SUBPIXEL DETECTION OF PYROCLASTIC MATERIALS IN CLEMENTINE UVVIS DATA. W. H. Farrand$^1$ and L.R. Gaddis$^2$, $^1$Space Science Institute, 1540 30th St., #23, Boulder CO 80303, USA (farrand@colorado.edu), $^2$U.S. Geological Survey, Astrogeology Program, 2255 N. Gemini Drive, Flagstaff AZ 86001, USA.

Introduction: Lunar pyroclastic deposits represent a style of volcanism different from that responsible for the flood basalts that fill the mare basins. As volatile-coated, primitive materials originating deep (~400 km) within the Moon, these products of explosive volcanic eruptions are also important as probes of mantle composition [1] and as a potential resource [2] for future settlers. While many of the lunar pyroclastic deposits are spatially restricted and relatively small in size, they are easily resolvable at the spatial scale (~100 m/pixel) of the Clementine UVVIS camera. Recent studies confirm previous results indicating that these deposits are not compositionally uniform [3,4], and suggest that further analyses can help to identify possible genetic relationships among lunar pyroclastic deposits, to characterize their juvenile components, and to clarify their relationships to nearby maria.

Among the juvenile materials from sampled lunar pyroclastic deposits are the orange glass and devitrified black beads found in the Taurus-Littrow Valley [5,6], and green glass as found by Apollo 15 [1]. Recent studies [3,4] suggest that deposits dominated by materials such as these may represent endmembers in the observed compositional variations among the lunar pyroclastic deposits. Here we present preliminary results of analyses focused on the use of the Clementine UVVIS data for characterizing the composition and distribution of juvenile pyroclastic materials. Our test case for detailed mapping of a lunar pyroclastic deposit is that of the Apollo 17 landing site in the Taurus-Littrow Valley (TL; Figure 1). Although black beads dominate the observed spectral reflectance at this site [5,6], sample data show that the pyroclastic eruption changed character, producing first orange glass and then black beads [3]. To assess the compositional variability of this deposit, especially our ability to distinguish the orange glasses, we apply techniques based on spectral mixture analysis [7] to detect materials at subpixel scales. The low albedo and subdued absorption features of the Taurus-Littrow deposit make this a challenging task.

Detectability Analysis: In recent years, several subpixel detection techniques have been developed for use with terrestrial airborne imaging spectrometer data [e.g., 8–10]. A technique that is functionally equivalent to spectral mixture analysis, the orthogonal subspace projection technique (OSP) [11] is used for the simulations presented here. In OSP, a target spectrum is projected onto a subspace that is orthogonal to a set of background spectra. In this process, the response from the background spectra are nulled and that of the target is maximized. For the TL site, the spectra used for the simulation (Figure 2) included three laboratory measured sample spectra [12] convolved to the five UVVIS bandpasses, and two spectra extracted from UVVIS data over the TL Valley. The target spectrum was the orange soil sample 74220 from the Shorty Crater rim. “Background” spectra were from samples 74221 (a gray soil found near the orange soil) and 75111 (a dark mare soil). From the UVVIS data, additional background spectra were obtained at the mare/highland interface and from the “crater cluster” area in the TL Valley. In the simulation, the background spectra were randomly mixed in each of 100 samples with 0.1% Gaussian noise added. For samples 20, 40, 60, and 80, the orange soil target was added in abundances of 90, 80, 60, and 40%. The 100-sample set was then reduced via OSP (Figure 3). For this example, the orange soil was detectable only at the 90 and 80% abundance levels. It was found that the addition of higher noise levels (~1%), made the orange glass undetectable even at the 90% level. However, using background materials more representative of the highlands made the orange soil detectable at lower abundances.

Future Work: These results suggest that we should be able to map the distribution of juvenile pyroclastic materials, such as the orange glasses, using the Clementine UVVIS data and subpixel analysis techniques such as spectral mixture analysis [7] and foreground background analysis [10]. Given the low albedo of these materials, a high fill factor will be required on a per pixel basis in order to achieve that mapping; however, observations made by others, including orbital observations by the Apollo 17 astronauts [14] have indicated that these abundances are met for several pyroclastic deposits. The production of such maps will help to constrain the dynamics of pyroclastic eruptions on the Moon by providing information on the type, relative quantity, and distribution of juvenile volcanic materials [15].
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Figure 1a: 750 nm band for Taurus-Littrow Valley. The Sculptured Hills are in the upper right and South Massif is in the lower left. North is toward the top.

Figure 1b: Albedo-normalized [14] composite of 950, 750, and 415 nm bands. Colors are due to both compositional and maturity differences. Bright blue units such as those in the crater cluster (upper middle) expose fresh regolith of highland composition. Other green and blue-green features mark the locations of highland massifs and fresh craters. Soils with substantial pyroclastic components, primarily black beads, are shown in bright red with yellow overtones.

Figure 2: Endmembers used in detectability simulation.

Figure 3: Normalized response from detection simulation. Sample 20 contained 90% of the orange soil target, sample 40 contained 80%, sample 60–60%, and sample 80–20%. The higher response in samples 20 and 40 indicate detection of the target.