

to say whether this use of the personal pronoun in place of the pronominal suffix had a wider currency. Another anomalous use occurs in the phrase "ta imi na ratou e kai," *the people who ate him* (132). The Maori idiom would be "nana i kai."

A curious inverted construction is found occasionally in which the direct object of the sentence is treated as if it were the indirect object: Ko ta imi t'iei haramai i tangat, ka pang etu ki ri ngakau, *As for the tribes from which no men went with him, he threw them the entrails* (80); Ri oro mai au nei ki t' opeope, *He threw me a scrap.*

The phrase "no ro mē," *because* (Maori, "no te mea"), takes also the peculiar forms "ka ro a mē" and "ka ra wa mē," which it is difficult to explain grammatically. A similar difficulty is raised by the sentence "E mē wa mē mehoki naku" (132). Shand's translation, *They are things belonging to me*, no doubt gives the sense, but fails to explain the syntax.

The points reviewed in this paper do not, in the opinion of the writer, make for any special theory as to the identity or origin of the Moriori race. In fact, it is well that we were pledged to no theory, for it seems that the only conclusion we have succeeded in establishing is the entirely negative one that the Moriori tongue is not correctly described as "a subdialect of New Zealand Maori." So far from that being the case, it has as much right to be considered independent as any of the known dialects of the Polynesian language.

ART. XXXVII.—*Report on the Natural Features of the Arthur's Pass Tunnel.*

By a Committee of the Philosophical Institute of Canterbury: C. C. FARR,
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[Read before the New Zealand Institute, at Christchurch, 4th–8th February, 1919; received by Editor, 21st May, 1919; issued separately, 19th August, 1919.]

IN 1907, when the railway-tunnel from Otira to Arthur's Pass was about to be commenced, the Philosophical Institute of Canterbury arranged to make a series of records of the phenomena of natural and physical science that were revealed by the piercing of the tunnel.

It was designed to pay special attention to (1) the rock-formation exposed by the section; (2) the temperature of the rock in the bore as compared with that of the rock on the surface; and (3) the radio-activity of the rock in the tunnel (to determine whether the temperature gradient in the earth's crust and the radio-activity of the rocks were related in any measureable degree).

The tunnel was to be about 5 miles 25 chains in length; to penetrate the main chain of the Southern Alps from near the headwaters of the Otira, which flows into the Taramakau, to near those of the Bealey, which flows into the Wamakariri; to be in a straight line from portal to portal; and to rise with an even gradient of 1 in 33 from the Otira end.

A Tunnel Committee was appointed by the Council of the Institute, a series of suitable slow-acting thermometers and other apparatus were obtained, and satisfactory arrangements were made with the contractors

for the boring of the holes into the rock for the temperature observations—arrangements that were continued when the work was taken over by the Public Works Department. It was desirable that the temperature bores should be as close to the working face as possible, so as to prevent the cooling of the rock by the air of the tunnel, and so it was arranged that the bores should be put in 4 ft. behind the working face of the bottom heading, that they should be 5 ft. deep and 1 in. in diameter, sloping slightly upwards to prevent the accumulation of water in them, and lightly plugged with tow to prevent the circulation of air. For ease of rediscovery they were for most of the distance put in every 10 chains, at a height of 4 ft. from the floor, and on the east side of the tunnel. Different members of the Committee visited the tunnel at various intervals, either to make the observations or to note their progress in the hands of those to whom they were deputed. The tunnel is not yet completed, but, as the bottom headings have met, it is considered that no new phenomena are likely to be disclosed. The results of the observations are almost entirely negative.

ROCK STRUCTURE.

The course of the tunnel is entirely through rocks of the Maitai system. Its direction makes a small angle with the axis of an anticline, and therefore little can be learned of the order of occurrence of the various beds. There are the usual variations from coarse-grained light-coloured to fine-grained dark-coloured beds, and through these run irregular veins of quartz and occasionally of calcite. Some of the rocks, particularly those of the fine-grained type, are distinctly carbonaceous, and are found to contain in places nests and lenticular masses of impure graphite. All the rocks are somewhat calcareous, and contain in one or two places nodular concretions about the size of a hen's egg. A record of the dip and strike of the veins running through the country rock was kept for some miles from the Otira end, and this record is in the hands of the Public Works Department.

Owing to the rocks exposed being in the axis of an anticline they are frequently faulted, and are broken and shattered to a high degree. This has had an important effect on the permeability of the mass to water, as will be noted immediately.

A complete series of specimens of the rocks obtained through the tunnel has been prepared for preservation in the Canterbury Museum.

INFLOW OF WATER.

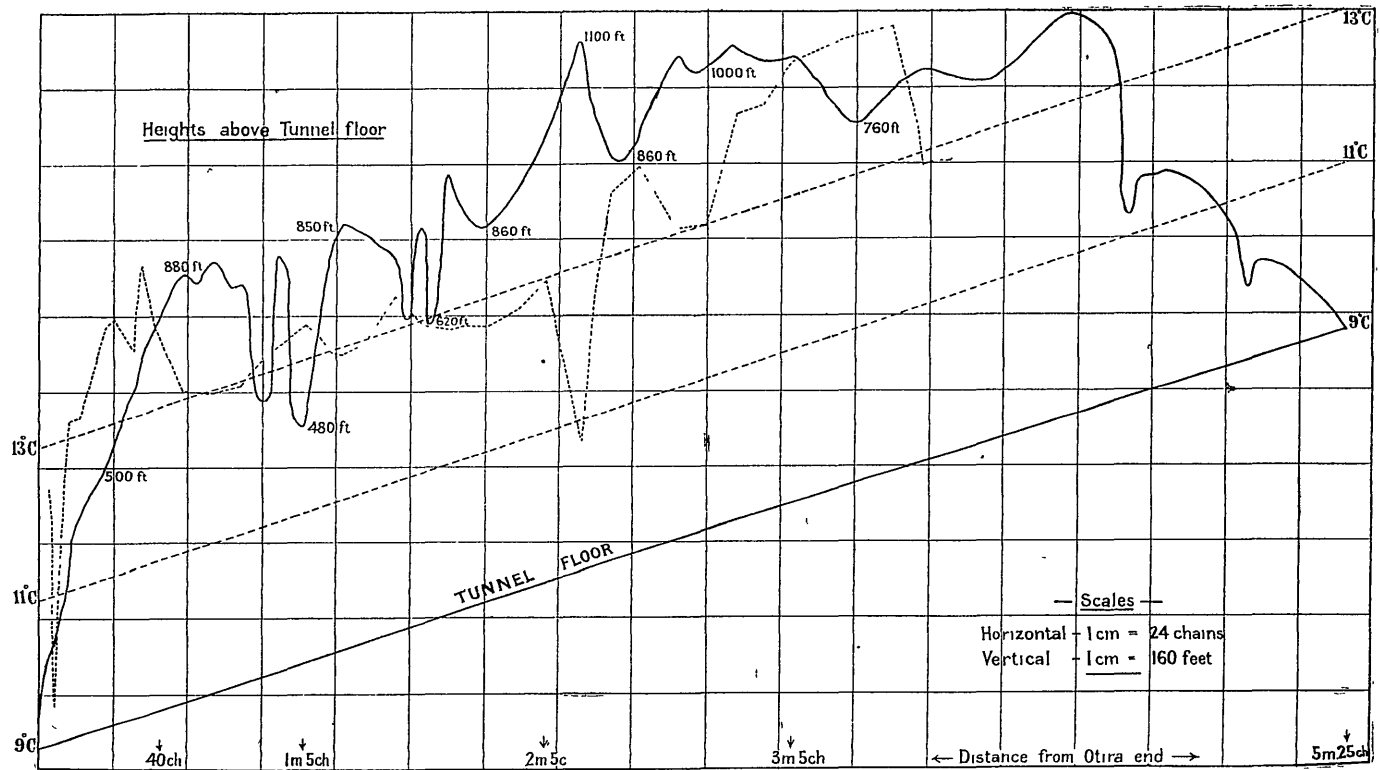
The shattered nature of the rock allowed the ingress of much water, and every time a blast opened up a wet seam streams of water would pour down on the workmen, greatly retarding the progress of the tunnel. When the bore was in 5 chains from the Otira end the influx of water was 0.1 cubic foot per second. The places where the water came in worst were from 10 to 40 chains apart, and these usually occurred where the rock was crushed and broken. In certain places the rock, shattered to pieces the size of a walnut, flowed in with the water, opening up great seams that required much timbering. The occurrence of the wet seams was most capricious. For instance, on one occasion the bottom heading opened up quite dry, but when the tunnel was enlarged to its full size a bad inflow of water was struck. There was no relation between the amount of rock overhead and

the inflow of water, one of the worst flows being met with where the overburden was 900 ft. of rock. The course of the tunnel followed very nearly the courses of the Otira and Bealey Rivers, and several times passed under these or their larger tributaries, but there was no relation between the influx of water and the position of the tunnel in respect to these rivers. As a general rule the entering stream dried up considerably in a few weeks or months, but this was not always the case. The remaining flows, with the smaller drips that are practically continuous throughout the length of the tunnel, now produce a considerable stream, discharging 7 cubic feet per second. As the concrete lining is placed in position the water is confined behind the lining, which is pierced with weep-holes at sufficient intervals.

The concrete lining consists of a solid mass up the walls, but the arch is formed of concrete blocks. Between these very small drips occur, and the dripping water, having dissolved in it some of the materials of the concrete, has on evaporation formed stalactites, which are very noticeable objects as they hang from the roof. Their composition is essentially CaCO_3 , with traces of Fe, Al, organic matter, and NH_3 , the last probably from the organic matter. There is no Mg, PO_4 , or SO_4 . The stalactites are about 1 ft. long, and about $\frac{1}{4}$ in. in diameter. They look solid as they hang, but when broken from the roof are so fragile that they can hardly be held in the hand without breaking, for they have a large hollow down the centre, the solid matter forming the thinnest possible shell. Their rate of growth has been about 2 in. per annum, which is probably a hundred times as fast as stalactites grow in a limestone cave. The difference is due to the fact that in the case of the tunnel it is the soluble calcium hydrate that the water has had to work on, instead of the relatively insoluble calcium carbonate. It is probable that the rate of growth may be temporarily increased by the through draught caused by the opening of the bore from end to end, although the draught is neither so considerable nor so constant as might be expected considering that the tunnel is a mathematically straight line and is 860 ft. higher at one end than at the other. The draught is usually upward, but sometimes is quite absent and sometimes flows downward toward Otira.

ROCK TEMPERATURES.

When the tunnel was started it was designed to take at each of many places three simultaneous observations as follows:—(1) The rock temperature in the tunnel; (2) the rock temperature at the nearest surface above the temperature-hole in the tunnel; (3) the radio-activity of the rock exposed in the tunnel. By this means it was hoped to contribute to our knowledge of whether, and to what extent, the internal heat of the earth is due to radium emanations as distinct from its residual heat. The conditions were, however, most unfavourable. In the first place, though the tunnel pierces a great mountain-chain, it passes under a low saddle, so that the overburden of rock is at its maximum only 1,100 ft. If the tunnel had been two miles east or west of its actual position the overburden would have been increased to 4,000 ft. or 5,000 ft. In the second place, the great influx of water made it quite clear that the observations would give the temperature not of the rock, but only of the percolating water. Of the temperature-holes bored half were distinctly wet, while the others were so near to wet places that the rock and the thermometer were undoubtedly affected by the water.



LONGITUDINAL SECTION OF ARTHUR'S PASS TUNNEL.
Full line, contour of mountains; dotted line, temperature-readings.

The accompanying graph gives the rock-temperature for three miles and a half from the Otira end, the observations being taken every 5 chains for the first 45 chains, and thereafter every 10 chains. No readings were taken at the Bealey end. Since it was desired to correlate the temperature-readings with the overburden of rock, the basal temperature line (9° C.) on the graph has been given the same slope as the tunnel-floor. It will be noted that the temperature graph is roughly parallel to this basal line, and that the minor variations in it, amounting to 3° or 4° C., show no sign of parallelism with the overburden of rock. The capricious variations shown are due chiefly, if not entirely, to the rate at which the water near by percolated from the surface or from the seams in which it was lying. That some heating effect was produced by the passage of this water through the rocks is, however, apparent from the fact that the average temperature of the wet rocks in the tunnel is about 10° C., while the water in the surface streams is about 4.5° C.

Temperatures were read twelve, twenty-four, and forty-eight hours after the insertion of the thermometer, but in only four out of the thirty-five holes put in was there any difference among the three readings of the same hole. The greatest variation shown was at the hole at 1 mile 55 chains, where the readings were 13° , 12.9° , and 12.8° C.

BIOLOGY.

The only observation of biological interest was the growth of the fungus known as *Armillaria mellea* on the temporary timbering of the tunnel, where it formed great pendulous bunches of mycelia about 3 ft. long, and somewhat similar in size and appearance to a horse's tail except that the individual strands were coarser. Only the vegetative form of the fungus was found, and this was found only on the pine timbers of the Otira end, being absent from the eucalyptus props of the Bealey end. Probably the fungus occurs in the bush whence the timber was cut and the spores are carried in when the props are placed in position, where the equable temperature, the moisture, and the darkness provide suitable conditions for vigorous growth. The estimated minimum rate of growth is about 3 ft. in a year, but this has been noticeably altered by the completion of the bore, the constant aeration having produced greatly accelerated development.

The Committee wishes to express its sincere thanks to the Right Hon. Sir Joseph Ward, who, as Prime Minister, made a grant in aid of the expenses of the investigation; to the Hon. G. W. Russell for permission to publish the report in the *Transactions of the New Zealand Institute*; to Messrs. McLean Bros. (the original contractors for the tunnel) and to the Public Works Department for facilities for making the observations recorded; and especially to Mr. A. Dinnie, Engineer in Charge, for his unfailing courtesy and willing assistance, and to Mr. Manson, underground foreman, for making most of the temperature observations.
