
Introduction: Clementine color (ultraviolet, visible or UVVIS) and Lunar Reconnaissance Orbiter (LRO) Wide Angle (WAC, 7 bands, 100 to 400 m/p) and Narrow Angle (NAC, ~0.5 m/p) camera data [1] provide the means to investigate pyroclastic deposits on the southeastern limb of the Moon. Our goals are to (1) confirm the pyroclastic nature and study physical characteristics of these deposits with LRO NAC data; (2) extend methods used in earlier studies of lunar pyroclastic deposits (LPDs) with Clementine spectral reflectance (CSR) data (e.g., [2]); (3) explore the potential of LRO WAC data to complement the CSR data for compositional analyses; and (4) apply these combined data to characterize interdeposit and intradeposit variations in this neglected region of the Moon.

Background: Pyroclastic deposits have been recognized all across the Moon, identified by their low albedo, smooth texture, and mantling relationship to underlying features [3-5]. Gaddis et al. [2] presented a compositional analysis of 75 potential lunar pyroclastic deposits (LPDs) based on CSR measurements. New LRO camera (LROC) data permit more extensive analyses of such deposits than previously possible. Here we study six sites on the southeastern limb of the Moon that have nine potential pyroclastic deposits (Fig. 1): Humboldt (D=207 km), a floor-fractured crater with four distinct dark mantle deposits (DMDs); Petavius crater (D=177 km), with several large graben and at least four distinct DMDs; Barnard (D=105 km), Abel B (D=41 km), and Abel C (D=31 km) craters; and the highlands east and southeast of Titius crater (D=73 km). These deposits range in size from 69 km² to 2159 km² and are considered “localized” DMDs [2,5,6]. They vary in their proximity to other known volcanic as they become available to assess whether the deposits truly are pyroclastic, locate potential volcanic vents, examine the fresh craters where we are collecting multispectral data, and assess physical characteristics of the DMDs such as thickness, roughness, and rock abundance.

The corrected and calibrated Clementine UVVIS multispectral mosaic (100 m/p) [7] was used to generate 5-band spectra (415, 750, 900, 950, and 1000 nm) from sites within and around each DMD. These data were then used to create plots of reflectance at 750 nm vs. 950/750 nm ratio, and 750 nm vs. 415/750 nm ratio. These ratios are interpreted as proxies for mafic content (950/750 ratio: lower ratio = higher mafic content) and titanium content (415/750 ratio: higher ratio = higher titanium content) [2,6-10]. In contrast to earlier studies of these DMDs, this study focused on spectrally fresh material exposed in crater walls and ejecta within and adjacent to the deposits for comparison to spectrally mature material to assess if measurements of fresh material can provide better compositional discrimination among materials. The LRO WAC acquires multispectral images at two ultraviolet (UV) and five visible (VIS) wavelengths (320, 360, 415, 565, 605, 645, and 690 nm) at a resolution comparable to Clementine (~400 m/p UV, ~100 m/p VIS) [1]. WAC data therefore complement CSR data by increasing the spectral range with which we can examine the Moon. Although fully corrected and calibrated WAC data are not yet available, we used a simple correlation function to coregister the five visible bands from selected raw images to produce ratio images of selected DMDs. These products allow preliminary compositional discrimination between targets. The ability to combine high-resolution images with spectral measurements supports an integrated study of morphology and composition that will significantly enhance our ability to infer emplacement mechanisms for these deposits.

Results and Discussion: The LRO NAC data represent a new paradigm in the study of the lunar surface, and it is likely that many critical details of potential LPDs will be revealed in these high-resolution images. A NAC mosaic of the Humboldt SW
deposit (Fig. 2) shows details of the contact between the dark deposit and adjacent highlands. The embayment of the dark material into the adjacent highlands is suggestive of emplacement of lava in a topographic low rather than mantling by ballistically transported pyroclastic material. Figure 3 presents an ‘albedo’ (690-nm) mosaic of Humboldt assembled from 10 WAC images. A false-color image of the NE deposit in Humboldt (Fig. 4) was created from a single WAC frame (wac000085a1); in this product, brighter reds indicate a steeper visible slope and inferred higher titanium content. The morphology (sharp margins, embayment of adjacent highlands) of the dark deposits seen in these images is consistent with that of the SW deposit shown in Figure 2 and suggests a similar origin.

In our analysis of CSR data, although mature exposures for individual deposits plot very close to ratios measured previously for whole deposits [2], ratio data for fresh exposures show a significantly wider range of spectral variability than the mature materials. To test whether spectrally fresh material from beneath the DMDs influenced our results, we compared spectral data for shallower craters to those of deeper craters and found that the latter do not resemble adjacent background materials. An analysis of maturity trends [11] within the deposits shows that Petavius, Barnard, Titius, and Abel C follow the expected trend of increasing 950/750 ratio with decreasing 750 nm ‘albedo’; however, the four Humboldt deposits and Abel B follow a different trend, suggesting a difference in mineralogy or physical characteristics (e.g. grain size, glass content) between these two groups.

**Conclusions and Future Work:** Analysis of NAC and WAC data for Humboldt dark deposits suggests that at least some portion of these materials may be ponded lavas rather than pyroclastic (in agreement with [2]). High-resolution images from LROC now allow us to distinguish such deposits and to address the relative importance of pyroclastic volcanism in these and other areas on the Moon. We will continue to use these data to characterize the physical features of potential small lunar pyroclastic deposits, search for and characterize source vents, and constrain deposit thicknesses. Our preliminary analysis of six DMDs utilizing UV-VIS CSR data suggests that extracting spectral measurements from fresh exposures will enhance compositional discrimination. DMDs in Humboldt and Abel B may differ in mineralogy or physical characteristics from the other deposits studied. The spectral data set will be extended and enhanced with the addition of fully calibrated LROC WAC data. Additional measurements for these and other potential LPDs will constrain the range of their compositions, source materials, and emplacement mechanisms.