ART. XLIX.—Taupo Plateau and Lake: a Retrospect and Prospect.

By H. Hill, B.A., F.G.S.

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Plates XLII. and XLIII.

Very little is yet known as to the history of the Taupo Plateau. Situated in the heart of the North Island, at an elevation varying from 1,400 ft. to 3,400 ft., with a gradual slope to the Bay of Plenty, it presents an area of exceptional interest to the geologist. Hochstetter in 1859 saw a portion of it, and his journey from Tokaanu at the south end of Lake Taupo to Tapuharuru at the north end, and thence on to Rotorua, enabled him to understand some of the geological aspects of this interesting region. But he little realised the extent of the volcanic area, or imagined that the whole of it was in a large measure directly connected with the history of volcanic phenomena extending over a much longer period than is usually assumed. We are so apt to view the isolated volcanic areas of to-day in their limited extent that we overlook the fact of the present areas of activity being connected directly and continuously with the earth's history from the time when the earth was a mass of molten matter. It is certain that new areas of volcanic agency have begun within the human period, and that volcanic cones have built themselves as mounds of accumulation by the material that has been thrown or has flowed from the cratetal opening that is made by the gyration of superheated steam or gas during and following great earth-movements. But, whilst this is readily conceded, it must be evident from the study of volcanic phenomena and the distribution of volcanic products that volcanoes have always existed from the time when the solidification of the earth's crust took place. Nor is there any reason why many of the volcanoes now known should not be directly connected with the earliest period of the earth's history. If we assume that earth-changes have taken place without those great cataclysms which the earlier geologists assumed as necessary—and the evidence of the rocks is fairly complete that such changes were gradual and continuous—then it may be asked, why should there not be volcanoes that have existed through the varying changes of deposition as illustrated by the stratified rocks? The science of geology teaches us that the forces of nature are constant in their operation, although the results from period to period may be dissimilar. The external forces that are ever in operation in their action upon the earth's
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surface, though similar in kind, are not continuous in intensity. The pressure of the atmosphere, the force and direction of the winds, the moisture in the air, the heat of the earth’s surface, the movements of the water of the ocean, are ever changing, though always acting and operating in degree: hence it may be said that the forces of nature, although similar in kind, have been unlike in their results, as the outcome of the varying differentiations that are ever in progress.

But to return: Along the East Coast district of the North Island the stratified rocks are represented by Tertiary and the Younger Secondary. With a single exception there are no traces of volcanic rocks. this exception is at Red Island, some miles to the south of Cape Kidnappers. Fifty miles inland from the coast there is the country that is generally known as the volcanic district. Ruapehu in the south and White Island in the Bay of Plenty are usually understood as representing its southern and northern limits; but these are by no means sufficient to determine the extent of the area that is the direct outcome of volcanic phenomena. The present centres of volcanic activity are embraced in a large measure within the limits of the places named, but it must be set down that the larger portion of the North Island is the direct product of volcanic agency. From the south-west corner of the Island where the extinct volcanic cone of Mount Egmont stands, right away to Tarawera, fifty miles north-west of Napier, a volcanic line may be traced. Right away to the north from Egmont there are volcanic rocks, and it would seem as if the great bight between Egmont and Kaipara Harbour represented an area of subsidence that corresponds to an area of elevation midway between Taupo and the great bight above mentioned. At present the centre of volcanic activity is represented by a line running from the crater-puia on Ruapehu in a north-easterly direction, and embracing the whole of the area affected by the Tarawera eruption of 1886. But this line of activity far from represents the area of volcanic energy such as the Taupo Plateau has experienced in past times. The attention that has been paid to the active phenomena as they appear to-day has led to the partial neglect of historical volcanic phenomena in relation to the Island as a whole. As viewed by the activities such as they appear to-day, the volcanic phenomena compared with the past are small and almost insignificant. When it is considered how extensive is the volcanic belt and how widely distributed are the lavas of rhyolite, one is led to inquire as to the magnificent grandeur of the volcanoes of the past, or, if not volcanoes, then of welling seas of lava that spread in sheets over the Taupo Plateau for many hundreds of square miles. At the present
time we see extending from Ruapehu volcanic cones of accumulation with intervening areas of depression, and extending for two hundred miles or more across the Island. Ruapehu, Ngauruhoe, Tongariro, Pihanga, Motutaiko, Tauhara, Maungangonganga, Kakaramea, Mount Tarawera, and Edgecumbe are the product of the welling-up of lavas, or they are the outcome of explosions by means of which great quantities of loose material have been thrown out of volcanic orifices. Still, it is of importance to notice that, notwithstanding the wide distribution of lavas over the eastern and western parts of the Taupo Plateau, there remain but few traces of those older volcanoes that must have preceded Ruapehu and other adjacent volcanoes in the history of the Taupo country.

In January, 1902, I had the pleasure of coaching to Taupo from Napier in company with Mr. Cheeseman, F.L.S., of the Auckland Museum. Between Petane and Taupo barometric observations were taken for every mile of the journey. Within fifty miles of Napier the volcanic lavas appear for the first time on the roadside, at an elevation of 1,520 ft. above sea-level. They are in the hills two miles or more to the eastward of Tarawera. The Maitai slates are the prevailing rocks, but the country in many places is deeply covered with fine white pumice, in which are seen many specimens of trees burnt to a charcoal. The lavas seem to have flowed through the valley from the west, for they are not seen in the exposed rocks near the Tarawera Township, but they appear in the ridge over which the coach passes, a mile or so to the west. This ridge runs as an offshoot from the main line of hills, and ends in a single hill overlooking the Waipunga River, into which a hot spring flows from the hill. In several places the lavas appear on the roadside in the beautiful valley known as the Nunneries, and between the 56th and the 57th milestone from Napier the rhyolitic lavas are largely developed. From this place onward to the Rangitikei River they appear as the only massive rock-structures by the way. At Ohinehuka (61 m.), where there is a small native settlement, the country is covered with heavy bush, but wherever an exposure of rocks is seen they are rhyolite lavas of a greyish dull colour. At the 65th milestone the road crosses the Waipunga Stream (2,100 ft.), and the entire bed is seen to be made up of lavas, and presents the appearance of paving-stones throughout the whole bed of the stream. A mile or so lower down the stream the rocks change somewhat, where three streams meet and fall into a deep gulch-like area between enormous walls of black basalt-like rock, which appears to have come from the hills a mile or two south-east of the falls. Beyond Waipunga the country begins to open into extensive swamp-areas leading
on to the Taupo Plateau. From this swamp-area long, deep, and narrow valleys run between cliffs of pumice. These cliffs present steep faces, as if they had been shorn, and they extend for miles without any apparent alteration in their width. The bottom of each valley shows the lava-sheet surface similar to what is to be seen in the Waipunga Stream. In many places the lava is exposed on the surface of the road, where a kind of "scaling" takes place after a frost. At the 67th milestone the height of the plateau is 2,350 ft., and here again the rhyolites are exposed. At the 68th milestone an extensive area of swamp country is reached, and from the basin-like appearance, surrounded by sloping hills, it seems as if this area was the remnant of an old volcanic crater. The walls remain, and what may be termed the crater-lip provides an exit for what is at present a large swamp-lake, and the source of the Waipunga and possibly other streams. Between the 68th and 69th milestones the land begins to rise, and it continues to do so as far as the 73rd milestone, which is 2,320 ft. above sea-level. The ridge separates the volcanic-crater basin from the present Rangitikei River basin. The ridge is made up entirely of loose pumice material overlying rhyolite lavas that must be 150 ft. or more below the surface, as the lavas are seen to form the bed of the Rangitikei River just as they do of the Waipunga Stream. The former river crosses the Taupo Plateau seventy-five miles from Napier, and at a height of 2,170 ft. above the sea. From the river the road gradually rises in the direction of Taupo. Thus, at the 78th milestone the height is 2,270 ft.; at the 80th, 2,335 ft.; the 83rd, 2,380 ft. This is the highest point of the plateau on the coach-road, and from here onward there is a gradual fall towards the lake. Thus, at the 84th milestone the height is 2,370 ft.; the 85th, 2,300 ft.; the 87th, 2,029 ft.; the 88th, 1,850 ft.; the 91st, 1,720 ft.; the 94th, 1,400 ft.; the 95th, 1,370 ft. This height is not far from the site of the Terrace Hotel, which is about two miles and a half from the Taupo Post-office, and 160 ft. above the level of the lake. Cussen gives the height of Lake Taupo at 1,200 ft., Hochstetter at 1,250 ft., and Dieffenbach at 1,337 ft. Compared with the height of the lake, it is interesting to notice the height of the lavas on the Napier side of the Tarawera Township. These lavas are 320 ft. above the surface of the lake, fifty miles further inland, and they gradually rise in the direction of Taupo, as they are 2,170 ft. above sea-level at the Rangitikei, and much higher than thus in the lowlying hills that cross the plain to the north-west and south-east, a few miles further in the direction of Taupo. Between the 73rd and 83rd milestones the slope is towards the Rangitikei River, the longer slope being from the south-west. The latter
(83rd) milestone marks the watershed between Taupo and the Rangitikei River; but it is important to observe that the high ridge runs in the direction of Ruapehu and Ngauruhoe, whilst a glance at these mountains from the high plateau between the two slopes shows that the original drainage-area was to the eastward of the present Lake Taupo. Thus it seems that at one period in the history of volcanic activity a line of volcanoes existed twenty miles or more to the eastward of the present line, just as they did to the westward, and that from these volcanoes or great fissures issued sheets of lava of vast extent, with which no modern outflow in this Island can be compared.

It will have been noticed that from the 83rd to the 96th milestone there is a sudden fall to the lake. The fall is very noticeable when proceeding by coach, as old margin-lines or basins are to be seen, showing by their gradual slope what were at one period in the history of the plateau sloping banks to a large lake, equal in extent to Taupo itself, but now a dry area of pumice mounds, covered here and there with tussock-grass, hardy Dracophyllum, and a few stray gentians and alpine plants.

But it is necessary to obtain a full idea of the general character of the country in order to understand the great changes that must have taken place to bring about the present conformation of the district. The valley of the Rangitikei is much more than a mere Post-Tertiary and Pliocene area, as the geological map of the Island has it. The high ridge running between the Taupo Lake and the Rangitikei Valley in a north-westerly direction separates farther in the direction of the Kaingaroa Plain the drainage of the Waikato River from that of the Rangitaiki; but this was not always so. The lava-beds that cover the plateau preceded the deposition of the pumice and attendant volcanic grits and stones, and we have the fact that the swamp-area in the vicinity of the 68th milestone is much lower than the general area of the surrounding hills, which are composed wholly of rhyolitic lavas. Before the distribution of the pumice in such abundance over the Taupo Plateau it seems as if large volcanoes extended more to the eastward and ran across the plain in a north-westerly direction, crossing the present line of volcanic intensity. For many miles ridges can be traced from the coach-road between the Rangitikei River and Opepe, running in the direction of Wai-o-tapu. Many of these present the appearance of chimneys, and convey the idea that they are the remnant of crateral walls of volcanoes that once played an important part in the history of the volcanic area.

It is certain that the time was when Lake Taupo did not exist, and there could have been no Waikato such as is known to-day. The drainage or watershed of the country was very

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much modified by the material that was thrown from the volcanoes of Ruapehu and Ngauruhoe. The ridge to the east of these mountains is known as the Onetapu Plain and Rangipo Desert. It is made of materials thrown from the mountains, and it forms the watershed between the north and south parts of the Island. The drainage appears to have been towards the Rangitaikiki Basin and thence through the Kaingaroa Plain into the great Whakatane Swamp. Subsequently it went through the Wai-o-tapu Valley, and thence into the Tarawera River. The Waikato of to-day is the product of the Taupo Lake; but when did the lake come into existence, and under what circumstances?

The whole of the western side of the lake is surrounded by cliffs that rise 1,500 ft. or more in vertical height from the bottom of the lake. Along the eastern and northern sides pumice is the predominant material, and in some places pumice cliffs rise to a height of 200 ft. or more above the surface of the lake. It is evident that important physical surface-changes must have taken place to bring about the conditions such as at present are to be found. A map of the Taupo district shows the present drainage-area of the lake. From Ruapehu and Ngauruhoe proceed many streams, of which the Tongariro (Waikato?) is one of the chief. It falls into Lake Taupo at the south-eastern corner. At the northern end of the lake the Waikato River begins. It is the only river that flows from the lake, and represents the difference between the total inflow and the amount of evaporation that takes place. But the history of the lake is the history of volcanic phenomena along the line of weakness, which is at present the line of greatest activity within the volcanic zone. Thus, Tokaanu at the southern end of the lake, the Terraces and the Spa at the northern end, then Wairakei, Roto-kawa, Orakei-korako, Wai-o-tapu, and the great Rotomahana–Tarawera rift, are included within a belt drawn north-east and south-west so as to include the eastern and western sides of Lake Taupo. Within this belt all the phenomena traceable to volcanic action are to be found. But this line of weakness is only a remnant of volcanic action. The volcanic work on a large measure has been done; and that work is to be estimated not by the cones that remain along the present line of weakness, but rather by the distribution of lavas over a very large part of the middle and northern portions of the Island. The volcanic cones of Egmont, Ruapehu, &c., are mostly cones of accumulation made up of material that has been thrown out by explosive force and by the welling-up of lavas. As they grew in height, and during their earlier periods of activity, probably much larger flows of lava took place from
Ruapehu and adjacent volcanoes; but the area of country to the east of these extensive volcanoes and covered with lava is very limited in extent. Southward of Ruapehu volcanic lavas disappear beyond the base-limits of the mountain, and if large flows ever took place they must have spread in a northerly direction.

But it has been pointed out that the country between Tarawera and Taupo is composed mostly of rhyolitic lavas, and similar lavas are found for many miles to the westward of the lake at heights varying from 1,500 ft. to 3,500 ft. It may be that these lavas flowed from Tongariro; but, if so, great differential surface-movements must have taken place to account for the varying heights of the lavas, which are extensive over the country. Again, there are volcanic cones on either side of the lake, just as there are traces of old craters, with crumbling walls, and all these were probably formed at an earlier date than Tongariro, Ngauruhoe, and Ruapehu. It was during the period of activity of these latter mountains that Taupo as an area of depression was formed.

But in order to interpret the changes that actually took place it is necessary to study the site of the Tarawera eruption, where to-day the greatest activity is found within the volcanic belt of weakness. What took place at Tarawera in 1886 took place at Taupo at a period that may be measured by hundreds of years. The Tarawera eruption was an explosive one, by which is meant that it was brought about by superheated steam being imprisoned as in a boiler, the tension being so increased that the overlying rocks were unable to sustain the increasing strain.

It would seem that the first or initial step in volcanic phenomena is of an explosive character. A shaft is formed from below for the imprisoned steam or gases, and, as the pressure increases when the steam is nearing the surface, the final effort is explosive, a cup-like or crateral hollow being formed. The material thrown out of the shaft soon forms a rim, which continues to increase in height as the base becomes wider, and if the volcano continues active the mound of accumulation becomes cone-like in appearance. All this has taken place many times over within the volcanic belt, and both Rotomahana and Mount Tarawera showed the explosive effect of superheated steam acting along a line of weakness in the earth's crust. The crateral hollows that were formed became centres of increased activity, as they were the lines of least resistance to the gases and superheated waters from below. But what Rotomahana was before the eruption in 1886, and what it has since become, show the character of volcanic changes that go on incessantly within the limits of the
volcanic belt. The existence of the inimitable terraces, and the activities that prevailed over a large extent of country in their vicinity, showed that the underlying forces were yet powerful and far from being played out.

Lake Rotomahana was a warm lake of varying temperature at the time of the eruption. It had an area of 180 acres, and was situated 1,080 ft. above sea-level, or 120 ft. below the level of Lake Taupo. Near its northern end was the celebrated Te Tarata, or White Terrace, and on the western side of the lake was the Pink Terrace. Rotomahana communicated with Lake Tarawera by means of the Kauwaka Stream of warm water, which entered the lake near Te Ariki, a small native settlement. Rotomahana Lake appears to have been little more than a lid covering in an intensely warm area—in fact, a crater solfatara that slowly became filled with warm water. Round about the lake were hundreds of hot springs that showed the intensity of the pressures in the vicinity of the lake. Every steam-vent, constant or not, is evidence of pressure. Hochstetter's map of Rotomahana, published in 1859, after his visit to New Zealand, shows the location of most of the ngawhas, puias, fumaroles, and solfataras that surrounded Rotomahana. After the eruption, what was Lake Rotomahana became a huge crater-like area, 515 ft. in depth, at the bottom of which stood a small lake about 10 acres in area. Within the crater intense activity prevailed: “the whole of the space seemed to be occupied by a vast number of small craters ejecting mud, water, and steam, all in a furious state of eruption, whilst ever and anon an explosion that caused the surrounding hills to shake denoted a more than usually violent outburst, which was accompanied by a discharge of great rocks.” But the whole of those eruptive centres are now hundreds of feet beneath a lake that has increased since the eruption to the depth of Lake Taupo. To the north-east and south-west of Rotomahana deep chasms were formed, and many changes took place in the surface features of the country. Without taking any estimate of the quantities of material from the chasms and rifts, Mr. Percy Smith, the late Surveyor-General, estimated that 600,000,000 cubic yards of material was thrown out of Rotomahana alone, the crater extending over 2,000 acres with an average depth of 515 ft. The lowest point of ejection was Rotomahana, and the highest Tarawera.

Attendant upon the eruptions at Rotomahana and Tarawera, and the formation of numerous craters of explosion, were a number of earthquake-cracks in the vicinity of Waikorua and Pareheru. Two photographs of these were taken by the late J. C. Blythe, an old friend of my own, who was at Wairoa at
the time of the eruption, and went through the awful experiences from which he escaped only with his life. The photographs show a downthrow and a subsidence, the latter of more than 90 ft., the sides being vertical. Here the difference is seen between a force acting upwards and overcoming the downward pressure, and a force acting downwards and overcoming the upward pressure. The former is explosive at the surface, and the latter simply shears and shows a steep face or faces along the boundary-area that subsides. If the whole of the area affected by the Tarawera eruption is traced, two separate and distinct activities are seen to have taken place—one upward and the other downward. The great quantity of material thrown out from the numerous vents and shafts, exclusive of Rotomahana, shows the existence of underground movement. The scoria, blue mud, ashes, and many varieties of volcanic rocks were distributed for miles over the district affected by the explosions; but the material did not come from great depths, and appears to have been acted on by superheated steam of so high intensity that dust, and scoria, and steam rose over the seat of explosion to a height of many thousands of feet.

But all the phenomena of the Tarawera eruption such as were found in the mountains, in the rifted valleys, and about the subsided areas, were no more than the display that took place daily at Te Tarata and Otukapuarangi, or the White and Pink Terraces, but on a much grander scale than was daily displayed at those places. The explosions along the great fissure with its centre at Rotomahana were most likely the direct result of stoppages in various parts of the volcanic area, but which were manifested along the line of greatest weakness—a weakness that perhaps had its origin in the frequent shakings that had taken place in the immediate vicinity of Rotomahana. Mr. Percy Smith, in his excellent résumé of the Tarawera eruption, points out that the fissure seemed to prefer the face of a hill to the bottom of the valley; but the reason is that the valley passes across the lava-flows, and not in the direction taken by them as they move over the land when flowing from a volcanic orifice.

The Wai-o-tapu Valley is at present separated from the line of fissure by deposits from two volcanic mountains known as Maunga-kakaramea and Maunga-ongaonga, both of which show many signs of recent activity. Thus the valley of the Wai-o-tapu, with its crateral lakes, its mud volcanoes, terraces, fumaroles, geysers, and boiling springs, is only separated from the great fissure at Tarawera-Rotomahana by a comparatively low ridge of volcanic débris, and the earthquake-cracks at Pareheru and Waikorua are at the apex of the two valleys. The Wai-o-tapu stream begins in the crateral lakes at the foot of Kakaramea
and flows south-by-west, meeting the Waikato River near the place where the latter river takes its great north-west bend, about nineteen or twenty miles below the place where the river leaves the Taupo Lake. The Wai-o-tapu Valley presents direct evidence of explosions and of great changes throughout its entire length. The rifts, the crateral hollows, the boiling caldrons surrounded by terrace formations, and the numerous signs of volcanic activity, present appearances that are very similar to what are seen in the vicinity of Rotomahana and the line of the great fissure. But for the ridge between the two volcanoes at the head of the Wai-o-tapu Valley the great fissure would extend from Tarawera Mountain right away into the Wai-o-tapu, which is a part of the drainage-basin of the Waikato River, and in the direct line of another great rift, to which reference will be made in the sequel.

Up to the present reference has been made as to the build of the Taupo Plateau, the probable direction of the Waikato River before Lake Taupo existed, and the causes that led to the eruption at Tarawera in 1886, during which Rotomahana Lake became a great crateral hollow and a line of fissure was made extending for twelve miles. In the light of the facts that have been made available as the outcome of the Tarawera eruption it may be possible to obtain a clue as to the origin and history of the Taupo Lake.

**Lake Taupo: Historical.**

The first European to visit Lake Taupo, as far as we have any knowledge, was the Rev. Mr. Chapman, a church missionary, who visited it three weeks before the arrival of Mr. Bidwell. In his "Rambles in New Zealand," published in 1841 by W. S. Orr and Co., Paternoster Row, Mr. Bidwell writes: "As I was the second European who had ever seen Lake Taupo, my visit having taken place three weeks after my predecessor (Mr. Chapman), it is very certain my account of it, imperfect as it will be, must be the only one that has ever reached Europe, and may therefore be considered valuable. Taupo [Taupo] is one of the most superb lakes in the world, not from its size, although that is considerable, but from the extreme magnificence of the scenery surrounding it. Mr. Chapman considers it to be thirty-five miles long and twenty broad. I do not think it is thirty-five miles, but the width is not overestimated at twenty. It is situated in lat. 39° 35' S., east long. 175° (about). . . . The form of the lake is a sort of irregular triangle, with the two most distant angles forming the north and south ends. The most peculiar feature about Taupo is the immense height of the surrounding cliffs; they are always perpendicular, although in
some instances rising in terraces one behind the other and varying from 500 ft. to 1,000 ft. high in several parts of the lake, particularly north-north-west and north-east sides. These rise perpendicularly from the water to such a height that I never saw their tops through the clouds for above five minutes together during the whole eight days I was on the lake. . . . There are but few places where a canoe can land, and at these the beaches are short and narrow: they are covered with black sand, and always indicate the entrance of a small stream of water. . . . At the north end of the lake is a very peculiar mountain (Tauhara), with an outline as regular as if it had been the work of art. . . . The cliffs around the greater part of the lake are of a dark-greenish colour, tinged sometimes with red, and are basaltic. . . . The River Waikato runs into Taupo at the south-south-east end, and makes its exit at the north. At the place where it enters it is a small sluggish river about 25 yd. wide and from 2 ft. to 4 ft. deep. . . . On one side of the river, about two miles distant, is situated the great pa of Taupo, and on the east side, at about one mile from the river, is a small pa called Coteropo [Ko te Rapa ?], where I was encamped. There are several other pas on the west side of the lake, and three in the east, but not large ones. It is, however, decidedly the most populous place I have seen or heard of in the Island. I should think the population in the pas on the lake could not be less than five thousand.”

Mr. Bidwell visited Taupo in March and April, 1839. On the 30th December of the same year the Rev. H. Williams, a Church missionary from the Bay of Islands, reached Tokaunu by way of the Wanganui River. His account is very bright, and is contained in the Church Missionary Society Record of January, 1842. He says, “We continued our march till 4, when we arrived at a settlement on Lake Taupo—a magnificent sheet of water about thirty miles in length, with very fine bays.”

This account of a first visit to Lake Taupo is in marked contrast with that of the Rev. James Buller, who visited Taupo early in the year 1840. The following account is taken from the “Annual Report of the Wesleyan-Methodist” for the year ending April, 1841: “Taupo is a magnificent lake, covering a surface of at least three hundred miles. It is evidently the effect of a violent volcanic eruption at some remote period. Its neighbourhood abounds with hot springs and boiling pools, and the stupendous mountain Tongariro is still in action, sending forth its smoky volumes. The country in this part is very mountainous. Adjacent to Tongariro is the snowy mountain Ruapaka or Paretataatonga [Ruapehu], whose crested summit, rising into the clouds, is discernible from the sea on either
coast. Shocks of earthquakes are frequently felt at Taupo; but the natives, little conscious of their cause, have been in the habit of regarding them as tokens of fruitful seasons. Tongariro they supposed to be the place on which Maui’s hook fastened when he fished up the Island of New Zealand. They have a curious tradition of the origin of its sulphurous fires: they say that a man or some other being named Ngatoroiringi, with his two sisters, Taungaroa and Haungaroa, came from a great distance in the north to fix their abode in this neighbourhood; but Ngatoroiringi, in ascending Ruapaka, found his feet affected by the snow, whereupon his sisters lit some brimstone on Tongariro to warm them, and, having cured his feet, they departed; but the brimstone has continued to burn since that period. They also say that Taranaki, or Mount Egmont, was formerly situated by the side of Tongariro, but that they quarrelled about another mountain named Kōpihanga lying between them: they fought, Tongariro conquered, and Taranaki fled to his present position.”

Dieffenbach, in May, 1841, was the first man with scientific training who visited Taupo, and he thus writes of it: “Lake Taupo is situated in a straight line between Cape Egmont and the East Cape, the direction of which is nearly north-east and south-west. From bearings of the compass of points of the coast astronomically ascertained, its lat. is 38° 45’ S., and its long. 176° E. In this north-east and south-west direction the country is impressed with the traces of volcanic action, which is indeed still going on, and had its principal point of activity in the crater of Tongariro, the base of which is about twelve miles distant from the lake. There are, besides, innumerable boiling springs, solfataras, and tufas in the same line, and its easternmost boundary is the island of Puhia-i-wakari, or White Island, which must be regarded as the summit of a crater still active and but little elevated above the level of the sea. Besides these proofs of a powerful volcanic action, there is in that geographical line a chain of lakes, most of them intimately connected with the eruptive character of the country. Of these lakes Taupo is the largest: it has an irregular triangular shape; its greatest length is about thirty-six miles, its greatest breadth not less than twenty-five; its borders are in many places deeply indented. . . .

The northern and western shores of the lake are the most hilly, while the eastern shore is much more open. Here, to the north-east, a volcanic cone marks the place where the River Waikato issues from the lake. . . . The scenery on the western shore of the lake is magnificent—vigorous trees overhanging the black trachitic or basaltic escarpments of the shore. . . . Where this shore joins the delta of the Waikato there is a narrow belt of flat land, on which stands the
village of Te Rapa. Behind it the hills rise to about 1,000 ft. above the lake. In ascending, the ground is found to be of a high temperature. The surface is bare, or is scantily covered with mosses and lichens: it is formed of a red or white clay of a soft and alkaline nature, which the natives use instead of soap, and sometimes eat."

The only other writer whom it is necessary to quote is Hochstetter, who visited New Zealand in 1859. The account of his visit to Taupo and the volcanic district is of much interest, and will be found in his volume entitled "New Zealand," page 365 et seq. He says: "Lake Taupo is a real inland sea, twenty-five miles long from south-west to north-east, its greatest breadth about twenty miles, and of a depth as yet unfathomed. It lies 1,250 ft. above the level of the sea. . . . The lake is everywhere surrounded with volcanic formations. Quartzous trachytic lavas in the most different modifications of structure and colours (crystalline and vitreous), together with huge masses of pumice stone, are the prevailing rocks. They form round about the lake a high table-land from 2,000 ft. to 2,200 ft. above the level of the sea, upon which numerous volcanic cones arise, built up of trachyte, pherolite, trachydolerite, or andesite, and partly also of basalt. The lake itself evidently owes its origin to a break in the plateau, and seems to be of extraordinary depth, especially in its western half."

Since the time of Hochstetter, although there have been more detailed accounts written of Taupo and district, little additional information has become available. Both Dieffenbach and Hochstetter fully appreciated the extent of the volcanic forces in the hundreds of cones that are to be found scattered over the district. Some of the cones have no craters, and would seem to have had their origin as huge blisters on the flowing lavas as they met with surface waters that caused an expansion of steam. These are seen to the west of Tongariro and Ruapehu, and pass for miles across the country. They are also found on the Taupo Plain, such as at Maunganamu.

The actual dimensions of Lake Taupo, as given by the Survey Department, are—length, 24 miles 70 chains; breadth, 16½ miles; the area being 242 square miles, or a little over 154,000 acres. The depth may be said to vary between 390 ft. and 570 ft. It contains the small island of Motutaiako, situated towards the south-east of the lake. The form of the lake bears a strong likeness to the African continent. At the south end the Waikato, or, more correctly, the Tongariro, River enters the lake and forms a delta extending from Tokaanu round the south-east side for some miles. Between Tokaanu and the waterfall known as Waihi, at the south-west corner
of the lake, hot springs, fumaroles, and geysers are numerous, and on the slope of the hills at the back of the native settlement near Waihi—the home of the once celebrated native chief Te Heuheu—there is a large area of country in the solfatara state, and immediately behind stands the old volcanic cone of Kakaramea, 4,350 ft. in height. So also at the northern end of the lake, in the line of direction where the Waikato flows from the lake, similar phenomena occur as at the south-west end. At the place known as the "Terraces," and running five miles or more on to the Taupo Plain, hot springs, boiling caldrons, and steaming areas are common. The hot springs are in abundance on the shore of the lake, so that a cold bath in the lake and a hot bath on the beach can be had at any time. The Spa on the right bank of the Waikato shows numerous spots of activity formed here and there in valleys and in broken ground, which appear as countless springs on the surface. On either side of the river as you proceed there are scores of places where traces of volcanic agency may be met with.

At Wairakei, on the left bank of the Waikato, and Roto-kawa on the right bank, are hundreds of interesting spots that will occupy the student of geology for many days. Every aspect of volcanic phenomena is to be found, except the flow of lava and the expulsion of dust. There are steam-holes, geysers, thudding of the ground as from a hammer, mud-craters, and hundreds of crater-like areas where intense activity prevails in the solfatara and sulphur areas, as the various acid gases force themselves through the growing crystals of sulphur that are formed by the chilling of the gases.

Similar traces of volcanic activity appear further down the river to Orakeikorako, a little below the junction of the Waiotapu with the Waikato. This portion of the Waikato River has to be studied along with the lake, for the history of their origin is the same. The bed of the Waikato from its exit from the lake as far as Orakeikorako is through a rift—not a valley of denudation—which is as plainly marked as the Tarawera rift. From the south of the lake and extending to the north-east and north-west for many miles the country is covered with a capping of pumice, sometimes fine, sometimes mixed with fine grit and dust, and sometimes containing huge blocks of pumice mixed with blocks of various heavy lavas.

The Island of Motutaiko rises about 320 ft. above the present level of the lake. It is made up of some curious ropypavas, some of which look like the rounded stems of small trees, branched here and there, but broken off a foot or two from the trunk, and some not unlike pieces of prepared starch. Capping the whole of the higher portion of the island is a deposit of
pumice, in places more than 60 ft. in thickness. The walls of the island rise out of the water in perpendicular cliffs, and the pumice presents the same steep face as the more solid and massive parts of the island. It could hardly be supposed that the pumice was deposited over the more massive rock-structures after the island was separated from the mainland. In fact, rocks on the strand to the eastward of the island clearly belong to the same series as is on the island, so that we may suppose there has been a subsidence along the eastern side of the lake since the deposit of pumice took place that covers not only Motutaiko but so large a portion of the North Island. Along the beach further to the north-east of the island there are traces of submergence, for large timber trees can be seen in the water with their roots still fixed in the ground.

The depression forming the lake-basin occupied a larger surface-area at one period of its history. An old beach is clearly traceable round the lake 100 ft. above the present level, and in places there are traces of several other beaches, the highest being 300 ft. or more above the lake. The pumice-deposits appear as if they had been saturated with water at one period of their history, and in sinkings in the vicinity of Taupo Township water-worn gravel is found here and there.

The following letter, dated the 16th September, 1903, from the Rev. H. J. Fletcher, of Taupo, will be found interesting: "There are several wells in Taupo Township which were sunk several years ago. The formation passed through is exactly that which can be seen along the shores of the lake at Taupo. Water-worn gravel such as I got in sinking my well is rather scarce, but a considerable patch occurs in the roadside just above the Huku, and, strange to say, several large masses of water-worn gravel-cemented by puia-deposit into a compact rock are to be seen a short distance below the bridge at Taupo. The earthquake you allude to took place in August, 1895. In regard to the long valleys you mention, I have long thought that they were caused by a sudden fall in the level of the lake, either by the wearing-away of some barrier in the course of the river, or by the subsidence of a large area in the lake or adjacent to it. I am inclined to the latter."

Mr. Fletcher put down a well to the depth of 65 ft. at a spot 145 ft. above the level of the lake, and about 50 ft. down he met with a thin band of water-worn shingle. It is not difficult to realise the large surface-area that must at one time have formed a part of what is known as Lake Taupo.

In 1886 Mr. Cussen, an able officer of the Survey Department, made a hydrographic survey of Taupo, and gave some interesting information and facts concerning it. His paper will be found in
vol. xx., art. xlii., of the Transactions, and is well worth perusal. He estimates that the inflow per second from all the rivers flowing into Taupo amounts to 16,483 gallons, and the outflow to 16,230 gallons. Accepting these estimates as generally correct, and taking the dimensions of the lake as already stated, the cubical contents of the lake amount to nearly 100,000,000,000 yards, or a hundred and sixty times more than the quantity that is estimated by Mr. Percy Smith to have been thrown from Rotomahana at the time of the eruption in 1886. The daily inflow to the lake at 16,500 gallons per second is 1,425,600,000 gallons. At this rate of inflow, and without making any allowance for evaporation, the lake such as it is to-day would require 307 years to fill, and at least 1,200 years to increase the depth 300 ft. more, as the surface of the lake would become so largely extended.

And what has to be said of the Waikato River? There certainly could have been no Waikato River whilst the lake was filling, for the river is made up of the surplusage of the lake. Mr. Percy Smith, writing in May, 1894, “on the present state of the country immediately round the site of the Tarawera eruption,” says that “the crater of Rotomahana, which was formed in 1886, and at the bottom of which was a lake 25 acres in extent, had filled up with water from a level of 565 ft. to 985 ft., or 420 ft.; and that the lake had grown in dimension from 25 acres to 5,600 acres.” He points out that Rotomahana had yet to rise 95 ft. before its waters would commence to overflow and clear a channel down to the level of Lake Tarawera and drain off a considerable portion of the present Lake Rotomahana. This lake, with its extended rifts to the north-east and south-west, is separated from Lake Tarawera by “loose incoherent ejecta,” and is the counterpart of Lake Taupo, with its north-east rift along what is now the Waikato River bed, and with Pihanga as the highest point of explosion to the south-west. What has taken place in connection with Rotomahana during the past eighteen years enables us to look back to a time when Taupo and district underwent hydrothermal disturbances of much greater intensity than was experienced at Tarawera. It was then that the pumice was spread over the Taupo district, and the lava plateau that is now so extensively covered with volcanic débris was split in twain and subsidence took place. The raised mass of débris that covers the land along the north end of the lake from the Terrace Hotel to the Spa Sanatorium represents material that has filled up a part of the original crateral rift, which can be traced for many miles down the present Waikato River.

When the later volcanic disturbances began, the present
Lake Taupo was the centre of the disturbed area; but crateral rifts appeared along extensive lines of weakness, including Wai-rakei and Roto-kawa. For many years the rift that narrowed to the north-east was filled with thousands of steam-vents, that have played an active part in cementing the pumice or in decomposing it by means of the acid gases that issue from the fissures under high temperatures. As pointed out by Judd, the action of acid gases causes iron, lime, and alkaline materials to be converted into soluble compounds known as sulphates, chlorides, carbonates, and borates, which on removal by rain leave a white powdery substance like chalk in outward appearance, but composed of almost pure silica; and this action is everywhere going on within the volcanic zone. For hundreds of years the rift through which the Waikato flows from Lake Taupo was the scene of intense hydrothermal activity not unlike what is seen to-day along the line of rift extending from Tarawera to Pareheru. On either side of the main rift there are deep transverse valleys that are directly connected with the present Waikato Valley, and in which hydrothermal action is still very active. If we suppose that Lake Taupo was once much fuller than it is now, there will be no difficulty in understanding the position of its outflow from the lake. The river passes through soft pumiceous material until it reaches lava-sheets farther down. The surface rocks in the vicinity of Taupo are composed of pumice and hard volcanic grits cemented together by the action of heat, and the same kind of indurated pumice and grit stone go to make up the material over which the river rushes and forms the celebrated Huka Fall.

If we accept the explanation here stated as to the origin of Lake Taupo, of its once much larger extent, and of its eventual overflow into the extensive rift that was formed in a north-east direction in the line of the Wai-o-tapu and Rotomahana, it will readily be understood that Tarawera, Rotomahana, and the active geysers and fumaroles in the Wai-o-tapu Valley but represent portions of a great fracture or fault that has at times affected the surface of the whole of the North Island. The high cliffs bounding the western shores of Taupo are made up of lava-flows. Even towards the top of the vertical cliffs at Karangahape Point a band of red scoriaceous lava is clearly seen from the deck of a steamer, although the band is 800 ft. or more above the surface of the lake. Karangahape is 2,465 ft. above sea-level; Motuopa, to the south-east, on the opposite side of the lake, is 1,632 ft.; and Mangamotu, to the north of the Hinemaihai River, on the east-side of the lake, is 2,060 ft.; and old crater-cups are numerous about the lake. Between them stands Motutaiko, with its cap-covered deposit of fine powdery
and small pebbly pumice showing trituration and wear. If a line be drawn in the direction of the outlet of the lake and the raised pumice terrace extending between Maunganamu and the Crow's Nest, there will be no difficulty in understanding how the deposit on the Island of Motuaitako took place. It seems to me that the evidence of pumice capping the island, the existence of the Horomatangi reef and the submerged forest, point to a subsidence along the eastern side of the lake at a time when the water stood at least 320 ft. above its present level. The dry watercourses that are met with by the hundred surrounding the lake on the eastern side, and gradually dipping towards the lake, imply a rapid scouring of the pumice by a kind of rocking motion; and it was perhaps at this time that the waters of an extended Taupo Lake found their way through the north-east portion of the Taupo rift, forming what is now the Waikato River. Many explosions must have taken place at this time, for the evidence appears to be complete that the whole line extending from Ruapehu to Tarawera, and thence to Edgecumbe and White Island, constitutes a continuous line which is at times affected in one place, and at times in another, in accordance with the capacity of the overlying and ever-changing deposits to bear the strains set up from beneath. The disappearance of the waters to their present level in the Taupo Lake exposed hundreds of hot springs, geysers, fumaroles, &c., that were pressed down beneath the waters of the lake. The filling of the Rotomahana crater with water, underneath which are hundreds of intensely active lines of steam-tubes, of necessity creates new possibilities. If the weight of water or the pressure of the overlying water is sufficiently great to overcome the steam-pressure from below, the pressure will either accumulate or it will find a line of weakness in the underlying rocks. Waimangu Geyser is the outcome of the filling-up of Rotomahana with many millions of tons of water. The same things took place in the rift that now does duty for the Waikato River. In many places are geysers and other objects of volcanic phenomena which broke out as the result of the Taupo eruption and the subsequent filling-up of the crater-basin with water. Hence the phenomena seen over the whole of the volcanic district, as illustrated by hot springs, fumaroles, solfataras, and mud-volcanoes, are the outcome of unstable conditions that are set up by the constant changing of pressures, known as stress and strain. They are attendants of volcanic action, and they have acted for many years along the great fault-line of which Taupo is the centre.

Thus we come to view Taupo as having a similar origin to the rift in Tarawera Mountain, the crater-basin of Rotomahana, the subsiding areas at Pareheru and Waihou, and the crater-
Hill.—Taupo Plateau and Lake.

valley of the Wai-o-tapu. Elevation and depression are complementary events in the history of volcanic phenomena, and one cannot exist without the other. Probably ever since the watershed from Ruapehu and Tongariro presented the same general slope as at present a river has flowed towards the north, but, as explained already, its direction appears to have been into the Bay of Plenty. The present Waikato River could only have flowed after the filling-up of Taupo; and if the greater Taupo is considered, not less than twelve hundred years would have been required to fill the lake. During that time there could have been no Waikato River. Nor does it appear as if the Waikato had flowed for a long period. The rift through which the river flows is made up in many places of loose pumice, and yet the sides are steep and denudation has done but little, there being as yet no valley formation as usually understood.

Pumice.

The Taupo Lake and the rift appear to have supplied the pumice which has covered so much country in the North Island; but how long ago cannot be stated. A glance at the country suggests a period that is comparatively recent. The freshness of the pumice, the absence of denudation, the limitation of vegetation, all show that no other volcanic event has taken place since the pumice was deposited. Maunganamu is composed of a fine trachyte almost similar in appearance to pumice, and resembles it in many respects. A similar deposit is met with along the northern portion of the lake. The great depression in which Taupo is situated might easily lead us to understand that extensive areas have been covered to a great depth with the débris that was thrown out, and so hidden volcanic orifices. Travellers have wondered at the extensive distribution of pumice over the Island, and every visitor to the volcanic district is struck with the everlasting sterility of the country where the pumice is found. The Napier hills a few feet below the surface are covered with it to the depth of several feet, and it is found, sometimes below a capping of black light soil, and sometimes as a surface deposit, over all the stratified-rock country to the westward as far as Tarawera. Further west the pumice-deposit increases, and the whole country is covered to the depth of many feet, the varieties being numerous. Beyond the Rangitaiki River the pumice is mixed with volcanic grits and angular and partly rounded stones such as are found on the strand at Taupo. As you descend towards the lake from Opepe every exposure by the roadside shows an increasing quantity of stones and rock-masses, and the latter increase in size, some being tons in weight. The distribution of the pumice, however, is not limited to the east-
ward of the lake: it is everywhere. Northward, westward, and southward similar deposits occur, but the quantity is much less to the southward, and volcanic grits and stones are absent. It is evident that the pumice-deposit is the most recent up to the time of the Tarawera eruption, as it is continuous over such a large extent of country, and shows that the distribution must have been from the same general centre. It would be difficult, if not impossible, to give even an estimate of the quantity of pumice that is distributed over the volcanic belt of this Island; but it seems certain that the ejection took place, as in the case of Rotomahana and Tarawera, suddenly, and as an attendant of hydrothermal activity. Volcanic outbursts do not send out the same kind of products, and it is doubtful whether any of the volcanoes to the south of Roto-aira have ever ejected pumice in quantity. Had the pumice been ejected from Ruapehu, Ngauruhoe, or Tongariro, much larger quantities might have been expected to the south and east of these mountains. Their growth and that of Mount Egmont is similar. Pumice is distributed by explosive means, lava by flows; the former is ejected, the latter wells and spreads as a plastic mass. In these mountains the traces of lava-flows are common, but not so in the case of pumice. A scoriaceous kind of pumice and clinker is spread lightly over the Rangipo Desert, but nowhere in the direction of the mountains; hence the probability is that the great rift extending from Pihanga through the present Lake Taupo and down the Waikato in the direction of Wai-o-tapu was brought about by explosions that spread pumice and varieties of lavas over such a large extent of country, just as the Rotomahana explosion spread blue mud, scoria, and varieties of shattered lavas.

What Rotomahana is becoming by the inflow of water, Taupo became perhaps hundreds of years ago. Volcanic action and volcanic phenomena are yet active in the North Island, and there is evidence of continuous activity from the Secondary period. Nor is there any reason to suppose that the volcanic district will not again be subject to lava-flows and explosions due to hydrothermal causes: both may be expected, and in the coming years science may be able to determine even the times of their coming.