Art. XIV.—*The Mokoia Aerolite; with a Few Introductory Remarks on New Zealand Meteoric Phenomena.*

By George R. Marriner, F.R.M.S.,* Curator, Public Museum, Wanganui.

[*Read before the Wellington Philosophical Society, 4th August,* 1909.]

Though several meteoric stones have been found in New Zealand, the information concerning them is difficult of access, owing to its being published in so many different journals; therefore, before describing the recent fall at Mokoia, I would like to briefly summarise the different meteoric phenomena witnessed in the Dominion. In doing so I will include all the evidence that can be found on the Makarewa and the Wairarapa meteorites, so that future workers on this interesting subject may find the data easily available.

Numerous brilliant meteors have from time to time flashed across our sky, but, unfortunately, very few have been recorded.

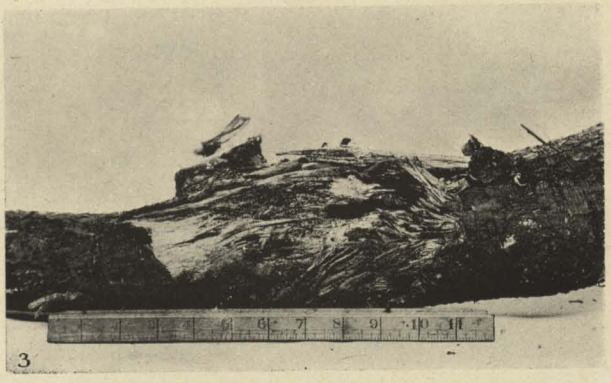
Besides these, three meteoric stones have been found, and by their analyses a little more has been added to our knowledge of the heavenly bodies. The first was discovered in 1864, at Tohirua, near Masterton, in the Wairarapa Valley, North Island, and is known as the Wairarapa meteorite; the second was found in 1879, at Makarewa, a small station near Invercargill, in Southland, South Island, and is known as the Makarewa meteorite; the third is the one included in this paper, and fell at Mokoia, in Taranaki, North Island, in 1908, and I have termed it the Mokoia meteorite.

The earliest instance of any meteoric phenomena being seen in New Zealand is one given me by an eye-witness—Mr. H. C. Field, of Wanganui—who states that it took place about the year 1853, but is not certain of the exact year. He describes it as follows: "I was standing outside my house at Waitotara, just after sunset, when I heard a loud whizzing noise overhead. On looking up I saw a brilliant body, apparently about the size of the moon, passing overhead in a S.S.E. direction, until it was lost behind some sand-hills. A few days afterwards I saw by a paper that it was seen in Christchurch, and was supposed to have dropped into the sea S.E. of that town. While travelling across the sky it gave out a white-bluish light."

The next account that I have is from the Rev. P. W. Fairclough, who says in a letter to me, "I happen to know that a great aerolite passed over Wanganui about 1865, or between April, 1864, and March, 1867. It made a loud roaring noise, and seemed to travel towards Nelson, low down."

Mr. H. C. Field records another meteor that was seen from Wanganui, between 1864 and 1867, but travelling in an opposite direction to the former. Unfortunately, I cannot get the details from the newspapers, as the early records of the Wanganui *Chronicle*, in which a report was published, were some years ago destroyed by fire. It seems that at 2 o'clock in the morning Mrs. Field was up attending to a sick child, when she saw a sudden flash which made the room as bright as midday and quite eclipsed the light of the candle that she was carrying. A few seconds later a tremendous explosion was heard, sounding very much like the noise made by people

* Mr. G. R. Marriner died on the 25th February, 1910.—[Ed.]



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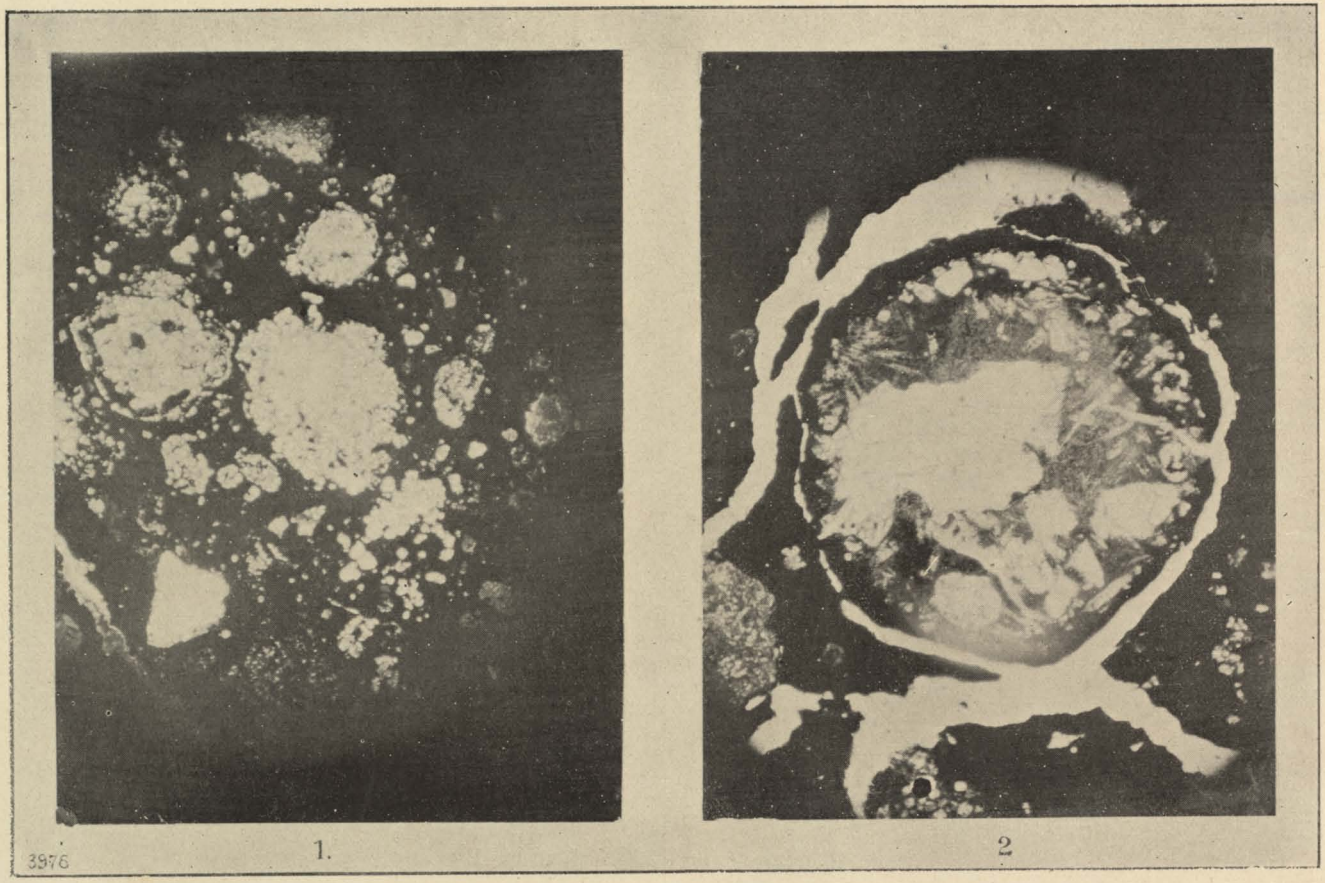
Face p. 176.



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THE MOKOIA AEROLITE.—MARRINER.

trying to imitate thunder by shaking a sheet of metal. Colonel Logan, who was stationed at Wanganui at the time, made all the sentries who were on duty that night report themselves to him next day. Mr. Field, who was acting-editor of one of the newspapers, was asked to be present. All the sentries except one stated that a very brilliant meteor came out of a thick bank of clouds off the mouth of the river and passed overhead northwards, and then exploded. The remaining sentry saw the meteor, but said that it travelled in an opposite direction.

THE WAIRARAPA METEORITE.

It was not till 1864 that the first specimen was discovered, by Mr. Richard Collins, at Tohirua, near Masterton, in the Wairarapa Valley, North Island.

In the *Geological Magazine* the following short account is published: "I have to thank Dr. Hector, F.R.S., Director of the Geological Survey of New Zealand, for a short account of the only meteorite which has yet been found in that colony, and which is preserved in the Colonial Museum at Wellington.* It is in the form of an irregular six-sided pyramid, 7 in. high and 6 in. across the base; the edges are rounded, and the sides slightly convex and indented with shallow pits. The capacity of the stone is 49 cubic inches; the weight, 480 oz.; and the specific gravity is 3·254; the hardness, 5–6. It is strongly magnetic, but exhibits no decided polarity. The surface is of a light rusty-brown colour, and is stained with exudations of iron chloride and sulphate. A freshly fractured surface is dark grey mottled with a bright metal-like particle of what may be iron-monosulphide. By treatment with copper-sulphate the presence of what may be iron in the form of metal was determined; with hydrochloric acid sulphuretted hydrogen was evolved, sulphur set free, and a large quantity of gelatinous silicic acid separated. The insoluble portion, consisting of silica and insoluble silicates, constituted 56 per cent. of the stone. In the soluble portion the predominating ingredients were iron (amounting to 24·01 per cent.) and magnesia, along with nickel, manganese, and soda; alumina and chromium are not present. These reactions so far indicate in the New Zealand meteorite the presence of olivine and an insoluble silicate, in addition to nickel iron and what may be triolite or magnetic pyrites."

There is also a similar account in the Juror's Report of the New Zealand Exhibition of 1865; it runs as follows: "An interesting form of iron exhibited was a rusty-looking mineral, weighing about half a pound, being a portion of a meteorite found in the Wairarapa Valley, in the Province of Wellington. It was not thought necessary to make a complete analysis of this mineral, but only sufficient to prove the similarity of its composition with that of other meteoric stones generally. The external surface of this mineral was of a rusty-red colour, in parts covered with exudations of chloride of iron, with a little sulphate. Freshly fractured, it showed a dark-grey colour, mottled over with bright metallic-looking particles (most probably protosulphide of iron). The shape of the mass is an irregular pyramid with rounded edges, measuring as follows: Height, 7 in.; length of base, 7 in.; breadth of base, 6 in.; contents, 49 cubic inches; weight, 9¼ lb. The surface was broken by rounded indentations never exceeding ½ in. in depth, evidently produced by weathering. No distinct cleavage was

* The stone was only deposited in the Museum. It is now in the possession of Mr. W. G. Mantell, of Wellington, to whom it belongs.

observed; hardness, 5 to 6; specific gravity, 3·254; moderately fusible in blowpipe-flame to a shining black magnetic slag with soda reactions. It was powerfully affected by the magnet, but did not exhibit any decided polarity. A little native iron was detected by the sulphate-of-copper test. Treated with warm HCl, a little sulphuretted hydrogen and sulphur were liberated, with a large quantity of silica in a gelatinous form. The total amount of insoluble matters after ignition was 56 per cent. of the original substance, consisting principally of liberated silica; the rest was undetermined silicates. Among the soluble matters, iron and magnesia predominated; there was a little soda, manganese, and nickel. Aluminium and chromium were tested, with negative results. The total quantity of iron present was 24·01 per cent. From the preceding facts it may be assumed that this mineral is a mixture of protosulphide of iron with iron chrysolite, with a small amount of insoluble silicates. The presence of native iron and nickel is almost conclusive of its meteoric origin." Mr. Donovan, of Wellington, is at present making a more complete analysis of this stone.

In 1868* Mr. E. Baker published an account of a brilliant meteor which was seen at Wellington. He says, "At about a quarter after 7 o'clock on the evening of the 5th August . . . I observed a light, very much brighter than the moon (which . . . was only two days old), shining brightly in a clear sky. The light appeared to be a large round ball of fire, about the size of the moon, travelling from an easterly direction towards the west. The ball of fire burst, and a portion of it apparently struck the ground at about fifty to a hundred yards from my house at Karori. There was a rumbling noise at the time of the descent of the meteor." Though mention is here made of a portion of the meteor falling to the earth, no stone seems to have been discovered.

In 1869† the Rev. A. Stock recorded a meteor which was seen at Wellington on the 8th November. He describes it in the following words: "It appeared suddenly in the E.S.E., at an altitude of 20°, and fell with a very rapid motion vertically. When it was first seen it appeared about three times as large as Venus, and shone with a yellow light. It suddenly appeared to diminish to a point of light, each diminution being accompanied with a shower of sparks, falling vertically. It suddenly increased to its old brilliancy, as suddenly diminished, then increased. Thus there were three brightnesses and two darker intervals. Another peculiarity was that it showed all the prismatic colours. There was no train of light left after its disappearance."

The Makarewa Meteorite.

In 1879 the second stone was unearthed, this time at Makarewa, near Invercargill, in the South Island.

Professor Ulrich, F.G.S., writing on the find,‡ says, "The stone under notice was not seen to fall, but the following description regarding the site of its discovery, its mineral character, and structure can leave no doubt of its being of meteoric origin. Towards the end of the year 1886, when a large party of mining prospectors were preparing, with Government aid, for departure to the Big Bay district, west coast of Middle Island, Mr. Th.

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* Trans. N.Z. Inst., vol. i, p. 39.
† Trans. N.Z. Inst., vol. ii, p. 402.
‡ Proc. Roy. Soc., 1893, vol. liii, p. 54.

Fenton, a student of the Dunedin University School of Mines, was sent to Invercargill, where the party assembled, to instruct those of the men who desired it in rough assaying for gold and the use of the blowpipe. On the occasion of one of his lectures he received from a Mr. Arch. Marshall, for examination, a piece of stone which, from its weight and appearance, was supposed to be something out of the common. Mr. Fenton made a rough qualitative analysis of a sample of the stone, and on finding strong reactions for nickel thought it of sufficient interest to preserve the several small fragments remaining of the piece received from Marshall and to bring them with him to Dunedin, where he placed them at my free disposal. One of these fragments I devoted to the preparation of a number of thin sections sliced in different ways, and the microscopic examination of these convinced me at once of the meteoric character of the stone. After this I made every endeavour, by correspondence and ultimately travelling to Invercargill, to ascertain the exact locality where and under what circumstances the stone was found, and to obtain more of it if possible, for the surface outlines of the remaining fragments clearly indicated that it must originally have been of considerable size. The results of my investigations in these directions are the following: In the year 1879, at the completion of the connection of the railway-line Invercargill–Winton and the branch line Makariwa [Makarewa]–Riverton, two workmen, the brothers Arch. and I. Marshall, while engaged in removing a clay bank at Makariwa Junction, found in the clay, about 2½ ft. from the surface, a roundish stone which at once attracted their attention on account of its weight and because of the fact that in the clay-covered plain surrounding Makariwa Junction stones of any kind are a great rarity. They broke the stone with the pick, and, finding the inside of different aspect from the outside, took the fragments home, and, experimenting with them, discovered that they affected the magnetic needle. With the intention of having the stone some day further examined, the pieces were kept as curiosities; but, being unsightly, they were kicked from one corner of the room into another, and specimens were occasionally knocked off for friends interested in the find. Mr. Arch. Marshall, who gave me these particulars, told me, on further inquiry, that the stone when originally found had a knobby, roundish shape, was of the size of a large man's fist or perhaps a little larger, and might have weighed between 4 lb. and 5 lb. The exact place of the find was about half-way between the railway-station on the Winton line and the Stationmaster's house, some 20 ft. from the line of rails. A search by Mr. Marshall for another piece of the stone, which he thought was still somewhere about the premises at the time he gave the one to Mr. Fenton, proved, unfortunately, unsuccessful, and the only secured pieces of this meteorite are the two pieces sent with this paper and another small piece divided between the Dunedin and Wellington Museums. The specific gravity of the stone, determined from several small fragments, varied between 3·31 and 3·54; the variation is no doubt due to the unequal distribution of the metallic particles." A very thorough analysis of this stone was made by Mr. J. L. Fletcher, M.A., F.R.S., Keeper of Minerals in the British Museum.

In 1905 another meteor was seen and heard at Wanganui, and I am indebted to Mr. J. T. Ward, Director of the Wanganui Observatory, for the following description: "The meteor train of 1905, June, 10 days 5 hours 30 minutes: The streak only was seen by myself, but others heard the report also elsewhere. When first seen the track was plainly visible as a

broad white band about 1·5° in width, on the western sky, in a straight line between the clouds; on looking a few moments later another portion of the band was seen, at an angle of about 90° to the first, bearing W. 65°; alt., 30°. Business prevented my watching it for any length of time, but it remained visible for about twenty minutes or more."

The Mokoia Aerolite.*

This stone is by far the most interesting meteoric find yet discovered in New Zealand, and is unique in being the only one that was seen to fall.

Mr. J. L. Fletcher, of the British Museum, states that few aerolites are known that have not been seen to fall. He points out: "This may be due to the fact that a meteoric stone is less easily distinguished than is a meteoric iron, from ordinary terrestrial bodies, and will thus in most cases remain unnoticed unless its fall has been actually observed, while, further, a quick decomposition and disintegration must set in on exposure to atmospheric influences."

It was found at Mokoia, a small wayside station about fifty miles north of Wanganui, on the North Trunk Railway.

At 12.30 p.m. on Thursday, the 26th November, 1908, the people living near Mokoia were startled by a number of loud, sharp reports coming from the north, like rifle-shots, following very closely after one another. Those who were outside state that before they could recover themselves a white flash shot across the sky, leaving only a thin white cloud. Almost immediately several objects were seen to fall. One fell with a thud in a pine plantation (*Pinus insignis*) within an eighth of a mile from Mr. C. Hawken's homestead, and half a mile S.E. of the Mokoia Station. Mr. Hawken heard the whizzing sound and the report when the stone came in contact with the earth, being within an eighth of a mile from where it fell.

A ganger at a bridge over the Manawapou Stream states that another piece fell into some thick bush on the steep bank of the stream; and some time after a third portion was heard whizzing through the air like a rocket, and fell into the creek with a splash and hiss.

The Noise of the Fall.

Mr. C. M. Campbell, of Inaha, gives a very vivid description of what he heard. He says, "On the 26th November I was living on the East Road, ten miles about due east from Stratford, and I heard the reports very plainly. At first it sounded like a loud furnace-blast, and then, at intervals from three to five seconds, the report seemed like heavy rock-blasting, but there was a roar like heavy thunder during the whole time. From the first blast to the last would be fully twenty seconds."

Several men who were working on the railway-line heard two sharp explosions, resembling the crash of a number of horses galloping over a bridge, or like numerous rifles firing in a volley; while others say that it sounded like heavy iron tanks being rolled about on a lorry. This was almost immediately followed by a louder explosion, and then a hissing sound similar to that of a rocket travelling through air.

I was in Wanganui at the time, and I heard a sudden bang, which I put down to a very sudden and short earthquake-shock, and naturally I

* Working on Mr. Fletcher's classification of meteoric stones, I have termed this one an aerolite.

thought no more about it until I saw in the newspapers that it had been heard much louder in other towns.

The noise of the fall was heard for a distance of over a hundred miles in a direct line, along the west coast of the North Island, from Mount Egmont to the Rangitikei River, and as far back as Pipiriki.

Mr. Clemance, schoolmaster at Pipiriki, states that so loud was the noise there that a man who was working some distance from the settlement hurried back, thinking that a powder-magazine had blown up.

What was seen.

The day, though slightly cloudy at Wanganui, was clear and cloudless around Mokoia, but very little could be seen of the phenomenon, owing to the bright sunshine. At Mokoia itself only a think streak of a white film or vapour was seen for a few seconds after the fall.

Mr. E. Evans, of Waingongoro, writing to the Hawera *Star*, says that he observed the disturbance, which he says was caused by the passage of two meteorites through our atmosphere, and which travelled along parallel lines, from N.E. to S.W., leaving behind two streaks of smoke like railway-lines. The smoke was observable for quite fifteen minutes after the meteors had sped their way. With nearly a blue sky for a background, the sight was of great interest, but Mr. Evans thinks that if the event had occurred at night the brilliancy of the light as the balls flashed through the air would have been a never-to-be-forgotten spectacle.

Mr. Walter Hosken, of Bell Block, Taranaki, gives the following account of what he saw: "It may interest you to know that I witnessed it from the New Plymouth Racecourse. I was attending the Show, and at about half-past 12 I was standing talking to two young ladies, when one of them drew my attention to a curious object in the southern sky, and travelling in a westerly direction. At first sight I thought it was a kite, but found that I was mistaken when it burst and left a long tail of smoke behind, but we did not hear any report."

Mr. H. Chadwick states that his wife was also on the New Plymouth Racecourse, and saw a similar sight, but heard no sound, owing, no doubt, to the amount of traffic on the road at the time.

Mr. A. C. S. Tebbet, of Rangitikei, describes the sight as like a big shooting star, brighter than the sun, with a long tail.

The Alarm caused by the Noise.

The noise caused by the explosions and the mass rushing through the air not only alarmed the people in the vicinity, but caused a great stampede among stock. At Waingongoro the cattle and sheep were thoroughly startled, and ran huddling together. At Kakaramea horses and cattle were much scared, the former especially so, and were seen galloping about the paddocks. At Mokoia the effect was similar, and a man who was ploughing some distance from the station had all that he could do to keep his team from bolting.

What fell.

As nothing was known in Wanganui of the phenomenon except the noise, it was not taken much notice of, but on Sunday afternoon Mr. William Syme called on me at the Museum, and stated that a meteorite had fallen near Mokoia. In support of this statement he produced a small

piece of rock of a dark colour, and said that it was obtained from the spot where the meteorite fell. My thanks are due to Mr. Syme for his promptness in letting me know of the fall, for the chances are that if he had failed to do so the stone would have been lost.

As the rock had all the appearance of a meteorite, I went to Mokoia by the first train on Monday morning. Fortunately for Mokoia, it is only a small station, with a few houses, a church, and a creamery, or else a fair amount of damage might have been done by the meteorite. I went first to Mr. Hawken's homestead, where the meteorite had fallen. He kindly took me to a plantation which surrounded his house, and showed me where the ground had been struck. He himself had heard the whizzing sound, and also the noise made by impact with the earth; but he did not send the boy to investigate until some time afterwards, so that no evidence is forthcoming as to whether the stone was warm when it reached the earth.

The spot was not more than two hundred yards from the house, near which the owner's children were playing.

In its descent it snapped off a small branch of a fir-tree, and then struck a root that was growing on the surface of the ground. The stone hit the buttress about 29 in. away from the tree, but only struck it half on; therefore it skidded off, after splintering the root somewhat, and buried itself in the earth. The hole was only 11 in. deep, 15 in. and 17 in. in diameter. In this cavity Mr. Hawken found the two lumps which are figured, and which are really the whole of the fragments that were found, with the exception of a few pieces which were found scattered around the hole to a distance of some yards. The lump A weighed 5 lb. 3 oz., and the lump B 5 lb. 2 oz.; and both were presented to the Public Museum, Wanganui.

I cut off the root showing the splintered portions, and deposited it, with the portions of the meteorite, in the railway-station. Then, walking for a mile down the line, I came to the spot where the other portion was supposed to have fallen. This was on the high, steep banks of the Manawapou Stream, in which a third piece was said to fall. The banks are about 100 ft. or 200 ft. high, and are covered with a dense undergrowth and bush, into which one sank up to the waist at each step. As the day was a rainy one, and the bush sopping, it made travelling very slow, and after half an hour's scramble, during which I did not get very far, I was obliged to get back in order to catch the train, without having seen any signs of the other supposed piece of the aerolite.

The aerolite seems to have passed over Mokoia, as the descriptions given to me by eye-witnesses all agree that it was directly overhead. As it travelled across the sky, the numerous explosions evidently split some fragments off, and these fell at this spot, while the aerolite proper apparently went out to sea.

There seems to be some evidence to show that after passing Mokoia the force of the explosions broke the stone into two pieces, as two eye-witnesses say they distinctly saw two streaks of smoke behind the aerolite. This is supported by the fact that at Castlecliff (situated at the mouth of the Wanganui River) a portion at least was seen to fall into the sea with a loud report; and a number of witnesses who were on the beach state that they saw a flash and the commotion caused by the mass falling into the sea, and they also heard the loud detonation.

Now, this place is about forty-two miles south of Mokoia, and, though the angle is too great for the stone to fall into the sea off the Wanganui

Heads, yet an explosion powerful enough to split the aerolite would easily give a portion of the stone a southern direction, so that it would fall near Wanganui.

The stone at Mokoia, in its fall, cut a branch of a fir-tree (*Pinus insignis*) in two at a height of 108 in. from the ground, and then fell on to a root that was growing on the surface of the ground and very much shattered it. When a perpendicular was dropped from the broken tip of the branch to the ground I found that the stone had travelled 46 in. due south from the time that it struck the branch. The branch was too small to alter its direction in any way.

By working from the above figures, I find that the fragments fell at an angle of 66° 56′ due south.

Analytical Report.

I am much indebted to Mr. B. C. Aston, Chief Chemist of the Department of Agriculture, who kindly analysed the stone for me. His report is as follows:—

"The fragment received for analysis consisted of fused globules interspersed in a black metallic oxide, while the centre of the piece contained nodules of a softer siliceous matter, white, grey, and purple in colour. The analysis below is probably only correct for the piece received, as the meteorite is evidently not homogeneous in character:—

Analysis.	Per Cent.
Ferrous and ferric oxide (as Fe_3O_4)	36·95
Ferrous sulphide	5·64
Nickel-oxide	2·20
Manganese-oxide	Trace
Silica	37·55
Alumina	2·62
Lime (CaO)	3·50
Magnesium-oxide	6·30
Phosphoric anhydride (P_2O_5)	0·64
Soda	2·86
Cobalt-oxide	Trace
Graphite	1·25
	99·51

The meteorite consists of the usual nickel iron generally found in meteorites (but in this case it has been completely oxidized), together with such siliceous minerals as augite and olivine."

Dr. C. Coleridge Farr, Canterbury College, who tested a fragment of the aerolite for its radio-active properties, says, "Your meteorite contains $0{\cdot}438 \times 10^{-12}$ gramme of radium per gramme of the meteorite. This is rather low value, judging from the radium contents of terrestrial rocks. The average of igneous rocks is about $1{\cdot}7 \times 10^{-12}$, or four times as great as the meteorite, and for sedimentary rocks about $1{\cdot}1 \times 10^{-12}$, or nearly three times as much."

Petrological Description of the Mokoia Aerolite.

Mr. R. Speight, M.A., B.Sc., Lecturer in Geology, Canterbury College, forwarded me the following report: "Macroscopically the stone is of a black-grey colour, with small rounded chondri of whitish appearance

plainly visible. The determination of the specific gravity of a fragment gave a result 3·41, which is somewhat low; but this meteorite is remarkably vesicular, which makes is appear lighter than it really is. However, the graphite constituent points to the former existence of a hydrocarbon, and meteorites with hydrocarbons appear to be noted for their low specific gravity. Under the microscope it shows the following characters: It consists largely of a groundmass of dark unindividualised matter, which contains numerous irregular crystal fragments of small size, consisting chiefly of olivine, and occasional patches of brownish glass full of bubbles and black dust. In this base are numerous chondri up to 1·5 mm. in diameter, usually rounded and distinct from the groundmass, but at times ill-defined and grading into it. Some of the patches are cloudy and indefinite in character, but obviously of crystal particles. Many of the chondri show a nucleus of coarser grain, with a halo of smaller grains between it and the surrounding base. When enstatite is present they usually exhibit a fibrous structure. They are composed chiefly of olivine fragments, which are brecciated and irregular in shape, much fissured by cracks, clear as a rule, and containing rounded black grains and bubbles, apparently of gas. The size of the fragments is tolerably uniform in each chondrus, with the exception of those showing the halo, and they grade downward from 1 mm. in length to those which can only be separated by higher powers of the microscope. Augite and also enstatite are present, some of the chondri being composed exclusively of the latter mineral arranged in sheaf-like aggregates, but it occurs frequently associated with olivine in the same chondrus. Small fragments of feldspars are occasionally seen with fine twinning of the albite type. The only means of determination that could be employed was Michel-Levy's method, and from the small number and size of the fragments even this was not altogether satisfactory. There were several small extinction-angles, but they ranged as high as 27°, corresponding to an acid labradorite. Anorthite appears to be the common feldspar of meteorites, though others have been observed occasionally. The chemical analysis shows that the rock contains no potash, but 2·86 per cent. of soda, and this may have come from soda-bearing feldspar, as none of the other minerals present are usually alkaline. Some of the chondri contain a small quantity of glass, occasionally as a kind of nucleus, and in one case it has apparently corroded the olivine crystal where it has been in contact with it. This is the only evidence which I have been able to find which points to a high temperature preceding the final consolidation of the meteorite. The phenomenon is an isolated one, and the brecciated structure of the chondri with their interior of larger fragments surrounded by a row of smaller ones, as well as absence of melting on the edge of the fragments, distinctly suggests that this has not been the case, or, if it has been, the rock has cooled very quickly. I was unable to detect with certainty in the specimen at my disposal any of the sulphides or native elements usually occurring in meteorites, and no doubt it belongs to that class usually designated as 'stony.'"

Dr. P. Marshall, Professor of Geology, Otago University, Dunedin, to whom I gave a fragment of the stone, sent me the following remarks: "As you anticipated, it proved a very difficult matter to make a section of the piece of the meteorite that you gave me. However, I send you the result. The clear crystals are olivine, and the spherules are, I fancy, formed of radiating crystals of the same mineral. There is a very little native iron. By far the greater portion appears to be magnetite. The magnet will lift

quite large pieces of the meteorite, and the mineral is perfectly opaque, so I have little doubt as to its nature."

In conclusion, I should like to express my indebtedness to all those who have so willingly assisted me, especially Mr. C. Hawken, Mokoia; Mr. J. L. Fletcher, British Museum, London; Mr. A. Hamilton, Wellington; Mr. J. T. Ward, Wanganui; Mr. R. Speight, M.A., Christchurch; Dr. P. Marshall, Dunedin; Mr. B. C. Aston, Wellington; and Mr. W. Syme, Wanganui.

EXPLANATION OF PLATES XXIV AND XXV.

PLATE XXIV.

Fig. 1. Fragment A of Mokoia meteorite; $\frac{1}{3}$ of natural size. Weight, 5 lb. 3 oz.
Fig. 2. Fragment B of Mokoia meteorite; $\frac{1}{3}$ of natural size. Weight, 5 lb. 2 oz.
Fig. 3. Portion of the root of fir-tree (*Pinus insignis*), showing where it was struck by a portion of the meteorite.

PLATE XXV.

Fig. 1. General structure of meteorite, showing chondri in base. × 15.
Fig. 2. Chondrus composed of olivine and enstatite separated by a circular crack from the surrounding base. × 36.

ART. XV.—*On the Radio-activity of the Artesian-water System of Christchurch, New Zealand, and the Evidence of its Effect on Fish-life.*

By C. COLERIDGE FARR, D.Sc., &c., and D. C. H. FLORANCE, M.A., M.Sc.

[*Read before the Philosophical Institute of Canterbury, 13th July,* 1909.]

SOME time ago a committee was set up by the Philosophical Institute of Canterbury to examine the various problems suggested by the artesian system of Christchurch; and, though the committee is in no way responsible for the opinions which will be expressed, and, indeed, may not agree with them, yet this paper may be regarded as a first result of its labours, as it fell to the authors to examine the water with regard to its radio-active condition, whilst others are undertaking other investigations.

The method of examining the water for radio-activity was that adopted by others, notably by Strutt. The water was collected in a flask holding approximately half a litre. This was immediately corked, with a piece of glass tube passing through the cork, on the outer end of which was a short piece of rubber tubing which was closed by a pinch-cock. The same time (twenty minutes) was allowed to elapse between the collection of each sample of water and the commencement of operations for its testing. To test the gas the indiarubber tube was connected to a Liebig condenser, and the water boiled so as to drive off the gases contained in the water. These, together with the air left in the top of the flask, which was never quite filled with water, were collected over water, and, to insure their all passing over into the collecting-vessel, at the close of the boiling the condensing-water was stopped, and steam was sent through the apparatus. The boiling