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**CONSTRAINTS ON MARS SAMPLING BASED ON MODELS OF BASALTIC FLOW SURFACES AND INTERIORS;** J. C. Aubele and L. S. Crumpler, Dept. of Geological Sciences, Brown University, Providence, RI 02912

We assume that basaltic plains units on Mars are a dominant terrain type and, for future missions, will be a landing site of choice due to engineering or sampling constraints. Proposed rover/sample return missions will traverse, or at least photograph and sample, small-scale surface blocks and outcrops within large flow units. Actual contacts between rock types may be difficult to find or recognize for an in situ lander or even for a rover of limited range. However, the surface characteristics of the plains units, (blocks, cobbles, outcrops, dunes, and other surficial materials) will be visible, and may even act as limiting parameters to rover trafficability or lander sampling strategies. These surface characteristics can be interpreted in a geologic context if we understand the nature of degraded basaltic flow surfaces.

Recent field observation and numerical modeling of the pattern and origin of vesicle zones and joints in terrestrial basaltic flows [1] has resulted in increased understanding of the processes which affect flow surface morphology. This work has documented the ubiquitous occurrence of three vertical zones in basalt flows: (1) an upper vesicular zone; (2) a middle vesicle-free zone and (3) a lower vesicular zone. The upper vesicular zone is generally about one-half of the total flow thickness. Computer modeling of the development of these zones confirms that vesicle zonation is a result of the nucleation, growth and rise of bubbles in solidifying lava and can be expected to occur in all basaltic flows. Degradation of basaltic flows, therefore, will produce vesicular blocks until the erosional level reaches the central vesicle-free zone. In addition, observation of terrestrial basaltic flows [2] has shown that most thin (less than 10m thick) flows have a regular pattern of orthogonal joints in vertical section in which the spacing of joints increases with depth beneath the flow surface. Therefore, as a flow erodes vertically the degradational surface of that flow will be characterized by blocks of a size similar to the spacing of joints at that level in the flow. Generally, as a crude approximation, the joint spacing at a specific level in the flow will be roughtly equivalent to the depth from the primary flow surface to that level. As a basaltic flow degrades, the erosional surface will be characterized by a bimodal distribution of fines and blocks. The mode of the block size population is an indication of the depth to which that flow has been eroded.

Using these studies we have performed a preliminary analysis of the Viking lander sites [3]. If the rocks at the Viking lander sites are basaltic, and if the pits visible in lander imagery are vesicles, then certain basic assumptions can be stated regarding the geology of the sites. The natural degradation of a basaltic flow can result in a blocky surface. Impact disturbance of the surface may add some large blocks but is not required as a mechanism for generating the observed blocks on the surface. The general size of the block populations at both sites [4] indicate a flow disturbed by erosion to a depth of tens of centimeters. Blocks containing abundant vesicles could be from the upper vesicular zone. A few large blocks (greater than 1m), without vesicles, visible at both lander sites probably represent excavation by impact from some greater depth in the flow than has been reached by erosion.

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These studies, and the new understanding of basaltic flow surfaces that they provide. also have implications for future Mars sample return missions. For example, trafficability is related to the abundance and size of blocks at the surface, which in turn is related to the depth of erosion of a basalt flow. Flows which have experienced disturbance of the surface to a deep level may be more difficult to traverse because modal block size will be larger. In terms of an *in situ* sample mission, a sample from near the surface of a basaltic flow will contain less mass per unit volume than will a sample from the vesicle-free interior. In other words, a sample collected from the top of the upper vesicular zone would be predominantly voids. Maximum mass per unit volume will occur in samples from the vesicle-free zone. In addition, basalt from the upper vesicular zone is frequently more microcrystalline than is basalt from the vesicle-free zone and consequently more difficult to characterize petrographically. For these and other reasons, optimal sampling of a basalt flow would require a sample from the vesicle-free zone. If basaltic flow structure on Mars is comparable to that on Earth, then this means a flow which has been eroded down to one-half its total flow thickness. But this type of surface cannot be easily traversed, in the event of a rover mission, because of its large blocks. One solution may be a landing site on a basalt flow of intermediate age with a surface disturbed by a few small impact craters which have excavated blocks from the interior of the flow.

In future work, we anticipate formulating a detailed model of the mechanics of formation of the interior structure (vesicle formation, vesicle zones, joint patterns) of basaltic flows, and the way in which this structure constrains the surface morphology of degraded flows. This model will then be used to (a) predict the surface properties of basaltic plains units which will act as limiting parameters to future Mars lander/sample return/rover missions, and (b) to construct models of basaltic surfaces by which the imagery and samples from future lander missions can be evaluated and interpreted.

**References.** [1] Aubele, J.C., et al., 1987, *J. Volc, Geoth. Res.*, in press; [2] Aubele, J.C., et al, 1980, *NASA TM-82385*, 231; [3] Aubele, J.C. and Crumpler. L.S., 1987, *Lunar Planet. Sci. Conf. XVIII*, (abst.), 36; [4] Garvin, J.B., et al., 1981, *Moon Planets*, 24, 355.