THE SIGNIFICANCE OF BLOCK SIZE AND PIT DIAMETER IN ROCKS AT THE VIKING LANDER SITES, MARS; Jayne C. Aubele and L. S. Crumpler, Dept. of Geological Sciences, Brown University, Providence, RI 02912

Introduction. The surface of Mars exhibits a variety of erosional landforms in orbital imagery suggesting that the surface has been modified by aeolian and fluvial processes. In addition to ablation of existing surfaces, there is evidence for mantling and burial on local and regional scales by deposits which are, in some places, interbedded with volcanic deposits and fluvial landforms. One of the questions remaining from analysis of the Viking Lander images of the surface of Mars at Chryse Planitia (VL–1) and Utopia Planitia (VL–2) is the nature of the surfaces and whether the observed distribution of rocks and fines represents a surface that has been extensively eroded, either by aeolian or fluvial processes, relatively uneroded, and/or mantled and exhumed. New analysis of the VL–1 and VL–2 sites, based on an understanding of the details of the origin of the surfaces of basalt flows, suggests that vertical erosion of the original surfaces is minor and that the basalt plains in these areas could be ultramafic in composition.

Viking Lander Site Geology. The predominant rock type at both Viking Lander sites has previously been interpreted to be basalt on the basis of orbital photography [1,2], composition and strength of surface materials [3,4,5] and mean sphericity and shape of rocks in the landing site areas [6]. There have been suggestions of aeolian or chemical weathering mechanisms of formation to account for abundant pits in the rocks at the lander sites [2,7]. However, if the rocks are assumed to be volcanic, then the simplest and most consistent hypothesis is that the pits are vesicles.

Both lander sites consist of rocks in the centimeter to meter size range and abundant fine–grained ($< 100 \mu m$) material. The VL–2 site exhibits a bimodal distribution of fine–grained material and rocks 10–20 cm in diameter. A detailed study of the characteristics of rock populations 2–4 m distance from the landers at both sites has shown that mean sphericities, form ratios and roundness factors are similar, for the rocks analysed, at both lander sites and do not indicate re–shaping by fluvial processes [6]. Size ranges from 1 to 25 cm are present at both sites but pebble size (1–6 cm) predominates at VL–1 and large cobbles (12–25 cm) at VL–2. Pits on rocks at VL–1 are small, shallow cavities of all shapes (.3–1.0 cm). Pits on rocks at VL–2 are medium sized cavities of moderate depth with predominately round shapes (up to 3.0 cm). Previous studies have indicated that little rock breakdown and removal ($\leq$ tens of meters) has occurred over the last 3 b.y at the landing sites but evidence exists for a rapid redistribution of loose fine grained material [1,8].

Origin of Vesicles and Vertical Structure of Lava Flows. In a recent study [9] we described the origin of vesicles and vesicle zonation of lava flows and suggested that the vertical section of typical lava flows can be characterized by three zones: (1) an upper vesicular zone; (2) a central vesicle–free zone; and (3) a lower vesicle zone. The upper vesicle zone and the central vesicle–free zone comprise most of the flow thickness, since the lower vesicular zone is relatively minor in thickness. The thickness of the upper vesicular zone is generally about 1/2 of the total flow thickness.

Within the upper vesicular zone, vesicles increase in size with depth. The largest vesicles in a flow occur near the boundary between the upper vesicular and central vesicle–free zones. In terrestrial basalt flows, the size of vesicles is specified by the diffusion coefficient of the gas in the liquid, the concentration of the gas species in the liquid, hydrostratic pressure, viscosity, temperature, and time. The growth rate of a bubble in a basaltic melt is sensitive to the three basic parameters of viscosity, temperature and gas content of the magma. For typical terrestrial basaltic magmas, these three parameters fall within relatively restricted ranges and yield final vesicle sizes on the order of less than 1 cm.

In addition to the vesicle zone pattern, jointing in basalt flows has also been observed to follow a pattern in vertical section [10]. Joints tend to increase in spacing with depth so that the distance between joints is an approximation of the vertical distance from the surface of the flow.

These two characteristics: (1) vesicle size and abundance, and (2) joint spacing, result in a characteristic relationship between block size and vesicle size in terrestrial basalt flows undergoing vertical erosion. Initial erosion results in small cobbles containing abundant small vesicles. As erosion proceeds, larger blocks containing much larger vesicles, are excavated. Continued erosion may excavate larger blocks with few or no vesicles as the non–vesicular zone is exposed.

Significance for VL–1 and VL–2 Sites. The Viking sites contain blocks on the order of 1 cm to 1 m in size [1]. Garvin, et al. [6], measured approximately 240 rocks within 2 to 4 m of each lander and found a size range of 1 – 25 cm which is comparable to the 10 – 20cm modal size range found at VL–2 [2]. This appears to be the predominant size range at both sites.

Most rocks, at both sites, contain abundant pits ranging in size from 0.3 to 3.0 cm. Rocks with no pits are scarce. A few large blocks ($\geq$ 1m in diameter) at VL–2 contain pitted and non–pitted portions.

On the basis of our analysis of vesiculation and jointing in terrestrial lava flows, we interpret both VL–1 and VL–2 to be *in situ* lava flows which have been eroded to a depth of tens of centimeters. Erosion does not appear to have exposed the non-vesicular zone. The few large blocks, which exhibit no pits and appear to be from the non-vesicular zone, probably represent ejecta blocks excavated by local impact craters.

Vesicle size, at the lander sites, is somewhat larger than in typical terrestrial basalts. Considering the controls on vesicle size, larger vesicles can be generated if (1) the viscosity is reduced, (2) the temperature of the melt is increased, or (3) the gas content of the magma is increased. The mafic nature of the XRF analyses of martian soils, and the suggestion of McGetchin and Smythe [11] that probable martian mantle partial melts would be ultramafic, supports the idea that large vesicle size may be a consequence of the growth of vesicles in ultramafic lavas.

Conclusions. On the basis of block size, we suggest that erosion at the VL–1 and VL–2 sites is tens of centimeters or less. This small amount of erosion could be a result of (1) very low erosion rates or (2) mantling and subsequent stripping of the mantle material, as has been suggested by other recent studies [12] in related area on Mars. On the basis of vesicle size, we suggest that the composition of rocks at the landing sites, particularly VL–2, may be more mafic than typical terrestrial basalts.

References. [1] Binder, A.B., et al., 1977, *J.G.R.*, 82, 4439; [2] Mutch, et al., 1977, *J.G.R.*, 82, 4452; [3] Baird, A.K., et al., *Science*, 194, 1288; [4] Huck, F.O., et al., 1977, *J.G.R.*, 82, 4401; [5] Toon, O.B., 1977, *Icarus*, 30, 663; [6] Garvin, J.B. et al., 1981, *Moon Planets*, 24, 355; [7] McCauley, et al., 1979, *J.G.R.*, 84, 8222; [8] Arvidson, R.E., et al., 1979, *Nature*, 278, 533; [9] Aubele, J.C., et al, 1987, *J. Volc. Geoth. Res.*, in press; [10] Aubele, J.C. et al, 1980, *NASA TM–82385*, 231; [11] McGetchin and Smyth, 1978, *Icarus*, 34, 512. [12] Grizzaffi and Schultz, 1987, *Lunar Planet. Sci. Conf. XVIII*, (abst.).