MORPHOLOGY OF ETNA LAVA TUBES : INSIGHTS FOR LAVA FLOW EMPLACEMENT MECHANISMS

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Abstract

Lave tubes play a pivotal role in the formation of many lava flow fields. A detailed examination of several compound ‘a‘a lava flow fields on Etna confirmed that a complex network of tubes forms at successively higher levels within the flow field, and that tubes generally advance by processes that include *flow inflation* and *tube coalescence*. *Flow inflation* is commonly followed by the formation of major, first-order ephemeral vents, which, in turn, form an arterial tube network. *Tube coalescence* occurs when lave breaks through the roof or wall of an older lava tube; this can result in the unexpected appearance of vents several kilometres downstream. A close examination of underground features allowed us to distinguish between ephemeral vent formation and tube coalescence, both of which are responsible for abrupt changes in level or flow direction of lava within tubes on Etna.

Observations of active ‘a‘a lava flows emplaced during the 1991-93 eruption suggested that inflation of the flow fronts of mature ‘a‘a lava flows was an important aspect of tube formation (1). This statement is confirmed by features that we observed underground. A striking feature in many etnean lava tubes is the association of large chambers with narrow passages. We interpret these features as the product of flow inflation in the frontal zone, followed by opening of first-order ephemeral vents on the snout region. This suggests that the production of multiple flows connected by secondary vents is an essential mechanism of tube growth on Etna. This process can be observed on the surface where new, long-lived vents open at the margins of previously inactive ‘a‘a lava flows, and underground as multiple linings and lateral benches.

Tube coalescence is an important process during the emplacement of long-lived flows. This occurs when an upper tube drains into a previous, lower tube because of roof collapse. The re-occupation of a deeper and possibly longer tube may cause a re-activation of distal parts of the flow field, and a consequent increase in flow field length. The possibility of new flows breaking through the roofs of previously inactive tubes has important consequences in hazard assessment. Our surveys indicate that a crust thickness of 0.5 m is the minimum required for ‘a‘a lava flows, and we propose a simple formula to calculate roof stability for a typical etnean ‘a‘a lave flow.

In conclusion, our underground surveys help to confirm (1) that subterranean effusive processes play en important role in the development of ‘a‘a flow fields. They show how tube inflation and coalescence can result in considerable lengthening of lava flow fields beyond the distance that can be attained by channel-fed lava flows. This work has clear implications for hazard assessments during future effusive eruptions on Etna. Finally, in view of the ease with which lava can break through the roofs of lava tubes, we consider that the process of tube coalescence may be an integral part of tube development, not only on Etna, but also on other basaltic volcanoes.

References

CALVARI S. AND PINKERTON H., 1998. *Formation of lava tubes and extensive flow field during the 1991-93 eruption of Mount Etna*. Jour. Geoph. Res., 103, 27291-27302.