SECOND EDITION

Volcanoes in the Sea

THE GEOLOGY OF HAWAII

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HONOLULU

small patches of black glassy ash that lie here and there on its flanks. One of the patches can be seen at the back of the playground at Robert Louis Stevenson School. They fill erosional gullies, and commonly are separated from the older tuff by red soil. Early workers attributed this ash to a new eruption of Punchbowl. Stearns and Vaksvik (1935, p. 147) have pointed out, however, that the ash does not thicken or become coarser toward the crater, as would be the case if Punchbowl were its source. Instead, with little question it is merely a part of the wide-flung blanket of ash that was formed by eruptions of Sugarloaf and Tantalus.

Round Top (Puu Ualakaa), Sugarloaf (Puu Kakea), and Tantalus (Puu Ohia) mark a row of vents along the ridge of the Koolau Range back of the city west of Manoa Valley. All three are cinder cones formed by Strombolian-type eruptions. Round Top may be somewhat older than the other two. No crater is preserved in it, but whether the crater was filled by the last eruptions or was destroyed by erosion is not certain. The cone is largely mantled with black ash from the later vents. Brown to gray, fine, well-bedded cinder is exposed along the road in Ualakaa Park. And, in the quarry at the hairpin bend in Round Top Drive, just north of the park, coarse cinder contains many nearly spherical, dense balls that appear to be spherical bombs smoothed by repeated tossing and milling in the vent. In the valley of Makiki Stream, two dikes of nephelinite trend toward Round Top and apparently represent the feeding fissures for the eruption.

Sugarloaf is a double cone built around two craters, and a well-formed crater indents the summit of Tantalus. Both cones appear very young, and their products are intermingled and generally indistinguishable. In addition to ordinary cinder, irregular and ribbon bombs, and lapilli, both contain roughly spherical balls up to about 10 centimeters in diameter, some with a rough spiny surface and others smoothed like those at Round Top. Both vents produced lava flows. The flow from Sugarloaf (dated by Gramlich *et al.* (1971) as 67,000 years old), issued on the east side of the main cone (fig. 21.17), and cascaded down the wall of Manoa Valley, piling up in great heaps of clinker against the base of the wall. On the valley floor it spread out to form the broad, nearly level surface on which the University of Hawaii is built. The old Moiliili Quarry, at the seaward edge of the University campus, was excavated in the dense center of this 12-meter-thick aa flow of melilite nephelinite. The rock in the quarry walls is unusually coarse grained for a relatively thin lava flow, and contains many veinlets of pegmatoid. Openings are commonly lined with well-formed crystals of nepheline, augite, apatite, and zeolite, some of them more than half a centimeter long. The lava must have been unusually rich in gas. The general terminus of the flow was formerly marked by a 12-meter escarpment a short distance north of the present Lunalilo Freeway, but beyond this a narrow tongue continued southward another half kilometer through the present Moiliili. Near the mouth of Manoa Valley

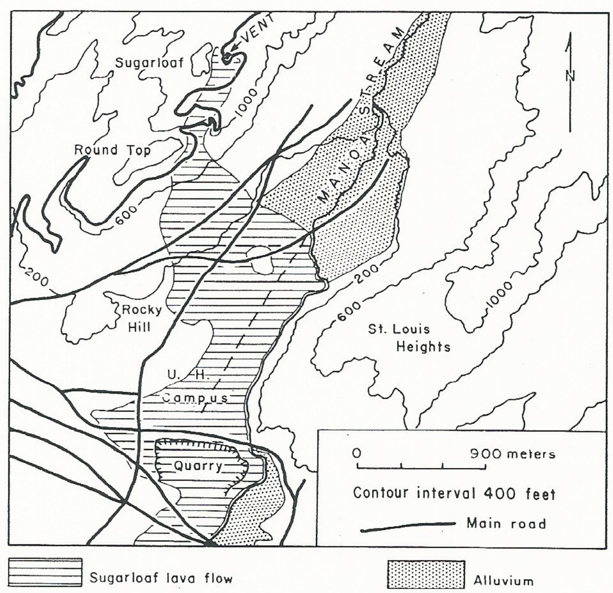


Figure 21.17. Simplified geologic map of Manoa Valley and surroundings, showing the lava flow from Sugarloaf (also called the Moiliili flow). The lower course of Manoa Stream has been pushed over against the eastern wall of the valley by the lava flow. The approximate former course of the stream is shown by the dashed line. (Adapted from Stearns, 1939.)

the lava rests on limestone of the Waimanalo stand of the sea. Although the surface of the flow has now been much modified by construction, in general it has been very little eroded. In the vicinity of Dole Street, however, Manoa Stream has cut a steep-sided gorge about 10 meters deep below the original surface of the flow.

The Sugarloaf flow profoundly altered the drainage of Manoa Valley. In spreading over the valley floor it forced Manoa Stream out of its former channel near the midline of the valley and caused it to swing far eastward, where it now follows the boundary between the flow and the ridge of Koolau rock that bounds the valley on the east (fig. 21.17). The flow raised the level of the floor of the valley near its mouth, which reduced the gradient of Manoa Stream and caused it to deposit alluvium in the upper part of the valley, building up the valley floor upstream from the lava flow until it is now in essentially continuous slope with the lava-covered portion at the mouth.

The lava flow from Tantalus spilled westward, into upper Pauoa Valley. The abrupt humpy headward termination of the main valley is clearly visible from Punchbowl or from Auwaiolimu Street. This termination is the edge of a mass of lava 150 meters or more thick that filled the upper end of the valley. The flow extends on down the valley for about 2.5 kilometers. At its mountainward end the top of the flow came within less than 30 meters of the level of a low part of the ridge between it and Nuuanu Valley. The nearly uneroded surface of this upper part of the flow forms the Pauoa Flats. Pauoa Stream has been crowded against the western side of the valley. The Tantalus flow most likely is similar in age to the Sugarloaf flow.

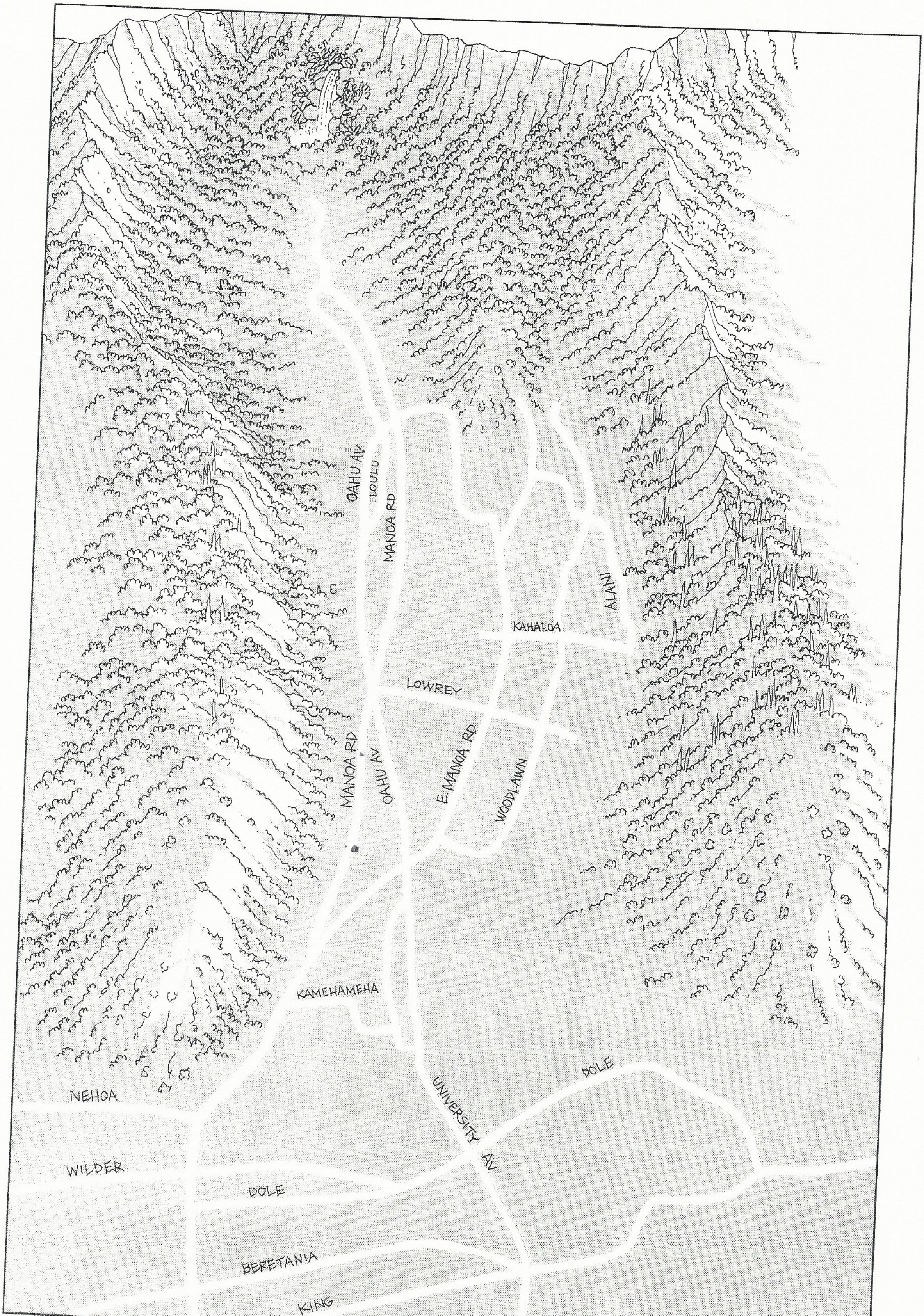
The most conspicuous row of vents of the Honolulu Series extends across the eastern end of the island (figs. 21.18, 21.19). In order northeastward, the vents are: Koko Head, Hanauma Bay, Kahauloa ("Rifle range") Crater, Koko Crater, the Kalama cinder cone, the Kaupo vent, Kaohikaipu Island, and Manana (Rabbit) Island. Collectively, the cones and lava flows are known as the volcanics of the Koko fissure. A submarine ridge extending about 5 kilometers southwestward from Koko Head shows that this series of eruptions continued beneath the sea (fig. 20.32).

Manana Island is a cone of palagonite tuff built around two vents, each marked by a crater. The cone is somewhat gullied by erosion and partly mantled by colluvium. A bench, in places more than 45 meters wide, has been cut around it by waves of the Manana (plus-1.5-meter) stand of the sea. Tuff from the Manana eruption lies on coral reef of the Waimanalo stand on the mainland of Oahu about 1.5 kilometers southwest of the cone, and overlies gravel in a cave cut by the Waimanalo sea now about 6 meters above present sea level in the cliff almost directly below the overlook point where the highway crosses the crest. Thus the Manana eruption occurred between the plus-7.5 and plus-1.5-meter stands of the sea.

Kaohikaipu Island is a cone of red to black cinders and spatter, with a pahoehoe lava flow of alkalic olivine basalt on its western side. Since cinder from the Kaohikaipu vent overlies the tuff on Manana Island, the Kaohikaipu eruption must be the younger. It may have occurred at the same time as the Kaupo eruption, which produced a lava flow of similar composition. The fact that the Kaohikaipu eruption built a normal cinder cone instead of a tuff cone suggests that the eruption took place on dry land when sea level was lower than it is now, probably during the Mamala-Kahipa or Penguin Bank stands of the sea.

The Kaupo flow issued on the talus at the foot of the cliff, about 60 meters above sea level. It poured downslope into the ocean, building the present Kaupo peninsula, on which Sea Life Park is located. The vent is marked only by a small mound of spatter. The surface of the lava flow is almost untouched by erosion and has a very youthful appearance, which lends support to the age of 32,000 years reported by Gramlich *et al.* (1971). Certainly it is one of the youngest flows on Oahu.

The Kalama eruption built a cinder cone about 10 meters high with a crater 15 meters deep at its summit. A ridge of spatter and cinder built along the eruptive fissure extended north-northeastward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