THE GEOLOGY OF THE VIKING 2 LANDER SITE REVISITED. B. J. Thomson and P. H. Schultz, Brown University, Department of Geological Sciences, Providence, RI 02912 (Bradley_Thomson@brown.edu).

Introduction: Remotely sensed data have greatly advanced our knowledge of the Martian surface, yet the link between orbital observations and surface processes remains incomplete. The basic issue is spatial resolution: while orbital data sets with global coverage typically have spatial resolutions ~100 m/pixel or coarser, the physical interactions that control spectral observations made from orbit operate on much smaller spatial scales (e.g., 10^{-6} m for visible light). Our only access to Mars at such small scales is at the landing sites, of which we are limited to only five (VL1, VL2, MPF, Spirit, and Opportunity). The flood of recent orbital data allows us to apply a new level of scrutiny to the older landing sites and to reassess their geologic histories.

This study focuses on the Viking 2 Lander (VL2) site, which at 47° N is the highest latitude successfully landed site. We first assess the extent and timing of regional deflation using remnant landforms and crater statistics. We then interpret the distribution of rocks at the surface in the context of the observed deflation. Finally, we synthesize these observations and reinterpret the geologic history of this region.

Lander location: Enhanced horizon topography has been used to locate the lander relative to nearby surface features [e.g., 1]. The VL2 site is roughly 15 km away from the pedestal crater Goldstone. South of the lander is a lobe of high-relief Mie ejecta. Thus contrary to some initial interpretations [2], VL2 did not land on Mie ejecta, nor is any part of the crater or its ejecta visible from the landing site. Instead, the lander lies on intracrater material that appears to be representative of the bulk of the northern plains. The question has been asked if the Viking landing sites are representative of the surface of Mars [3]. On a plot of TES bolometric albedo versus thermal inertia plot, the VL2 site lies near the center of a mode that represents roughly one-quarter of the surface of Mars [4, 5]. Given this fact and coupled with the knowledge that VL2 does not lie on Mie ejecta, it would appear that the VL2 site is indeed representative of much of the Martian surface.

Extent and timing of deflation: Previously, we measured the extent of deflation around the VL2 site using topographic measurements of pedestal craters [6]. These results indicate that at least 120 m of easily eroded material has been stripped from the vicinity of the landing site. Although the minimum extent of deflation has been estimated previously [7], the time frame over which deflation occurred was not addressed. Here we examine the total impact crater population to provide insight into the resurfacing history. Impact crater densities were measured with Thermal Imaging System (THEMIS) infrared images, THEMIS visible images, and Mars Orbiter Camera (MOC) images. The results are given in Figure 1. The 2 and 5-km-crater densities (N2 and N5) are 570 and 116 craters>D per 10^6 km^2, respectively, which correspond to a Late Hesperian surface according to the crater-density boundaries of *Tanaka* [8]. Smaller craters, in contrast, are severely depleted. Less than 10% of the predicted original population of craters 200 m in diameter remains. Craters 100 and 50 m in size have been reduced in number two orders of magnitude such that less than 1% of the original population remains. This deficiency indicates an extreme loss of craters by erosion and/or infilling.

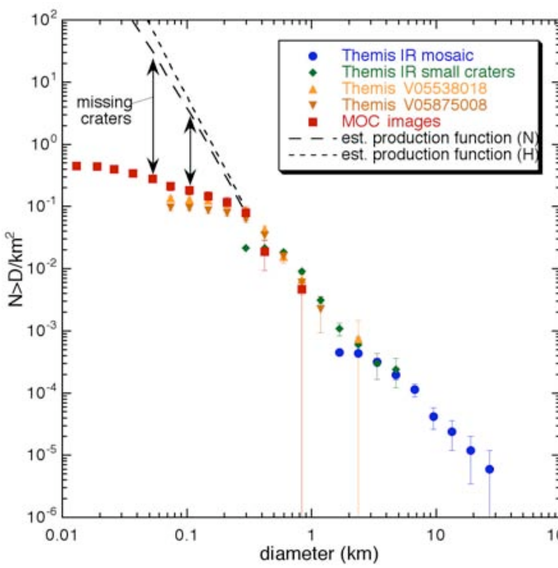

Figure 1. Cumulative crater density of the VL2 region. Error bars represent ±√N. Estimated Martian production functions (from [9]) are given as dashed lines below 300 m to indicate number of missing craters.

A deficiency of small craters in high-latitude regions was observed with Mariner 9 data and was attributed to a debris mantle extending down from both poles to 30-40° N and S latitudes [10]. Both Viking [e.g., 11, 12] and Mars Global Surveyor [e.g., 13] data have further documented the presence of a latitude-dependant mantle deposit. Mars Odyssey gamma-ray and neutron spectrometers have also revealed that high-latitude regions are enriched in hydrogen, which is consistent with the presence of significant water ice in the near surface [e.g., 14].

Many attempts have been made to correlate layered deposits with climate variations induced by subtle interplay of Mars's spin and orbital parameters. These dynamic parameters, in particular obliquity, exhibit chaotic behavior that can only be accurately reconstructed for the most recent geologic past (~10 Ma) [15], leading some to conclude that the apparent youthfulness of these mantling deposits implies they were recently formed [16]. While the crater statistics presented in this present study support the conclusion that these deposits have been recently modified, their formation age and the onset time of resurfacing episode(s) of the lowermost sedimentary layers stretches back further into time [e.g., 17].

One way to determine the age of the mantle deposit is through an analysis of nearby Mie crater. Mie is a 104 km diameter structure that serves as an important regional stratigraphic marker. One of the ENE rays of Mie ejecta exhibits a distinct change in morphology as the distance from the parent crater increases. Close to Mie, this secondary chain is expressed as a series of linear pits elongated in the downrange direction. As the distance increases, it transitions to a series of linear cratered mounds. The floors of some of these distal structures lie above the elevation of the surrounding plains, indicating they have been topographically inverted through erosion (in a manner similar to some Lyot secondaries [18]). This stratigraphic relationship demonstrates that the mantle layer was present when the Mie impact event occurred, and thus the age of this event provides a minimum age constraint on the mantle. Assessing the number density of subsequent impacts that are superposed on Mie ejecta is complicated both by the relatively small area and by the hummocky topography of the inner ejecta facies. Nevertheless, the results indicate an N(5) age of roughly 100, which places the impact within the Late Hesperian. Therefore, the mantle deposit itself dates back to at least the Late Hesperian period. This conclusion indicates that eolian processes have been dominant for a significant fraction of the age of the plains upon which the mantle lies.

Implications of rock abundance: The surface area covered by rocks at VL2 is in the range of 16-19% [19, 20]. At the MPF location (and by extension VL1), some of the rocks were assumed to be flood-deposited debris. This is unlikely to be the case for VL2, which lies over 6000 km from the mouth of the outflow channel system. Rocks at this site are likely impact-emplaced and some may even be impact-derived (i.e., impact melt breccias) [21]. Looking at the total number of small visible craters around the landing site and assuming a simple ejecta scaling relationship [e.g., 18], the total accumulated amount of predicted ejecta is 7×10^{-3} m at VL2, in contrast to an observed thickness of 1-2$\times 10^{-2}$ m (converting the observed volume and fractional area of rock coverage into an equivalent thickness). This suggests either that more small craters than are presently observed have contributed rocks or a component of Mie ejecta accounts for this discrepancy. As evidenced by the small crater depletion, the observed number of craters represents only a fraction of the total population of impact events that have occurred. The missing craters may have contributed to the present rock population, resulting in the current erosional landscape that is not unlike desert pavement.

Conclusions: The deficiency of small craters documented in this study is consistent with the presence of a recently active, deflated debris mantle. Topographic inversion of a Mie crater secondary chain indicates that this mantle was emplaced before the end of the Late Hesperian. The rock abundance at VL2 is consistent with the idea that some of the rocks are impact-emplaced and possibly impact-derived. These observations suggest that the present surface at the VL2 site, which is representative of much of the northern plains, is an erosional lag deposit.

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