**EROSION RATES AT THE VIKING 2 LANDING SITE.** B. J. Thomson and P. H. Schultz, Brown University, Department of Geological Sciences, Box 1846, Providence, RI 02912 (Bradley_Thomson@brown.edu).

**Introduction:** The Martian surface has been eroded in a non-uniform manner in both space and time. While many regions retain much of the impact signature from the heavy bombardment during the very earliest epoch of Martian history [1], other high latitude terrains are almost devoid of craters [2]. Erosion rates on the south polar residual cap, for example, are high enough that it is visibly disintegrating on a time scale measured in years [3]. Understanding the rate of landscape evolution can provide insight into the nature and vigor of erosive processes through time [e.g., 4-6]. Temporal variations in erosion rates are also likely tied to climate variations. In this work, the erosion rate in the vicinity of the Viking 2 lander (VL2) is estimated using direct measurements of pedestal crater relief. We then compare these rates to other erosional rates established for a variety of Martian surfaces.

**Erosional signatures:** Many processes on Mars have the potential to modify and degrade landscapes. These include impact degradation, eolian abrasion, creep of ice-rich material in the near surface, and burial by deposition of eolian, fluvial, lacustrine, or mass-wasting sediments. Each of these processes produces unique geomorphologic fingerprints that can be used for identification. Pedestal craters are one type of diagnostic erosional landform. Initially recognized with Mariner 9 data [7], pedestal craters are mesa-like impact structures that are perched above the surrounding terrain. In these craters, the impact process produced an annular resistant surface, thus preventing the material immediately around the crater from removal by eolian activity [8]. Given its susceptibility to erosion, the surrounding material appears to consist of weakly consolidated sediments [4, 7, 9]. The extent of deflation between the pedestal crater and surrounding terrain provides a measure of the former surface level and can be used to estimate the thickness and volume of material removed.

**Observations:** Many of the craters in the vicinity of the VL2 site appear to be pedestal craters. Measurements of pedestal heights were made using the 128 pixels per degree gridded topographic data set [10]. One of the more prominent pedestal craters is the 3.0 km diameter crater Canberra, located about 50 km west of the VL2 site. Canberra is a "classic" pedestal crater in the sense that the floor of the cavity lies above the level of the surrounding plains. Perched atop the eastern edge of the pedestal is another, smaller pedestal crater (diameter = 0.9 km). The ejecta from this smaller unnamed crater superposes the ejecta of Canberra; the topographic profile in Figure 1 indicates that its upper surface lies some 120 m above the surrounding terrain. This stratigraphic relationship indicates that deposition of material was still occurring after the Canberra impact crater formed. A minimum of 40 m of material was emplaced upon it. Subsequent removal of this material exhumed Canberra and only lightly degraded it, as evidenced by the relatively sharp rim crest that is still visible in Figure 1. The preservation of certain small topographic features indicates that both the depositional and erosional processes in this region were gentle enough not to heavily degrade resistant surfaces, a fact that has been noted before in other friable Martian deposits [9].
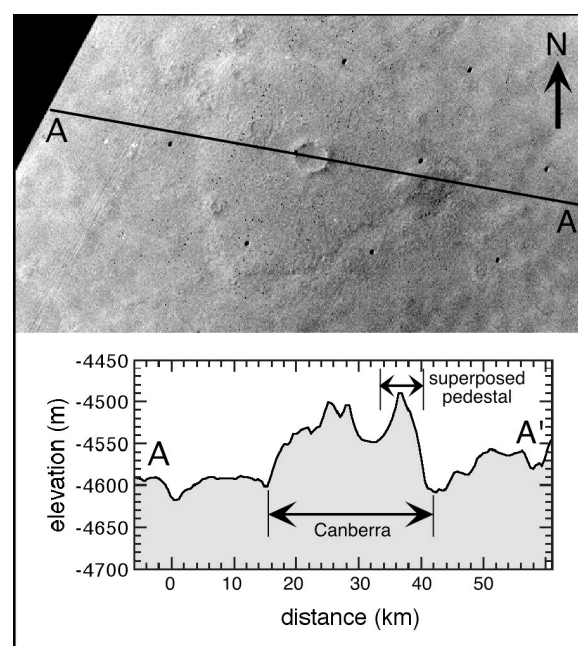


**Figure 1.** Portion of Viking orbiter image 9B14 (83 m/pix) showing pedestal crater Canberra. Topographic profile was extracted from 128 pix/° gridded data [10]. (v.e.≈130×)

**Inferred erosion rates:** The VL2 site lies within the margins of the Vastitas Borealis Formation (VBF). Global-scale mapping efforts based on Viking images placed the bulk of the VBF formation in the Late Hesperian [e.g., 11]. If erosion of the region around VL2 continued from the Late

Hesperian to the present, then the average rate of erosion would be about $3.5 \times 10^{-8}$ m/yr or 35 m per Ga (based on the surface age estimates of [12]). If the erosional activity was largely confined to a specific epoch, the rate of erosion could have been substantially higher. For example, if deflation ceased by the end of the Early Amazonian, the average erosion rate would have been $9.2 \times 10^{-8}$ m/yr (~0.1 µm/yr), which is consistent with previous estimates of erosion rates near VL2 [4]. Erosion on even shorter timescales would result in correspondingly higher erosion rates.

There are several caveats that apply to these erosion rate calculations. Assigning a discrete crater retention age to this surface is difficult due both to the large degree of regional stripping and the fact that deposition and erosion of these friable deposits may have been episodic or periodic. The surface age estimates are also subject to considerable uncertainty (a factor of 2 to 3) due to the lack of radiometrically dated surface units. Ages for the middle range of Martian history are particularly prone to errors due primarily to uncertainty in the estimate of the Mars/Moon cratering rate [12].

**Implications:** The erosion rates estimated for the VL2 site in this work are 1 to 2 orders of magnitude higher than those inferred for the VL1 site (~$10^{-9}$ m/yr) [4], and 3 to 4 orders of magnitude higher than the rates estimated at the Pathfinder site since the end of the Hesperian ($1\text{-}4 \times 10^{-11}$ m/yr) [13]. Nevertheless, the erosion rates estimated for VL2 are generally lower than the very high erosion rates (up to $10^{-5}$ m/yr) estimated during the Noachian [e.g., 14]. The dramatic decline in erosion rates at the end of the Noachian is one indication that conditions on early Mars may have differed substantially from current conditions. But the relatively high erosion rates at VL2 indicate that regional post-Noachian erosion is significant in certain terrains.

The erosion rate at the Viking 2 landing site indicates that the surface may have experienced a deflation rate of 1 m per 10 million years (or perhaps higher if the erosion was more short-lived). Sedimentary deposits subject to deflation through winnowing of fine-grained material can develop lag deposits of coarser debris (if coarser materials are present). It has been suggested that the rock population at VL2 is a lag deposit of largely ejecta-deposited blocks [i.e., 15]. Interestingly, despite the fact that the Pathfinder site is reported to have experienced only minimal eolian deflation [13], it exhibits a rock size distribution that is greater than or equal to the VL2 site [16, 17]. Although other processes besides deflation can concentrate rocks at the surface, this suggests that the deflation at Pathfinder may have been underestimated.

**References:**
[1] Schultz P. H. (1988) *LPI Tech. Rep. 88-05*, 117-119. [2] Thomas P. et al. (1992) in *Mars*, Univ. of Az. Press, 767-795. [3] Malin M. C. et al. (2001) *Science*, *294*, 2146-2148. [4] Arvidson R. et al. (1979) *Nature*, *278*, 533-535. [5] Grant J. A. and P. H. Schultz (1990) *Icarus*, *84*, 166-195. [6] Schultz P. H. (2002) *LPC XXXIII*, Abstract #1790. [7] McCauley J. F. (1973) *JGR*, *78*, 4123-4137. [8] Schultz P. H. (1988) *LPS XIX*, 1039-1040. [9] Schultz P. H. and A. B. Lutz (1988) *Icarus*, *73*, 91-141. [10] Smith D. et al. (2003) *NASA PDS*, MGS-M-MOLA-5-MEGDR-L3-V1.0. [11] Tanaka K. L. (1986) *JGR*, *91*, E139-E158. [12] Hartmann W. K. and G. Neukum (2001) *Space Sci. Rev.*, *96*, 165-194. [13] Golombek M. P. and N. T. Bridges (2000) *JGR*, *105*, 1841-1854. [14] Carr M. H. (1992) *LPS XXIII*, 205-206. [15] Mutch T. A. et al. (1977) *JGR*, *82*, 4452-4467. [16] Golombek M. P. et al. (1999) *JGR*, *104*, 8585-8594. [17] Haldemann A. F. C. and M. P. Golombek (2003) *LPS XXXIV*, Abstract #2029.