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SOME NEW ZEALAND VOLCANOES.*

By J. MACKINTOSH BELL.

INTRODUCTION.

FROM the most remote days of geological time that we know of in New Zealand these Southern Pacific islands have been scarred and burnt by volcano, and racked and torn by earthquake. Volcanic fires rose from New Zealand's earliest land, and like beacons have never throughout the long ages, save perhaps for brief periods, ceased to glimmer! Throughout the length and breadth of the land we read, by the natural features, the record—here, of a gigantic outburst changing completely for broad stretches the configuration of the land; there, of a minor outbreak, leaving but scant evidence of an event long since faded from the geological memory. Recent volcanic activity has been limited to the central and northern parts of the North island, and to the islands lying off its coast in the Bay of Plenty—a prominent embayment in the north-eastern part of the North island. To those parts of the Dominion this paper is limited, and I propose to describe briefly some of the principal centres where vulcanism has either recently or comparatively recently been active, but is now apparently dead; and other centres where it still rages.

TAUPO VOLCANIC ZONE.

Extending from Ruapehu, in the centre of the North island, to White island in the Bay of Plenty, is the chief volcanic district in New Zealand. This area, named by Hochstetter † “The Taupo Volcanic Zone,” lies along the line of weakness called the great Whakatane fault.‡ On the course of this fracture are situated the only active and intermittent volcanoes in the Dominion, as well as others thought to be recently extinct or dormant.§ To the former class belong Mounts Ruapehu, Ngauruhoe, Tongariro, Tarawera, and White island; and to the latter, Mounts Edgecombe, Kakaramea, and Tauhara.

Connected with this zone and the name of its most constantly active volcanic centre, Mount Ngauruhoe, is one of those interesting Maori legends that show the powers of observation possessed by the *native* mind. It was told to Hochstetter || by Te Heuheu, a great chief who then lived on the shores of Lake Taupo.

Reaching New Zealand from the ancient racial home of Hawaika, the mighty pioneer chief, *Ngatirovangi*, started into the interior on a journey of exploration. Desiring to secure a better view of the country than was obtainable from the forest-clad plains, he and a faithful follower, *Ngauruhoe*,

* Royal Geographical Society, March 11, 1911.

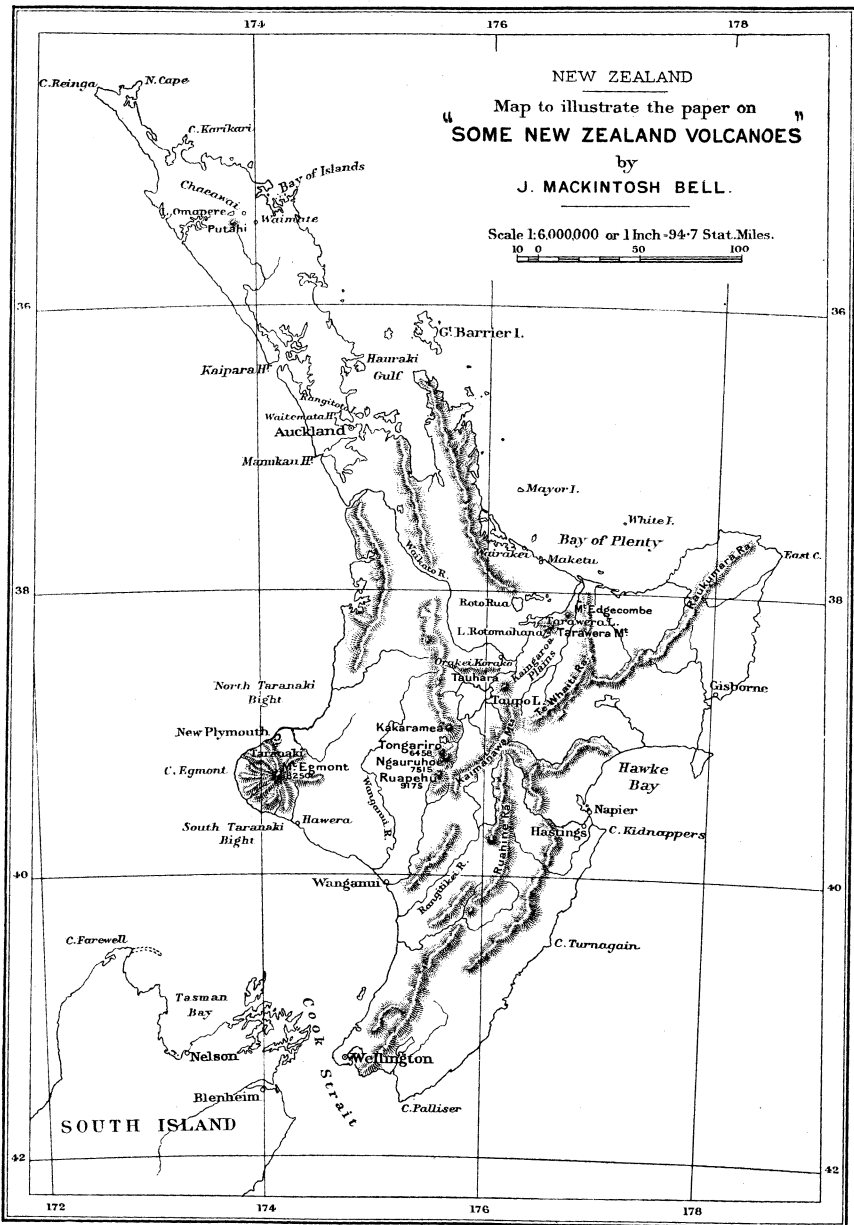
† ‘Geology of New Zealand’ (Explanation of Atlas, etc.), p. 38.

‡ James Park, ‘The Geology of New Zealand,’ p. 262.

§ *Ibid.*, p. 174.

|| ‘Geology of New Zealand’ (Explanation of Atlas, etc.), p. 38.

ascended the highest peak of the mountainous range of Tongariro. Whilst on the summit they became numbed by the intense cold, and, afraid of being



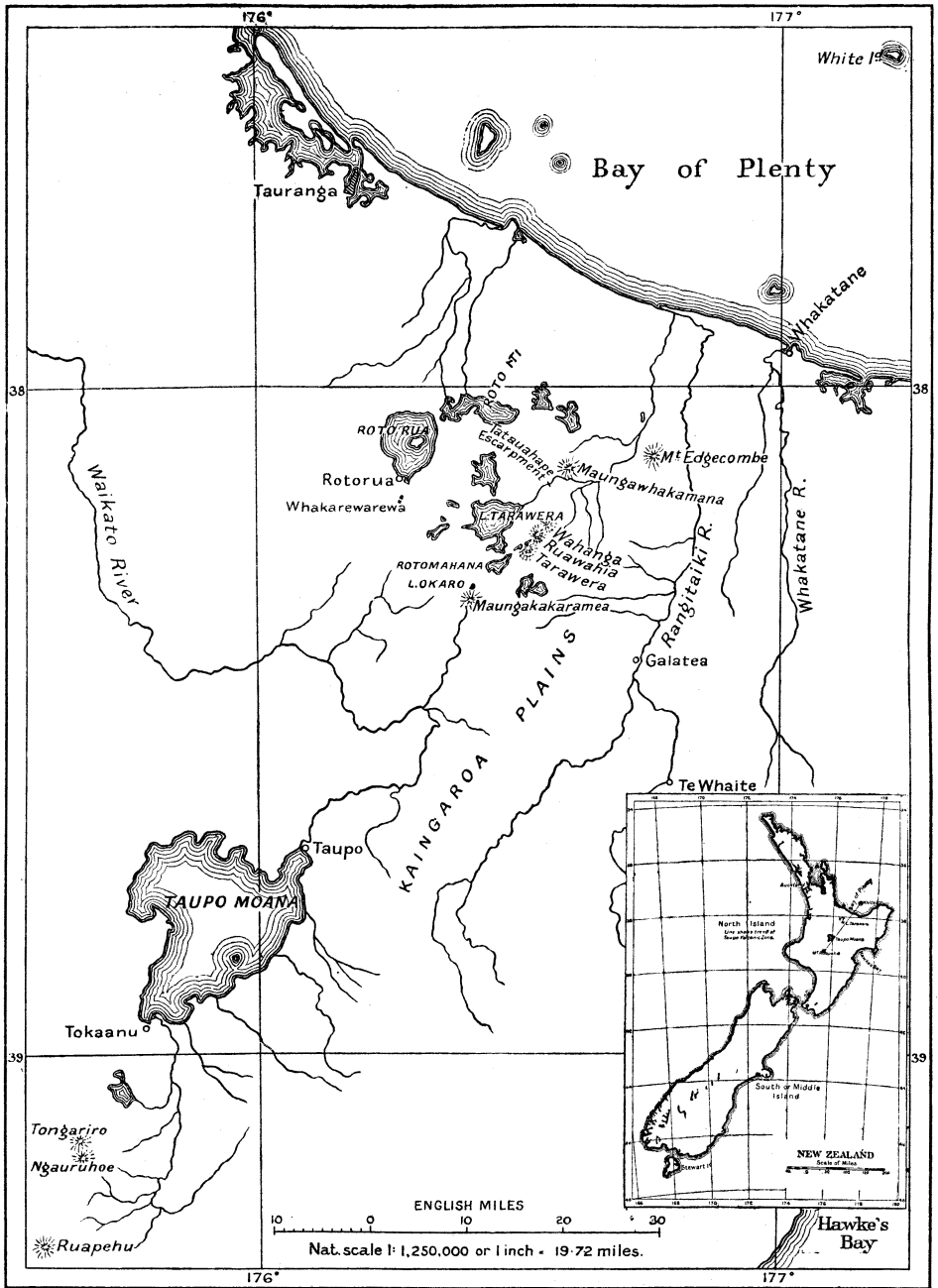
frozen to death, Ngatiroirangi shouted to his sisters who lived at White island to send him some of the fire that they had brought from Hawaiki in

the great canoes *Pupu* and *Te Haeta*. Shortly afterwards the fire, arriving by way of a subterranean passage, burst forth from the lofty crest on which they sat in time to save the life of the chief, but, alas! not that of the servant. The spirit of poor *Ngauruhoe* was already on its flight for "another Hawaiki." Thus the name of the faithful *Ngauruhoe* was given to the cone whence the fire burst forth. Even to this day the steam, constantly rising from the crest of *Ngauruhoe*, and in many places along the subterranean passage by which the original fire passed, testifies that the sacred flame sent to warm *Ngatiroirangi* still burns brightly!

Within the Taupo volcanic zone occur widely distributed centres of solfataric activity, more especially on the northern and southern shores of Lake Taupo and at Wairakei, Orakei Korako, Waiotapu, Rotomahana, Whakarewarewa, and Rotorua. At these localities are seen, to a degree almost unrivalled elsewhere, geysers, fumaroles, and steam-jets, which attract every year an increasing number of tourists, who scale the heights of the region, bathe in its tepid pools, or are awestruck at its wonders. None other of the world's thermal lands is more interesting for study. Though the world-renowned pink and white terraces were destroyed by the great Tarawera eruption of 1886, and the great geyser of Waimangu which broke out thereafter has ceased to play, new marvels of activity frequently come into being and old hydrothermal centres are occasionally rejuvenated.

The Whakatane fault, immediately along which occur more than half of the hot springs, etc., that give fame to the region, has a strike of about N. 38° E. It is undoubtedly the line of greatest activity at the present time, and that along which future activity may be expected. It is interesting to note that this line has a general parallelism to the axes of the principal mountain ranges of the North island, to the lofty chain of the Southern Alps, and to the submarine ridge stretching from East cape to and beyond the Kemadec islands.*

* See, also, 'Report on Eruption of Tarawera and Rotomahana,' by A. P. W. Thomas, p. 4. A continuation of this same line of weakness, or one closely parallel thereto, runs through the city of Wellington. Near the city, moreover, several other tectonic breaks radiate from the main line, or are parallel thereto, whilst others appear to run transversely. From time to time the capital experiences slight earthquake shocks, and during the middle decades of the last century was on several occasions severely shaken—most notably in 1855. Towards the close of the century, shocks of earthquake, which wrought considerable damage, were felt in the north-eastern part of the South island, along the same or parallel lines of weakness as those in the neighbourhood of Wellington. The writer believes that a close connection exists between volcanic and seismic activity in New Zealand, as elsewhere, and he strongly recommends to vulcanologists and seismologists the Taupo volcanic zone, the vicinity of Wellington, and the north-eastern part of the South island as remarkably interesting fields of study. From such study may be obtained much information of great scientific interest and of highly practical value to the people of New Zealand. See 'Earthquakes in New Zealand,' by Alexander Mackay; and "The History of Wellington Harbour," by J. M. Bell, *Trans. New Zealand Institute*.



TAUPO VOLCANIC ZONE

MOUNT TARAWERA.

Situation and Environment.—Mount Tarawera forms one of the most conspicuous landmarks in the north-central portion of the North island. Its crest displays three peaks, namely, Mount Wahanga—quite distinct from the other two—and Mount Ruawahia, and Mount Tarawera proper, occurring close together.

To the west-south-westward of Mount Tarawera lies Lake Rotomahana, filling a vent formed during the eruption of 1886. North-westward of Tarawera, and lying just at its base, is the lake of the same name, surrounded by low volcanic hills rising to a height of 400 or 500 feet. North-eastward from Mount Tarawera extend rolling hills, clothed in volcanic ash, from which still rise tall stumps of trees—the ghastly tombstones of the eruption. Eastward and south-eastward from the mountain lie the monotonous stretches of the Kaingaroa plains. All of these and many other features were displayed before my eyes when, after a two-hours' trudge up the scoria slope, I reached the crest of the mountain one crisp July day. Standing out in sharp relief in the clear air was a marvellous panorama, stretching from White island, smoking in the Bay of Plenty to the north-east, to the snow-covered peaks of Ngauruhoe and Ruapehu, dimly showing on the far south-western horizon.

State of Tarawera prior to the Eruption.—It is difficult to obtain very precise information regarding Mount Tarawera prior to the eruption of 1886—the most momentous event in New Zealand's recent geological history. The name Tarawera (warm vent) would suggest that the mountain had been active since the Maori occupation of the land, or roughly within the last 400 years. As the Maoris have no direct tradition of the mountain having formerly been in eruption, this name may have referred not to the crest itself, but to the numerous warm springs occupying the present site of Lake Rotomahana, and situated within a distance of 4 to 6 miles to the south-west. The mountain is said to have been covered with vegetation from base to summit, the latter being held sacred by the Maoris and used as a burying-ground for their dead warriors. Old photographs of the mountain and of the neighbourhood of the terraces show that at least small trees grew. Their presence suggests that many years must have elapsed since the mountain had been formerly active, though not so long as would be necessary for vegetation to grow in land less favoured climatically. Moreover, the scar of any previous outburst had been well cicatriced before the last outburst occurred. Prof. Thomas, who investigated the nature of the mountain immediately after the eruption, considered that the original Tarawera cone had a mode of origin analogous to the domitic puy's of the Auvergne district in central France.*

* Thomas relates a number of somewhat extraordinary events that took place in the Taupo volcanic zone prior to the eruption of June 19. None of these, however, are especially remarkable. See 'Report on Eruption of Tarawera and Rotomahana, N.Z.'



THE EXTINCT VOLCANO OF TAUHARA, WITH THE STREAM BORDERED BY HOT SPRINGS IN FOREGROUND.



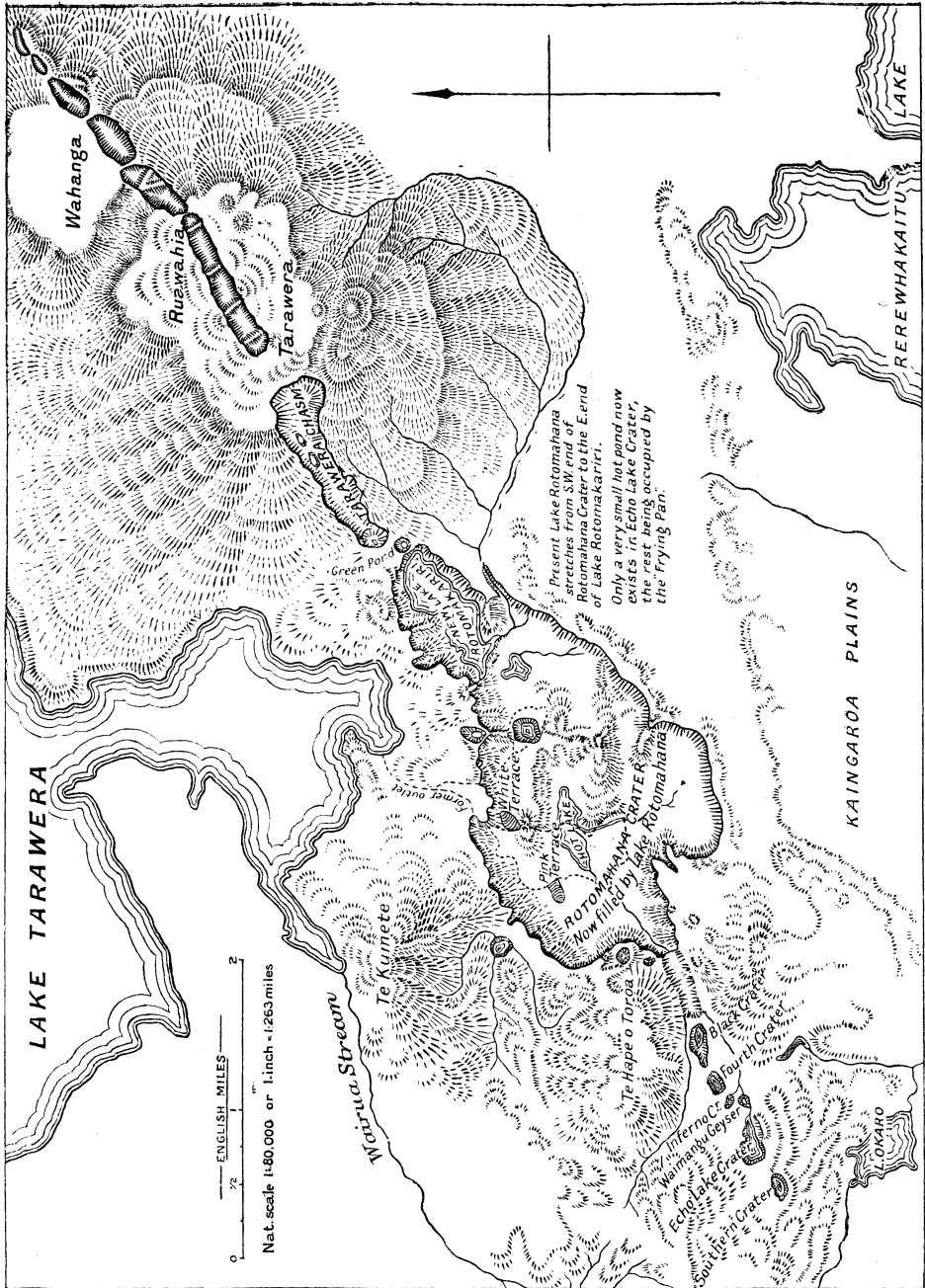
TARAWERA MOUNTAIN, SHOWING GREAT RIFT.



MOUNT RUAPEHU.



MOUNT RUAPEHU, WITH A LIGHT COVERING OF WINTER SNOW.



TOPOGRAPHY OF THE TARAWERA VOLCANIC RIFT
SOON AFTER THE ERUPTION OF 1884.

Premonitory Symptoms of Eruption.—Those who have visited Rotorua and have met that picturesque and interesting old figure, Sophia—the guide, and the heroine of Tarawera—will remember that according to the somewhat embroidered and exaggerated story of that sprightly old lady, the Maoris noticed some premonitory warnings of the coming catastrophe. According to her account, some of the geysers near the terraces grew more active, others apparently became moribund; while the near-by lake of Tarawera rose, fell, and rose again.

The event does not seem to have been immediately heralded by any unusual atmospheric conditions,* the barometer and temperature, as far as can be ascertained, being normal for the time of the year. The actual event, whatever may have gone before, came with appalling suddenness on a clear, cold June night, so much so that the native dwellers near the Terraces who had evidently been unimpressed by previous symptoms of the eruption were unable to escape. At Wairoa, some 8 miles distant, a number of people also perished. Some, however, survived, and it is from these spectators that we obtain the record of the chief events that occurred on that never-to-be-forgotten night.

Progress of Eruption.—The disturbances were inaugurated by a slight earthquake shock about 12.30 a.m. (June 10, 1886). For the next hour earthquake shocks followed one another rapidly and with increasing violence. About 1.30 a.m. the eruption seems to have commenced on one (Wohanga) of the summits of the mountain. About 2 a.m. a violent earthquake, followed by a loud and prolonged roar, occurred, which seems to have rent the crest of the mountain. Afterwards, hanging over the whole mountain, could be seen a great black cloud which expanded upwards like a huge fungus. “. . . Red bodies, which were doubtless red-hot fragments of ejected rock, were now seen darting from the black cloud, whilst lightning began to shoot out from it, accompanied by the roll of thunder. A red glow lit up the column, and from time to time, as a fresh outburst took place on the mountain, the clouds were lit up with a stronger glow, and red-hot stones, described by observers as fire-balls, were seen falling around the summit. By this time the mountain seems to have been in full eruption, and presented a magnificent spectacle. The electrical phenomena must have been of a very remarkable character.” *

“It is not clear at what time the eruption commenced at Rotomahana, as lofty hills obscure the view in that direction, both from Rotorua and Wairoa. It is probable, however, that the craters at Rotomahana were in eruption soon after 3 a.m., for about that time the earthquakes were especially severe, the heaviest one noticed happening at 3.20 a.m. There is a similar uncertainty as to the hour at which the craters to the south-west of Rotomahana were opened.” †

* A. P. W. Thomas, ‘Report on Eruption of Tarawera and Rotomahana, N.Z.’ p. 31.

† *Ibid.*

The violent phase of the eruption seems to have ceased about 6 a.m., though at Wairoa mud or ashes continued to fall until 9 a.m.; while towards the east, the direction towards which the wind was then blowing, the fall of ashes and the consequent darkness were noticeable to a much later hour. For weeks afterwards, moreover, the ejection of fragmental material proceeded in the immediate vicinity of the various craters.

Effects of Eruption.—The direct results of the eruption of Mount Tarawera were many. The chief of these many be briefly stated.

The district was fortunately very sparsely inhabited, and only one hundred and thirty persons lost their lives. All the remarkable hydrothermal centres, including the pink and white terraces situated near the old lake of Rotomahana to the south-west of the mountain, were completely destroyed, and their places taken by a portion of a long line of craters. This line of craters, running in a direction of S. 58° W., extends some 9 miles from Mount Wahanga, the most north-easterly part of Mount Tarawera, to a point some 600 yards beyond Lake Okaro.

Along the line many new hydrothermal centres have appeared, the most remarkable being the great geyser of Waimangu, which was for years the greatest wonder of the thermal region. Waimangu was not discovered until July, 1900, and is not thought to have been active much before that date. From the time of its discovery until July, 1904, it played nearly every day. Then for seven weeks and five days it remained dormant, to again break out and give nearly daily exhibitions until November 1 of the same year. Since that date the great geyser has never again fully displayed its energies, though there have been spasmodic outbursts from time to time. The "shots" from the Waimangu geyser were gigantic in their proportions: at the finest outbursts, water, mud, and even huge boulders were ejected vertically into the air in a column of dirty black water. Though accurate data relating to the measurements of these outbursts are difficult to obtain, the highest is said to have ascended to a height of about 1500 feet above the mouth of the geyser, and to have carried a volume of 800 tons. The visual effect of the great column, as it rose in the shape of a huge cauliflower-like mass, showering mud, sand, and boulders back into the water below and even high up on the surrounding slopes was awe-inspiring and wonderful; while the thunderous roar gave an infernal sound to this remarkable phenomenon.

Though lavas rose to the surface at Tarawera mountain itself, their extent and consequent influence on the character of the topography were extremely limited. The eruption was essentially one of fragmental material. Owing to the high wind prevailing at the time, this material was carried mainly towards the east and spread over an area of country some 6000 square miles in extent. Near the mountain itself the country was completely devastated. The thickness of ejected material is naturally greatest near the fissure, being on Tarawera mountain upwards of 20 feet,* and narrowing laterally.

* Park ('Geology of New Zealand,' p. 169) mentions 50 feet.

Present Topography of the Mountain.—The general character of the topographical outline of Tarawera mountain seems to have altered comparatively little since the eruption, though there is a marked difference in the photographs taken before and after that event. Prior to the eruption the height of Ruawahia, the central and highest peak of the mountain, was 3606 feet, while to-day it is 3770 feet. The slopes of the mountain, though grooved by numerous ravines and furrows, are, in general, extremely smooth, but moderately steep. The south-west slope is deeply cleft by a great chasm, representing that portion of the rift between Lake Rotomahana and the summit of the mountain. On the mountain the great rift is not continuous, but is broken by wall-like partitions into an irregular line of long somewhat funnel shaped craters. The deepest of these craters is now, owing to the collapse of the walls, 500 feet shallower, it is said, than it was immediately following the eruption. The sides of the craters display graphically the geology of the volcano, the lower portions being composed either of light-coloured rhyolitic lavas or breccias, and the upper portion of darker tuffs—the augite-andesites of the last eruption. In places steam issues from the walls, in bizarre contrast to the red and purples of the upper lavas and more sombre light and dark greys of the lower rocks. Very little vegetation as yet relieves the dreary slopes, though here and there some quick-growing shrubs are struggling to extend their roots in a loosely consolidated and incoherent soil.

MOUNTS RUAPEHU AND NGAURUHOE.

Situation and Environment.—The mountains that flank the southern limits of the Taupo volcanic zone, and which are known as Ruapehu, Ngauruhoe, and Tongariro, are sometimes grouped together under the name of the Northern Alps of New Zealand. This designation, however, is quite inappropriate. The mountains are entirely volcanic, and present none of the characteristics ordinarily associated with peaks of Alpine character.

Ruapehu, the highest peak of the North island (9175 feet), is practically a solitary mountain, though a low narrow ridge does connect its base with that of Ngauruhoe (7515 feet). The group of mountains surrounding Mount Tongariro (6458 feet) are closely joined to Ngauruhoe, the whole being sometimes known as the Tongariro range. Not far to the north-eastward of Tongariro the country descends in a series of low volcanic hills to the spacious basin of Lake Taupo.* South-westward of the mountain tussock-covered plains are soon lost amid the bush-clad landward stretches of the Wanganui coastal plain; while eastward broad grass-covered flats lead to the base of the forest-covered Kaimanawa mountains.

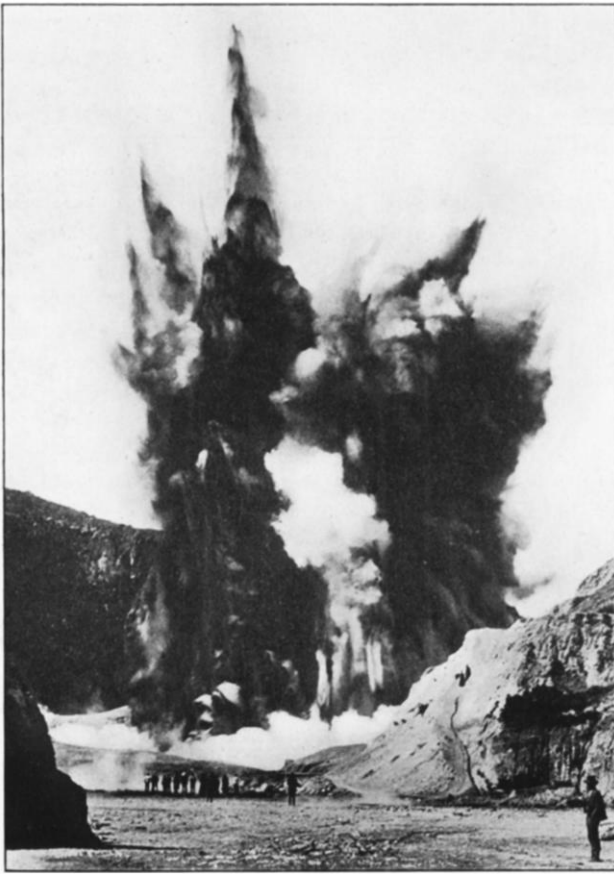
* Lake Taupo occupies a graben or basin of subsidence on the course of the Whakatane fault. The hydrothermal phenomena at Tokaanu and Waihi on its south shore, and near the "Terraces" and "Taupo Spa" on the north shore, lying close to the fault line, are of great interest. At Waihi, serious landslides have occurred within recent years through the softening of the hill slopes by steam.



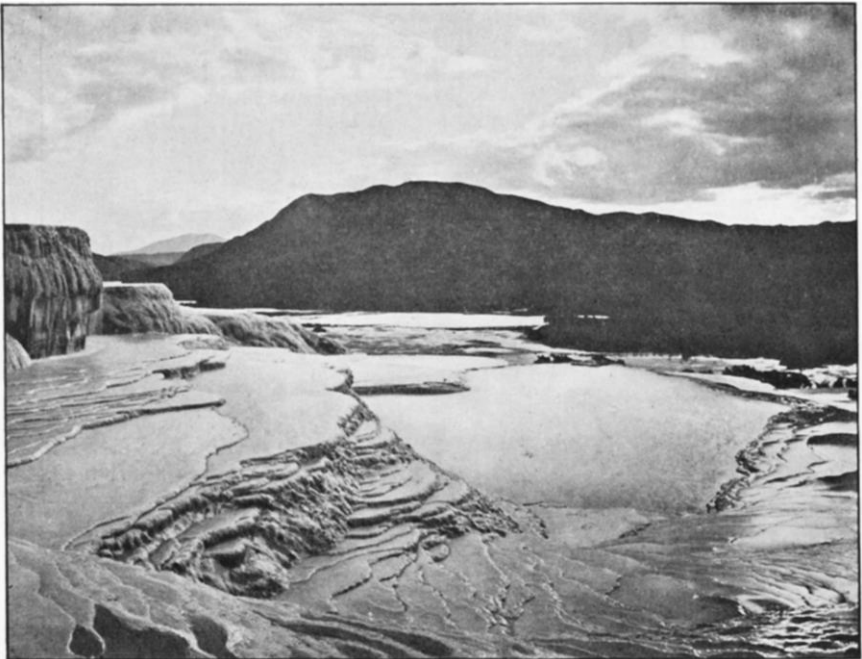
MOUNT NGAURUHOE.



THE CRATER OF WHITE ISLAND.



WAIMANGU GEYSER IN ERUPTION.



WHITE TERRACES (NOW DESTROYED).

Narrative.—It was in September, 1907, that, in company with J. M. Clarke, a well-known New Zealand Alpine guide, I first visited Ngauruhoe and Ruapehu. Both mountains, from their summit to their base, were covered with a snowy mantle, which also stretched over the surrounding plains. So furious were the storms that prevailed immediately after our arrival that we were unable to attempt more than one ascent, namely, that of Ruapehu, during our brief stay. Even this mountain proved much more difficult than we expected. The snow from the shelter-hut on the eastern slope of Ruapehu to the base of the cone of Ngauruhoe was, for the greater part of the way, very soft, and from that point upward extremely hard. Thus, for the first 5 miles we kept plunging and falling; while for the last 2000 feet we had to use the ice-axe for every step we advanced up a steep ice-slope of 40° . Even then we failed to reach the actual crest of the volcano, though we were within close range of it when we had to turn back at nightfall, numbed by an icy wind blowing off the snow-covered peak of Tongariro to the northward. We had been near enough to the crest of the volcano to be affected by the sulphur-laden steam which from time to time was wafted from the crater and froze on our clothes.

In the following two years I made several short stays in the neighbourhood of Ruapehu in the hope of making another ascent. The weather on each occasion was, however, hopeless for climbing, and it was not until March, 1910, that I was able to take advantage of suitable conditions. Then from a camp pitched high up in one of the valleys, descending from Ruapehu to the north-west, both that mountain and Ngauruhoe were easily ascended, though unfortunately there was not time to visit Tongariro proper. Probably no other season of the year is more satisfactory than the late summer for the ascent of these mountains, because Ngauruhoe is then quite free of snow, and there is very little on its higher neighbour save at its summit. Neither ascent at this time of the year presents any danger, or exertion more serious than a long tiresome trudge up seemingly unending scree or scoria slopes. In the case of Ngauruhoe, we rode to the base of the cone, and, there tethering our horses, made, in about an hour and a half, the ascent of the last 2000 feet—the portion that had a few winters before given us so much difficulty and taken so long to accomplish. Unfortunately the weather was misty, and we were only able to obtain passing glimpses of the interior of the crater.

Next day we made the ascent of Ruapehu. We left camp in a dense fog, and after crossing a low ridge, rode up the valley of the stream in which our camp was pitched. We managed to grope our way to its headwaters, and were, owing to the thick weather, just on the point of retracing our steps when the clouds suddenly lifted, and we beheld ahead of us the jagged, rusty red palisades which in places flank the mountain on its northern side. Leaving our horses, we continued our way on foot, and after three hours of wearisome trudging up long stretches of lava and scoria slopes, reached the north peak of the mountain, and looked into the

spacious ice-filled basin of the inner summit. The eastern landscape alone was open to our view; in every other direction stretched a sea of cloud.

Activity of Mountains.—"The last eruption of lava from Mount Ngauruhoe," according to Prof. Park,* "took place in 1869, when a flow of andesite, accompanied by showers of scoria, was emitted. . . . A remarkable feature of this eruption was the loud underground detonations which continued for over three months, being clearly audible for a distance of 120 miles." Since that year the mountain has been in a state of more or less continuous solfataric activity, and from time to time violent explosions, which spread ashes over the cone of the mountain, and even on to the surrounding plain, take place.

Within the memory of Europeans there has been no known outpouring of lava from Ruapehu, though many of the flows on its slopes look as if they had been deposited but yesterday. Prof. Park relates † that "until a year before the Tarawera eruption no volcanic activity of any sort had ever been observed at Ruapehu, either by natives or Europeans. The mountain was looked upon as an extinct volcano. Even in January of 1886, when the mountain was ascended by the author" (Prof. Park), "that was six months before the Tarawera eruption took place, what is now the crater-lake was occupied by a sheet of ice." Since the Tarawera eruption there have been occasional periods of activity, mostly feeble and hydrothermal, but on one or two occasions between 1906 and 1911 more violent eruptions took place. The centre of activity was the crater-lake, and from here mud and even boulders were scattered over the surrounding ice-filled basin.

Topography of Mountains.—Topographically considered, Ngauruhoe is an almost perfect cone composed mainly of andesitic scoria, with rarer stretches of lava of the same petrological character. It rises on the south-east and west from the midst of a number of low volcanic ridges, in which occur the two small crater-lakes. On the north its symmetrical slopes are relieved by the northern outliers from Mount Tongariro. The crest of the mountain is occupied by an extensive crater, which has a width of 600 feet, and a depth, from the highest point of the mountain, of 250 feet. The bottom of this crater is not flat, and within it are two subsidiary craters, one being more active and larger than the other. Prof. P. Marshall, who, through many ascents of the mountains, probably knows better than any one else its peculiarities, considers that the character of the crater has undergone changes of late years.

Owing to the relatively great height of the plains surrounding both Ngauruhoe and Ruapehu, neither mountain gives the appearance of considerable altitude. Ngauruhoe is a mountain of such great symmetrical

* 'Geology of New Zealand,' p. 176. See also Thomas, 'Report on Eruption of Tarawera and Rotomahana,' p. 5.

† 'Geology of New Zealand,' p. 176.

beauty that height is not necessary to give it an imposing appearance. Ruapehu, on the other hand, looks scarcely more than a rocky ridge without stately crests, and with long, gradual slopes interrupted in places by rugged pinnacles. Its summit has been truncated by great explosions in the past, and thus has been produced a basin about a mile in width. The basin, which is now occupied by an icefield, is surrounded by a number of rocky peaks. These features, owing to the alternate sombreness and brilliancy of their colouring and the abruptness of their topography, stand in marked contrast to the smooth white ice below. Of these crests, the north peak and the south-east peak are the most conspicuous. The former is on the rim of the old truncated crater-basin, but the latter is a new parasitic cone. Near the south side of the snowfield is the remarkable crater-lake previously mentioned, and about 200 yards in diameter. The lake is surrounded by cliffs of ice, from which great chunks break from time to time, and are melted in the warm water below. The water is of a dirty greenish-grey colour, and is said to be always hot, though steam was not rising from it at the time of our visit. From the ice-filled basin a number of small, but well-developed cliff and valley glaciers, with numerous ice-falls, descend a few miles down the mountain slopes, and give rise to the larger streams flowing therefrom. On the slopes of the mountains between the glaciers lavas, both solid and vesicular, predominate over fragmental material, though the latter is also conspicuous in places.

MOUNT EGMONT.

Mount Egmont (8250 feet), though not the highest mountain in the North island, being nearly 1000 feet lower than Ruapehu, is certainly the most imposing and most beautiful of the many volcanic peaks of the country. It rises from relatively low country within 17 miles of the sea, and stands a solitary sentinel above the fertile fields and forested slopes of Taranaki. The wonderful symmetry of the mountain flanks is interrupted on the south side by the relatively inconspicuous parasitic cone of Fantham's peak; and on the north by the Pukewa ranges, from the denuded crests of which Egmont itself is thought to have risen.

According to Maori legend, Egmont, Tongariro, and Ruapehu were formerly three great giants who lived close to each other in the centre of the island. Egmont, or Taranaki as it is called by the Maoris, interfered in some way with the matrimonial relations of one or both of his brother giants, and to escape their wrath was forced to fly to the coast, where he now stands in lonely grandeur far from his former home.*

I was not so fortunate as to reach the top of Mount Egmont. One attempt was made, but a storm arose shortly after we started, and we were forced to return without reaching the summit. However, under good weather conditions the ascent presents no difficulty whatever. A

* F. von Hochstetter, 'Geology of New Zealand' (Explanation of Atlas, etc.), p. 27.

good track leads almost to the summit, and there is a "rest-house" fairly high up the mountain-side. The crater of the volcano, being above the level of perpetual snow, is always filled with ice and snow. Though the lava-flows on the mountain-side look to be of remarkably recent deposition, the Maoris have no record of any eruption, and the mountain is now—at least apparently—quite extinct.

VICINITY OF AUCKLAND CITY.

Hochstetter * describes some sixty volcanoes as occurring in the neighbourhood of Auckland. It is these cones, in fact, that give the charm and beauty to the harbours of Manakau and Waitemata, as well as to Auckland city itself, lying between them. Some of the cones consist entirely of scoria; others are composed entirely or mainly of lava. Many have lost their characteristic form, but some still have it well preserved.

The most conspicuous of the Auckland volcanoes, Rangitoto, lies at the entrance to Auckland harbour. The gradual slopes of the mountain suggest that the lava must have been in a distinctly liquid state when it was poured forth. The summit of the mountain is formed by a broad open lava crater, within which lies a small and more recent scoria cone. Most of these volcanoes have apparently been extinct for a relatively long time, and there is no historical evidence of any activity since the Maori occupation of the island. However, the fresh character of the rocks on the slopes of Rangitoto, and the almost complete preservation of the volcanic contours strongly indicate that the mountain must have been in active eruption within comparatively recent time. I hesitate to commit myself to anything but an approximate date. Several New Zealand geologists have told me that they think the period of activity may not be more remote than 500 years ago.†

NEAR THE BAY OF ISLANDS.

Inland from the Bay of Islands, on which was situated the first capital of New Zealand, and close to the old missionary centre of Waimate, lies a district in which relatively recent volcanic energy has built up lava and scoria cones and filled pre-existing valleys with volcanic material. Even at the present day solfataric action is still proceeding vigorously at the Ohaewai springs, where hot sulphur-laden waters are depositing mercury and gold-bearing sinters.

Some of the best-preserved cones lie close to the shore of Lake Omapere. Te Ahuahu (1200 feet) is a prominent cone composed of andesitic scoria with a well-developed crater on its summit. Its finely preserved slopes show the remains of Maori fortifications—the site of many a hand-to-hand fight in the early days.

Close to Te Ahuahu is the curious rounded rhyolitic mound of Putahi.

* F. von Hochstetter, *loc. cit.*, p. 39.

† Hochstetter, 'Geology of New Zealand' (Explanation of Atlas, etc.), p. 42, thinks many thousands of years ago.

At many points towards the summit of this hill occur narrow cylindrical shaft-like holes—apparently old steam-vents. Many of these holes are shallow, but some are 30 feet and more in depth. One hole which has been used by the Maoris for generations as a burying-pit is at least 100 feet, and possibly much more, in depth. The Maoris, in fact, aver that it communicates with an underground passage leading to the near-by Lake Omapere.*

WHITE ISLAND.

White island lies in the Bay of Plenty, and about 30 miles from the mainland. Its crater is in a constant state of solfataric activity, and the ascending clouds of steam make the island a conspicuous feature for many miles in every direction. Unfortunately, I was never able to visit the island, a landing only being possible under very favourable conditions.

The island forms a simple cone, with exceedingly steep sides of andesitic lava and tuff, excepting on the south side. Here the crater wall is broken down, thus providing a ready means of access to the crater-lake within. The water of the lake is of a vivid green, and is heavily charged with hydrochloric acid. The north-west corner of the lake presents a display of solfataric activity unrivalled even at the thermal centres of Rotorua and Taupo.†

MAYOR ISLAND.

Situation.—To the northward of White island, and lying some 15 miles off the coast of the Hauraki peninsula, is situated the solitary island known as Mayor island, so named by Captain Cook in honour of Lord Mayor's Day.

History.—Formerly the island was the home of a small though prosperous Maori community, the members of which, in its balmy climate, cultivated on the limited stretch of flat and arable land near the coast, plants which could not stand even the mild frosts of the adjoining mainland. Notwithstanding its isolation, there was not always peace on the island. For a time it was the scene of many a bloody fight between the islanders and the braves from the mainland. Old and decaying *whares* surrounded by ancient fruit-trees at Panui, on Opo bay, and on the shores of the lake of Aroarotamahine, testify to the former habitations of a people finally driven from its home by the invader. In later days whalers lived on the island, which served as a convenient base to scour the surrounding seas. Now only an occasional traveller visits its shores, though it would be difficult to imagine a place more inviting. When the small yacht on which our party journeyed from the mainland weighed anchor in the clear waters of Opo bay we found two old Maoris—descendants of the island's former inhabitants—encamped, and occupied in fishing and tending the *Kumera* crops which here grow to perfection. We pitched our camp near the sea-beach, being carefully watched meanwhile by the two old men lest

* See p. 27, *Bulletin* No. 8, New Zealand Geological Survey.

† James Park, 'Geology of New Zealand,' p. 175.

near Panui and another patch within the crater, is entirely mountainous. The highest points on the island are Tutaretare (1162 feet) and Opuahau (1274 feet). These guard the southern and western flanks of the great crater occupying the whole central and eastern part of the island. At the lowest part of the crater are two small lakes, one of which is about half a mile in length, joined together by a swampy stream. To the shore of the lake descend on the western slopes gently inclined scoria slopes, covered with a low forest growth. The eastern and southern flanks are for the most part precipitous. A narrow and relatively low ridge separates the crater-basin from the open sea, and near a saddle on this ridge a small stream of water issues from a vertical face of rock.

The coast-line of the island is indented by numerous bays, but most of these are fronted by steep precipices of obsidian, so that the interior of the island is accessible from only a few points where sandy beaches relieve the general steepness of the strand-line. A number of islets lie off the shore, the most extraordinary of these being several tall rectangular stacks of remarkable shape which guard the entrance to the shallow bay of Orongatea. At the northern end of the island some hot springs issue on a sandy beach. These represent the expiring phases of the volcanic upheaval that built the island up from the sea-floor. The island has not been an active volcano for many centuries, as the tall forest which appears in places, and the great amount of denudation in a few localities amply testify. It must, however, have (geologically) recently been in full eruption, since the characteristic volcanic topography is so well maintained.

Major LEONARD DARWIN (before the paper): Dr. Mackintosh Bell, our lecturer to-night, was for six years Director of the Geological Survey of New Zealand. He is a Canadian by birth, and in Canada he had excellent opportunities for studying geology and geography. Dr. Mackintosh Bell made a special study of those remarkably interesting regions—the volcanic regions of New Zealand, and it is with regard to that district he is going to speak to us to-night.

Major DARWIN (after the paper): When we hear of New Zealand and of its great prosperity, I think we are often apt to forget what a comparatively new country it is. Such being the case, I cannot help thinking that the greatest credit should be given to its Government for the way in which it has taken up this question of geological and geographical surveys. I feel certain that its Government will never repent the expenditure it has incurred in sending men like Dr. Mackintosh Bell to make scientific surveys of every region. I am sure we have all been extremely interested to-night, and I have hardly ever seen a lecture better illustrated with photographs. He showed us some views of those vanished white and pink terraces. I had the good luck to visit New Zealand in 1874, and I saw those wonderful places. I think he is right in saying that no photograph can really give an adequate impression of them, partly because of the extraordinary colour of the water. The colour of water in some reservoirs of waterworks—the intense blue you sometimes see, only a little more milky—gives one the best idea of the colour of the water in those terraces, an absolutely intense blue which, contrasted with the pink-and-white walls, made a most glorious effect. These terraces are places the beauty of which one can boast about with the greatest amount of