TOPOGRAPHY AND ALBEDO OF IUS CHASMA, MARS; A.S. McEwen, Department of Geology, Arizona State University, Tempe, Arizona, 85287

Radiometrically calibrated spacecraft images measure the apparent brightness of a scene; this brightness is the sum of two basic types of information: 1) the intrinsic albedo of surface materials, and 2) variations in brightness due to the shape of the surface. Most previous workers in photoclinometry have utilized methods that make no distinction between brightness variations due to topography and inherent variations in albedo (1,2,3,4). By these methods, variations in albedo are interpreted as changes in slope. A method designed to distinguish between albedo and topography is the "symmetric method" of Davis and Soderblom (5). For this technique, two profiles are measured from a single image, each assumed to be identical in albedo and slope. The identification of two identical profiles, however, is difficult in areas of complex topography or albedo.

The method developed here is like the symmetric method, except that two images of the same surface area, acquired under different illumination geometries, are used in place of two profiles from the same image. This eliminates the need for assuming identical albedos and slopes: the albedos and slopes are necessarily the same because they are two observations of the same point on the planet's surface (unless a real change has occurred during the time between acquisition of the two images). Profiles of both topography and albedo are output. The Viking Orbiter imaging data of Mars is an excellent data set for this technique, as many high-resolution image pairs of the same surface area are available, at a variety of sunangles. Simply looking at such pairs of images side-by-side is illuminating, as many structures apparent in one image are nearly invisible in the other, if oriented parallel to the sun azimuth.

The images utilized in this study cover Ius Chasma, in western Valles Marineris, and consist of two sets: 1) Viking 1 revs. 63-65, 75 m/pixel resolution, phase angles 30-37°, taken during L_s 112-113 of the first Martian year of Viking; and 2) Viking 1 revs. 923-928, 56 m/pixel, phase angles 60-70°, taken during L_s 200-204 of the second Martian year. Both sets of images were taken under clear atmospheric conditions and near normal spacecraft zenith angles, so the atmospheric haze is minimal. A simple correction for the haze was applied by subtracting the brightness of the shadows from the data. The sensitivity of the solutions was determined (6); for each pair of images, the accuracy is a function of profile azimuth.

The photometric function utilized is: $I = \phi(g)\ I_n[2L\mu_o/(\mu + \mu_o) + (1-L)\ \mu_o]$ where I is the apparent reflectivity, $\phi(g)$ is the phase function, g is the phase angle, I_n is normal albedo, L is an empirical factor, μ is the cosine of the emission angle, and μ_o is the cosine of the sunangle. The topographic constraint of equivalent plateau elevations on each side of the side canyons is satisfied by L = 0.5 (Figure 1).

The topographic results agree with the measurements from stereo photogrammetry (7), thereby substantiating the reliability of both methods. The photoclinometry, however, is much faster and less expensive than photogrammetry, the technique is applicable to a larger portion of the Viking dataset, and the solutions have higher resolutions. The stereo photogrammetry, though, produces a 3-dimensional topographic description rather than simple profiles. Techniques utilizing photoclinometry to produce 3-dimensional solutions will be investigated in the future.

Large areas of the canyon floor of Ius Chasma are brighter in the images acquired during the second Martian year. This is probably a real surface change, as a global dust storm occurred during the time between acquisition of the two sets of images. If this is interpreted as topographic, a drop in elevation of tens of kilometers to the south is implied, which is clearly inconsistent with topographic data from other sources. It could be due to a different photometric behavior for these materials, but this is unlikely because the images with the darker floor were acquired at lower phase angles and sunangles than the later set of images. This is the first reported observation of variable albedo features in Valles Marineris. Variable dark features on Mars have been interpreted as due to deposition and removal of thin veneers of bright dust (9), so these changes may be due to the deposition of dust following the global dust storm of 1977.

References

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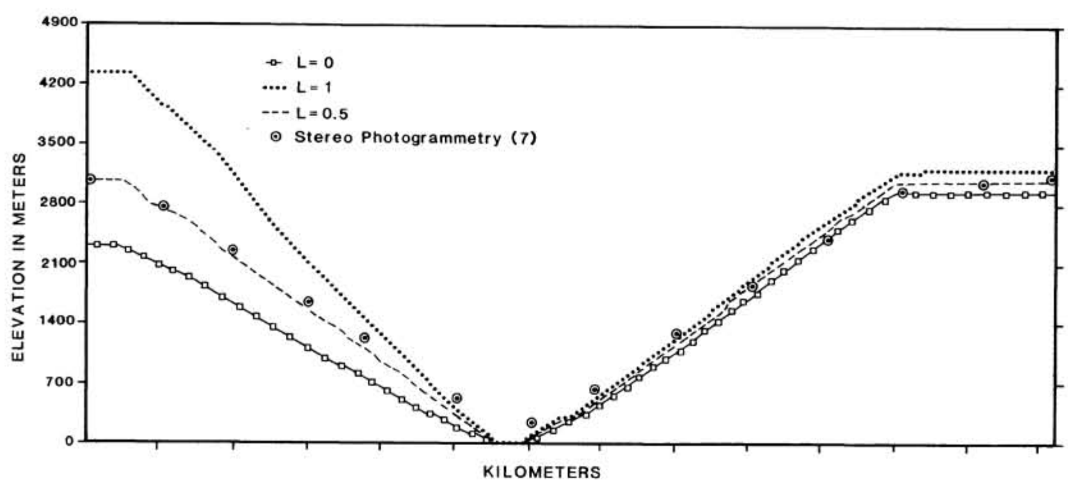

Figure 1. Profiles across a valley spur south of Ius Chasma, based on 3 values for the photometric factor L, and on stereo photogrammetry (7). Assuming that the plateau elevation is equal on each side of the spur, then L = 0.5 is appropriate.