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A visit to Mount Tarawera

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board seemed to point in the same direction. This material will throw light on the hygienic conditions during our expedition, and may be very important in view of future expeditions; but, unfortunately, it is not sufficiently worked out to allow me to set it forth here. I dare only say that the malady which has hitherto been feared more than anything else in Arctic exploration ought not to occur often, as it is undoubtedly very easily avoided if proper precautions be taken.

Dr. Torup, professor of physiology at the University of Christiania, has come to the conclusion, after examining the subject, that scurvy must arise from poisoning, caused, in particular, by badly preserved meat and fish. He thinks that in the decomposition which takes place in meat imperfectly cured—in salt meat, for instance—there is poisonous matter allied to the so-called ptomaines, which, when constantly partaken of, engenders the malady we call scurvy. Particular attention was paid to this at the time of our equipment, and from our experience and the investigations I had the opportunity of making during our journey, I can entirely subscribe to Torup's opinion on the matter. It is to be hoped that in the near future there will be scientific elucidation of this important point; and it is equally to be hoped that certain means for avoiding the hitherto so fateful sickness may be devised.

Another thing with regard to the mode of investigation of the Arctic regions which our expedition learned was, perhaps, this—that even with small means good results can be obtained. By acting on the hints given by the Eskimo, and pushing forward with kayaks, sledges, and dogs, one is enabled to penetrate into, and cover considerable distances in regions which have hitherto been considered very difficult of access. The drift-ice itself can thus be travelled over, even at a considerable distance from land—even where it is in motion; and I think this is one of the ways in which it should be endeavoured to investigate the great unknown region between the North American Arctic archipelago and the Pole. Here, no doubt, many interesting problems are awaiting their solution. May a not far distant future see those tracts trodden by human feet.

A VISIT TO MOUNT TARAWERA.

By HENRY M. CADELL of Grange.

(*With Maps.*)

NEW ZEALAND has been called the "Britain of the South," and in so far as its area and insular position are concerned, the description is no doubt apt enough; but in physical geography, climate, scenery, and variety of natural resources, the Britain of the South quite surpasses its northern prototype. It may, I think, be safely asserted, that for its size New Zealand is the most interesting part of the British Empire, the only misfortune being its great distance from home, which prevents it from

receiving the attention at our hands to which its many natural advantages entitle it.

New Zealand has been richly endowed with the stores that go to build up the wealth of nations, and if the colony is not so prosperous as it should be, the fault must not be laid at Dame Nature's door. Its mountain slopes are at many places clad with forests of valuable timber, while beneath the surface there are rich mines and coal deposits that have as yet been scarcely touched. Most of the useful metals occur in greater or less abundance, and gold is to be found in formations of widely separated geological age, both in the North and South Islands, and in positions where it can be mined under conditions often more favourable than those which obtain in Australia or South Africa. Mountaineers in search of pastures new are beginning to leave the well-beaten tracks in Europe, and turn their eyes and feet towards its unscaled peaks and Alpine solitudes, with their valleys, lakes, and glaciers of surpassing beauty and magnificence. The climate of New Zealand, which varies between sub-tropical and temperate, has been so often praised that further reference to it is unnecessary here, and the whole possibilities held out in the way of colonisation and agriculture are almost unlimited. The natural flora of the islands is luxuriant; but it is a remarkable fact that New Zealand contains no fauna of any importance, so that one can roam through the silent, tangled forests of tree-fern, creeper, and pine, without any chance of treading on a snake or a scorpion, or of meeting any four-footed inhabitant more formidable than a rabbit or a wild hog of European pedigree.

It is to some of the features of its interesting physical geography that I wish now more particularly to refer; and here again New Zealand presents to us a fully plenished storehouse of materials in which the geologist and the physical geographer may well delight to revel. Iceland has its active volcanoes, snowfields, and geysers; but all are more or less inaccessible, owing to the unfavourable climatic conditions in that desolate island. In the Yellowstone National Park of America there are splendid geysers, hot springs, and the ruins of old volcanoes, but none which has been active within historic times. In New Zealand, however, spread out before us, are abundant examples of volcanic phenomena in all stages of development, as well as snowfields, glaciers, and evidences of the working of earthquakes, and other striking geological agencies. We can study in the North Island the old Tertiary andesite lavas and rhyolites of the Hauraki goldfield, in which the gold reefs are found, and the extinct cones and craters of the Auckland district of more recent age. From these evidences of ancient volcanic action it is natural to pass on to the thermal springs, geysers, mud volcanoes, and fumaroles of modern times, and these again lead us up to the vents of Tarawera, and the huge, steaming craters of Tongariro and Ruapeho, that rise majestically towards the clouds amidst their covering of perpetual snow. We find, therefore, in New Zealand a combination of the wonders of the Yellowstone and Iceland, in a country that has many additional points of interest, not too far apart, and fairly accessible from the sea on all sides.

In September 1895, while returning home from Australia, I took advantage of a favourable opportunity to visit the North Island, and spent some time in the Hot Lake district, within range of Mount Tarawera and the principal geyser basins. The terrible eruption of Mount Tarawera on the 10th of June 1886 will long be remembered in connection with the destruction of the famous Pink and White Terraces of Lake Rotomahana. Every traveller bent on seeing the "lions" of the North Island made a point of visiting the Terraces, and descriptions of their beauties have been published by many authors, the last of whom, Mr. Froude, gave in his *Oceana* a graphic account of his experiences in the Hot Lake district the year before the great catastrophe took place.

To those readers who may not be intimately acquainted with the geography of New Zealand a few words of explanation may be useful. To employ a very homely illustration, the North Island looks on the map like a shabby old boot with a high, narrow heel, and a long, ragged toe pointing to the north-west. The Bay of Plenty forms the well-marked instep, and the Hauraki Peninsula represents a part of the sole that has left the "uppers," and is hanging in shreds ready to drop off, the Firth of Thames being the gaping rent produced by the tearing open of the sole. Auckland is situated at the top of the toe, a short distance below the lacing, and the volcanic zone, which comprises the hot springs and active volcanoes, extends from the middle of the instep in a south-westerly direction through Lake Taupo. This extensive lake and the active or dormant volcanoes of Tongariro, Ngauruhoe, and Ruapeho (8878 ft.), to the south-west of New Zealand, form what may be compared to a large patch on the top of the ankle, while the magnificent snow-capped cone of Mount Egmont (8270 ft.) rises in solitary grandeur at the extreme south-west corner of the island, and marks a separate volcanic focus, the heat of which has apparently died out long ago.

The splendid harbour of Auckland, with its islands, bays, and green smiling shores, dotted with comfortable houses and blooming gardens, reminded me of the Kyles of Bute and the Mediterranean combined, and few panoramas in the southern hemisphere are said to approach in beauty the view from the old crater of Mount Eden, immediately behind the town. Auckland has been named the Naples of New Zealand, but its Vesuvius is no longer active, and although some sixty-three craters have been counted within a radius of ten miles, we must take the train and travel 134 miles south-eastward before the first symptoms of the dormant volcanic fires become perceptible.

Rotorua, a township on the flat shore of Lake Rotorua, forms the railway terminus, and as we approach it the smell of sulphur in the air, and the clouds of steam circling lazily upwards through the ti-tree bush, show that we have reached a place where the crust is dangerously thin, so that we can hardly consider ourselves standing on *terra firma* proper any longer. Lake Rotorua, a sheet of water about twenty miles in circumference and one thousand feet above sea-level, is, next to Taupo, the largest lake in the North Island. It lies in a roundish depression not more than about thirty feet deep, which may have been produced by a volcanic subsidence. Abundant signs of thermal activity appear along

From photograph by Mr. J. Martin, F.G.S., Auckland.

THE WHITE TERRACE CUPS.

its shores in the shape of hot springs, boiling mudholes, fumaroles, and sulphur baths, greatly valued by invalids. The surrounding country is uneven and hilly, and is covered by a dense growth of the ti-tree or manuka bush, which in winter has a warm russet brown hue like heather, but is spangled with white blossoms when the bloom is on. The principal geysers are grouped together at the native village of Whakarewerewa, two miles south of the township of Rotorua. These are exceedingly interesting, but are not nearly so fine or so imposing in their performances as the splendid geysers of the Yellowstone, which I visited in 1891. The art of soaping the geysers, which was accidentally discovered in the Yellowstone Park, is practised here when an eruption is wanted to order; and after trying the experiment by means of a bar of soap cut up into small pieces and thrown into the funnel, we were successful in inducing Pohuto, one of the principal spouters, to favour us with a very creditable performance. At the sanatorium of Rotorua, on the shore of the lake, some interesting experiments were made a few years ago by Mr. Camille Malfroy, C.E., the engineer in charge of the Government works there, after the eruption of Mount Tarawera.¹ These experiments were designed to illustrate Mr. Malfroy's theory of geyser action, and went to show that the difference between a fumarole, hot spring, mud volcano, and a true geyser is very small, and depends on the shape of the funnel and the facilities for the descent of water to the heated cavities below. The practical result led the author to conclude that geysers can be regulated and controlled to some extent, and hot springs can be converted into geysers by certain mechanical arrangements, and made to play at will. In proof of this, the hot springs supplying the baths at Rotorua were converted into small geysers at Mr. Malfroy's suggestion, and have continued to play regularly for the entertainment of visitors. It may appear sacrilegious thus to interfere with curious natural phenomena, and thrust iron pipes and concrete into the throats of beautiful boiling springs. To my mind, however, the charms of nature can in this way be greatly enhanced, and one can only regret that the geysers of Whakarewerewa have not been improved a little in their working. There is ample room for scientifically embellishing both their sinter deposits and their surroundings; but the Maoris, to whom they belong, do very little beyond drawing toll from visitors (which is done on correct and most scientific lines), and squatting in the warm pools with their wives and families. A feeble attempt has, it is true, been made to build up the sinter, so as to produce in time a far-off imitation of the lost Terraces, but much more might be effected in this direction, both at Whakarewerewa, Wairaki, and at other places, were the custody of the geyser basins in more intelligent hands. Soaping the geysers has been prohibited in the Yellowstone Park, and other regulations have very properly been strictly enforced for the preservation of their amenity; and perhaps at some future time the Government may see fit to acquire the New Zealand Wonderland in the same way, and improve it for the benefit of the public in all time to come.

¹ For an account of these experiments see Mr. C. Malfroy's paper, "On Geyser Action at Rotorua."—*Transactions of the N. Z. Institute*, 1891.

Mount Tarawera is about twenty miles by road from Whakarewerewa. The first ten miles are covered on horseback *via* the old road through the Tikitapu bush to the ruined village of Wairoa. Before the eruption, when the shores of Lake Tarawera were inhabited, and there was a well-populated township at Wairoa, the road was used for vehicles, but it is now merely a bridle track, the greater part of it having been destroyed or allowed to go to decay for want of use. For the first few miles the road runs along a flattish plain that slopes gently from the high ground towards the shore of Lake Rotorua, and is clad with a bosky mantle of ti-tree bushes. The ground is all made up of volcanic ash of various ages, most of it being light yellow or grey pumice, the product of ancient eruptions. The ash of Mount Tarawera is dark grey or nearly black, and it is thus an easy matter to tell when we are within the area affected by the eruption. At first the traces of the eruption are only apparent to the trained eye of the native of the district, but soon the layer of dark material becomes evident to the most careless observer. The limits of the ash have been carefully mapped out by Professor Thomas, of Auckland University College, who investigated the district immediately after the eruption, and published a valuable report on it in 1888. As the wind was from the south-west when the outburst took place, most of the ash was blown in a north-easterly direction towards the sea, and scarcely any fell so far west as Whakarewerewa and Rotorua. After leaving the plain the path turns southward through the once luxuriant Tikitapu bush, and follows for part of the way a small valley, on either side of which the hills rise to a considerable height. Moerangi, the highest summit, has an altitude of 2240 feet, and rises steeply from the shores of the Tikitapu and Rotokakahi lakes, whose waters once sparkled like sapphires in the sunlight, but are now as dull as milk, or at least as white as opals without the "fire." The fine bush along their margin is blasted and blackened, and although the luxuriance of the vegetable growth is, after ten years of repose, beginning to reassert itself, and clothe the landscape with some of its former verdure, many years must elapse before the first rude traces of the catastrophe become hidden from view.

One effect of the shower of ash on the physical geography of the district interested me exceedingly, and brought into prominence a phenomenon that can seldom be observed, from its rare occurrence. Where the fall of ash exceeded six inches, the whole ground was covered with a dense black skin, which, when saturated with rain, turned into an impervious bed of clay, that overspread hill and dale like a waterproof sheet. Before the eruption the rain fell upon ground thickly overgrown with vegetation, and a great part of the rainfall was thus retained for a time, absorbed, or allowed to trickle into the lakes or percolate slowly and quietly into the porous soil. After the coat of volcanic mud was put on all was changed. The heavy rains no longer fell on a bosky, absorbent surface, but were precipitated on to a smooth, watertight cover which, like the slated roof of a house, shed the drops as fast as they fell. The water ran in streams down the slopes, and these united to form fierce torrents in the flat bottoms of the valleys between the hills. These hollows had, in former days, been occupied by small rills that warbled

From photograph by Mr. J. Martin, F.G.S., Auckland.

ERUPTION OF THE WHITE TERRACE GEYSER, 22ND NOVEMBER 1885.

quietly down to the lakes without scooping out deep channels or notably wearing away their mossy sides. When these brooks gave place to roaring torrents that rushed along with wild fury whenever a heavy shower fell, and dried up as soon as the clouds rolled away, quite a new effect was produced on their beds. The waters quickly dug out deep channels, and in a short time their courses were marked by gorges or small cañons with perpendicular sides, which were undermined and further excavated by each fresh spate. The ground rock being soft, light pumice fragments, with little coherence, excavation was not a difficult matter.

As we approached Lake Tikitapu the road followed one of these stream courses, and we gradually ascended the valley for a few miles riding close to the edge of the cañon cut out during recent floods. Our Maori guide, A. Warbrick, said that the gorge in the middle of the valley had been nearly all excavated within the last five or six years, and had

THE CHASM ALONG THE ROAD TO WAIROA.

no existence before the eruption. It was at places over sixty feet deep, and the sides were perpendicular or even dangerously overhanging. At one place where the hillside above sloped rather steeply down to the chasm, the path, only about two feet wide, ran along the very brink. This was at a bend in the stream where its eroding power was greatest and the depth was fifty or sixty feet. I dismounted and led my horse past it, not relishing the idea of a possible fall over the edge on horseback. If the path were to give way under us it would probably be more comfortable to fall separately. After passing the critical place I looked round and found that the cañon wall was really overhanging, and I made up my mind that when we came back, another way past must be found out. When we did return in the evening there was no need of impressing this

caution on our guide, as the path had disappeared during our absence into the chasm! The above sketch, which was taken a short distance farther up the stream, illustrates roughly the appearance of this last product of the eruption. The walls of the gorge reveal an excellent section of the stratified pumice beds with which the old valley was filled, and at the time of our visit the weather was fortunately dry, so that the bottom of the stream channel was quite bare.

This particular cañon was, it must be stated, partly produced at first by a large earthquake crack, along which there were several subsidences, reaching at one place a depth of ninety feet, such as are common elsewhere in the district. The water took advantage of this line of weakness and has gone on excavating and widening it every year. The steepness of the walls shows that the process of excavation is rapid, and that the natural disintegration by the atmosphere and rain is quite insignificant compared to the erosion by the stream, just as it is on an infinitely greater scale in the celebrated Grand Cañon of the Colorado. The old valley, on the other hand, is shaped like a roofing tile, showing that the tendency to crumble away at the sides was formerly greater than the tendency to undergo deepening through the stream's action. An excavation of this sort starts at first by the stream eating down its bed near the lower end, where it debouches on flat ground and has a "free toom" or available space to deposit its burden of detritus in the shape of a fan or delta. The gorge begins at the apex of the cone, and when once started eats its way steadily backwards up the valley, deepening and widening its section as it grows in length; and so long as the fall is great enough to let the stream carry away all the detritus, the process will go on. As we proceeded on our way this was made quite clear, for the chasm grew smaller and narrower, so that at last we could step across it, and it finally dwindled down to a mere fissure a yard or two deep, on the line of the old earthquake crack, with vertical walls entirely bridged over at places by the vegetation.

This is only one, and perhaps not the best, example of a process that is going on all over the ash-covered district. Professor Thomas told me of other and much deeper gorges produced in the same way, without the assistance of earthquakes. Now it is interesting to note that this is only a temporary phase of the physical evolution of the region. Provided no fresh eruptions occur, the ashy covering will be gradually washed off the hills, or at least the deposit will disappear under the growing vegetation, so that the sudden torrents will diminish in force and erosive power. The sides of the gorges will fall in, as it is not natural for soft strata to stand long in the form of vertical cliffs where the climate is moist and the rainfall abundant. Small but regularly flowing streams will again occupy the channel, and these will not be able to transport all the stuff that falls into them, so that in time there will be found a smaller tile-shaped valley inside the greater, and a step-like feature along the hillsides will be all that remains of the original perpendicular cañon walls shown on the sketch.

In the Taupo volcanic district the tributaries on the right bank of the Waikato river, which is far beyond the area of the Tarawera ash,

WAIROA TOWNSHIP BEFORE THE ERUPTION.
LAKE TARAWERA IN DISTANCE.

SITE OF WAIROA AFTER THE ERUPTION,

have cut cañons with vertical sides 200 feet or more in height. Professor Thomas points out that the preservation of the walls is largely due to the porous nature of the pumice strata, which allows the rain to sink into the ground instead of streaming over the surface and wearing away the margin of the cañon. The preservation of the walls of the Grand Cañon of the Colorado is due, on the other hand, to the very small rainfall of the part of America across which the greater part of the river has formed its bed. The absence of frost is also conducive to the preservation of sharp natural features of this sort, since soft, porous cliffs would, in a wet region nearer the Poles, be particularly liable to disintegration by the winter's frosts.

The township of Wairoa was, up till June 1886, a smiling village, beautifully situated in a valley, amid luxuriant forests and well-tilled land, on the banks of the stream that falls from Lake Rotokakahi into Lake Tarawera. It is now a blasted and blackened waste, with ruins of wooden houses half buried under ashes; and the solitary inhabitant that met us was a brown cat, the only resident that had, after escaping with a whole skin, apparently thought the place still attractive enough for a permanent residence. The trees were partly burnt and partly overthrown by the fury of the indraught of wind caused by the eruption; but these are now sprouting again, and the dull, leaden grey of the landscape is becoming enlivened with spots and patches of warm russet brown or green. Professor Thomas has calculated that Wairoa is situated at the outer edge of the area over which the ash fell on the average three feet deep, and as we approach the volcano the depth of course continually increases. A fall of from two to three feet of ashes and mud may not seem a very serious matter, but it was quite enough to crush in the frail roofs of the houses and cause the death of over a dozen persons. The eruption took place suddenly in the small hours of the morning, and in the pitchy darkness it was impossible to escape. The two native villages of Te Ariki and Moura, on the shores of Lake Tarawera, near the volcano, were entirely overwhelmed, and not a soul was left to tell the awful tale of their destruction. Altogether 111 natives and Europeans were killed, the majority of the inhabitants of Wairoa having survived the eruption, which, though terrific while it lasted, did not happily last long, but was all over, so far at least as the ash shower was concerned, in about five hours. Although large volumes of steam continued to rise from the newly formed vents for months afterwards, no fresh explosion has since taken place, and the mountain has been steadily cooling down for the last ten years, almost no steam being now emitted from the craters.

We left our horses at Wairoa, and clambered down the steep path past the charming waterfall at the head of an arm of Lake Tarawera to the white beach of pumice and obsidian sand, where our Maori guides had a boat ready to take us to the volcano on the opposite shore. As we rowed across the milky waters our boatmen related how, eleven days before the eruption, the inhabitants of the native settlements on the shores had been startled by the form of a huge, phantom war-canoe moving stealthily over the lake, coming from an unknown port, and going no one

knew whither. The meaning of this apparition was not understood at the time; but after the catastrophe was past, the few survivors were convinced that this had been an omen from the world of spirits to warn them of the approach of the destroying angel.

The length of our little voyage was about eight miles, and we landed in a bay where a torrent had cut out a gorge in the black scoriæ and spread out the detritus in the form of a broad fan sloping gently downwards to the beach. The configuration of the ground has here been entirely changed by the eruption. For miles around, the shores of the lake, once decked with luxuriant vegetation, are now deeply buried under a leaden grey coating of volcanic mud and scoriæ. The surface of the ground is cut up with multitudes of deep, wavy furrows, as if it had been raked all over with gigantic combs. At places these furrows are so deep and numerous that they resemble glacier crevasses, and make the country quite impassable for man or beast. They can be seen miles away from the neighbouring hills radiating outwards and sweeping in regular curves corresponding with the changes in the slope of the ground. A good impression of the remarkable appearance of the district may be gained by looking at the hill-shading on some of our Ordnance maps, whose black radial hatchings bring to mind the black, sharp groovings in the scoriæ hills round Mount Tarawera.

Mount Tarawera is an ugly, flat-topped mass that rises steeply from the lake, and at the water's edge terminates in abrupt cliffs. The lake is about 1000 feet above sea-level, and the mountain rises over 2700 feet higher, so that the climb is not a matter involving much expenditure either of time or muscle. The upper part of the mountain is entirely made up of black or reddish scoriæ, lapilli, and dark rounded bombs or "fireballs" of augite-andesite lava with a vesicular spongy core and a hard shell rather smooth at times on the surface. In many cases, however, the core is seen to be a lump of white, hard rhyolite, the rock of the original Mount Tarawera. This has been blown into fragments, many of which were wrapped round with a skin of the black andesite lava during the progress of the eruption.

On reaching the crest of the ridge a strange scene presented itself. After climbing the steep, ashy slope we came suddenly to the brink of the great chasm that has cleft the mountain into two parts. This huge fissure extends for a distance of over nine miles through the top of Tarawera and the site of Lake Rotomahana at its base, on whose shores the Terraces were situated. The eruption produced a row of deep craters along this line, and these are separated by a series of bridges or partitions, some of which are quite sharp and thin at the top, and others have a breadth of several hundred yards.¹ The sides of the chasm reveal an interesting section of the mountain, which is seen to be made up of cream-coloured rhyolite lava beneath, with deep red or dark grey stratified ash-beds at the top, and here and there a dark, slaggy patch of the new lava plastered on to the side, or lying like a saddle on the back of the

¹ These diaphragms or bridges are shown on the accompanying map of the great fissure and lake.

separating bridges. With the exception of these isolated splashes, there is no sign of any lava streams among the products of the eruption. The eruption produced nothing but ashes and scorix, and this is to be explained by the fact that there was so much water present that the molten rock beneath was blown to fragments by the sudden expansion of the steam imprisoned in its pores before ever it rose to the edge of the craters. There was, no doubt, lava at a certain depth, and some of it can be seen in the bottom of the deeper craters, and the fact of its existence proves that a true volcanic eruption took place, and that the explosion was not due merely to the pressure of highly heated steam. Small volcanoes are sometimes produced by steam explosions, but in such cases the materials thrown out are found to be composed of shattered fragments of the rock beneath, unaccompanied by matter of a genuine eruptive character. The sides of the chasm are still warm at places, and hot vapour or steam issues from cracks along the edges here and there.

The eruption of Tarawera did not last long—only about five or six hours—but while it lasted the explosion was one of tremendous energy. A long row of huge craters, some of them over 800 feet in depth, were blown out of the solid rock, and from these was ejected a shower of stones, mud, and ashes, estimated by Professor Thomas to have a bulk of 1,960,000,000 cubic yards, or nearly two-fifths of a cubic mile. The ash fell over an area of more than 6000 square miles on land, and a good deal was carried away seawards by the south-west wind, to fall into the Bay of Plenty.

The observations of Mr. Percy Smith, Assistant Surveyor-General, who has from time to time published very accurate maps and reports on the volcano and its surroundings, show that the effect of the accumulation of ash was to raise the summit of Tarawera to 3770 feet, which is 164 feet above its original altitude.

The most important change in the topography of the district is the formation of the new Lake Rotomahana at the western base of the mountain, and about half a mile south from the nearest part of Lake Tarawera. The general appearance of the new lake is shown on the accompanying topographic sketch, and on the right a small part of the Tarawera lake comes within the view. The crater lake of Rotomahana has steep sides, and covers the hollow in which were situated the small Lake Rotomakariri, and the larger hot lake Rotomahana, whose shores were adorned by the terrace formations. The surplus waters overflowed into Lake Tarawera by a small stream which has been obliterated by the eruption. During the explosion the lake was entirely blown up, and a huge hole formed with a small pool in the bottom about 400 feet below its original surface. The line of the great fissure ran straight through the top of Mount Tarawera and the bed of Lake Rotomahana, and a row of craters mark its course across the country. Another crater lake farther along the line of the chasm, and close to the foot of the mountain, was produced at the same time, and was named Rotomakariri, after the original tarn of that name. Both lakes have gradually been filling up, and now, instead of together occupying an area of about twenty-five acres, which they did in August 1886, they have

joined into one imposing sheet of water, three miles in length, covering 5600 acres or more. The level of the water was found, from surveys made in 1893, to have risen 420 feet during eight years, and at the time of my visit in 1895 it had crept up still farther, and covered up some of the features shown on Mr. Percy Smith's map published in 1894. When it rises to 1080 feet above sea-level, or ninety-five feet above its level in 1893, it will either find a subterranean outlet through the porous soil, or it will overflow the ashy ridge, and again find an outlet to Lake Tarawera. A channel in the soft scoriæ will again be excavated, by which a considerable part of the water will be drawn off, and the surface of the lake will, after reaching a maximum, begin to decrease in area, leaving no doubt a small notch or terrace round its margin to show the line of high-water mark. The accompanying map shows the great fissure, the original lakes Rotomahana and Rotomakariri, and the area of the new lake at the date of my visit.

The accompanying topographic sketch from near the top of Tarawera shows the appearance of Lake Rotomahana and the country to the west and south on the 27th September 1895. The day was happily very clear, and we were fortunate in catching a glimpse of the top of Ngauruhoe and Tongariro, about ninety miles off on the south-western horizon; and as the clouds lifted for a few minutes, the steam issuing from the cone of Ngauruhoe (7841 feet) was distinctly visible.

A sharp pointed rock, known as the Pinnacle, formed a prominent landmark on the north or right side of the Rotomahana crater after the eruption. As the water rose, the Pinnacle became an island, and gradually diminished in size until nothing but the tip appeared above water. This was shown on Mr. Percy Smith's panorama, taken in 1893, and published along with his latest report in the following year, and at the time of my visit the continued rise of the lake was clearly proved by the diminished size of the Pinnacle, which is shown on the sketch as a mere speck, and may by this time have completely disappeared. The Pinnacle was close to the White Terrace and near the head of the Kaiwaka stream, by which the old Lake Rotomahana overflowed into Lake Tarawera. The course of this stream is still marked approximately by the storm channel shown on the sketch.

The view north-eastwards along the volcanic belt was equally clear. The following sketch gives a glimpse of the Tarawera chasm and the craters and bridges between them, and on the horizon on the left is seen, far out to sea in the Bay of Plenty, the great fumarole of White Island, seventy miles distant, from the summit of which clouds of steam are constantly rising. The panorama from Mount Tarawera thus embraced a distance of 160 miles, and included the entire length of the volcanic zone, between whose extremes nearly all the curiosities of the New Zealand Wonderland are to be seen.

Mount Tarawera gives an example of what has taken place in pre-historic times, and what may again take place within this thin-skinned region. The presence of so much water—an important factor in volcanic eruptions—with the evidence of great heat not far down, make it quite likely that the district may at any time be visited by a similar catastrophe

VIEW SOUTH-WESTWARD FROM MOUNT TARAWERA SHOWING THE NEW LAKE ROTOMAHANA.

VIEW LOOKING NORTH-EASTWARD FROM THE EDGE OF THE CRATER OF MOUNT TARAWERA.

to that of the 10th of June 1886. Happily that part of New Zealand is mostly poor in soil, and but thinly inhabited, and after what has already happened, sensible people should not settle too near the volcanic zone, but keep away from such an uncanny corner of the Empire. It is a place well worthy of an occasional visit, and its sulphur baths are almost unsurpassed in medicinal virtue; but beyond this, the district should be regarded as a great natural museum, full of rare and awesome objects, highly instructive indeed, and well deserving of a visit, but not adapted for purposes of settlement or permanent residence by a large population.

PROCEEDINGS OF THE ROYAL SCOTTISH GEOGRAPHICAL SOCIETY.

LECTURES HELD IN APRIL.

Professor Prothero delivered, by special request, in Edinburgh, on April 8th, an address on the "Principles of Federation," as a sequel to the series on the "Unity of the Empire," reported in previous numbers. Sheriff W. C. Smith presided.

"The Market Fishes and Marine Commercial Products of Australia" was the subject of a lecture delivered by Mr. W. Saville-Kent, in the Society's Hall, on April 22nd. The Chair was taken by Mr. Grant Ogilvie.

MEETINGS IN MAY.

On May 7th Sir Henry Tyler will address the Society in Edinburgh, at 4.30 p.m., on "The Geography of Routes of Communication."

It is hoped that a lecture on Queensland may be arranged in the latter part of the month.

GEOGRAPHICAL NOTES.

By THE ACTING EDITOR.

EUROPE.

Rain, Evaporation, and Drainage in Bohemia.—The concluding number of the fifth volume of Professor Penck's *Geographische Abhandlungen* contains the results of Dr. Vasa Ruvarac's measurements of rainfall and river discharge in Bohemia, and an essay by Professor Penck on the relations of rain, drainage, etc. We can select only a few facts from the concluding chapter of this work.

During the five years 1876-90 the mean annual volume of rain that fell in Bohemia was 8.45 cubic miles, corresponding to a mean fall of 27.24 inches. This mean height was exceeded over 42.4 per cent. of the country, and not attained over 57.6 per cent. The rainfall is heavier in the higher parts on the borders of Bohemia—the crests of the Böhmerwald, the Riesen, Iser, and Erzgebirge, where the annual amount exceeds 47 inches—while in the central lower parts it is not more than 16 inches. In both parts there are localities evidently sheltered from the rain, while others are more especially exposed to it. The striking symmetry in

MAP SHOWING THE VOLCANIC ZONE OF NORTH ISLAND, N.Z.

The Edinburgh Geographical Institute

Scottish Geographical Magazine, 1897

John Thomson & Co.

MAP OF TARAWERA DISTRICT IN SEPTEMBER 1895.
SHOWING THE NEW LAKE ROTOMAHANA AND LINE OF THE GREAT FISSURE