

line with Ngauruhoe. Flows of dark andesite from Ngauruhoe cover the upper portions of collapsed areas on either side of Pukekaikiore Hill, a remnant of ancient Tongariro. The latest of these outpourings (most likely one that took place at the time of the 1869 eruption) descended to the bottom of the steep slopes of the cone. The others are much older, for they are covered by the Taupo shower of pumice. The flows and fragmental ejects of the volcanoes already dealt with are all hypersthene augite andesites, except a flow of hornblende andesite in the wall of Tama Crater. The Tama Lakes, near the saddle between Tongariro and Ruapehu, lie in explosion craters that, in addition to the country rock, erupted angular fragments of dense black basic augite andesite not unlike Tarawera lapilli.

Overlying grey-andesite conglomerate and forming the surface flow on the plateau west of Pukekaikiore Hill is an extensive sheet of vesicular olivine basalt with clear bright-green olivine crystals up to $\frac{1}{4}$ in. in length. Pukeonake is an olivine basalt scoria cone, 4,018 ft. high, on the eastern margin of the sheet. A viscous flow of dark olivine basalt poured out of a fissure on Pukekaikiore and ran several chains down the side of the hill.

Kakaramaea and Tihia are really one complex volcano of hypersthene augite andesite, which, like its neighbours to the south, has suffered collapse. This has taken place along a fault trending east-north-east which crosses the mountain within a few yards of the highest peak of Kakaramaea. The Tihia peaks are about 400 ft. lower than those on Kakaramaea. Pihanga, a conical-shaped mountain without a crater, is composed of andesite with big augite crystals but no hypersthene.

One isolated mass of flow rhyolite, a pumiceous hornblende-biotite rhyolite similar to that of Haparangi Dome near Rotorua, was found on a low peninsula on the western side of Lake Roto Aira.

The ash and lapilli showers that follow the present contour of the land are well exposed in road-cuttings. A typical cutting on the Tokaanu-Waiouru Road shows, in downward order,—

White rhyolite pumice from Taupo (much dark vegetal refuse in top 6 in.), 4 ft.

Thinly bedded dark-grey andesite ash containing leaves, 1 ft. 6 in.

Fine brown andesite ash, 3 ft. 6 in.

Layer of andesite lapilli, 1 ft. 6 in.

The leaf-bearing ash, probably from a violent eruption of Ngauruhoe, is thinner on the western side of Tongariro than on the eastern. The andesite ash, 3 ft. 6 in., and lapilli, 1 ft. 6 in., at the bottom of the section most likely came from Tama craters.

FUMARoles AND HOT SPRINGS.

In the area here described hot springs are far less common than in the Rotorua district; fumaroles are, however, more plentiful. Thermal activity occurs at Ketetahi, Tokaanu, and in the craters of Ngauruhoe, Tongariro, and Ruapehu. Near Tokaanu Township there are a number of hot and boiling alkaline pools, some of which have a salty taste. Taumatapuhipuhi Geyser plays regularly to a height of about 20 ft. at intervals varying between twelve and fifteen minutes. Actually three "shots" take place in quick succession, followed by intervals of twelve minutes to fifteen minutes. The total overflow of water from the three "shots" on the occasion it was measured was 65 gallons. The geyser-pipe is about 2 ft. wide at the top, but at a depth of 4 ft. 6 in. it narrows to a few inches. The springs of Waihi, situated farther to the west along the shore of Lake Taupo from Tokaanu, lie on the fault already mentioned that crosses Kakaramaea. The gases from the three main fumaroles issue at a little above atmospheric pressure, and much gas rises from the muddy acid pools in the vicinity.

The active subcrater of Ngauruhoe was filled with molten lava when seen in March, 1928; but in March and May of this year no lava was in sight, and the funnel-shaped crater was dotted with fumaroles depositing sulphur, which in some cases was liquid. White aluminium sulphate and yellow ferrous sulphate are deposited abundantly. A few had their vents coated with white salts, and these probably had a temperature above the melting-point of sulphur. Small weak fumaroles were found high up in Red Crater. Te Mari, last seen in active eruption in 1896, has not yet been visited.

The water in one of the craters on Ruapehu is warm. A white deposit, 1 in. thick, of thermally altered rock coating the higher slopes of Ruapehu was ejected from the volcano shortly before the arrival of European settlers.

At Ketetahi, on the northern slopes of Tongariro, the fumaroles and small hot springs occur together in a depression about 12 chains square. The main fumarole, which is on the eastern edge, issues at atmospheric pressure from a wide vent. Three fumaroles in the middle of the depression emit steam at slightly higher pressure, and about equal to that of Karapiti near Wairakei. Two of these emit a spray of water in addition to steam. Probably they all contain a low percentage of gases other than steam, although such noticeable gases as sulphur dioxide and sulphuretted hydrogen were not detected in the field.

ECONOMIC.

Soil.—Except on steep slopes, the soil is derived from the Taupo rhyolite pumice, which is the parent material of the soils over many square miles of country. From Lake Taupo, extending northward to within a few miles of Rotorua and eastward to Te Pohue near Napier, Taupo pumice predominates. On the plateau close to the mountains there is probably a dusting of andesite ash from Ngauruhoe on the pumice. Among the successful farms on the pumice land are the Hautu and Rangipo penal settlements. On the steep slopes—e.g., south-west of Waihi and west of the Wanganui River, north of the Waimarino-Tokaanu Road—the reddish-brown fine-textured soils are derived from andesite ash that antedates the pumice shower.

Sulphur.—The main accumulations of sulphur occur at Ketetahi, where there are two shallow basins containing not more than a few hundred tons.

Diatomaceous Earth.—Although no noteworthy deposits of diatomaceous earth have been found in the Tongariro Subdivision, other outcrops in addition to those already listed* have been found in

* 22nd Annual Report, N.Z. Geological Survey, p. 11; 1928.