RECOVERY AND ANALYSIS OF DIGITAL ELEVATION DATA FROM VIKING LANDER CAMERA OBSERVATIONS.
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Introduction: We report the initial results of a multifaceted effort to recover the fine scale topography for the two Viking landing sites. This information is important for photometric analysis and surface characterization, and critical in the landing site selection process for the 2003 Mars Exploration Rover Mission. The Viking landing sites, in conjunction with the Pathfinder landing site, are the only locations where ground truth is available to relate fine scale surface properties to orbital data sets.

The two fundamental elements of this effort include 1) the recovery, validation, analysis, and delivery to the Planetary Data System (PDS) of the Viking Lander Range Data Sets (RDS) produced in the 1970's [1], and 2) the use of modern stereo processing procedures to generate the highest-possible resolution digital elevation model of each landing site.

Range Data Sets: RDS were derived from Viking Lander camera stereo images using the RANGER stereo system [1]. Range data were largely computed in support of mission operations such as trenching and soil analysis. As a result, the majority of the range data are within a few meters of the landers. However, RDS were also produced from the nearly 360º panoramic stereo mosaics for overall characterization of both the VL1 and VL2 landing sites. The site characterization data consist of systematic profiles that extend from the lander to the horizon at 5º azimuth intervals (Figure 1), and elevation contours spaced as closely as 5 cm.

Following the close of the Viking mission, much of the RDS information was published in the form of plan view and image context maps [2]. The original RDS digital files are in a format native to the now obsolete RANGER stereo system. Using the RANGER documentation as a guide [3], a procedure was developed to read the RDS data files and to perform all of the necessary conversions, transformations, and corrections. Each data record is a seven element vector containing the line and sample coordinates of corresponding points in the stereo images, as well as the calculated position of the surface point in three-space. The RDS files also contain ancillary information complementary to the surface vector data such as the requisite transformation matrices and offset vectors. The entire RDS archive is in the process of being extracted and validated. When the process is complete, these data will be delivered to the PDS to be made available to the community.

Full Stereo Solution: A complementary effort being undertaken is making use of Ames Research Center stereo pipeline technology [4]. VL1 and VL2 images are being processed using stereo vision techniques to produce detailed geometric representations of the landing sites. Documentation of the internal and external geometry of the VL camera system was used to construct software camera models for each lander. Candidate image pairs from each system were also identified. Stereo processing consists of matching each pixel in the first image to the corresponding pixel in the second image through geometric and numerical correlation routines. In calculating the disparity maps for each image, the range and vector maps are also created. After post processing that removes inconsistent and otherwise erroneous values, additional products such as triangle meshes and digital elevation maps are generated from the final vector maps

Preliminary Analysis: Preliminary stereo processing has resulted in several disparity, range, and digital elevation maps, in addition to VRML surfaces corresponding to areas surrounding VL1. A color-coded and contoured range map for frame number 11A023 is shown in Figure 2.

In addition, twenty-six of the azimuth profiles obtained from the VL1 RDS were converted to Local Mars System (LMS) coordinates, allowing for the calculation of the 1-D statistical properties of the surface at very fine scales. Variogram analysis of the profiles (Figure 3) suggests a Hurst exponent of between 0.5-0.7, comparable to that found at the Pathfinder site. The 10 cm scale surface roughness (Allan deviation) at the VL1 site is identical to that at Pathfinder (2.2 cm), whereas at the 1m scale, the VL1 site appears to be ~20% smoother (7.0 cm to Pathfinder's 9.5 cm).

As the RDS are validated they will be incorporated into an extensive ongoing study regarding the fine scale topographic characteristics of the three Mars landing sites. Consideration will also be given to the use of the data for calibration of orbital and Earth based observations.

References: [1] Liebes, S. and Schwartz, A. A. (1977) *JGR, 82,* 4421-4429. [2] Liebes, S. (1982) Viking Lander Atlas of Mars, NASA CR-3568.

[3] Schwartz, A. A. (1979) RANGING Documents, JPL Space Image Processing Group software documentation. [4] Stoker, et al. (1999) *JGR, 104,* 8889-8906.

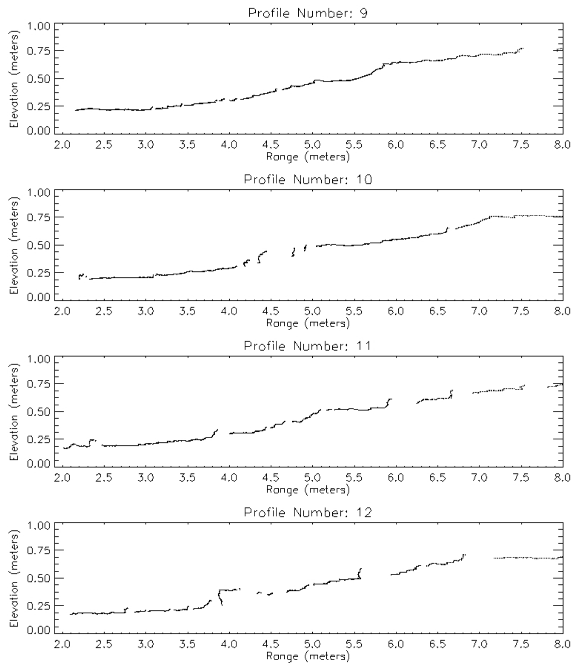

Figure 1. Four of the twenty-six elevation vs. range profiles extracted from the VL1 RDS. Profile gaps correspond to regions hidden from view in the image.

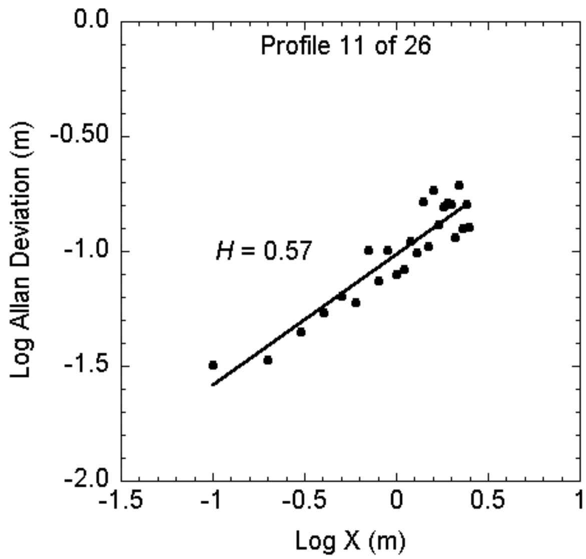

Figure 3. Variogram typical of those calculated from the RDS profiles.

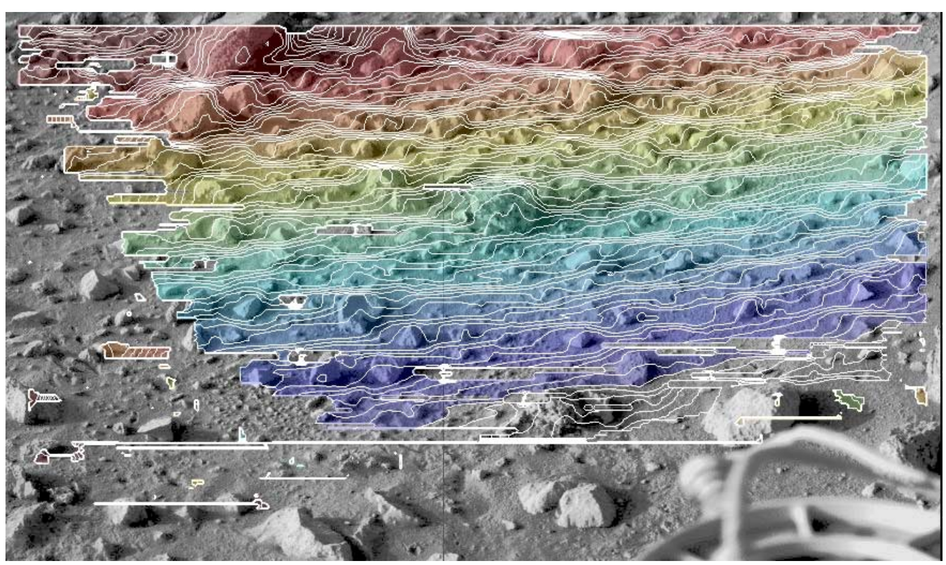

Figure 2. VL1 frame number 11A023 with range colors and contours calculated using ARC stereo pipeline technology. Color ramp extends from 2.3 m to 4.6 m. Contour interval is 0.25 m.