TOPOGRAPHIC CONTROL OF LAVA FLOW EMPLACEMENT: EARTH, MARS, AND VENUS. D. Hanley[1] and J.R. Zimbelman[2]; [1]Dept. of Geology, Univ. of Maryland, College Park, MD 20742, [2]CEPS/NASM, Smithsonian Institution, Washington, D.C. 20560, Internet: jrz@ceps.nasm.edu.

The complex physical and rheological conditions present in an active lava flow pose a considerable challenge to mathematical models for simulating lava flows under a wide range of conditions, as would be encountered on planetary surfaces. Here we take the approach of utilizing software developed for the study of hydrologic problems to investigate the effects of one parameter, surface topography, on the emplacement of lava flows. Detailed information published on the 1983-84 eruptions of Kilauea volcano (1) was used to evaluate the utility of this approach. Projection of flow orientation for the first 18 episodes of the Kilauea eruptions was very successful, derived solely from the maximum gradient available at each pixel of a Digital Elevation Model (DEM). Slope-derived flow orientations were compared with observed flows in large flow fields on Mars (Tharsis Montes region) and Venus (Kawelu Planitia region). Flow orientations on all three planets show that topography alone plays the major role in determining the path followed by lava flows. Deviations from topographic control may hold important clues to the scaled distance at which cooling and/or other physical conditions become significant in flow emplacement mechanisms.

ARC/Info software (2) includes several functions designed to study hydrologic flow over a DEM. The DEM used in the Kilauea study was derived from digitized (pre-eruption) topographic contours of the area, interpolated by routines available in ARC/Info. Field measurements of flow thicknesses were used to add relief to the DEM for each flow episode. Digitized outlines of each eruptive episode were then compared to the projected course of an overland flow originating within the flow. An ARC/Info function determined the magnitude and orientation of the steepest topographic gradient available to each pixel in the DEM, from which overland flow paths were derived. Pre-flow topography alone was sufficient to account for up to 90% of the total flow path of most flow episodes (Fig. 1), although some physical change (flow front stagnation?) could have caused certain flows to switch drainages (3).

Long individual lava flows between Pavonis and Ascraeus Montes, Mars, were also compared to existing topography (Fig. 2). The observed flow front locations (4) do not correspond to movement down the steepest gradients in existing topography (5). In particular, the flow field makes a pronounced swing to the right (NE) below the 5 km contour, where the DEM is essentially flat. Either errors in the topographic data, or an unrecognized post-emplacement tilt, could account for this result. Numerous additional examples of long lava flows exist on Mars, mostly in or around the Tharsis region, and they will be the subject of future investigations.

Volcanic features are abundant on Venus (6), including some spectacular large flow fields (7). One example of a volcanic flow field is the intermixed digitate flows in Kawelu Planitia (Fig. 3), where both individual flows and the entire flow field appear to follow extremely subtle topographic trends. Magellan altimetry (8) indicates that the entire 400-km-long flow field occurs over a regional elevation drop of only 400 m, corresponding to an average slope of only 0.05° (9). Such extremely shallow gradients still appear sufficient to control the trend of the flow field, although individual flows do not correlate as well with gradients in the DEM. Future work will focus on a detailed examination of Magellan DEMs for use in flow orientation projections.

References: 1) E.W. Wolfe et al., 1989, USGS Prof. Paper 1463, 1-98. 2) Environ. Sys. Res. Inst., 1992, ARC/INFO User's Guide, Redlands, CA. 3) J.R. Zimbelman and D. Handley, 1994, EOS 75(44), 736-7. 4) J.R. Zimbelman, 1984, PhD diss., A.S.U.; see Map 1 (in NASA TM-88784, 1986, 271-572). 5) USGS, 1991, Map I-2160. 6) J.W. Head et al., 1992, JGR 97, 13153-13197. 7) K.M. Roberts et al., 1992, JGR 97, 15991-16015. 8) P.G. Ford and G.H. Pettengill, 1992, JGR 97, 13103-13114. 9) M.B. Helgerud and J.R. Zimbelman, 1993, LPS XXIV, 637-638.

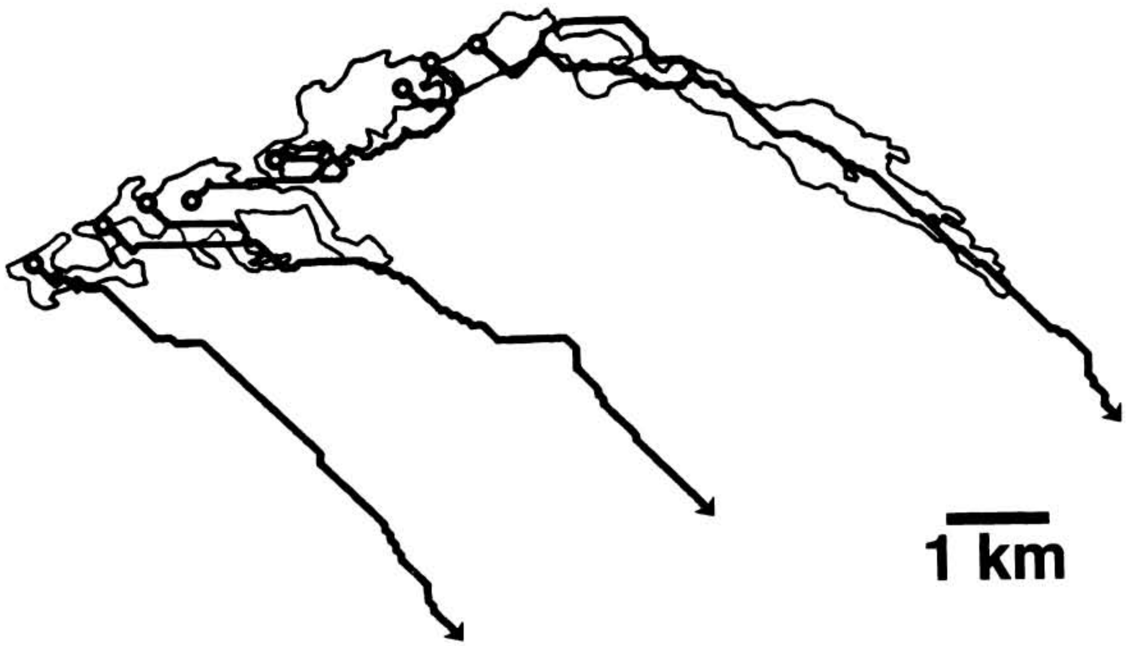

Figure 1 (above). Actual flow locations (white area) and projected flow directions (heavy lines) derived from pre-flow topography; Episode 1, 1/3-8/83, Kilauea eruption (1; Plate 1). Circles represent starting points for flow predictions.

Figure 2 (left). Flow outlines (white) and 1-km contours (black) for long flows on the western flank of the saddle between Pavonis and Ascraeus Montes, Tharsis region of Mars. Shading highlights the change in topography from below 5 km (darkest area, at top) to above 10 km, measured from the Mars datum (5). Area shown: 3°-16°N, 107°-112°W (North is to the top).

Figure 3. Intermixed flows in the Kawelu Planitia region of Venus (portion of F-MIDR 40N251; center at 41°N, 251°). Magellan topography (described in 8) shows 400 m of drop (left to right) across the flow field that extends over 400 km.