

the volcanic centre of Tongariro and Ruapehu Mountains. While the deep-terraced valleys are the result of long-continued erosion by water, we see, on the other hand, the effects of volcanic fire displayed in an immense number of hot springs, in which the country abounds. If we suppose two parallel lines to be drawn from Lake Taupo, touching its east and west shores, and extending in a north-east direction as far as the Bay of Plenty, then these two lines, including the range of hills and mountains situated between the Kaingaroa Plain and the wooded Patetere plateau, border likewise the space upon which, from more than a thousand places, hot vapours arise, calling forth all those phenomena of boiling springs, fumaroles, mud-volcanoes, and solfataras for which the North Island of New Zealand, and especially the 'Lake District,' is so remarkable. The southern point of this wonderful zone of hot springs, which by far exceeds all others in the world in variety and extent, is the Tongariro volcano with its solfataras, and the northern end is marked by the ever-steaming Island of Whakari [White Island], in the Bay of Plenty, a distance of 120 sea-miles. [pp. 389-390.]

"Through a small side valley, called Rotoparu, we ascended the right bank of the Waikato, crossed a fern-hill, and came into the Rotoreka Valley, a dreary and swampy plain, with here and there an isolated *tī*-tree. Towards the west the valley is bordered by low, woodless hills; towards the east a high rocky bluff ascends almost vertical, extending in the direction N. 24° E. in a straight line. Above the steep precipice numerous rugged cliffs tower up, and in the middle of the rocky wall a high wooded peak Pairoa [or Paeroa] projects towards the west. After this prominent peak, I have called the whole extent of the bluff the Pairoa Range; and it is easy to be seen that along this range an immense dislocation took place, that the almost perpendicular western side of the range is caused by a 'fault' corresponding to a deep fissure in the earth-crust, and that the low lands between the Pairoa Range east and the Patetere plateau west were produced by a breaking or sinking of a large part of the volcanic table-land. In a most remarkable manner the fissures and lines of dislocation are also indicated by the numerous hot springs issuing along the Pairoa Range, at the foot of the precipice, on its slopes, and even above on the heights. [pp. 400-401.]

"Having thus given a description of the principal ones of the thousands of *pūias* and *ngawhas* on the North Island, I will now say a few words about general features and about the origin of the springs. We can distinguish three parallel lines of springs, striking in the direction N. 36° E. One line connects the two volcanoes, Tongariro and Whakari. On this line are situated the hot springs of Lake Taupo, the fumaroles of the Kakāramea Mountain, and the hot springs round Rotomahana. The second line is the line of *pūias* of Orakeikorako and of the Pairoa Range; and to the third line belong the hot springs of Rotorua and the solfataras of Rotoiti. . . . Both kinds of springs [intermittent and permanent] owe their origin to the water permeating the surface and sinking through fissures into the bowels of the earth, where it becomes heated by the still existing volcanic fires. . . . The rocks from which the silicious hot springs of New Zealand derive their silica are rhyolites and rhyolitic tuffs containing 70 and more per cent. of silica; while we know that in Iceland palagonite and palagonitic tuffs with 50 per cent. of silica are considered as the material acted upon and lixiviated by the hot water. By the gradual cooling of the volcanic rocks under the surface of the earth in the course of centuries the hot springs also will gradually disappear." [pp. 441-434.]

The above extracts show that Hochstetter was of opinion that the earlier and greater eruptions within the Taupo zone were on the site of the high volcanic mountains that lie between Kakāramea and the southern end of Ruapehu, and that the first outbursts were submarine. Also Hochstetter seems to have been of opinion that great part of the solid rocks north of Lake Taupo to and beyond the Waikato after it turns to the north-west were emanations from the volcanic cones of the Tongariro and Ruapehu systems, and that the Kaingaroa Plain gives evidence of currents of water flowing towards the Bay of Plenty. As regards the submarine condition of the earlier eruptions reasons have already been given in support of this theory. The evidence, however, is not in favour of the assumption that the bulk of the pumice emanated from vents situate on the southern part of the Taupo zone, and this neither in the earlier nor the latter phases of eruptive activity.

Hochstetter's impression that the southern slope from Ruapehu to the shore of Cook Strait was covered with volcanic ejecta in like manner as is the slope from the northern end of Lake Taupo to the shores of the Bay of Plenty proves to be erroneous, Older Pliocene and Upper Miocene marine sediments forming the bulk of the rocks appearing at the surface in that direction. The flat cone as indicated by a section from the shore of Cook Strait to that of the Bay of Plenty may, indeed, be due to gradual upheaval of the land since volcanic activity began, but, contrary to what we might expect, Ruapehu and the Tongariro Range are not built up on a basement of eruptive matter giving evidence of deposit in the sea and of being mainly pumiceous in character. To the contrary there is evidence that the earliest emanations from these vents rest on Palæozoic and Tertiary rocks of a sedimentary character, and, it may be, to the west of Tongariro, on coal-bearing strata. And yet it is evident that by way of the southern part of the Taupo zone much pumiceous matter found its way into the Pliocene sea occupying the area now drained by the Wanganui and rivers eastward to the Ruahine Range. Older Pliocene rock on the Kaimanawa Mountains at heights exceeding 3,000 ft. above the level of the sea shows that the southern part of the Taupo zone shared in the depression that then prevailed and gives evidence of the probability that there was a continuous and broad water-way through the middle part of the North Island connecting what are now Cook Strait and the Bay of Plenty.

Volcanic eruptions probably first commenced in the north, towards the Bay of Plenty area, and floating pumice was carried south and deposited in the Pliocene sea, over the areas within which pumice-sands and gravels are now found in connection with beds of that age; also, thick deposits of pumice must have probably accumulated over the southern part of the Taupo zone. The farther the distance from the eruptive source the finer the pumice would become, and hence