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LAVA FLOW-FIELD MORPHOLOGICAL CLASSIFICATION AND INTERPRETATION: EXAMPLES FROM VENUS. J. W. Head[1], K. Magee Roberts[1], L. Wilson[1,2] and H. Pinkerton[1]. [1]Dept. Geological Sci., Brown Univ., Providence RI 02912 USA, [2]Environmental Sci. Div., Lancaster Univ., Lancaster LA1 4YQ, U.K.

Introduction: Recent analyses[1] suggest that thermal constraints will act to limit the maximum length of an advancing lava flow being fed at a given volume or mass effusion rate from a vent. These constraints can be characterized through the Grätz number[2], which has a large value at the vent and decreases down flow; under a wide range of conditions, motion apparently ceases when the Grätz number has decreased[1] to a value close to 300. In cooling-limited flows, effusion from the vent should be steady; the flow front thickens, eventually stops due to this cooling, and the central channel does not drain (Fig. 1). If the vent remains active, a break-out flow will form from some point on the margin of the initial flow unit. If flows on planetary surfaces can be shown to be cooling limited, eruption rates can be estimated[1]. In this analysis, we illustrate the morphological characteristics of various flow configurations, and we describe the application of these concepts to a flow length histogram for a hypothetical flow field and then apply this to an example on Venus.

Variations on the cooling limited theme: A variety of factors may prevent a flow from reaching its maximum potential cooling-limited length (Fig. 1): In volume-limited flows, the front stops when effusion stops; the flow is shorter than a cooling-limited flow formed at the same effusion rate. The central channel of the flow unit may drain to form a thinner and narrower flow unit; no break-out flows will occur. Accidentally-breached flows will form a break-out somewhere upstream of the blockage; the parent flow will be shorter than if it had not been breached. Break-out flows form in cooling-limited flows if effusion at the vent continues after the flow front stops due to cooling, or from the sides of accidentally breached flows. Flows captured by pre-existing topography often show confinement to a narrower channel; these flows reach a greater cooling-limited length than if they had not been captured. For non-captured flows, the total flow width, central channel width and flow thickness will all increase systematically with decreasing substrate slope. Tube-fed flows are flows fed by a roofed-over tube system; once magma has emerged from the roofed-over tube system, the flow units formed obey the same rules as those given above for flows fed from a primary vent.

Typical histogram: These morphological factors can be applied to examples of mapped planetary flow fields in the following manner[1]: In a compound flow field consisting of many flow units which have been produced by long-lived eruptions, most of the flow units will be cooling limited. Mapping of compound flow fields allows one to identify discrete units and to determine superposition and continuity relationships between units or groups of units. A histogram of the lengths of the units should show a distinctive peak corresponding to the length, L, of a single cooling-limited flow unit; significant peaks at lengths which are integer multiples of this basic length (2L) may correspond to unrecognized break-out flows from the front of an earlier unit (Fig. 2). Peak sharpness will depend on effusion rate constancy: a declining effusion rate yields shorter cooling-limited flows and a skewing of the peak towards lengths shorter than L. Superimposed on the simple pattern due to cooling-limited flows will be a distribution of lengths arising from volume limited and accidentally breached flows (lengths shorter than L by various amounts) and of captured flows (lengths greater than L). If it is possible to distinguish these variations, the main peak due to cooling-limited flows, at the flow length, L, can be used to estimate the mean effusion rate feeding the flow field[1].

Application to Venus: Measurement of the lengths of 41 of the most distinctive flows surrounding a volcanic edifice about 375 km in diameter in Imdr Regio (214°; -46.5°) (Fig. 3) shows a broad peak between 140 and 220 km, slightly skewed toward greater lengths, and minor peaks at 250 and 330 km. If the flows were cooling-limited and emplaced with the longest flows first, than the 250 km lengths imply effusion rates of 3400 m^3/s (8.8×10^6 kg/s) and the 330 km lengths imply effusion rates[1] of 5300 m^3/s (14×10^6 kg/s). The two peaks in the shorter flow sequence (150 km and 190 km; Fig. 3) imply effusion rates of 1500 m^3/s (4×10^6 kg/s) and 2200 m^3/s (6×10^6 kg/s) respectively. A simple interpretation of this would be that the different lengths represent differing phases in the evolution of the edifice, with the longer ones representing early high-effusion rate eruptions, and the shorter ones, later lower effusion rate eruptions as the source region evolved. Alternatively, the presence of numerous lateral and distal break-out flows and the lack of a clear superposition stratigraphy between units of different lengths suggests that the basic broad peak between 150-190 km may represent the typical range of flow lengths for a single cooling-limited flow unit (mean effusion rate of 1850 m^3/s, 5×10^6 kg/s). The other peaks might then represent break-out flows emerging from the front of previous flows, with lengths at multiples of L of the short and long end of the range. In contrast, Sif Mons[3] is characterized by a series of five flow units which have fairly distinctive flow lengths over large parts of the volcano (for example, the SE quadrant). This distinctive stratigraphy suggests that the flow units are not multiples of L (the cooling-limited flow length), but that they may represent sequential periods of evolution representing decreasing volume-limited stages, or cooling-limited flows representing phases of decreasing effusion rates. We are presently undertaking detailed mapping of several other examples to assess these factors.

Figure 1.

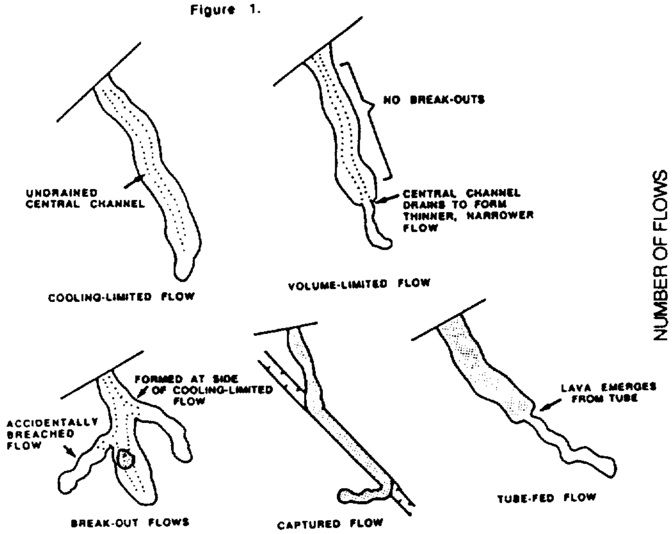
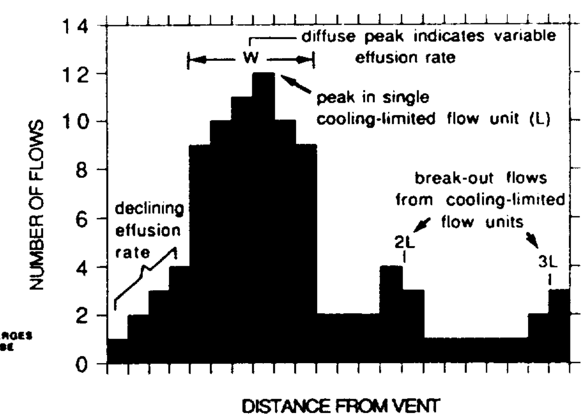


Figure 2. Hypothetical histogram of flow lengths



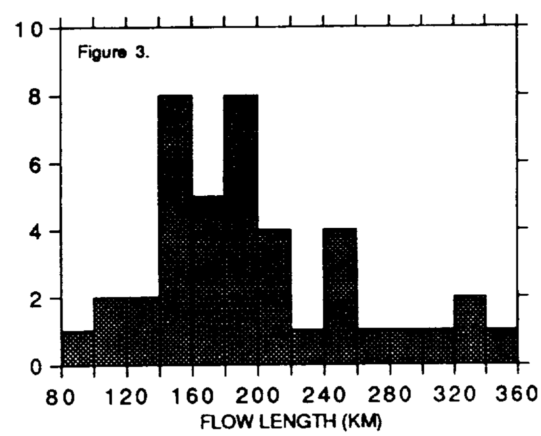


Figure 3.

References: 1) Pinkerton, H. and Wilson, L. (1992) Factors controlling the lengths of channel-fed lava flows, submitted to *Bull. Volcanol.*; Wilson, L. *et al.* (1993) A classification scheme for the morphology of lava flow fields, *LPSC XXIV*, this volume; 2) Knudsen, J.G. and Katz, D.L. (1958) *Fluid dynamics and heat transfer*. McGraw Hill; 3) Keddie, S. and Head, J. (1992) *LPSC XXIII*, 669.