DETECTABILITY OF LUNAR TEPHRA DEPOSITS: EXAMPLES FROM THE APOLLO 17 LANDING SITE; Donald E. Sabol Jr., John B. Adams, Milton O. Smith (Department of Geological Sciences University of Washington, Mail Stop AJ-20, Seattle WA 98195), and Patrick C. Pinet, (UPR 234/GRGS/OMP, 14, Av. E. Belin, 31400 Toulouse, France)

Introduction: Lunar samples have provided evidence that a variety of types of volcanic glasses are present on the surface of the moon. Although petrographic evidence indicates that they are volcanic in nature, their exact origins are not well known. The spatial distributions of these glassy materials, can provide a valuable key for determining both their origins and processes of deposition[1]. The main types of lunar volcanic glasses (black, orange, and green) are spectrally distinctive in the visible and near-infrared [2,3] and may be mapped using multispectral images. To map small quantities of each of these glasses, it is critical to determine their detectabilities relative to the (background) regolith. The purpose of this study is to: 1) determine the minimal amount of each glass that would have to be present to be detectable by applying detection threshold analysis, an analytical technique based on spectral mixture analysis [4] , and then 2) apply these detection thresholds to a multispectral telescopic image of the Apollo 17 landing site.

Methods: Detection threshold analysis is used to predict the spectral detectability of a target material under given conditions of target-background spectral contrast and system noise. Two detection thresholds are determined for each target-background combination. The first is Continuum Analysis, where the target is included as a spectral endmember. In this case, the detection threshold is the smallest fraction of the target that can be measured above system noise. The second is Residual Analysis. Here, the target is not included as an endmember and is detected as deviations of the observed mixed spectrum (including the target) from spectral mixtures of "background".

For this study, the detection thresholds were determined for orange (74220), green (15401), and black (74001) glasses in backgrounds composed of mature upland (74241) and mare (70051) soils using spectral measurements of lunar samples. "Shade" was included as an additional background endmember to account for shading due to the lighting geometry of the surface. Both linear and non-linear mixing models were employed to account for both macroscopic and intimate mixtures between the glasses and regolith. Signal-to-noise (SNR) levels of both 20/1 and 100/1 as well as a confidence level of 90% were used. The detection thresholds were then applied to fraction images (derived from CCD image data) to create detectability maps of the glasses for the Apollo 17 landing site. To determine the "best case" for detecting these glasses, we initially used high resolution laboratory spectra (1076 bands between 0.350 μm and 2.500 μm). The analysis was then repeated using these laboratory spectra convolved to the 9 bands of a telescopic CCD image data set (bands at 0.560, 0.730, 0.91, 0.95, 0.97, 0.98, 0.99, 0.102, an 0.105 μm). These images were collected at the 2-meter telescope (F/D=25) of the Pic du Midi Observatory in France.

Results: Detection threshold analysis showed that the three glasses were more detectable using continuum than residual analysis. Detection thresholds (continuum analysis) for the laboratory spectra of the glasses were generally low; ranging from 2% to 13% at 20/1 SNR and from 1% to 6% at 100/1 SNR (Figure 1). The thresholds for these same materials, as measured by the CCD camera, were reduced to levels ranging from 3% to being undetectable. Of the glasses, the green glass showed the greatest detectability.

DETECTABILITY OF LUNAR TEPHRA DEPOSITS... Sabol, D.E. et al.

Conclusions: This study indicates that the volcanic glasses can be spectrally detected at relatively low abundances when using high-resolution, hyperspectral data. The detectability of the glasses (particularly the black and orange glasses) is reduced in the CCD images because: 1) only a few bands were used, and 2) the target spectra have relatively low spectral contrast with mixtures of the background materials at the wavelengths collected.

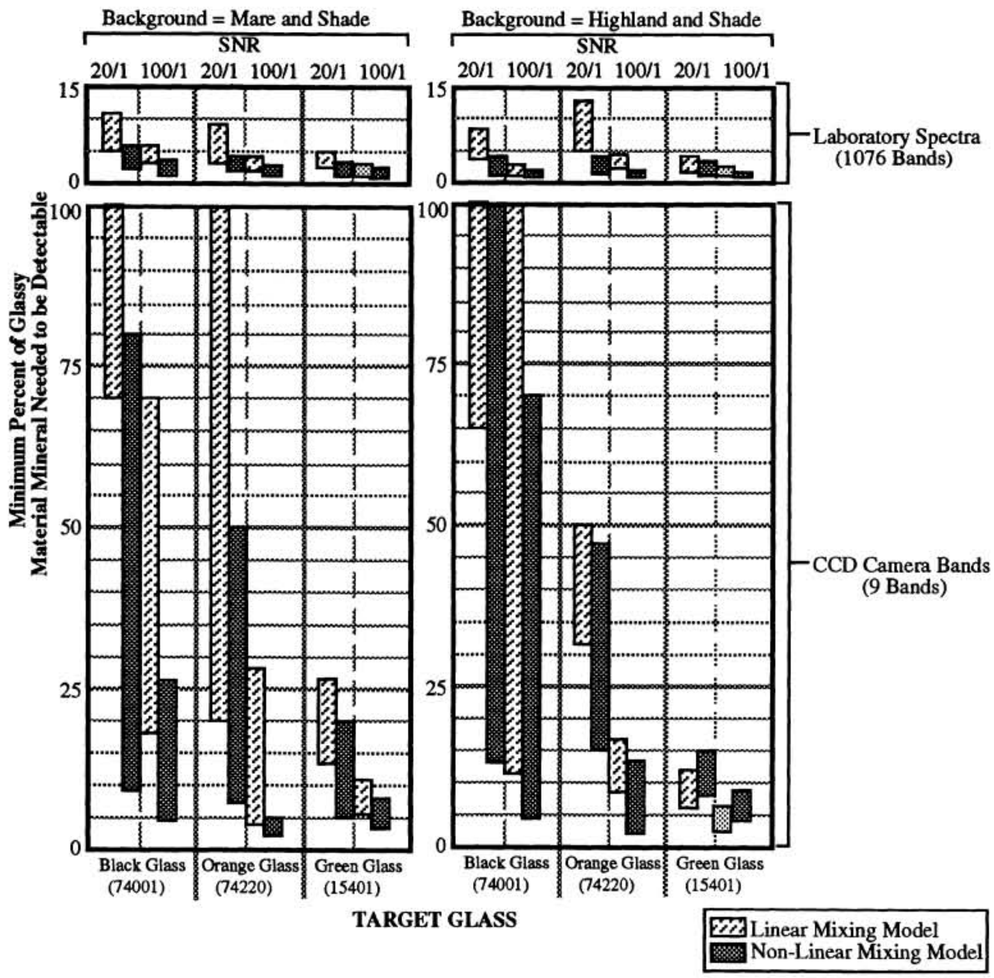

Figure 1: Continuum detection thresholds of black, orange, and green volcanic glasses against backgrounds of: 1) a mature mare soil and shade and 2) a mature highland soil and shade. The range of detection thresholds for each glass varies with the fractional composition of the background. The results for both linear and non-linear models are shown at both 20/1 and 100/1 signal-to-noise ratios.

References: [1] Coombs, C.R. and B.R. Hawke (1992) LPSC XXII, 303., [2] Adams, J.B., and T.B. McCord (1973) LPSC IV, 63., [3] Adams, J.B., and T.B. McCord (1974) LPSC V, 1171., [4] Sabol, D.E. Jr., J.B. Adams, M.O. Smith (1992) JGR, 97, 2659.