestone in this district, and the conclusion was almost forced upon me that within this part of the Wanganui watershed the coal-seams will prove to be at the base of the Tertiary series of formations. On the other hand, from Park's description of the rocks of the Mokau coalfield† it appears there might be doubts both as to the Cretaceo-tertiary age of the Mokau coalfield and as to a difference in age of the coal that appears to lie at the base of the sequence here described. If it be otherwise the boundary between the Tertiary and the coal-bearing formation must be nearly as shown on the map of the district which accompanies Park's report of 1886 "On the Geology of the Western part of the Wellington Provincial District and part of Taranaki." The accompanying sketch shows the arrangement of the rock along the route of travel between Toko and the Tangarakau River.

The Under-Secretary, Mines Department. ALEXR. McKAY.

RESULT of ANALYSIS of Specimen No. 8529, forwarded by the Government Geologist from Tangarakau River. Received 29th April, 1899; reported on 3rd May, 1899.

Brown Coal.—This sample as received contained 18 lb. per cent. of water. The analysis here given was made upon it as pulverised and exposed to the air for three days—the accidental water is therefore excluded in the computation. The coal is non-coking, burns pretty fairly, and gives a buff-coloured ash.

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* "Geological Reports," 1886-87, p. 57. † "Geological Reports," 1886-87, pp. 44-47.

Analysis.

Fixed carbon	50·14
Hydro-carbon	27·72
Water	15·01
Ash	7·13
	100·00

Evaporative power on old standard—the American formula, 6·5 lb. The above results prove this to be a good coal of its class. WILLIAM SKEY, Government Analyst.

REPORT ON THE SUPPOSED OCCURRENCE OF AURIFEROUS ROCKS AT HORSE-SHOE BUSH, NEAR WADE, AUCKLAND.

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

IN 1884 I visited Wade in connection with the general geology of the East Coast, Auckland, north of Waitemata Harbour to Mahurangi, and at that time examined some prospecting works on Mr. Lloyd's farm, and further west some outcrops of highly siliceous rock on Mr. Bond's property.

In the case of the prospecting shaft on Mr. Lloyd's farm, this had been sunk through marly strata and fine-grained sandstone forming part of the coal-bearing series as this is developed in the Wade district. Nests and small veins of calcite occurred in these rocks, but quartz was absent, and I had to conclude that the prospector had mistaken calcite for quartz. Further up the valley, on Mr. Bond's farm, quartz-rocks, apparently the deposit of a hot spring, appeared on the hill-slope on the west side of the valley. This was supposed to contain gold, but its appearance was certainly unfavourable for the occurrence of that metal. From the immediate district, more towards the Orewa, prospecting for reefs is at present being carried on, and during my last visit I was shown samples of quartz of a kind likely to carry gold. A test of this stone made in Auckland gave but a trace of gold.

In the matter that more immediately concerns this report, the locality of the supposed find is at Horse-shoe Bush, five to six miles to the west of Wade, and two to three miles north-west of Dairy Flat. I was accompanied to the place by Mr. Acres, of Takapuna, who had applied to the department, requesting that this examination should be made. It appears that several years since some prospecting had been carried on here and in the vicinity, and returns of gold were supposed to have been obtained on samples being tested in Auckland. This seems to have led to the erection of a one-stamp battery, mainly a wooden construction, which is still in place at the mouth of the drive where the principal workings are situated. The material operated upon is a breccia conglomerate, which shows in the bed and banks of a small creek draining the south-west side of the hills between the waters going by way of Dairy Flat and those falling into the Wade River. The exposure is made along a line of fault, striking north and south, the hade of which is to the west at an angle of 60°. The breccia-conglomerate, showing on the west side of the fault, dips at a lower angle, but to the westward also shows as vertical banks 6 ft. to 8 ft. on each side of this creek, and forms the bed of a cascade for some little distance up the creek.

The breccia-conglomerate plunging to the west, a dip drive has been made in this direction, a distance said to be 40 ft. But the drive was full of water when visited by me, and the length of the excavation could not be ascertained. The material said to be auriferous was, however, well exposed at the mouth of the drive and in the banks adjacent. It consisted of fragments of soft green sandstone derived from the rocks underlying and eastward of the fault-line, mixed with a considerable proportion of chalky limestone and siliceous clays (fire-stone) bleached white, and containing a small percentage of calcite in plate-like pieces. The matrix of the whole was a greenish sandy mud derived from the underlying rocks, and a small percentage of the whole consisted of iron pyrites which had evidently formed since the other material was laid down.

I procured three dishes of wash from parts whence former prospects, said to yield gold, had been taken. These I took and washed with my own hands, with the result that not a single spangle of gold could be detected, although extreme care was taken in dealing with the material. When panned off to a very small quantity, no black sand remained in the dish, and no heavy material except a little pyrite. It was explained to me that the gold was contained in the slimes, meaning thereby in the muddy part of the deposit. This statement I could not very well credit, because unlikely in the nature of things, and, further, because in all three cases I had taken such care that any gold, down to what is usually invisible to the unassisted eye, must have been retained in the dish. I therefore concluded that the deposit was not auriferous. To this conclusion all the surrounding circumstances conspired, and the deposit in question is about the last in which an experienced miner would look for gold.

On inquiry as to what foundation there was for the supposition that gold was present, or what had induced Mr. Acres to apply for an examination of the locality as a gold-bearing one, I was referred to the returns said to have been made, but of which no actual proofs were shown, and further learned that no evidence of the presence of gold had been sought for immediately prior to application for my services in this connection, that it was solely because there was an idea that gold existed in the district—a wish rather—and that in order to place the thing before the public and on the market a report was required, that my services had been sought. This sort of thing is to be reprehended.

The rocks are Tertiary sediments, derived from the destruction of older Tertiary and Cretaceous rocks, are themselves in no sense mineralised, and, as far as the particular stratum prospected, of material not such as form the usual associate of the precious metal. The same material stretches across Dairy Flat south-west, across the upper part of Lucas's Creek to Riverhead, and eastward to

the base of the Hunua Range, and in the higher beds is essentially rhyolitic, and must be regarded as of Pliocene age; therefore not likely to be mineralised so as to give probability of its bearing quartz-reefs, and, as regards the material in an unaltered state, not at all likely to carry alluvial gold.

Samples of the breccia-conglomerate were taken for the purpose of being further tested in Wellington. These, for the present, have been mislaid, and the results of the analysis of these cannot for the present be given; but the tests made on the ground were amply sufficient to show that no payable gold exists in the deposit examined.

22nd March, 1899. ALEXR. McKAY.

SIR,—

In the matter of Professor Hutton's communication of the 14th October, 1898, I have the honour to report that between the 19th and 26th of November last the Assistant Geologist (W. A. McKay) visited Pelorus Sound and made examinations with a view to the determination of the different rocks present, and more especially to ascertain the source of the boulder of sandstone with foot-print thereon, forwarded by Mr. H. Wynn Williams to Professor Hutton.

The results of the examinations made tend to show that no Tertiary rocks are present in the immediate neighbourhood of where the boulder showing the foot-print was found. The fundamental rocks of the area east and south of Clova Bay are silky argillaceous schist (phyllite) and a semi-metamorphic rock that prior to alterations consisted of fine-grained breccias and sandstones. Both these rocks are not younger than the Devonian period. A raised beach of modern date is found on some parts of the shore of Clova Bay, but the material of this is generally coarse and angular with patches of finer material as incoherent sands. The alluvial deposits of the various creeks are of the same character, and thus neither of these younger deposits can have been the primal source of the boulder impressed by the foot of a bird as described by Professor Hutton. This has therefore been derived from a distance, or if the beds on which the foot-print was stamped did at one time exist in the vicinity of Clova Bay they have been removed, and, excepting one solitary boulder, no trace of them remains.

Since the following report was written a letter received from Mr. Williams states that fossiliferous strata of probable Tertiary date occur about eight miles from Clova Bay, and it is therefore just possible that the specimen found on Manaroa Run, Clova Bay, has been derived from a distance. Some thirty examples of the rocks of the district round Clova Bay were collected. These are all of Palæozoic age, and had it been that even a remnant of Tertiary sandstone remained the probability is great that this would be represented in the collection made.

I have, &c.,

The Under-Secretary, Mines Department. ALEXR. McKAY.

MEMORANDUM OF INSTRUCTIONS for MR. W. A. McKAY, Assistant Geologist.

BY the first opportunity you will proceed to Picton and there make inquiries as to the best means of reaching Manaroa, on the east shore of the outer part of Pelorus Sound, where, on the property of Mr. H. Wynn Williams, your work will begin. The position of Mr. Wynn Williams's homestead is marked on the plan herewith supplied for your guidance, and on which you will mark the boundaries of the different formations that may be present. The principal object of your examinations will be the collection of further samples of foot-prints of struthious birds in the soft sandstone of the creek near Mr. Williams's house. As Mr. Williams found and forwarded to Professor Hutton the original of these impressions, and having an interest in the matter, he will probably aid you in pointing out the locality whence he obtained his specimen. The formation containing these foot-prints is probably not of great extent, as to the eastward the western slopes of Mount Stokes (see plan) is composed of foliated schist, a metamorphic rock totally unlike the sandstones in which the foot-prints occur, and to the westward, the peninsula in that direction is also probably formed mainly of schist. Your first work, therefore, will be to study the sandstone at and near where the foot-prints have been found. Observe and note carefully the strike and dip of the rocks. Follow the sequence upwards to the uppermost beds present, describing the different varieties of rock, and collecting samples of the same (samples to be not less than 4 in. by 3 in. when squared and well dressed), which must be ticketed or labelled on the ground, and a catalogue of the same made as the collections accumulate. Search carefully in the different exposures of the younger formation for remains of marine life, sea-shells, &c., and, failing to find such evidence in the overlying rocks, follow the sequence downwards bed by bed, if possible, till the lowest resting on the schist is reached. Wherever the rocks are of a flaggy character, be sure that you split many of them in the hope of finding foot-prints of some kind in the partings of the rock, and in the lower part of the section be as careful to search for marine fossils, and to make collections of rock-specimens as has been stipulated for the upper part. You should have no difficulty in mapping the younger formation containing foot-prints, but see that you do not confuse it with the deposits of modern raised beaches which are present in other parts of the Sound, and are liable to occur at Manaroa. Professor Hutton is of opinion that the foot-prints occur in strata of considerable age, and this may prove to be the case, but marine fossils will be required to show this. On the other hand, it may be that the strata is comparatively recent, and scarcely to be distinguished from the modern deposits alluded to. This doubtful relationship should spur you on to search for the evidences the rocks contain of their ages. The older rocks consist of schist foliated with quartz, and a semi-schist without quartz foliæ. The first of these it is that which you are likely to find in the west lower slopes of Mount Stokes, and adjacent to the sandstones, more especially engaging your attention. Examine the older rocks for lodes of quartz and other indications of the presence of metals.

If there be difficulty in reaching Manaroa, the best plan will be to consult John Duncan, of the Grove, at the head of Queen Charlotte Sound. A letter of introduction will be given you, and as he knows all about the different arms and bays in both sounds, his advice should be followed. Probably you must reach Manaroa by boat from Mahakipawa or Havelock. Mr. Williams probably avails himself of small vessels trading to Havelock. In any case, there is some ready means of reaching the place.

In as far as you can, make your examinations complete. If you find marine shells in the formation affording the foot-prints, it will not be needful that a further and more rigorous examination be made, as the fossils will determine the age and the rock-collections will show the character of the strata. ALEXR. MCKAY.

12th November, 1898.

REPORT ON THE DISTRICT EAST AND SOUTH OF CLOVA BAY, PELORUS SOUND.

By W. A. MCKAY, Assistant Geologist.

SIR,— 8th December, 1898.

In accordance with your instructions dated the 12th November, I proceeded to Manaroa, Pelorus Sound, for the purpose of examining certain strata from which have been obtained rock-specimens carrying impressions considered to be the foot-prints of struthious birds, as indicated in your memorandum of instructions.

I left Wellington on the 16th November and arrived at Manaroa on the 19th, and on the following day saw Mr. Wynn Williams, who forwarded to Professor Hutton the original specimen of supposed foot-print of a bird, and to whom, therefore, I have to be indebted for pointing out the exact locality whence the specimen was obtained. As described by Mr. Wynn Williams, the specimen forwarded to Christchurch occurred as a loose boulder on the left bank of a moderately-sized stream that drains from the western slopes of Mount Stokes into Clova Bay, an arm of Pelorus Sound. The deposits of which the boulder formed a part consist of ordinary detritus brought down from higher levels and deposited, as is usual by mountain torrents, on each side, or alternately on one or other side of their valleys. The material is therefore coarse, and scarcely, if at all, stratified, and there are no beds of finer grain associated with the coarse angular bouldery deposit that obscures the fundamental rocks of the creek-valley. The stream at the present runs in a channel lower and at some distance from where the specimen was found.

The character of the country surrounding Clova Bay is of extreme ruggedness, and, except the lower shingle-flats of the creek valleys, the district is heavily bushed. Geographically the northernmost portion of the peninsula (which includes Manaroa) is but the ramifications of Mount Stokes. The only flats in the district are the areas formed by the alluvial of the creeks, which, however, are considerable, considering the size and drainage-area of the creeks. It was on one of these alluvial deposits that the imprint was found as a loose boulder by Mr. Wynn Williams. Geologically the country around Manaroa consists of a sandstone of a tough, fine-grained character, which in places contains much quartz in the form of stringers. The formation must go back for a considerable distance in the direction of Mount Stokes, for in none of the creeks around is there any sign of the underlying schist, and it is not until the outer heads of Clova Bay are reached that the older formation outcrops. The general strike of the sandstone is very regular, being east and west, while the dip is to the south at angles varying from 45° to 20° from the horizontal. It does not, however, give a very good example of stratification, the beds being thick and much broken up by joints.

In a section taken from the head of Clova Bay, along the eastern shore, a considerable development of recent deposit is shown in the form of raised beaches. The thickness of these beds is variable, ranging from a few feet to 20 ft. or 30 ft. The beds persist for fully a couple of miles, but in no case reach very far back from the water-line, and in places they are denuded, exposing the underlying beds to view. These deposits do not differ in their component materials from the present beaches in the vicinity, which consist of large blocks of stone, more or less angular, together with much smaller material, and the whole held loosely together in a matrix of sandy material. At some places the large blocks are absent, the smaller material being present with its matrix. The material of this conglomerate is made up of the detritus of the surrounding formations, being sandstone, brecciated sandstone, and schist. As aforementioned, these deposits—these beaches—expose between them the underlying sandstone. In the section under consideration these beds on the water's edge are always in a condition of far-gone decomposition, although the same rocks higher up on the hill-sides are perfectly sound.

At a point about half a mile to the south of Harvey's homestead, under and in direct contact with these younger sedimentary strata, is a rock which I consider a schist, the area of which is small, and the overlying rocks predominate. This rock is much contorted, possesses distinct lines of foliation, and is apparently conformable with the overlying formation. It is, I believe, the uppermost bed of the schist formation outcropping about one mile to the northward. In character they do not correspond, the uppermost beds being much more contorted, while the lower bed is a fine-grained rock, having a silky appearance, with a greasy touch. The foliæ is well shown, while the whole of the beds are slightly contorted. The quartz contained is chiefly in small stringers and veins, crossing and recrossing, the whole forming quite a network. The strike and dip is very decided and regular, the former being 10° east of north and the dip to the east at an angle of 45°. This older formation I traced for a considerable distance northward. The strike carries these beds to the westerly head of Clova Bay. It does not proceed inland any distance on this shore, for its dip carries it under the greater development of sandstone. It occupies a narrow strip at the water's edge, and from the contour of the coast should again disappear at Hopai homestead, about one mile distant to the westward. The foliæ and the contortion are very well developed.

As on the eastern shore of Clova Bay, the beds are of the same fissile nature and bluish colour, having quartz laminæ and the same mineral distributed in veins. They strike 45° east of north and dip at an angle of 45° to the S.E. The highest of these metamorphic beds is the rock No. 2339, of which there is a small development at Harvey's, as mentioned previously. On this side of Clova Bay its relation to the older beds is plain. Overlying it is the ordinary sandstone, interstratified with a slaty breccia. The general dip is easterly at various angles from 45° to 20° from the horizontal, while the strike is 60° east of north. The raised beaches are quite absent on this section, and, in fact, seem only in evidence on the one section where found.

During all these examinations a strict search was made for fossils, and the operations were not confined to the coast sections, the creek, in the bed of which the imprint was found, being followed for a considerable distance, and also the bed of the Manaroa stream and others. Nothing, however, was found of footprints of struthious birds, nor any fossils.

W. A. McKay.

List of Rocks collected at Manaroa.

2332. Quartz in aphanite or chloritic schist.
2333. Phyllite.
2334. Semi-metamorphic sandstone, decomposed
2335. Phyllite, with quartz veins.
2336. Semi-metamorphic breccia.
2337. Indurated semi-metamorphic sandstone.
2338. Phyllite, Hopai Point.
2339. Phyllite, western shore of Clova Bay.
2340. Green chloritic rock, with quartz veins.
2341. Altered Palæozoic sandstone.
2342. Indurated felspathic sandstone (quartz porphyry).
2343. Indurated felspathic sandstone (quartz porphyry).
2344. Phyllite.
2345. Phyllite.
2346. Phyllite.
2347. Semi-metamorphic schistose rock.
2348. Semi-metamorphic sandstone.
2349. Semi-metamorphic breccia, decomposed.
2350. Phyllite, decomposed.
2351. Semi-metamorphic rock, decomposed.
2352. Breccia of Palæozoic age.
2353. Semi-metamorphic sandstone.
2354. Indurated felspathic sandstone.
2355.
2356. Semi-metamorphic sandstone.
2357. Fine-grained sandstone.
2358. Semi-metamorphic breccia.
2359. Semi-metamorphic breccia.

REPORT ON THE GEOLOGY OF THE TROOPER RANGE, CASTLE POINT DISTRICT, WELLINGTON.

By W. A. McKay, Assistant Geologist.

Memorandum of Instructions for W. A. McKay, Assistant Geologist.

By the earliest opportunity you will proceed by rail to Masterton, and thence take coach, or other means, of reaching Castle Point, on the East Coast of Wellington. Take with you light outfit for camping, consisting of 6 ft. by 8 ft. tent and fly, and personal requirements suited for fine weather at the present season of the year. Provide yourself with a pick-hammer, and a lesser hammer for dressing rock-specimens. See that your barometer is in working order, and set to the mercurial barometer before leaving Wellington. You require a good pocket-compass, note-book, and packing-paper. Thus provided, camp at the eastern base of the Trooper Range, two to four miles south of Castle Point, at the debouchement on to the flat of the most considerable creek draining the east slope of the range, and from there as a centre commence the examinations, the nature of which are specified below. The object of your work is to collect the rocks of the Trooper Range, from the Masterton-Castle Point road south, to where the range terminates on the lower Whareama Valley. The rocks likely to be met with are sandstones and shales, with indications of coal. The coal-seams are small, but some of moderate thickness may be discovered. Search industriously for plant-remains in the shales, and sea-shells in any of the beds forming the Trooper Range.

A fine section is exposed on each bank of the creek near which you will camp. This must be examined, and described with care, and its rocks collected always in duplicate, and in the case of the more remarkable rocks, four hand-specimens should be taken. It was from a boulder in the bed of this creek that in 1874 I collected a specimen of Lucite. Lucite has not been found elsewhere in New Zealand, and the locality at Castle Point is, therefore, of great interest to petrologists. The particular rock looks like a fine-grained grey or dark andesite; but, while particularly attending to this rock, collect every variety of igneous rock to be found, not in this creek only, but in the other creeks that descend from the range.

Provide yourself with a sufficiently large-scale map of the district, and mark the position of the more important rocks and boundaries of the different formations and subdivisions made, while in the field and on the ground. Specially note the mode of occurrence of the igneous rocks, and if as dykes, ascertain the bearing and dip of these, noting their thickness, and how far they affect the sedimentary strata, and, in a word, every matter of interest concerning them. Collect samples of the different coal-seams, however small, and let all samples and specimens be accompanied by a ticket or label that will leave no doubt as to the exact locality of the specimen.

This work will occupy you till about Christmas. During the holidays you may return to Wellington or continue in the field, at pleasure. Keep a full diary of your daily proceedings, and report the results of your work under cover, addressed to the Under-Secretary for Mines. On finishing this work you should prepare a report, accompanied by map and section, showing position of the strata, dykes, &c., and generally illustrative of the matter of the report.

Wellington, 15th December, 1898. Alex. McKay.

Report on the Geology of the Trooper Range.

Under instructions dated the 15th December, 1898, I left Wellington *en route* for Castle Point on Monday, the 19th December, arriving at my destination on the 21st. On the following day, the 22nd, I examined the section shown by the Castle Point reef, and from the 23rd December to the 4th January I was engaged in examining the sections shown on the right and left banks of the Ngakauau Creek, on the coast, and of the bed and upper part of the same creek, where it penetrates the Trooper Range; also, the whole of the coast-line as far south as the Whareama River, a distance of ten miles from Castle Point, together with a search up the Otahome and other creeks in the south, and at their sources in the Trooper Range. On the 5th and 6th January I was engaged in packing specimens, &c., and on the 7th I left by coach for Wellington.

REPORT.

Physical Features.

The country examined stretches from the Masterton-Castle Point Road on the north and as far south as the Whareama River, its boundary on the east being the Pacific Ocean, and on its west the range known as the Trooper. The Trooper Range is the dominant feature of the whole, and is a broken piece of high country trending the whole length of the district under survey in a north and south direction. It rises to heights of 800 ft. in places, and is flanked on its eastern side by lesser hills, causing the descent on this side to be much modified. The range is terminated to the north by the valley of Whakataki Creek, while to the south its termination overlooks the Whareama, a river of considerable size, having a tidal entrance. Between these two rivers, a distance of ten miles, there is but one creek or watercourse worthy of the name—viz., the Ngakauau—which penetrates the Trooper Range in a westerly direction by a deep gorge, piercing back into it along a moderately-flat bed, the rise to near its source being not more than 200 ft.

Other than the Ngakauau, which reaches the sea two miles and a half south of Castle Point, there are no permanent creeks, the Otahome and others being for the greater part of the year dry watercourses. The country for the most part is open, or covered with a vegetation of scrub, forest land being all but absent.

General Geological Sketch.

Geologically, the country is made up of a series of rocks belonging to the Upper Cretaceous system, consisting of the coal-rocks of the Lower division, and the glauconitic sandstones of the Middle division. The coal-rocks themselves, made up of conglomerates, shales, and sandstones, with coal, are overlaid directly by limestone of Miocene age, as seen in the Castle Rock and the adjoining reef. Alluvia in the district is represented by the river-gravels of the Whakataki Creek and of the Whareama River, together with the æolian deposits at Castle Bay and on the coast-line to the southward, and marshy land in the beds of the Ngakauau and Otahome Creeks.

Table of Formations.

1. Recent	...	... Alluvial and æolian.
2. Upper Miocene		... Castle Point limestone.
3. Cretaceous	...	(*a.*) Glauconitic sandstones, sandstones, and shales. (*b.*) Conglomerates, sandstones, and shales, with traces of coal.

3. *Cretaceous.*

(*b.*) *Lower Division.*—The rocks of this division are the most important in the district. In extent they occupy a stretch of country from Castle Rock in the north, to a point two miles below the Otahome Creek on the south, and, in breadth, the width of the district examined. Neglecting the recent deposits, the sea-coast bounds the division on the east, a line drawn (approximately) westward from Castle Rock on the north, the limits of the survey on the west, and the foot-hills of the Trooper Range on the south. The rocks of this division form a series consisting of shales, sandstones, and conglomerates, the sandstones of which include much carbonaceous matter.

On the coast, stretching from Castle Rock southward, to a point a mile and a half below the Ngakauau, is seen the best section of these rocks, the coast-line being cut down in precipitous faces. Of the three members of this division the most important is the sandstone in which occurs the coal. This generally is a coarse, gritty rock, well bedded, in places being laminated in very thin beds. Interstratified with it as thin streaks is the coal, which is coal rather than buried plant-remains. The coal is very generally distributed throughout, occurring at times as pockets, but more often giving a laminated structure to the rock.

Invariably associated with the coal-rock (the sandstone) are beds of shales and mudstones. These vary as regards their thickness, being in places as much 4 ft. and 5 ft thick, while at times they are but 1 in. Although the coal-rocks are never present without the associated shales and mud-stones, yet at places these latter beds only appear. With the above coal-rocks are also associated conglomerate beds varying in thickness from a few inches to 2 ft., and also in the size of the component materials, the pebbles contained varying from 2 in. to pieces $\frac{1}{4}$ in. in diameter. Belonging to this division are sandstones unassociated with either shales, coal, or conglomerates, of a grey colour, well stratified.

To both the north and the south of the Ngakauau Creek, where these coal-rocks are well exposed, they have undergone contortion to a considerable extent. On the right bank of the stream on the coast the strike is 70° west of north with the dip almost horizontal and to the westward. In this case both the dip and the strike noted is purely local. Further on, the same beds are crumpled and contorted in all directions, the plications are small and the disturbances local, and, in consequence, they assume their ordinary course as rapidly as they veered from it. The normal strike of the beds is in a northerly direction with a dip of about 45° to 50° to the westward.

About half a mile to the south of the creek, on the coast, another small and local disturbance occurs, differing from the one just mentioned as having crumpled the strata very much; causing a displacement of from 2 ft. to 10 ft. without altering or shattering the beds themselves. This displacement can be traced not more than about 20 ft., and the beds beyond continue as before in the regularity of their strike and dip, till in the south, on approaching the Otahome Creek, they give way to the overlying soft sandstones and shales, which, in their turn, disappear under the blown sands.

To the north of the Ngakauau Creek and on the coast the same occurs again. The regularity of the strike and dip is broken by a succession of local faults and disturbances. On the left bank of the Ngakauau, in consequence of these disturbances, the beds strike due east and dip south at an angle of 15°. Passing this fault, which occupies approximately about 200 ft., the beds assume their normal strike and dip, the strike being 20° east of north, while the dip is at an angle of 60° and to the west.

At a point about half-a-mile north of the creek the strike alters to due north with a dip of 45° to the west, while further on the beds become quite flat and the interstratified shales become thinner. As Castle Rock is approached the coal in the coal-rocks becomes more abundant, occurring in places in pockets 2 in. and 3 in. thick, while the interbedded shales assume a more indurated and slaty character, and, as Castle Rock is neared, occur without the presence of the coal or the coal-rock. As mentioned before, the coal-rocks to the south disappear under a development of soft sandstones and shales, which rocks again are soon covered by the blown sands near the Otohome creek.

About two miles and a half to three miles up the Ngakauau, and in the heart of the Trooper Range, the typical coal-rocks again appear, the strike being due north and the dip 45° west. Here they consist of gritty rock with coal. The rock is very soft and friable. The coal is distributed in thin veins and laminæ and is of good quality. Associated with the beds are the usual shales and mudstones, and conglomerates, the former being thin-bedded.

(*a.*) *Middle Division.*—Second in importance is the Middle division of the Upper Cretaceous system, occuping two separated areas. The southern area is bounded on the south by the Whareama River, on the east by the Pacific Ocean, on the west by the limits of the survey, and on the north by the foothills of the Trooper Range. The northern area of the same division is bounded by the Whakataki Creek, in the north by the ocean and the Miocene rocks of Castle Point, on the west by the limits of the survey, and on the south by a line drawn in a general westerly direction from Castle Rock. There are no strong physical features to mark the boundary between the Lower division and the Middle division, excepting perhaps that the Lower division does not rise to any height on either the northern or southern boundaries. The division consists of a series of sandstones of various grades of coarseness and thickness, and of glauconitic rocks, associated with finely bedded shales.

On the left bank of the Whareama is seen a grey-coloured sandstone, interstratified with a grit of a similar colour, containing lime, the strike of which is 50° west of north, and the dip westerly, at an angle of 45°. Continuing north, this strike of the beds is changed to due north, while the dip has altered till, at places, it is seen to be quite vertical. Further on, the beds assume their normal direction and measurement, which are at no variance with the underlying rocks of the Lower division, in consequence of which the beds strike in a general northerly direction, with a westerly dip at 45°. At a distance of about one mile from the coast, and at a height of 600 ft. above sea-level, an outcrop of glauconitic rocks appear. They are of the usual green colour, with veins of glauconite passing through. The rock is coarse, and at places weathers to a grey colour. The strike and dip of these glauconitic rocks are never very distinct, but, as well as could be determined, differ in no way from the beds of the same division on the coast. In the valley of the Otahome, where the underlying rocks of the Lower division appear, a series of shales and sandstones are exposed. These are thin-bedded, and are associated with the glauconitic rock. They are well stratified, the strike being 20° west of north, and the dip at 65° to the west. The northern area consists of grey sandstones of a fine-grained character, together with shales and mudstones.

At a point about a mile and a half up the Whakataki Creek, from its mouth, the beds are composed of shales and sandstones, having a strike of 40° east of north, and a dip of 50° to west. These beds disappear under the alluvial of the creek. At the mouth of the Whakataki, small outcrops of a grey-coloured sandstone appear within the tide-way, and continue south to the head of Castle Bay, where they are seen to overlay a series of soft friable shales of a grey colour, upon which rest the Miocene rocks of Castle Rock.

At a point about due west from Castle Rock, at a height of 500 ft. above sea-level, is a sandstone, presumably a greensand oxidised to a deep-brown colour. Its strike is 40° west of north, dipping west at 45°. It is composed of gritty grains of quartz, cemented by iron-oxide. The whole beds as exposed are decomposed, but, if the decomposed zone of the rock could be passed through, the rock would be seen to be glauconitic sandstone, in no way differing from the glauconitic rock in the southern area. The sandstone immediately overlying it has a strike of 60° east of north, and dips east at 45°, while the beds upon which this decomposed glauconite rests strike 40° west of north, and dip west 45°.

2. *Upper Miocene.*

There is a very small but prominent exposure of the Miocene rocks. It forms the precipitous rock and adjoining reef known as Castle Point, trending in a north-east direction, having a width of about 500 ft. In Castle Rock it rises to a height of 400 ft. in vertical walls, being a very prominent landmark, while the reef itself, with vertical sea-walls, rises to 150 ft. or more. It is composed exclusively of a shelly limestone, which is seen in three or four different beds containing shells which are in different stages of conversion into a sub-crystalline limestone. In the uppermost beds the shells have dropped out from their calcareous matrix, and

where they have not fallen, the binding-material has been so much removed that the shells are projecting, giving the whole rock an extraordinarily rough and coarse surface. This applies to the whole of the beds, but elsewhere secretion has gone on considerably, and the result is in places that the shelly character has been almost obliterated, and a sub-crystalline limestone is the result. The effects of this action can be seen in various stages, in even moderately small hand-specimens. On a larger scale the effects can be seen in the cave which penetrates the reef from east to west, where a stalactitic growth is in formation. The cave, seemingly, is the result of the enlargement of a blowhole, of which there are a number on the reef. From the Castle Rock to the end of the reef the beds have a synclinal arrangement. At the point of the reef they have a low dip to the south-west, with a strike of 45° west of north, while at the southern end, with the same strike prevailing, the beds dip north-west, and still at low angles.

1. *Recent.*

The alluvial deposits call for but little comment. They consist chiefly of blown sands and morass, while in the Whakataki Creek bed occurs the ordinary detrital of a river. From the friable nature of the beds it traverses, the material has been reduced in size to small pebbles and sands. The material is chiefly the detritus of the shales and mudstones of the Lower division, and the glauconitic rocks of the Middle division, of the Upper Cretaceous system. The alluvial above is continued towards the southward to Castle Bay as blown sands. From the Otahome Creek to the south, æolian deposits are in evidence, covering up the Cretaceous rocks for a length of two miles. Due to the low fall, and the smallness of the body of water carried by the Ngakauau, Otahome and other creeks, their alluvial occurs chiefly as morass, of which both creeks have a considerable area.

Igneous Rocks.

The instruction in part received was to search for and examine dykes and other igneous rocks. As mentioned in those instructions, Mr. A. McKay found in 1874, in the bed of the Ngakauau Creek, a specimen of Lucite. Although the Cretaceous rocks further to the south, at the Kaiwhata River and at Waikikino, are penetrated by igneous intrusions, no such thing was anywhere observed in this area. The creek-beds of the Ngakauau particularly were examined, and the sections of the coast, all with the same result. The courses of the other streams in the district were also examined. As the area under survey is approximately twenty-five square miles, the same detailed examination could not be given to other parts that the rocks in the valley of the Ngakauau and the sections at its mouth received in the time taken. Moreover, the survey here dealt only with the eastern watershed, the summits of the Trooper Range being the western limits.

30th June, 1899. WILLIAM A. McKAY.

REPORT ON GEOLOGY OF EAST COAST FROM THE KAIWHATA RIVER TO GLENBURN, EAST COAST OF WELLINGTON.

BY W. A. McKAY, Assistant Geologist.

MEMORANDUM OF INSTRUCTIONS FOR W. A. McKAY, ASSISTANT GEOLOGIST.

MR. McKAY,— Wellington, 30th December, 1898.

On finishing your work between Castle Point and the Lower Whareama Valley, you will forward a progress report embodying all the facts you have collected respecting the area you are now engaged on. The collections made should be boxed and despatched, addressed to the Under-Secretary for Mines. They should be sent by sea from Castle Point, when opportunity offers, by some coastal steamer. You can arrange for the despatch of the collections, so that you may not be delayed in commencing further work south of the Whareama River, and the Under-Secretary must be advised as to the time of the despatch of the specimens, so that they may be received on arrival at Wellington.

These things done, or provided for, proceed to the Kaiwhata River, and camp, at least for a time, at the point where the stream leaves the hills and the road to Flat Point crosses it. You can provide yourself with stores and what else you may require from stations in the Lower Whareama or from Flat Point Station. Your work in this part will be—First, an examination of the valley of the Kaiwhata River, along which splendid sections of the rocks present are seen. Ample collections of the rocks must be made, the different formations discriminated, and your work placed on the maps while in the field. Sections must be sketched as, and when, seen, and ideal sections while yet the facts are fresh in your memory. The river must be followed up until reaching the Palæozoic rocks of the Brocken Range, constituting the water-parting between the Kaiwhata and the Upper Pahaoa. The rocks in the middle and lower valley of the Kaiwhata are probably of Cretaceous age, but fossils must be sought for in proof of this assumption. The rocks are of extreme interest, and consist of sandstones, shales, and limestones, associated with bodies of volcanic tuff and ash-beds, and numerous dykes of diorite, or syenite, and other hornblendic or augitic rocks. Second, having mastered the section along the river and the geology of the Kaiwhata Valley generally, continue the survey along the mountainous country in the direction of the Pahaoa Gorge, and approach your work from the coast-line at convenient and not too great distances from the last line of intersection. Third, search the older rocks for quartz-reefs and minerals of all kinds, and see also to the mineral contents of the younger formations.

This piece of country is practically unexplored, and in it you have a rare opportunity. Make ample field-notes, and let these, revised and in letter form, as progress reports, be sent as regularly as can be to the Under-Secretary. ALEX. McKAY.

Narrative.

The above instructions arrived at Castle Point after my departure, and followed me back to Wellington, where I received them.

Having utilised the 9th and 10th January in necessary preliminaries, I left Wellington on the 11th, arriving on the night of the 13th at the Lower Whareama Valley, and camped on the 14th in the valley of the Kaiwhata, about five miles from the coast. I commenced by making a trip up the Kaiwhata as far as the Te Maire Creek, and then down the river to the coast, which occupied three days, after which I started a detailed examination, beginning on the coast and working as far south as Flat Point, and gradually working up the Kaiwhata River and its tributaries, the Little Kaiwhata, Bismarck, and others, till Te Maire Creek and the Brocken Range were reached. This took from the 18th January to the 20th February, and included packing, collecting of fossils, and camp-work; during the whole of this time the weather was very bad.

From the 21st February to the 25th March I was engaged on the East Coast Road section, and in the middle area generally, which includes examination to the coast and south as far as Glenburn, to the southward down the Pahaoa Valley, also the Taipo Ranges, the valley of the Ruamahanga, &c. This took up my time till Saturday, 25th March, on which date I received notice to return to Wellington. The remaining days were occupied in packing, &c., and on the 29th I arrived in Wellington.

Description of the District.

The country under examination is situated on the East Coast of Wellington, about due east from Carterton and Masterton. On the north the approximate boundaries are the Kaiwhata River and Te Maire Creek, while the west is limited by the ranges of the Brocken and Taipos, the west by the Pacific Ocean, while the southern boundary is a line drawn from Glenburn on the coast to the southern end of the Taipo Ranges.

In the instructions the original intention was for the examination to proceed as far south as the Pahaoa Gorge, but the prevalence of broken weather made it impossible to get further south, than above indicated, in the time at my allowance. The block under survey is about twelve miles in length (from the mouth of the Kaiwhata River to Glenburn) and ten in width. The surface of the country is much broken, and is made up of two distinct systems of ranges, both trending in a south-east direction, and consequently parallel. Between them they contain two large valley systems containing the two dominant rivers, the Kaiwhata and Pahaoa, which valleys and rivers are divided by an extensive development of the coast range in a spur trending west till it almost abuts on the range of the Brocken. Of the two systems one is the coast range called the Maungaraki, which, commencing at Glenburn (in this block) keeps the coast till the south side of the Kaiwhata Valley is reached, at which point the range is cut through almost to sea-level by the river coming from the westward. At Glenburn, the range is perhaps at its greatest height, attaining to a point about 1,700 ft. or 1,800 ft. above the sea-level. Its mountainous character is maintained throughout and to the northward its elevation suffers but little till it is crossed by the East Coast Road from Carterton to Glenburn, where it descends to 1,000 ft. At this point the whole ridge loses in height and narrows very much and does not recover itself in height and breadth of its development till it nears the Kaiwhata. To the south of this river, without losing height, it occupies a considerable amount of the country, and its ramifications and spurs spread till reaching close to the sea on the east and to the southern portion of the Brocken on the west. The heights within this part are, at this point, little less than 1,400 ft. After crossing the Kaiwhata to the north the range continues on without any diminution in height, the slopes on the coast side of the range are precipitous, while the western side is broken up and flanked by the Kaiwhata. The whole range is characterised by its ruggedness.

West of the Pahaoa Valley, and opposite the Maungaraki Mountains, is a range of picturesque mountains of about 2,000 ft. in height, which commences at the junction of the Pahaoa and Wainuioru, about nine miles in a westerly direction from Glenburn, and continues to trend in a north-east direction. There is an important and peculiar break in their continuity. Just before the Kuamahanga Stream, a tributary of the Wainuioru, is reached they suddenly disappear, and the lower-lying country of the Kuamahanga takes their place for a distance of three miles, north of which space the Brocken Range commences, and continues the line of the southern range, *i.e.*, preserving the direction of the Taipos to the south. The Brocken Range differs but little geographically from the southern end of the system. The range is rough, and its sky-line presents a most fantastic outline of pinnacles and gulches. Towards the south the height becomes lower till the range merges with the lower elevations to the north of the Kuamahanga. The range of the Brocken has no great width, and the precipitous sides give to it a very striking appearance, standing out from the surrounding country like a huge dyke. It gives out few or no spurs, excepting, perhaps, in the north-east, near the junction of the Te Maire Creek and the Kaiwhata.

Continuing to the southern portion of the system, the Taipos are almost identical in physical respects to the range of the Brocken, having the same beetling cliffs and grotesque outlines. They differ, however, in being divided into two sub-parallel ranges, and while the eastern slopes are a series of precipices, the western sides are flanked by spurs and isolated hills, giving the range a very picturesque appearance. The height attained is about 2,000 ft.

Included between these two mountain ranges, the Maungaraki, and that of the Taipos and the Brocken, is the low-lying country through which the various rivers and tributaries make their way. The elevation of the valleys does not fall much below, or rise much above, 500 ft. The valley depressions, as a rule, are hilly or undulating; occasionally they are flat. The mountain-system has divided the country dealt with in this report into two distinct parts, the one, the valley of the Kaiwhata, the other, the valley of the Pahaoa, the latter resulting by the westerly development of

the Maungaraki Range. In these valleys the streams almost invariably cut through the rocks in deep trenches, varying from a few feet to deep cañons of 200 ft. and more in places. The consequence of this is the striking absence of alluvia in the district, and what there is is a fine pulpy mud, forming dangerous quicksands.

The river-system is very simple, and consists of two rivers with their tributaries: one, the Kaiwhata, rises to the north-east of the Brocken and flows south, taking on its right first the Te Maire Creek, the Waipapa and Haukawakawa streams, all draining the east side of the Brocken, while the Bismarck, as its chief confluent coming from the south-west, joins it about six miles from its mouth, and drains the country to the south of the Brocken. At a point about two miles and a half below the Bismarck Creek the Little Kaiwhata, from the western spurs of the coast range, joins the main stream. On the left bank is the Mangamouku and Prospectors' Creeks, both draining the western slopes of the Maungaraki.

After receiving the Little Kaiwhata, the main stream makes a turn from its prevailing southerly direction to an easterly one, and thus penetrates the coast range by a deep gorge some 800 ft. in depth. Debouching from the mountain range the river receives no further tributaries in a course of four miles to the sea, over which it passes along a broad bed with high banks in country that is hilly, rolling, and at places flat.

The Little Kaiwhata River and the Bismarck Creek both take their rise in the high mountainous ridge that forms the western development of the coast range, this spur being an important water-parting of the district under survey. It gives direction to the waters of the Pahaoa flowing south-west, and to the Kuamahanga flowing north-west to meet the Wainuioru; and although the range has nothing to do with the source of the Kaiwhata, yet it influences its final direction before it gains the coast.

The Pahaoa, rising on the north side of the East Coast Road, about three miles west of Wharau, after following a southerly direction for about three miles alters to a south-easterly. The general direction, as indicated, is very regular, yet along this line the river makes a very sinuous course, never proceeding any great distance without a turn. On both banks it receives small streams draining the western slopes of the Maungaraki with Deep Creek and others, flowing from the eastern flanks of the Taipo Range.

The Kuamahanga, a stream of no great volume, but of considerable length, rising not far from the source of the Pahou and Bismarck Creek, flows north-east to meet the Wainuioru. Almost from its source to the boundary of this survey it runs in a deep gorge between walls 100 ft. to 200 ft. in height, which, being bush-clad the whole way, gives a very picturesque appearance. Its bed is very uniform, which is characteristic of all the creeks and rivers in the district, notwithstanding the fact of the fall being very often considerable.

On the coast the streams are of necessity very short, the Maungaraki Range (the water-parting) being at no greater distance than two miles from the coast.

General Geology.

The main geological features consist of an underlying formation of Palæozoic rock, dipping in a westerly direction, upon which rests a formation containing coal and limestone of Upper Cretaceous age, forming in part synclines and anticlines, which ultimately disappear in the vicinity of Flat Point, leaving the main mass, dipping easterly, to continue south. These Cretaceous rocks appear usually underlying a series of clays and soft sandstones of Miocene age, which, for the most part, characterize themselves by keeping the low ground between the two parallel mountain ranges. They are generally of a low dip, and often horizontal. Over the coastal part of the district recent deposits, alluvial or æolian, have a moderate development. The only detailed material of any extent is in the lower reaches of the Kaiwhata, and a long strip of sand-dunes and other deposit on the coast, stretching from Flat Point to Glenburn, varying in width from a few hundred feet to a mile or more.

Table of Formations.

1. Recent		Blown sands, river gravels.
2. Lower Miocene		Clays, soft sandstone, conglomerates.
3. Upper Cretaceous	(*a.*) Upper division ...	Limestone, glauconitic sandstone, shales, sandstones.
	(*b.*) Middle division ...	Micaceous sandstone with plant-remains and *Inoceramus*.
	(*c.*) Lower division ...	Coal-rocks with clays, conglomerates, grits and coal, shales and mudstones.
4. Triassic or Carboniferous		Sandstone, serpentinous sandstone.

4. *Triassic or Carboniferous.*

This formation occurs in two separated areas, the one to the north of the Kuamahanga, the other to the south of the same stream. The general trend of the whole is in a north-east direction. In giving the boundaries, those to the west are omitted, on account of their being outside the block of country under survey.

Commencing with the southern area, and at its lowest extremity, its eastern boundary is found to conform with the general north-easterly direction of the Pahaoa River, on the right bank of which it keeps at a distance of about a mile. This direction is kept for about three miles, at which point it changes to due north, to again change to a north-west near Wharau, on the East Coast Road. The rocks wedge in at the confluence of the Pahaoa and Wainuioru, but nowhere cross the streams. The formation dips under the cover of two younger series of rocks. The Middle division of the Upper Cretaceous rocks, commencing on its boundary about two miles south of Wharau, overlie the beds for a distance of about three miles to the northward, when

their place is taken by the Miocene rocks of the Kuamahanga. The same rocks bound the formation in the Pahaoa Valley.

In the northern area, which is separated from the southern area by the low ground of the Kuamahanga Valley, the south boundary is the beds of the Cretaceous formation, with a westerly trend, which, giving way to the Miocene beds of the Bismarck Creek, change the boundary to a north-easterly direction. The formation keeps strictly to the high rugged country of the two ranges—the Taipos—and that of the Brocken, and occupies them to the exclusion of other rocks. The series consist mainly of a somewhat fine-grained sandstone, the beds of which are at places interstratified with drossy serpentinous shales. The whole does not present any variety. Everywhere they are much shattered, so much so that it is all but impossible to make out any strike and dip in the rocks. At only one place could this be determined with anything like accuracy. Everywhere they have been splintered and contorted in all directions. But in the one or two localities where dip and strike could be ascertained, as on the eastern flank of their exposure, about two miles from the junction of the Te Maire and Kaiwhata Creeks, at a height of 800 ft., it is seen to be at an angle of 40° to the east with a northerly strike. These measurements were approximately confirmed at a point about the same height four miles south of the East Coast Road.

In the Te Maire Creek, interstratified with these rocks, are seen drossy and serpentinous shales. There is a number of bands, all of which are crumpled and contorted. The approximate dip is at high angles, while the strike is in a northerly direction. The thickness of the bands is not great, not more than 1 ft., and at places no more than 2 in.

3. *Upper Cretaceous.*

(*c.*) *Lower Division.*—These rocks are the most extensive and important in the district, extending the full length of the district under survey, and occupying in places a width of four miles. This formation bounds (almost as a consequence) all the older and younger deposits. It is divided into two distinct and separated areas. One is a narrow strip occupying the East Coast from the right bank of the Kaiwhata at its mouth to Flat Point. It is not of any great width, being no more than one mile wide. The other and more important area is of extreme irregularity (in its boundary lines); commencing on the western flank of the Maungaraki Range in the Pahaoa Valley, it extends in a narrow strip in an easterly direction, narrowing down as it approaches the East Coast road to about half a mile. It here rises to the summit of the range in this section, and a little further north it extends westerly in a narrow neck to spread to the northward to meet the valley of the Kaiwhata and to the south as far as Whatipu Creek. The western portion continues north, keeping the mountain-tops and the western flanks of the Maungaraki Range. With the exception of a limited exposure of the Middle division of the Upper Cretaceous rocks in the Little Kaiwhata Stream, this part of the series occupies exclusively the western flanks of the Maungaraki Range. At the Kaiwhata it narrows down to about two miles, at which point it makes a northerly turn and trends along the left bank of the Kaiwhata Stream. The eastern branch of this area is very regular, trending in a general north and south direction between alluvial deposits and Miocene rocks on the east, and the Upper division of the Upper Cretaceous rocks on the west. These same rocks also give the western division its regular easterly boundaries, differing from the somewhat tortuous boundary provided by the Miocene and the Middle division of the Upper Cretaceous rocks on the west.

Of these two areas of this division the best exposure of the coal-rocks is in the smaller. It consists almost exclusively of the typical carbonaceous rocks and the associated beds. At the northern end they rise in a precipitous sea-face from 100 ft. to 200 ft. in height. Further south the hills recede. They do not penetrate inland up the Kaiwhata Valley very far before they disappear under the Younger Miocene formation. The rocks are identical with the coal-rocks of Castle Point, concurring with them in the persistency of the strike being due north, and in their westerly dip. The angles at which they disappear vary from 75° from the horizontal to almost vertical. This high dip is not generally attained by the same rocks elsewhere. The texture of the coal-rock is coarse, granular, and gritty. They are in all cases well stratified, occurring in laminations as small as $\frac{1}{16}$ in. to 1 in. in thickness. At places the laminations are wavy. Coaly matter is the predominating feature of the whole, occurring in small veins and pockets.

Invariably associated with these coal-rocks are beds of conglomerate, shales, and mudstones. In this area the inclusions in the conglomerates are small and do not make up such a proportion of the whole as the same beds elsewhere. The contained pebbles are in places small, and occur in many bands. Besides these conglomerates interstratified with the rocks under notice, is a series of fine shales and mudstones having none of the characteristics of the containing beds. They occur in varying thickness from a few inches to a couple of feet and more. In places they show much crumpling. As Flat Point is neared these shales and mudstones become associated with a coarse, gritty sandstone containing plant-remains, which take the place of the coal-rocks described above.

Owing to the cutting down of the face of the sea-cliff being approximately along the strike of the coal-rocks, and to the limited width of this area, no extensive section can be seen. Notwithstanding, the relation of the beds is very important when the general structure of the country is considered. For their whole length on their western boundary, they are overlapped by the Younger Miocene beds stretching southwards from the Kaiwhata, and in conjunction with their easterly beds they form the remnant of an important syncline that once was connected with the beds dipping east, belonging to the Lower and Upper division of the Upper Cretaceous rocks.

In the second and larger area of this formation, these typical coal-rocks occur in two distinct places. They are well seen in the watercourse of the Little Kaiwhata Creek, and in the main creek above the confluence with the smaller stream. These coal-rocks here comprise the usual shales and mudstones with conglomerates, but, due possibly to the larger section shown, they are

seen in several bands, and are interstratified with fine-grained sandstone and at places with coarse interstratified rocks. At the Little Kaiwhata they strike 20° west of north, while the dip is to the west at 50°. The strike of the beds carries them through a dividing spur to the main watercourse of the Kaiwhata. At this point, about half a mile from the smaller stream, the fine-grained sandstones and shales strike 10° west of north, with a dip of 45° to the west. These rocks are very fissile, the colour bluish, and the thickness of the bands is 2 ft. to 4 ft. The upper beds are thinner, while the dip in places is almost flat, and elsewhere they are vertical. They are associated with beds of conglomerate, which conform with the general strike and dip of the interbedded rocks. In places they no way differ from the same beds more intimately connected with the typical coal-rocks, but at times they assume the appearance of a slaty breccia, the fragmental inclusions being angular and set in a matrix which has undergone induration.

These beds are interstratified with coal-rocks similar to those of the coast, being the same coarse gritty rock with fine laminations, wavy in places, and possessing coal in veins and pockets. As on the coast, they are associated with the mudstones, shales, and conglomerates. The whole beds, however, differ in the mode of their occurrence in having associated with them another rock of the series, which is a coarse dyke-like mass of sandstone of a grey colour. This rock has plant-remains, which occur in great frequency towards to the west in the high range to the south of Bismarck Creek.

Of the coal-rocks, the conglomerates in this section are of much greater extent than elsewhere, and the component materials are much larger, the boulders being in places 4 in. and 6 in. in diameter. The dip of these beds at a point one mile above the Little Kaiwhata junction is to the west at an angle of 40°. At the junction of the Lower division of the Upper Cretaceous rocks with the Miocene beds, these coarse conglomerates, together with the massive beds of sandstone, give way to shales and finer sandstones, so that the line of demarcation is not so striking as might be expected.

In the small section, as shown on the East Coast Road, which is no more than half a mile wide, the gritty coal-rocks again appear. They occupy the crown of the hill, and to the east they are covered by the limestone of the Upper division, while the Miocene clays, shales, and conglomerates, rising from the valley of the Pahaoa, overlie them on the west. The associated conglomerates are not exposed, nor the clays and shales to any extent. The coarse, dyke-like rock mentioned elsewhere occurs, however, and rises in vertical walls from the adjoining beds in a way highly suggestive of volcanic material. The coal-rocks have a general north and south strike, while the dip is 40° and to the west.

Continuing the section across the intervening limestone through to the coast, the Lower division, consisting of sandstones and shales, are found to be much shattered and contorted, making it at places almost impossible to determine the strike and dip. At places the dip is low, at others high and in opposite directions. Its true angle is, however, always high, and the prevailing direction of the dip is easterly. This section along the East Coast Road is the shortest of the rocks of the Cretaceous system, and with the limestones it represents the remnants of the denuded syncline explained in describing the strata elsewhere. The trough of the syncline (the Miocene rocks of the lower Kaiwhata) is absent, together with a portion of the underlying beds. Further south it is reduced to still less dimensions (as regards its component beds) till nothing but the limestone rocks, dipping east, is left at Waikikino.

The coal-rocks continue a little south of the East Coast Road as sandstones with plant-remains, and associated with conglomerates, occurring as isolated patches in the swamp-land on the coast-line and in the tide-way. Of the remainder of the strata constituting the Lower division of the upper Cretaceous rocks little can be said other than that the rocks on the east slope of the Maungaraki mountains on the East Coast Road continue north, and occupy the area between the limestone and the Miocene rocks; while, as mentioned elsewhere, in the extreme west are the coarse, thick-bedded sandstones and shales, with and without plant-remains, dipping under the Miocene beds in the north and under the Middle division occupying the lower ranges in the valley of the Kuamahanga River.

(*b.*) *Middle Division.*—These rocks occupy two regularly-shaped areas, the one being in the valley of and in the country drained by the Kuamahanga River, and the other in the gorge of the Kaiwhata River, about three miles from its mouth, while an exposure of this rock occurs in the Little Kaiwhata Creek at its junction with the larger stream. The Kuamahanga area is about four miles in length and two in width, and the general trend north and south. It is bounded on the south by the Miocene rocks of the Pahaoa Valley, and forms the lower ranges at the head of the Pahaoa River. In this area of the Middle Division, like the Miocene beds, these do not raise themselves anywhere to any height; and, although they are found as a rule at higher elevations than the younger beds, yet they never are on any but the subsidiary ranges and spurs, and are confined to the outlying ranges lying to the west of the Maungaraki Range. On the west they are bounded by the foot-hills of the Taipo Ranges and the Miocene beds of the Kuamahanga River, on the east by the Lower division, and on the north by the Secondary rocks of the Brocken.

The Kuamahanga area and the small rock-exposure in the Little Kaiwhata are made up of a bluish-coloured micaceous sandstone, to the exclusion of other rocks. In the upper tributaries of the stream plant-remains are frequent. At places the rock is a little less micaceous, otherwise they present no variety throughout its whole extent. The strike is difficult to determine with any exactness, for the beds, although finely bedded, are twisted and much disturbed. The rocks being soft, they have given way to movements that would not have affected some of the older rocks. The best examples of the strike and dip are seen about two miles west of Wharau. Here the strike is approximately 30° west of north, and the dip westerly at high angles.

The second and perhaps the most important area of this division is seen in a small exposure in the gorge of the Kaiwhata. It is about a mile and a half in length, with a width estimated at

about a quarter of a mile. It is bounded on the north by the alluvial of the creek and the limits of the survey, on the south and east by the coal-rocks, and on the west by the limestone of the Upper division of the same rocks. In this area the division is made up of a glauconitic sandstone, grey sandstone, shales and mudstones, and micaceous sandstone, all of which are here seen standing at high angles, and when not vertical the dip is invariably to the eastward.

The lowest rock of the division is a decomposed glauconitic sandstone in the bed of the stream, with a strike of 45° east of north, and a dip to the west at an angle of 60°. Above this, is a series of beds of glauconitic sandstone interstratified with fine-grained shales and sandstones, the latter having plant-remains. These strike 15° west of north, and the dip is almost if not quite vertical. Overlying is a blue micaceous sandstone similar to the beds in the Kuamahanga, having the same fine texture. The interstratified grey sandstones are very thick-bedded, at places being 10 ft., without any apparent cleavage or line of deposit being seen. The associated sandstones and shales all conform with the glauconitic rock in the matter of their high dips and strike. Throughout the whole series calcite is in quantity, occurring as minute stringers or veins up to 2 in. in thickness.

Towards the eastward, down the valley of the Kaiwhata, where the glauconitic rocks have been separated from the main body by the encroachment of the alluvial, the rock is seen to be very much decomposed, which has given them various colours, ranging from bright yellow, red, blue, and a rich sooty black. The relation of these beds to the underlying rocks of the Lower division is not well seen. In the west they are separated from them (the coal-rocks of the coast) by the alluvial, and on the west the junction with shales and sandstones is, for the same reason, not visible.

(*a.*) *Upper Division.*—This important branch of the Upper Cretaceous rocks is broken up into two separate areas. The larger of the two commences at Glenburn in the extreme south, with a width of about four miles, extending over the Maungaraki Range into the valley of the Pahaoa. The eastern boundary for about two miles follows the coast-line till abreast of Whatipu Creek, and about one mile south of the East Coast Road, when, due to the conformation of the coast-line, it trends inland. The boundary of the formation is still due north, having on its east the coal-rocks. On the western side the boundary is first in an easterly direction, which quickly narrows the formation, till abreast of Whatipu it is no more than two miles in width. With both boundaries in a general north-east trend the divisions get less and less in width, till on coming to the East Coast road, they are only half a mile in width. Thus it is seen that the area is triangular in shape. The division for the most part keeps the main range of the Maungaraki, occupying both flanks in the south, and rising to the highest peaks. But passing Whatipu the beds keep to the eastern flanks, and at high elevations gradually rising from the low ground till the lowest beds are 800 ft. in height. The second area of these rocks is a long strip stretching from the Kaiwhata, where it cuts the coast range to a point within two miles of the northern extremity of the southern portion. The trend of the Kaiwhata area conforms with the southern portion, its eastern and western boundary having a general north-easterly direction. Its greatest width is about one mile. It occupies the eastern flanks of the Maungaraki, and to the north of the Kaiwhata rises to form the highest peaks, while it also descends to the creek-bed in the gorge of the river. As it proceeds south it gradually narrows, and runs out a little to the north of the East Coast Road. The boundaries of this division are made up, for much the greater part, of the underlying coal rocks, while in the Kaiwhata area the eastern boundary is for a very small distance the Middle division. In the south the Recent deposits form its eastern boundary. The limestone which exclusively composes the division in both areas is for the most part fine-grained and white, but in places is of a bluish colour, and at others, of an incoherent nature. In the gorge of the Kaiwhata the strike is 30° west of north, which carries it to form the highest peak above the gorge. The dip is 45°, and to the east, in places, calcite has been deposited in thin veins, forming a complete network, spoiling what would otherwise probably be an excellent lithographic stone. This refers particularly to the limestone in the vicinity of Glenburn, in the south. On the East Coast Road the beds are seen to be dipping 40° to the east, with a strike of 20° west of north.

2. Lower Miocene.

This formation has a considerable development in the district, and in all it occupies four distinct and separate localities. One is located in the valley of the Pahaoa in the south, another occupies the Bismarck Creek and Kaiwhata River, a third the Kuamahanga Stream, and a fourth is an area extending from Flat Point northwards.

Commencing with the largest and most important development of the formation, the first is the Pahaoa area. It occupies almost exclusively the whole valley of the same name. As a rule, the beds confine themselves to the low ground. This also refers to the whole formation throughout the district. An exception to this is in the Pahaoa area under consideration, which at places rises to heights of 800 ft. In its boundaries it is limited by the surrounding Cretaceous rocks on the north-east and the south, while the Secondary rocks, rocks of the Taipo Ranges, bound them on the west. The trend of the whole is in a south-east direction, narrowing in width as it proceeds. In the north-west it attains its greatest width along the coast-road, varying from three miles to three miles and a half, while lower down the stream, by the encroachment of Maungaraki Range from the eastward, they contract to a width of two miles. The beds are not found any distance away from the right bank of the Pahaoa, nor do they occupy any portion of the foot-hills of the adjoining Taipos, thereby differing from the same rocks on the eastern and southern boundary. On the western flanks of the Maungaraki (the coast-range), as mentioned elsewhere, the beds reach a height of 800 ft., and, although this elevation is attained and kept for almost the whole length from Wainuioru southwards, yet the tops of the ranges are never occupied by these rocks.

At places, as on the low saddle by which the East Coast Road crosses to the coast, the rocks rise to within 200 ft. of the water-parting. The high elevations which these Miocene beds

reach in this Pahaoa area, as compared to the low position occupied by the beds of the same formation, is due to the strong representation of the lower beds, which consist of a fossiliferous conglomerate, with but a small admixture of arenaceous material. These rocks are abundant at the base of the formation on the hills to the north of Wainuioru, and on the high slopes to the south of the East Coast Road. Elsewhere in this area the rock is not so prominent, and its absence is signalised by feeble resistance to denudation and a consequent low elevation. In the north, a little to the eastward of Wainuioru, they are overlying blue micaceous rocks of the Cretaceous age, which soon give way in the westward to the Secondary rocks, and in the eastward and southward to the underlying and older beds of the same series. The rocks of the uppermost are soft clay and sandstones, with harder bands at places interstratified with them. As a rule these are lying at low angles, while the beds below on the slopes of the coast range are tilted at considerable angles.

The second, or Kaiwhata area: This, both in point of size and importance, is in the valley of the Kaiwhata, about six miles from the mouth of the river. It is triangular in shape, and is about three miles in length, while its width is about two. Its physical boundaries are the foot-hills of the high ranges, completely surrounding it—viz., the Brocken on north and north-west, and the main range of the Maungaraki on the east and its western development on the south. It occupies about two miles of the lower portion of the Bismarck Creek, flowing into the Kaiwhata, and along the main river it extends to within a mile of the Te Maire's junction with it, and about half a mile south of the Bismarck Creek. Differing from the Pahaoa area of the same rocks, this exposure nowhere rises to any heights, occupying in all cases the low-lying parts of the valley, not rising above 500 ft. to 600 ft. This want of elevation is due to the absence of the fossiliferous conglomerates at the base of the series, the presence of which answers for the comparatively high elevation of parts of the Pahaoa area. In this locality the formation consists of soft shales and sandstones, interstratified with conglomerates and mudstones, the whole overlain by a heavy bed of mudstones, unassociated with sandstones or conglomerates, and possessing no fossils. These last beds are very conspicuous on the northern boundary, near Te Maire Creek. The strike of the beds are very regular, being 30° east of north, while the dip varies from 45° to almost flat. In all cases the high angles are confined to the lower beds, while the beds lying nearer the horizontal are the uppermost. The conglomerates, as aforementioned, at the base of the formation are absent, but their detritus is found in the creek beds as alluvial.

In section this area does not present much, its relation with the surrounding and underlying beds being simple. In the east and south it lies directly on the Cretaceous rocks, containing coal and pierced with volcanic intrusions. On the north the Cretaceous rocks give way to the Secondary rocks of the Brocken, which are in juxtaposition with all the beds of this area.

Third area, Kuamahanga: Directly west, and at a distance of about two miles, is a third, and the smallest area, of these Miocene beds. It is here called the smallest, for the reason that its western development carries it into the valley of the Wainuioru, and beyond the boundary of the present survey, leaving the area to be described of very limited dimensions. Its area is about two miles in length, trending direct north, with a width of no more than a half to three-quarters of a mile. It covers an area exclusively made up of the lowest beds of the Miocene formation, consisting of a highly fossiliferous sandstone. The whole series, differing from the same beds on the west slope of the Maungaraki, is characterised by the beds lying almost horizontal. From the thickness or quantity of fossils in these beds they would almost constitute a limestone. But the shells themselves have altered very little since their deposition; the matrix is still arenaceous, while the fossils can be separated from it with careful dressing. The beds do not rise to any height—no more than 400 ft., 200 ft. of which is in perfectly vertical walls in the Kuamahanga River. In this area it lies directly in contact with micaceous rocks of the Cretaceous age.

The fourth area of these Miocene beds, stretching from the Kaiwhata river-bed to Flat Point, is of importance, being the trough of the syncline occupying the East Coast. At the Kaiwhata they are about one mile in width, and consist of soft sandstone and shales, with interstratified beds of conglomerate. On both their east and west boundaries they rest directly on the Cretaceous rocks. The beds themselves form a syncline, dipping west on the coast side and east on their inland side, while the central beds are almost flat. They lie upon the coal-rocks of the coast at an angle of 45°, while the strike is 40° west of north; while on the west they incline to the east at 40°, with a strike of 20° east of north. At their junction with the underlying coal-rocks on the east the formation consists of heavy beds of shales, mudstones, and soft sandstones. The latter are thin-bedded, but the shales and mudstones are 10 ft. thick in places. The strike is as indicated above. After undergoing some local changes in the dips and strikes, and in the thickness of their bedding, they assume a level course, and, while resting thus, they give support to a series of consolidated sands and sandstones. Their colour is grey, and the thickness is some 20 ft., while the upper part only is stratified (the sandstone, the strike of which is 30° west of north, and the dip, east at 40°).

The western portions of these Miocene beds are found resting upon the western portion of the syncline of coal-rocks, the actual member of which is the gritty coal-rock of the coast, which is here dipping east. The Miocene beds, consisting of conglomerate, interstratified with sandstones and shales, conform with them in their easterly dip, and pass under the horizontal beds at the axis of the syncline. They are not, however, represented on the west side, for on the coal-rocks of the coast are superimposed the thick-bedded shales and sandstone, without the conglomerates.

The conglomerates are in six or seven distinct and parallel beds, from 6 in. to 24 in. in thickness, and are composed of angular and subangular pieces of the adjacent formation, chiefly of limestone and glauconitic sandstone of the Cretaceous formation, and of coal-rocks and conglomerates of the same age.

1. *Recent.*

As mentioned in a previous part of this report, the alluvial deposits of the district are of a very limited extent, due to the fact of the Miocene formation carrying most of the streams. These rocks offer but little resistance to denuding action, and the streams cut them down in deep trenches and gorges, reducing the detritus to a fine mud and carrying it completely off. For this reason the Kuamahanga and Bismarck Creeks show very little alluvial, and it is not till the Kaiwhata passes through these Miocene rocks, and enters the older formation of Secondary age, that the river forms a broad gravelly bed typical of New Zealand streams. In consequence, the alluvial at the portion of the Kaiwhata is of moderate extent, occupying a strip of the valley from the sea-coast to a point where the stream makes its exit from the mountain gorge. Elsewhere there is a development of recent rocks, as shown in the blown sands and swamp-land on the coast stretching from that point to Glenburn. It has not penetrated inland for reasons pointed out elsewhere—viz., the proximity of the water-parting of the Maungaraki Range to the coast-line. North of Huatokitoki the deposit is composed for the most part of the coal-rocks upon which they are resting, while south of the same creek the coal-rocks give way to the younger beds of the same age, the coal-rocks being limited to isolated rocks within the tideway.

Igneous Rocks.

Associated with the Cretaceous rocks are igneous intrusions and tuffs, consisting of hornblendic rock and ejectamenta. They crop out in three separated localities: the first occurs in the Kaiwhata river-bed about a mile below its junction with the Bismarck Creek, the second near the confluence of the Te Maire and the Kaiwhata. In both cases the cutting-down of the creek has exposed the beds, and the rocks do not appear at higher levels. A third exposure occurs on the coast at Waikikino, covered in part by the sands of the sea-beach and other alluvial. In the Kaiwhata river-bed below the Bismarck Creek the igneous rock occurs as a dyke crossing the creek in a general north and south direction, which, as well as could be made out, was determined as its strike. It is a dark dense hornblendic rock decomposed to a brown at places; associated with it is a tuff containing calcite. These tuffs occur in much larger masses higher up the river-bed opposite Te Maire Creek.

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