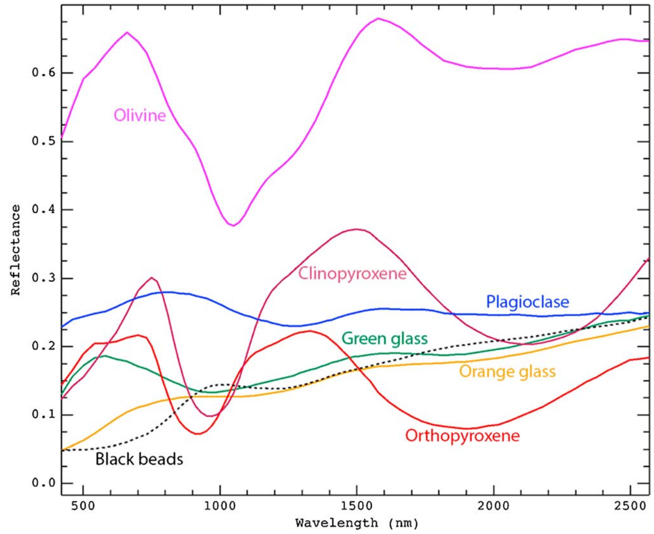

Figure 2. Reflectance spectra of lunar samples measured in the laboratory. Major lunar minerals are displayed along with volcanic glasses. Reflectance Experiment LABoratory IDs are LR-CMP-014 (olivine with chromite), LS-CMP-004 (plagioclase), LS-CMP-009 (clinopyroxene), LS-CMP-012 (orthopyroxene), LR-CMP-052 (green glass), LR-CMP051 (orange glass), and LR-CMP-050 (black beads).

analysis are to characterize the spectroscopic properties of five of the six recently proposed DMDs, to determine their mineralogy, and to assess their origin as pyroclastic deposits on the basis of their composition and morphologic setting.

2. Background

2.1. Lunar Minerals and Spectroscopic Properties

The spectral properties of major lunar minerals are presented in Figure 2. These minerals exhibit absorption bands that differ by their shape and position along the spectral domain. Pyroxenes have two absorption bands, one centered near 1 μm and another near 2 μm; these band centers move to longer wavelengths as Ca and Fe substitute for Mg [e.g., *Adams*, 1974; *Cloutis and Gaffey*, 1991; *Hazen et al*., 1978]. Olivine has a complex absorption band centered beyond 1.05 μm that moves as Fe substitutes for Mg [*Burns*, 1970, 1974]. Significant amounts of olivine in lunar volcanic deposits will broaden the pyroxene absorption at 1 μm and shift it to longer wavelengths [*Singer*, 1981], while the 2 μm band remains fixed. Because olivine lacks a band at 2 μm, the 1 μm absorption in olivine-rich lunar deposits will be strengthened relative to the 2 μm band. However, it has been shown that chromite-rich olivine, if present, exhibits absorption features near 2 μm that could diminish the strength of the 1 μm relative to the 2 μm band [*Isaacson and Pieters*, 2010]. The presence of Fe-rich volcanic glasses in lunar soils causes broad and shallow absorption bands because of the amorphous structure of the glasses [e.g., *Bell et al*., 1976]. The 1 μm band center of lunar glass is generally shifted to longer wavelengths when compared to pyroxene, and the 2 μm band center to shorter wavelengths. Thus, the 1 and 2 μm band center positions of lunar glasses will typically appear close together than those of pyroxenes. The lunar orange and green glasses shown in Figure 2 can be distinguished by these two band properties: the orange glass has a 1 μm band minimum shifted to longer wavelength relative to the green glass, which are both shifted to longer wavelength relative to pyroxenes, and the strength of the 1 μm band is notably stronger relative to the 2 μm band strength for the green glass. However, as noted further below (section 4.2), it is difficult to distinguish whether glass has a volcanic or impact origin. *Tompkins and Pieters* [2010] have shown that glasses with both origins have similar spectroscopic properties, and the crystallized material from that impact melt is nearly indistinguishable from igneous rock without geological context [see also *Smrekar and Pieters*, 1985]. Thus, other characteristics and criteria (e.g., overall morphology, presence of volcanic vents, and darker albedo) will help to distinguish between volcanic and impact glasses.

As outlined here, the major mineralogy and internal structures (i.e., crystallized versus amorphous glass) associated with both regional and localized DMDs can be identified and characterized with appropriate remote sensing data covering both the 1 and 2 μm absorption features.

2.2. Previous Work

Spectral analyses of pyroclastic deposits have shown that they are compositionally diverse [*Gaddis et al*., 2000, 1985; *Hawke et al*., 1989; *Weitz et al*., 1998]. These spectral classifications were largely based on the position and asymmetry of the 1 μm band, which was interpreted as variations in the presence and relative amounts of volcanic glass, olivine, and/or pyroxene. For these particular soil constituents, the use of the 1 and 2 μm band is very important since they have very different spectral behavior. For example, analysis of only