LATERAL MIGRATION AND ERUPTION OF MAGMA IN VOLCANIC EDIFICE RIFT ZONES: THE PU'U 'O'O ERUPTIONS OF THE EAST RIFT ZONE OF KILAUEA VOLCANO, HAWAII; J. W. Head, Dept. Geological Sciences, Brown Univ., Providence, RI 02912, and L. Wilson, Dept. Environmental Science, Univ. of Lancaster, U.K.

Using basic principles of magma ascent and eruption derived from previous planetary studies (1,2) we have been examining several aspects of the nature and deposits of recent eruptions of the Kilauea East Rift Zone. Below we summarize the areas of study and some preliminary results:

1. **PYROCLASTIC FOUNTAIN HEIGHTS AND EXSOLVED MAGMA VOLATILE CONTENT:** We have reviewed the factors determining lava fountain heights in Hawaiian-style basaltic eruptions such as those occurring during the recent series of eruptive episodes at the Pu'u 'O'o vent, east rift zone of Kilauea Volcano, Hawaii. Numerical solutions to the equations describing the fluid dynamics of such eruptions predict that lava fountain heights, which are indicators of the velocity of magmas in vents, should be controlled much more strongly by amounts of exsolved volatiles than by any other factors. The next most important factor is the width of the conduit system, which determines frictional losses and can be characterized by the volume flux of magma. The diameter of the surface vent required to accomodate a given discharge (i.e., instantaneous volume rate of eruption) is also a function of exsolved magma volatile content, but is less dependent on this factor than is the fountain height. We simulate fountain heights for typical discharges at Pu'u 'O'o and find implied exsolved gas contents very close to those determined by other methods. The corresponding predicted vent diameters are comparable with (and somewhat smaller than) the observed diameter of the Pu'u 'O'o vent. The discrepancy is probably a consequence of processes occurring in the lava pond which is present over the vent during eruptions. The variation of fountain height with time during eruptive episodes can be used as a measure of changing exsolved magma volatile content, which can be related to processes occurring in the subsurface dike system. (3)

2. **LATERAL MAGMA MOVEMENT IN DIKES IN RIFT ZONES:** Flank eruptions, especially those on the rift zones of volcanoes, are fed by lateral magma movement in dikes. The sizes and shapes of such dikes must be consistent with the dynamics of magma movement through them and with the static stress field generated in the surrounding rocks. We use data from the recent series of eruptions at the Pu'u 'O'o vent on Kilauea's East Rift zone to calculate the geometry of the dike system permitting steady magma flow, finding a dike thickness of about 1.8 m and a dike height close to 3 km. The typical magma speed (a little less than 0.1 m s^{-1}) is such that a given batch of magma moves only about one-fifth of the way through the rift system in a single eruptive episode, and thus undergoes several cooling events before being erupted. We use arguments related to the consequent modification of the rheological properties of the magma to discuss the factors controlling the onset and cessation of eruptive episodes. We also model the extent and consequences of the probable non-uniformity of the dike geometry resulting from the interaction of a new dike with the partly-cooled residues of earlier dikes. (4)

3. **NATURE OF CONDUIT SYSTEMS AT SHALLOW DEPTHS BENEATH BASALTIC VENTS:** We investigate quantitatively the sizes and shapes of conduit systems at shallow depths beneath basaltic vents. The fluid dynamics of eruptive episodes are used to determine the geometries of conduits, taking the well-documented eruptions at Pu'u 'O'o, Kilauea as illustrations. Cooling calculations are employed to study the long-term survival of conduits and the consequences of multiple dike injection events. We find that sub-vent conduits must have planar geometries at depths greater than a few tens to at most a few hundreds of meters, with thicknesses typically less than one meter, and lengths and heights of order one km. These structures are clearly the residues of the pre-eruption dikes. Although such features can be thickened somewhat by repeated dike emplacement events, there is no reason to suppose that much more equant magma reservoirs develop at shallow depth, even when considerable degassing occurs after single eruptions or between repeated eruptions. (5)

4. **FACTORS DETERMINING THE NATURE OF FOUNTAIN DYNAMIC MORPHOLOGY AND NEAR-VENT PYROCLASTIC DEPOSITS:** Two variables (magma gas content and volume flux) determine the detailed structure (dynamic morphology) of the gas-pyroclast dispersions (commonly called fire fountains) produced by explosive basaltic eruptions and the nature of near-vent pyroclastic deposits. The two main manifestations of variations in gas content and volume flux are clast size and fountain structure. Although the detailed relationships between gas content and clast size are not fully understood from a physical point of view, suitable empirical data are available for basaltic magmas. Fountain structure (dynamic morphology) is determined by the

velocity profile at any given pressure level and the maximum spread angle of the fountain from the vertical. These two parameters completely determine the paths of pyroclasts in the fountain and their ultimate resting places. The combination of the pyroclast size and the spatial distribution determines the clast number density and thus the opacity of the fountain and the ability of the pyroclasts to cool in their local fountain environment. For a given set of conditions, two factors thus become important in determining the structure and morphology of pyroclastic deposits: local temperature and accumulation rate. For example, in typical basaltic pyroclastic eruptions, the majority of pyroclasts remain inside the optically thick central part of the fountain, undergo minimal cooling, and return to the surface to coalesce and contribute to a lava pond or lava flow. In the optically thinner outer parts of the fountain, clasts undergo relatively more cooling and return to the surface to contribute to the building of the pyroclastic cone (if the accumulation rate is low) or to form rootless flows (if the accumulation rate is high and minimal further cooling occurs). The relationships between these various parameters are investigated for hawaiian-style eruptions in general and applied to the interpretation of post-eruption deposits (residual morphology). (6)

The results of these analyses are being applied to the study of the nature and evolution of shield volcanoes on Mars and Venus.

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