Lava Tubes at Mauna Ulu, Kilauea Volcano, 1972-1974*

Donald W. Peterson
U.S.G.S., Menlo Park, California 94025

Robin T. Holcomb
U.S.G.S., University of Washington, Seattle, Washington 98195

Extensive systems of lava tubes formed several times during the eruption of Mauna Ulu from 1969 to 1974, and the general origin and behavior of the tubes through 1971 were described in previous papers by various authors. Tubes that developed from 1972 to 1974 confirmed the earlier observations and provided further insights into the development of lava tubes and their role and significance in the growth of basaltic shield volcanoes.

Lava tubes at Mauna Ulu developed by at least four different processes: (1) accretion of flat, rooted crusts across streams within confined channels; (2) accretion of overflows and spatter to levees, which built arched roofs across streams; (3) jamming together and fusing of plates of floating crust; and (4) progressive extension of pahoehoe lobes by molten distributaries beneath a solidified crust. By these various processes, tubes can develop in different parts of lava flows under a variety of flow regimes. Tubes can therefore become ubiquitous within pahoehoe flows and distribute a large fraction of the lava delivered to the surface during a sustained eruption.

Tubes transport lava efficiently. Once formed, the roofs of tubes insulate the streams within, allowing the lava to retain its fluidity for a longer time than if exposed directly to ambient air temperature. This enables the flows to travel for greater distances and spread over wider areas. Even though supply rates were moderate at Mauna Ulu, generally about one to five cubic meters per second, the principal tubes conducted lava as far as the coast (13 kilometers distant) where it fed extensive pahoehoe fields on the coastal flats and added new land to the island. The largest and most efficient tubes developed during periods of sustained extrusion when new lava was being supplied at nearly constant rates.

Because of their ubiquity and efficiency, lava tubes exert significant control upon the shapes of shield volcanoes. Traditionally the low aspect ratio (height/diameter) of shield volcanoes has been attributed chiefly to the fluidity of basaltic lava. However, fluidity alone is not an adequate control because it depends so strongly on the temperature of the lava, and when lava is exposed to the air its temperature, and thereby its fluidity, declines rapidly. Lava tubes provide a means of insulating the lava, thereby preserving its fluidity, while they also serve as conduits that allow lava to travel for great distances across the surface. The process enables basaltic volcanoes to attain diameters that are very large relative to their heights.

At Mauna Ulu, during the episodes when surface overflows were brief and few tubes formed, a tendency was noticed for the angles of slope (and thereby the aspect ratio) of the lava shields growing around the vents to increase appreciably. In contrast, during sustained episodes when many tubes developed and much of the new lava traveled through them for longer distances, the slope angles of the shields tended to increase only slightly. The highly variable character of the eruptive activity prevented the relations among the volumes of surface flow versus tube flow and the resulting rate of change of the slope angle from being rigorously documented. However, future eruptions at basaltic shield volcanoes may provide opportunities to test these relations.

*a poster exhibit