APPROACHES FOR APPROXIMATING TOPOGRAPHY IN HIGH RESOLUTION, MULTISPECTRAL DATA.

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Introduction: Many authors [e.g., 1, 2] have pointed out potential problems associated with analyzing reflectance spectra from steeply sloped areas (crater walls, peaks, etc.). *Lucey et al.* [1] predicted absolute error of greater than 5 wt. %, in the calculated FeO value of steeply sloped surfaces within Clementine images acquired above ±20° latitude. *Robinson and Joliff* [3] confirmed the error estimate when examining topographic corrections using a digital elevation model (DEM) (derived from an Apollo 17 high resolution map) against Clementine UVVIS camera data.

However, because there is a dearth of existing topographic data at the resolutions required for application to Clementine images, work was begun last year on removing topographic effects by subtracting the effects of shade within a spectral mixture model.

Background: Spectral mixture analysis has been shown to be a powerful, multifaceted tool for analysis of spectral image data (Adams et al., 1986; Smith et al., 1990). During the first phase of the approach, a set of endmembers are selected from an image cube that best account for its spectral variance within a constrained, linear least squares mixing model.

Proper use of spectral mixture analysis requires that shade be used as an endmember (in areas where illumination geometry causes shadows). This endmember, typically a spectrum of 0 - 1% reflectance at all wavelengths, models the effects of macroscopic shading in a scene, as well as any non-wavelength dependent variables of the photometric function which describes the reflectance of a surface in terms of incidence, emission, and phase angles [e.g., 4].

In a landmark discussion of spectral mixture analysis and planetary remote sensing, *Adams et al*. [5] postulated that a well-selected shade endmember may serve as a proxy for the change in radiant flux due to incident angle variations, and thus can be used to mitigate the effect of topographic relief in an image. Thus a multispectral image from which shade has been removed may allow increased accuracy in the derivation of compositional parameters such as FeO and mineralogy. (Note that this type of correction is NOT intended to replace rigorous corrections with DEM data, where such data exist, but simply to provide a first-order means for working with what is currently a major obstacle in detailed compositional analyses.)

Methods: For a given Clementine scene, spectral endmembers were selected that best modeled the scene. The shade endmember was then removed and the abundance of the remaining endmembers renormalized to sum to 100%. The image was then reconstructed without shade. FeO abundances were calculated using both the uncorrected and corrected data.

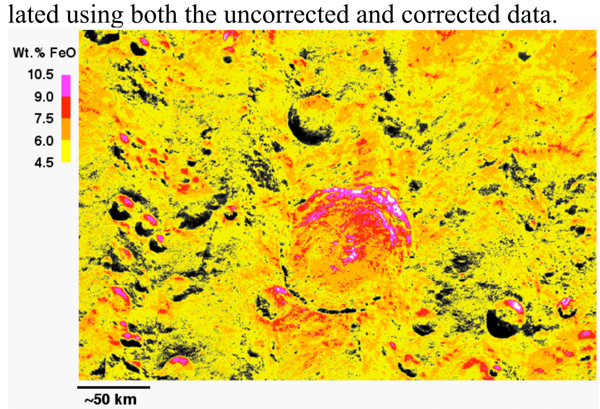

Figure 1: FeO map of Stevinus crater, with no topographic correction. Note sun angle and topographic slope-induced variations in apparent FeO abundance.

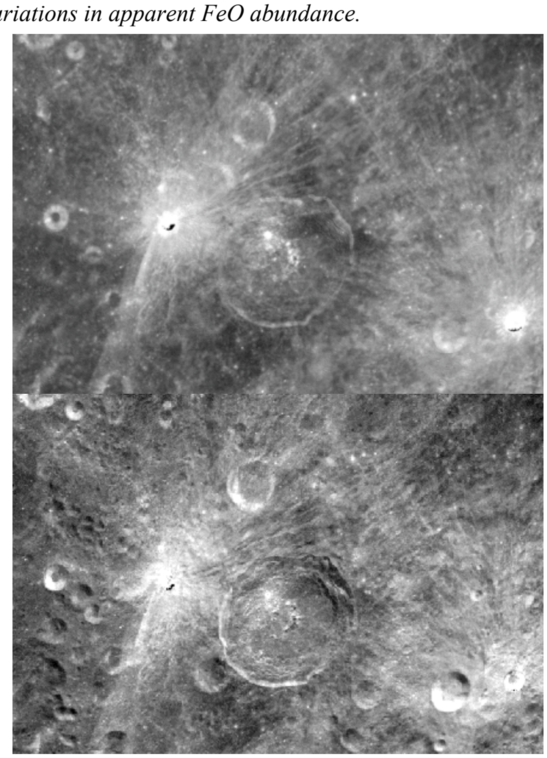

Figure 2: Top: Clementine UVVIS camera image at 0.75 µm of Stevinus. Note shadows. Bottom: After shade removal using a linear mixing model. Black spots in small fresh craters are saturated pixels in the original calibrated data.

Preliminary Observations: Initial results at the crater Tycho [6] proved to be promising, in that the FeO values derived from the shade-corrected image are consistent with Lunar Prospector gamma-ray FeO estimates. However, the Tycho data have a number of bad pixels in key areas, so the study was repeated at the crater Stevinus.

Qualitative assessment of the results has proven promising. Shown in Figure 1 is an FeO map of Stevinus, with obvious over- and under-prediction of FeO abundance due to sunlit and shadowed regions. These regions can also be seen in the top image of Figure 2, in which the 0.75 µm image is shown both before and after removing shade.

In Figure 3 is presented an FeO map using the shade-free scene, with background values (i.e., outside the crater) that are consistent with Lunar Prospector measurements.

Discussion and Future Directions: Qualitative assessment (comparison to ratio images, for example) indicate that the method is worthy of a more rigorous evaluation using images for which very high resolution (≤100 m ground sampling) DEM data already exist. The Clementine and DEM data used by Robinson and Joliff [3] offer a quantitative test bed, where SMA-based corrections can be directly compared to the "truth" of the DEM-based corrections.

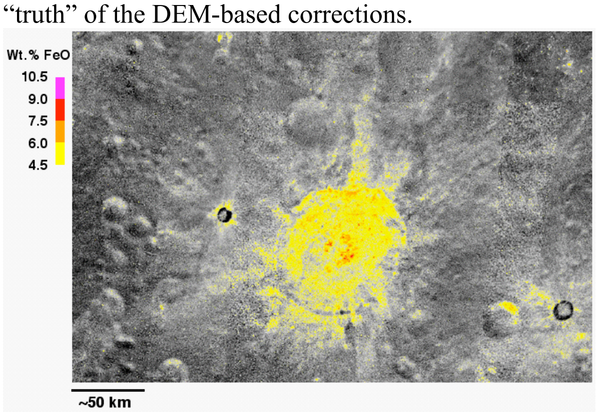

Figure 3:FeO map after shade removal using a linear mixing model.

References:

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