MULTISPECTRAL MIXTURE MODELING OF THE APOLLO 15 LANDING SITE

P. E. Johnson, Dept. of Physics & Astronomy, University of Wyoming, Laramie, WY 82071
P. C. Pinet, and S. D. Chevrel, GRGS, Observatoire Midi-Pyrenées, Toulouse, France, 31400
D. Sabol, and J. B. Adams, Dept. of Geological Sci., University of Washington, Seattle, WA 98195

ABSTRACT. We apply a new mixture modeling technique to telescopic CCD images of the Apollo 15 landing site. These images were made at ten wavelengths between 0.4 and 1.05 microns and have a spatial resolution of 500 meters. We have selected six endmembers and fit them, three at a time, to the image cube. A χ-squared analysis is used to test goodness of fit. We find three mare endmembers and three highland endmembers. The highlands endmembers appear to be mainly related to the maturity of the regolith. Endmembers from the image are compared with a spectral reflectance library obtained from returned lunar soils and rocks.

INTRODUCTION. Mixture modeling of remotely sensed images of the Earth and solid-surfaced planets has only recently gained wide acceptance as the premier technique for extracting surface mineralogy from remotely sensed data [1,2]. In this method, pixels in a remotely sensed image are modeled as a linear combination of "pure" endmember spectra. Two of the major problems with application of mixture modeling to multispectral images are the convergence on a unique set of endmembers and the robust calculation of fractional abundance maps of these endmembers. We have developed a new mixture modeling methodology that we have applied to the Apollo 15 landing site [3]. Images were taken at ten wavelengths, between 0.4 and 1.05 microns, with a visible CCD camera at the 2.0 meter Bernard Lyot Telescope of the Pic-du-Midi Observatory, near full moon. The spatial resolution on the lunar surface is approximately 500 meters.

APPROACH. We assume that each pixel is spectrally dominated by at most three endmembers. We then find the endmembers that fit the pixel spectra to within the estimated measurement error. Two or three endmembers at a time are chosen and used to model that part of the image that can be modeled satisfactorily by this endmember choice. We then iterate with another endmember set on the remaining image.

Close examination of the endmember spectra and their spatial distribution reveals several reasons for the spectral variations in this region. The highlands spectral reflectance curves consistently vary in shape. The curve shapes differ in the 0.98 micron band depth and the slope of the continuum, shortward of 0.6 microns. Spectral variations in our data are consistent with the notion that soil maturity is the main determinant of spectral shape within the highlands. Therefore, our highlands endmember abundance maps can be interpreted as maturity maps. Endmember 5 (Figure 1) is the most mature regolith; while 4 and 6 are compositionally distinct, they both represent the freshest soils. The freshest endmembers appear to coincide with topographical peaks, where the surface is exposed and is expected to lack a mature regolith. The mare spectra have three endmembers: 1, 2, and 3. Endmembers 2 and 3 represent the center of the mare region sampled and the transition zone from mare to highlands, respectively. Endmember 1 is confined to Hadley Rille and a mare crater adjacent to the rille. This suggests that the main variation in spectral shape for the mare is due to the mixing between true mare material and highlands soils. The highest concentration of endmember 3 occurs at the boundary separating mare from highlands and appears along a region approximately one pixel wide. This would imply that we do not have true intimate mixing, but merely the unresolved boundary between mare and highlands. The Hadley Rille endmember is spectrally extreme, with a blue continuum and a prominent 0.98 micron band, compared to the adjacent mare. This would suggest that the Hadley Rille endmember is immature mare soil, perhaps uncovered at the time of the formation of the rille.

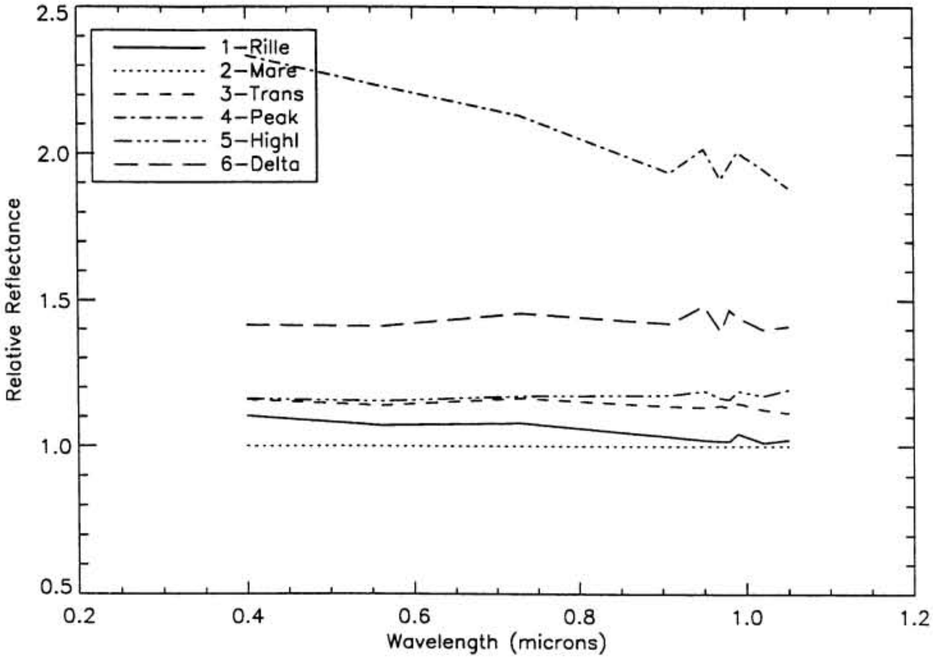

Figure 2. Reflectance spectra of the image endmembers. All reflectances are relative to endmember 2 (mare), and are otherwise uncalibrated.

REFERENCES.

1. Adams, J.B. et al. (1989) *Proc. IEEE Int. Geosci. Remote Sensing Symp. I, 16.*
2. Pinet, P.C. et al. (1993) *Science 260,* 797-801.
3. Johnson, P. E. et al. (1994) *Actes du Colloque National de Planetologie de l'I.N.S.U.*