OBSERVATIONS OF THE CAMPOUT TUBE-FED FLOW ENCOUNTERING A SLOPE BREAK, KILAUEA, HAWAII: AN ANALOGUE TO LAVA FANS ON OLYMPUS MONS, MARS.

J.E. Bleacher, Planetary Geodynamics Laboratory, Code 698, NASA Goddard Space Flight Center, Greenbelt, MD, 20771, jake@puuoo.gsfc.nasa.gov,

Introduction: Lava fans are features identified in *Viking* images on the flank of Olympus Mons, which were described as lava point sources [1]. While originally suggested to represent the terminus of lava tubes, these features were later suggested to represent eruption of lavas along deep concentric fractures [2], or vents fed by radial dikes possibly indicating rift zone activity [3]. Lava flow structures were recently characterized and their abundances and stratigraphic relationships were estimated based on lava flow mapping of HRSC and THEMIS images over a central north-south transect of Olympus Mons [4]. Results showed that lava tubes trend into or out of nearly all unembayed fans, and that many fans are located along slope breaks from higher (>3˚) to lower (<3˚) slopes leading to the suggestion that all fans are likely indicative of lava tube outbreaks [4]. The objective of this project was to observe the active emplacement of lava from within a lava tube that encounters a distinct slope break in order to determine if this style of lava emplacement might, at least in part, be responsible for the development of lava fans on Olympus Mons.

Campout Lava Tube: The Campout flow originated in May of 2006 as a sustained flow from a rootless vent above the Prince Kuhio Kalaniana'ole (PKK) lava tube (Figure 1), which is fed by the ongoing Pu'u 'O'o, eruption, and is located ~ 1 km south of that vent on Kilauea, Hawaii [5,6]. The Campout flow subsequently developed a lava tube system that extends 8-10 km southward where it delivers lava to an ocean entry at East Ka'ili'ili [5,6]. Observations were made of the East Ka'ili'ili ocean entry on September 15, 2006. Within several 10s of meters of the coastline a ~30˚ to 70˚ sea cliff separates the ~1˚ coastal plain, from a ~1˚ lava bench that borders the ocean. During the period of observation a small portion of the sea cliff collapsed, exposing a section of the Campout lava tube, enabling the emplacement of tube-fed lava over the high slope sea cliff onto the low slope lava bench.

Observations: Immediately following the outbreak of lava along the sea cliff, a narrow leveed channel developed that was ~1-2 meters in diameter, which delivered lava down the cliff onto the low slope lava bench (Figure 2). Upon encountering slopes of ~10˚-20˚ the channel began to widen, as has been described in the past for active basaltic flow fields [7] and from laboratory experiments [8]. Soon after the initiation of channel widening, and as the flow encountered decreasing slopes, the channel branched into two active channels of similar width to the original channel. The initial branching event was followed soon after by a second branching event below the original branch resulting in lava emplacement along three active channels.

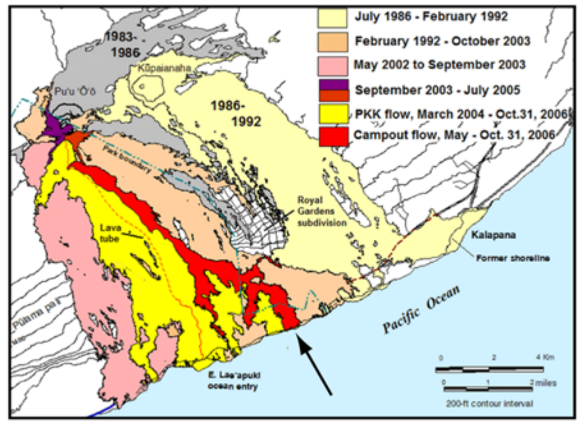

Figure 1. Lava flow map of the ongoing Pu'u 'O'o eruption (produced by the USGS HVO, available at http://hvo.wr.usgs.gov/kilauea/update/maps.html. Arrow indicates location of the East Ka'ili'ili ocean entry.

As each channel-fed flow encountered slopes of <10˚ the flows again began to widen and develop a surface crust. At this time, active emplacement of lava along the flow front transitioned from open channel-fed flows to development of budding lava toes, as originally described by [9]. As a steady supply of lava continued from the Campout lava tube, the flow fronts inflated and widened, and the rate of flow field advancement along the lava bench decreased. Slowly the occurrences of flow front breakouts declined at which time new channel branching events began both above and below the original channel branch. The newly established channels delivered lava to the areas between the three older channels.

Throughout the period of observation the same chain of events occurred several times, including: 1) advancement of lava within open lava channels over slopes of ~20˚-10˚, 2) flow widening and development of a surface crust at slopes of <10˚, 3) inflation and development of budding lava toes at the flow front, and 4) stagnation of flow lobes and breakout of new lava channels near the site of the original channel branching event. The resulting morphology of the tube-fed flow field as it encountered the slope break was a network of open lava channels and inflated, relatively smooth, liquid lava filled flow lobes forming a delta-like deposit for which the location of the original channel branching event was the apex.

Figure 2. Image showing the initial channel branches of the Campout tube-fed flow as it encounters a slope break between the sea cliff and lava bench. Active budding toes can be seen at the inflated flow fronts.

Summary and Conclusions: Lava fans are suggested to represent rootless vents associated with lava tubes [1] or eruptive vents fed from depth [2,3]. Based on HRSC- and THEMIS-based mapping, lava fans are described as delta-like features consisting of one, or a cluster of several hills from which a somewhat linear texture radiates downslope [4]. Often fans are located along slope breaks, of which an example is shown in Figure 3. In this example a tube-fed flow extends over a steep slope along the basal scarp of Olympus Mons, where slopes are between 15˚ and 40˚. Near the base of the cliff, where slopes decrease to less than 5˚, the tube-fed flow is embayed by a delta-shaped network of lava channels and smooth, lobate surfaces. This superposition relationship might represent the burial of a tube-fed flow by a fan-shaped vent that was fed from depth, or the development of a fan-shaped rootless vent formed where a tube-fed flow encountered a slope break. Although the former scenario cannot be ruled out, the observations of the Campout lava tube encountering the sea cliff and lava bench at the East Ka'ili'ili ocean entry, Kilauea, Hawaii, are presented here as a possible analogue to the fan deposit shown in Figure 3, supporting the inference that the Olympus Mons lava fans represent rootless point sources formed from impeded flow of lava within a lava tube.

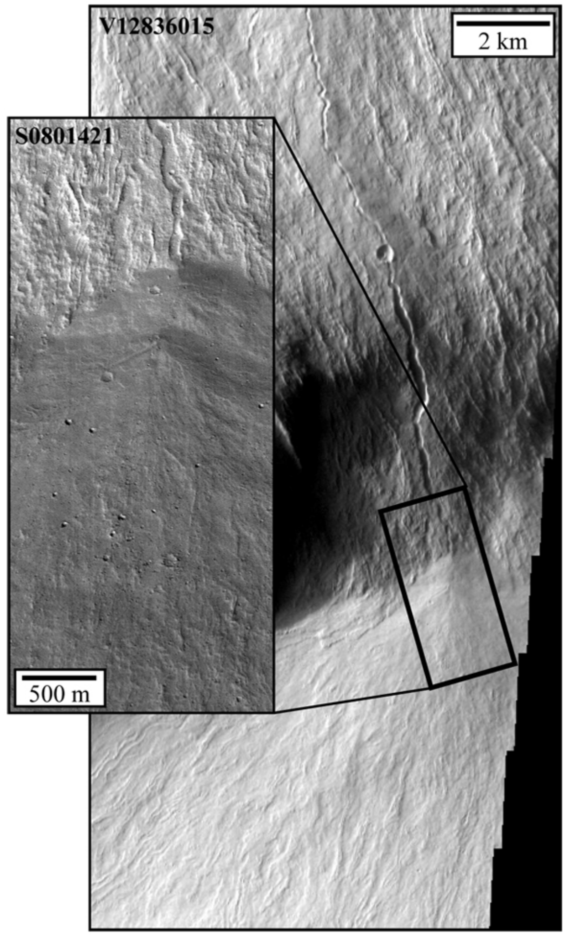

Figure 3. THEMIS VIS image V12836015 showing a lava fan and adjacent tube-fed flow. A similar view of the same feature was published by *Carr et al.* [1977], using Viking images, as an example of a lava fan. A higher resolution view from MOC image S0801421, requested through the MOC online target request website, shows detail of the contact between a tube-fed flow and lava fan.

Acknowledgements: Field support for this project was provided by M. Poland at the USGS, HVO, for which I am grateful.

References: [1] Carr et al. (1977) *JGR*, **82**, 3985. [2] Morris and Tanaka (1994) *USGS Misc. Inv. Series Map I2327*. [3] Mouginis-Mark and Christensen (2005) *JGR*, **110**, E08007, doi:10.1029/2005JE002421. [4] Bleacher et al., accepted, *JGRE*. [5] http://hvo.wr.usgs.gov/kilauea/summary/main.html. [6] http://volcano.wr.usgs.gov/hvostatus.php. [7] Kilburn and Lopes (1991) *JGR*, **96(B12)**, 19,721. [8] Gregg and Fink (2000) *JVGR*, **96**, 145. [9] Wentworth and Macdonald (1953) *USGS Bull*., **994**, 1.