Detecting Volcanic Glass in Lunar Localized Dark Mantle

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Abstract. Lunar dark mantle deposits (DMDs) of pyroclastic materials are distributed widely across the lunar surface, ranging from large, regional DMDs (>1000 square kilometers) to much smaller, localized DMDs (~200 500 square kilometers). Returned lunar samples of regional pyroclastic deposits have shown that significant portions of the DMDs can be composed of volcanic, mafic-bearing glass of varying compositions. Recently, the Moon Mineralogy Mapper (M3) has provided high-resolution VIS-NIR spectral data (~140 m/pix) that has allowed for detailed mineralogic analyses of the lunar surface. In this work, three localized lunar DMDs were analyzed using M3 data to observe the degree of spectral variability in an attempt to identify the variations in mineralogy and crystallinity within the deposits, as well as between the DMDs and nearby mare basalt units. The DMDs analyzed include those located in Alphonsus, J. Herschel, and Oppenheimer craters. Spectra of the pyroclastic material in these localized DMDs exhibited mafic absorptions indicating iron-rich compositions, but each DMD was spectrally distinct from nearby mare basalt units. Each DMD contained spectral evidence of mafic-bearing glassy material, although there are indications of compositional variations between the glasses in the different localized DMDs. The glass in Alphonsus and J. Herschel crater appear to be compositionally similar to that of green glass, while the glass in Oppenheimer crater may be more similar to orange glass. In addition, the absolute reflectance and 1 μm band position showed variations within the Alphonsus and Oppenheimer crater DMDs, suggesting variable deposit thickness and/or variations in the amount of mixing with the local substrate manifested as varying areal mixtures at scales smaller than the spatial resolution of M3. Two previously unidentified localized DMDs were also discovered to the northeast of Oppenheimer crater. The identification of volcanic glass in multiple localized DMDs in different locations suggests that the distribution of volcanic glass across the lunar surface is much more widespread than has been previously documented, and the compositional variability of the returned lunar glasses from regional DMDs may also be reflected in the localized DMDs. The detection of prevalent volcanic glass in these small, localized deposits implies an explosive, vulcanian eruption style for this type of lunar pyroclastic deposit, as this allows volcanic glass to rapidly quench, inhibiting crystallization, compared to the larger hawaiian-style eruptions typical of regional DMD emplacement where both glassy and devitrified beads were identified. Improved understanding of the local and global distribution of volcanic glass in lunar DMDs will further constrain lunar degassing and compositional evolution throughout lunar volcanic history. The major outstanding questions about these lunar dark mantle deposits are addressed and future human/robotic exploration strategies are outlined.