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

was continued for half an hour. After another interval (the same for all the waters tested, ten minutes) the gases so collected were passed on into an airtight electroscope which had previously been exhausted to about half an atmosphere. The partial vacuum so formed was never filled to atmospheric pressure by the gases collected from the water, as the volume of these was never sufficient. To make up for this deficiency, the necessary amount of air was allowed to pass through the whole apparatus to the electroscope, which acted as a further safeguard against any radio-active gas remaining in the tubes. Between the collecting-vessel and the electroscope two drying-tubes (the first containing calcium-chloride, and the second sulphuric acid) were placed. Previous experience had shown that these were sufficient to thoroughly dry the gas if (as was the case) it was passed so slowly through them that ten minutes was taken over the operation. The electroscope was charged to a potential of 220 volts, and the rate of motion of the leaf was examined by a reading-microscope with a micrometer eyepiece. The electroscope was standardised by performing the same experiment with a standard solution of radium, kindly given to us by Professor Rutherford. The solution used contained $3{\cdot}925 \times 10^{-10}$ grammes of radium, and before boiling was allowed to stand securely corked for at least three weeks, so that the equilibrium amount of radium emanation might be generated.

Results.—All the wells examined were found to contain radium emanation, though in none of them could any radium in solution be detected. For the standard solution of radium with the equilibrium amount of emanation the rate of leak of the electroscope was 64 micrometer-divisions per minute. The leaks per litre of the various wells examined were as follows :—

Well.	Depth in Feet.	"Leak" per Minute.
Museum	262	197·0
Boys' High School	290	209·0
Ward's brewery	420	199·7
West Christchurch School	490	144·6
Wharenui	406	163·0
Holly Lea	451	185·8
Waltham School	326	223·6
New well (Aikman's Road)	268	164·0
New well (Chemical Laboratory)	60–70	130·0
No. 1 well (Gardens)	65–75	143·0
No. 2 well „	65–75	135·5
No. 3 well „	65–75	143·0
Well-supply to aquarium in Exhibition	..	153·0
Dr. Moorhouse's well	238	152·0
San Marola Well, Papanui Road	..	127·0
Exhibition well	423	154·0
River Avon	..	27·0

Whilst these figures indicate that there is a considerable amount of radium emanation in the water of all the wells tested, they do not apparently show that there is any simple relation between the amount contained and the depth ; it is possible that some of the depths given may be wrong, though there is reason to believe that the distribution of the water-bearing strata is very irregular as regards depth. Thus we think, from consideration of nearness and radio-activity, it might be inferred that the same stratum supplied

both the Museum and the Boys' High School, whilst from the depths alone this inference might not be drawn. The conclusion might also be drawn that the water supplying Dr. Moorhouse's well does not pass through similar materials. For reasons to be subsequently explained, the wells in the Fish-hatchery Gardens of the Acclimatisation Society have been those most examined, and all these, together with a well of about the same depth at the new Chemical Laboratory building, give approximately the same radium-emanation content. On several of the wells—notably those of the Acclimatisation Society's Gardens—tests have been made several times of the radio-activity of the water; and the results show that over the period of these experiments (some two months) the amount of radium emanation per litre is approximately constant for the wells so tested. It is certain that the radio-active gas was radium emanation, for on several occasions the gases boiled off from a sample of water were left in the electroscope for four or five days, when the curve of decay followed closely that obtained from the gas boiled off from the radium-solution, and also the well-known radium-emanation curve. As a general rule, however, the rate of motion of the electroscope-leaf was determined as soon as the gas was in the electroscope—that is, one hour after the commencement of boiling. The leaks given are these, and not the maximum leak, which would occur about three hours later and would be about 25 per cent. more.

A comparison of the radio-activity of our springs with that of others is of interest. Curie and Laborde have examined the waters of certain mineral springs in France (Comptes Rendus, vol. cxlii, p. 1464). The radio-activity of these springs, expressed in our units, is as follows:—

Plombiers	Source Vanquelin	376
	Tron des Capucins	787
Aix-les-Bains,	No. 1	461
,,	No. 2	257
Bourbon-Laney, Source Le Lymbe		169
Contrexeville, Source de Pavillon		85
La Roche Posay		85

M. Repin (C.R., vol. cxlvii, p. 388) has given particulars of three other waters of special interest, whose values, expressed in the same units, are,—

Source de Villard Clement, No. 1	50
,, ,, No. 2	18
Source de St. Pancrece	27

The first series are well-known mineral springs which are rich in dissolved salts, and which might therefore be expected to contain a considerable amount of radium emanation. From these it will be seen that the waters of Christchurch contain an amount of radio-active gas comparable with that of well-known springs in Europe, and more than the amount in quite a number of these springs.

Seeing, therefore, that the Christchurch water contains radium emanation, and that this gas has properties of a remarkable and energetic character, it occurred to us to endeavour to ascertain whether any, and, if so, what, effects on animal life could possibly be ascribed to it. As fish were more likely to show its consequences than any other form of life, inquiries were set on foot relative to those inhabiting the streams and ponds supplied by the artesian system. Surprising results (to us, at any rate) were soon forthcoming. It appears that a disease amongst young trout in the yolk-

sac stage, called blue swelling, was until a few years ago common in the hatchery at Christchurch, when it was to a large extent eliminated by removing the newly hatched fry from the immediate neighbourhood of the well, and allowing the water to trickle over obstacles before reaching the boxes containing the fish. Various authorities informed us that more developed fish, if confined near a well, died within a few days; Mr. Johnston, whose name has been so closely connected with the introduction of trout into New Zealand, using the expression that water direct from a well was a deadly poison to them.

With a knowledge of these facts we decided to make some experiments to ascertain how far, if at all, the results were attributable to radium emanation; and for cordial assistance in this, as well as for supplying us with a large number of ova and also some fry for experimental purposes, our hearty thanks are due to the Council of the Canterbury Acclimatisation Society as a body, and particularly to Dr. Moorhouse and to Mr. Sloman. Our special thanks are due to Mr. Charles Rides, of the Fish-hatchery, to whom the experiments have given much additional work.

We first tested the alleged fatal results upon fish of water directly taken from a well, and, with the object of seeing the effect of radium emanation, we chose the well at the Museum, which, besides being conveniently situated, was particularly rich in radium emanation. On Tuesday afternoon, the 1st June, 1909, seven healthy yearling fry were placed in the sand-box of this well, whose radio-active content, expressed in our units, is 197. When this box is running over, the water is supplied to it at the rate of 3·4 litres per second, and this was its condition throughout the experiment. On the following Friday morning one of these fish was found dead in the box, on the Saturday morning two more had died, and on the Sunday two more, one of which, however, was found in the overflow-pipe, and might possibly have got there and been killed. Two survived until the following Tuesday, when they were removed alive and apparently well. Thus, neglecting the one in the overflow, 66 per cent. had died in five days. The radium-emanation content of the water from which the fish were obtained, and where they had been living for nearly a year, was found to be 80.

As it was felt that the environment of these fish was far from comfortable, and to eliminate any poisoning action due to a little old red-lead clinging to the sides of the sand-box which it was thought possible the fish might have eaten, a further batch of eighteen fish was obtained, of the same age as the last, and from the same pond. These were distributed in two lots, eight being put in the sand-box of radium-emanation strength 197, and ten in a considerably larger concrete tank, into which water from the sand-box overflows. In this tank water-weeds of various kinds are growing, though not in any great quantity, its radium-emanation value being 171. These boxes we call No. 1 (sand-box) and No. 2 (larger tank). The fish were placed in these boxes on Wednesday, the 9th June, at 4.30 p.m. On Monday, the 14th June, one was found dead in No. 2; on the 15th June four were found dead in No. 1 and two in No. 2; whilst on the next day, the 16th June, one fish was found dead in each box. Thus in six days six out of eight had died in No. 1, and four out of ten in No. 2. These facts (taken in conjunction with the experience of others) prove that the water of some wells is, if taken near the source, certainly deadly to a large proportion of the fish. Whilst this is so, it is also indisputable that fish live quite comfortably if the water be allowed to run along an open channel from the well to the pond; and this is also true of the well upon which these experiments have

been made, for the same water trickles on to a further tank in which goldfish are kept quite successfully.

Character of the Water.—As far as dissolved salts are concerned, the artesian water of Christchurch is remarkably pure, being used for many chemical purposes for which distilled water is usually necessary. Indeed, it has been quoted as an example of what an ideal water should be; but its character in this respect has no bearing on the question, as the cause of the effects under consideration rapidly escapes. In another paper* we deal with the gases dissolved, and with the way these gases are altered by rippling over obstacles. Messrs. Marsh and Goreham have (Report, Bureau of Fisheries, 1904, Washington, p. 345 *et seq.*) ascribed what appear to be somewhat similar results to an excess of dissolved gas, particularly nitrogen, and say that 2 cubic centimetres of gas per litre in excess of the saturation amount will cause symptoms, whilst a somewhat larger amount may be fatal. At present, however, we are concerned with the evidence in favour of radium emanation being a possible cause, as this was not considered by them.

We therefore made experiments to ascertain how rapidly the radium emanation escaped as the water fell over obstacles. Tank No. 1 has already been stated to have a value 197. In the very short distance from No. 1 to No. 2 the radium-emanation number fell away to 171, whilst the tank in which the goldfish live, and to which a very small trickle goes, gives a leak per litre per minute of 30. It thus appears that the emanation escapes rapidly; but, to test it further, some water from another well giving a value of 127 was poured three times from one glass to another, whereby the value beeame reduced to 39.

By the courtesy of the authorities of the Acclimatisation Society we have had facilities for observing the behaviour of 75,000 healthy wild brown-trout ova as they developed from the eyed state until they hatched, and of ascertaining how the mortality amongst them varied with distance from the well. For this purpose they were distributed in two parallel rows of five boxes in a row, each box containing 7,500 eggs. The water trickled down these two rows from box to box, falling from one box to the next over a fall of about 8 in. By this means the water, after supplying the eggs in one box, was re-aerated before it went into the next. It was known that there was a much heavier loss of eggs in the boxes the nearer these were to the well—so much so that the use of the top pair of boxes (one box in each row) had been discontinued owing to the great loss in them in the egg stage, and also to the greater development of "blue swelling" in the yolk-sac stage. The number of eggs taken dead out of the various boxes was counted for us by Mr. Rides whilst we made a determination of the radium-emanation content per litre and also (*loc. cit.*) of the gas content. In the following results the dead eggs in any corresponding pair of boxes are added together, and they are therefore the deaths in 15,000 eggs:—

	Dead Eggs before Hatching.	Radium Emanation.
First pair of boxes	6,675	126
Second ,, ...	5,232	111
Third ,, ...	4,650	95
Fourth ,, ...	4,713	83
Fifth ,, ...	3,252	69

* "On the Influence of Ripples on the Gas Content of the Artesian Waters of Christchurch." (See p. 237 of this volume.)

The radium-emanation content of the water taken actually from the well-pipe was in this case 135·5. These numbers show very conclusively how marked is the diminution of mortality with recession from the well; and, put another way, there is a strong correspondence between the number of dead eggs and the radium emanation. Thus, taking on the one hand the number of dead eggs in the top box as $100x$ (x, of course, then equals 66·7) and the radium-emanation content of the top box as $100y$ (then y is 1·26), we have the following correspondences :—

	Percentage of Dead Eggs.	Radium Emanation.
First pair of boxes	$100x$	$100y$
Second „	$79x$	$88y$
Third „	$69x$	$75y$
Fourth „	$70x$	$66y$
Fifth „	$48x$	$55y$

It is only right to add that these figures do not represent in any way the present practice at the hatchery. It was known that the mortality would be high, though the cause was not known; and it was to ascertain the cause that so large a number of eggs were sacrificed.

The figures with regard to blue swelling as it subsequently developed in these boxes, and to gas content, are given in the paper dealing with the dissolved gases (*loc. cit.*); but, even if death in maturer fish can be ascribed to an excess of gas, which to us does not yet appear to be certain, it is difficult to apply the theory of Marsh and Goreham to the mortality in eggs or to blue swelling.

Art. XVI.—*On an Isopod inhabiting Ants' Nests in New Zealand.*

By Charles Chilton, M.A., D.Sc., F.L.S.

[*Read before the Philosophical Institute of Canterbury, 3rd November*, 1909.]

It has long been known that an isopod, *Platyarthrus hoffmannseggii*, Brandt, is found associated with several species of ants in England and Europe. It has been described by Bate and Westwood,* Schoebl,† Webb and Sillem,‡ and others. Lord Avebury§ has also published the result of his observations and experiments upon it, and has suggested that it acts as a scavenger in the ants' nest.

When I was preparing my paper on the terrestrial *Isopoda* of New Zealand‖ in 1900, I heard from Mr. W. W. Smith that he had found two specimens of an isopod supposed to belong to the genus *Platyarthrus* in ants' nests in New Zealand, and that these had been forwarded along with the ants to specialists in Europe. My efforts to trace these specimens were

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* "British Sessile-eyed Crustacea," II, p. 464.
† Sitzungsb. d. k. Akad. d. W. math. naturw. Cl. xl Bd., No. 9, 1860, p. 279.
‡ "The British Woodlice," 1906, p. 30.
§ "Ants, Bees, and Wasps," 16th edition, 1902, pp. 75, 90, and 407.
‖ Trans. Linn. Soc., 2nd ser., Zool., vol. viii, p. 100.