ANALYSIS OF DARK MANTLE DEPOSITS ON THE SOUTHEASTERN LIMB OF THE MOON INCORPORATING LROC WAC AND M3 MULTISPECTRAL DATA SETS. J.Olaf Gustafson[1], B.R. Hawke[2], H. Sato[3], L.R. Gaddis[4], and T.A. Giguere[2,5]. [1]Dept. Earth & Atmospheric Sciences, Cornell University, Ithaca, NY; [2]Hawaii Institute of Geophysics and Planetology, University of Hawaii, Honolulu, HI; [3]School of Earth and Space Exploration, Arizona State University, Tempe, AZ; [4]Astrogeology Science Center, U.S. Geological Survey, Flagstaff, AZ; [5]Intergraph Corporation, Kapolei, HI. (jg72@cornell.edu).

Introduction: We previously studied dark-mantle deposits (DMDs) on the southeastern limb of the Moon using Lunar Reconnaissance Orbiter Camera (LROC) Wide Angle Camera (WAC) monochrome data, LROC high-resolution Narrow Angle Camera (NAC) images, and Clementine UV-VIS data. We have extended this analysis to include WAC color (two ultraviolet (UV) and five visible (VIS) wavelengths from 320-690 nm) and Moon Mineralogy Mapper (M3) data (spectral range 0.4-3 µm, 20 nm spectral resolution) as well as LROC-derived topographic data (GLD100 data set). Our goals are (1) to assess interdeposit and intradeposit compositional variations among the SE Limb DMDs and compare them to other volcanic deposits both within this region and elsewhere across the Moon, and 2) to characterize the topography of the DMDs and assess their mode of emplacement.

Background: Numerous potential pyroclastic deposits have been mapped across the Moon, typically based on their low albedo, smooth texture, and mantling effect over underlying terrain features [1,2,3,4]. Gaddis *et al.* [1] compared the composition of 75 potential lunar pyroclastic deposits using Clementine spectral reflectance (CSR) measurements. For this study, we have chosen a region along the southeastern limb of the Moon that contains nine of those 75 deposits at six locations (Fig. 1): Humboldt (D=207 km), a floor-fractured crater with four distinct DMDs; Petavius (D=177 km), a crater with several large graben containing at least four distinct DMDs (treated as one by [1]); 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). The results presented here continue and extend our previous study of this region [5,6], utilizing data generated by the LROC WAC and Chandrayaan M3 instruments.

The various multispectral data sets that exist for the Moon each have slightly different capabilities, strengths, and weaknesses, including differences in spatial and spectral resolution, areal coverage, illumination conditions, and data quality. By utilizing LROC WAC and M3 data to supplement the CSR data used previously, we hope to refine the compositional classification of the target deposits and therefore constrain possible genetic relationships. Anaysis of the topography is also an important tool for understanding the mode of emplacement of a DMD (e.g. effusive vs. explosive volcanism) as well as possible relationships between DMDs.

Methods: The LRO WAC acquires monochrome images using a 605 nm filter at a resolution of ~75 m/pix, and multispectral images at two ultraviolet (UV) and five visible (VIS) wavelengths (320, 360, 415, 565, 605, 645, and 690 nm) at a resolution of ~400 m/pix in the UV and ~75 m/pix in the visible [7,8]. WAC color analysis was perfomed using a photometrically normalized 7-band near-global mosaic computed using the median value from many repeat observations for each pixel [9]. The M3 instrument acquired multispectral images across a spectral range 0.4-3µm at 20 nm spectral resolution, with a spatial resolution of ~140m/px or ~280m/px depending on the orbital period [10]. Level 2 v1.0 data were downloaded from the Planetary Data System [11], and spectra were extracted from minimum

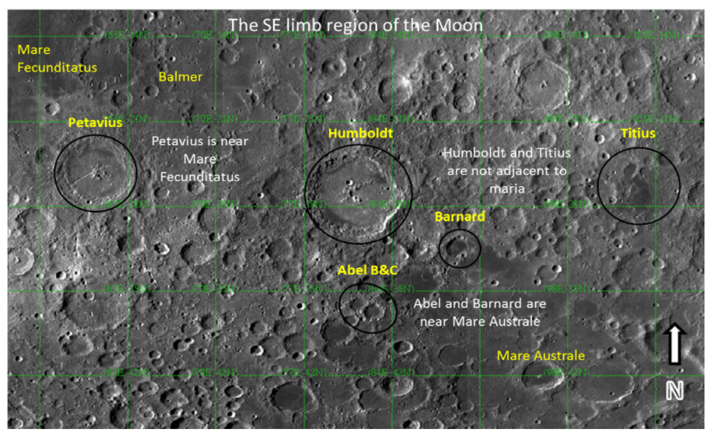


Fig. 1- Study area on the SE limb of the Moon (portion of global WAC mosaic [8], NASA/GSFC/ASU)

5x5 pixel regions for each geologic unit. Continuum removed relative reflectance was derived by fitting a straight line across both the 1 µm and 2 µm bands (after Besse *et al.* [12]). Our topographic analysis was based on the WAC GLD100 DTM [8].

Results and Discussion: Our initial analysis of the SE Limb region utilizing WAC and M3 color data has focused on the deposits within and near Humboldt. Figure 2a presents a WAC color ratio image designed to emphasize differences in UV reflectance that differenti-

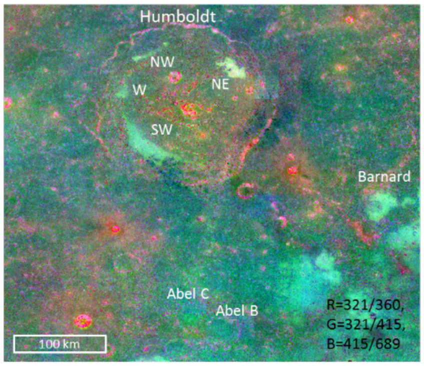


Fig. 2a - WAC Color Ratio Image of Humboldt Region (NASA/GSFC/ASU)

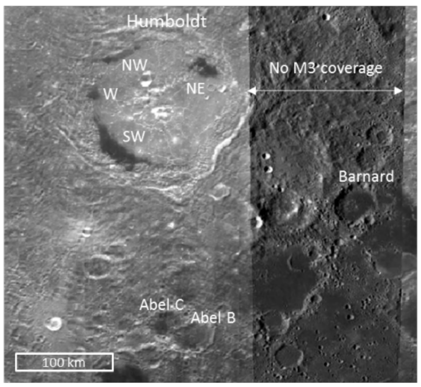
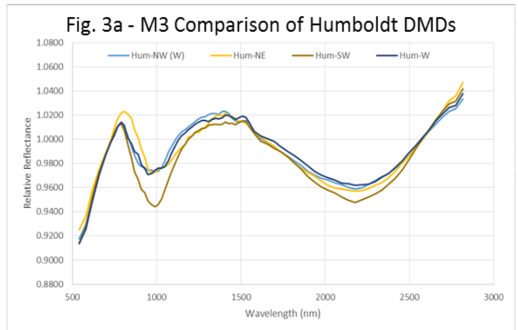
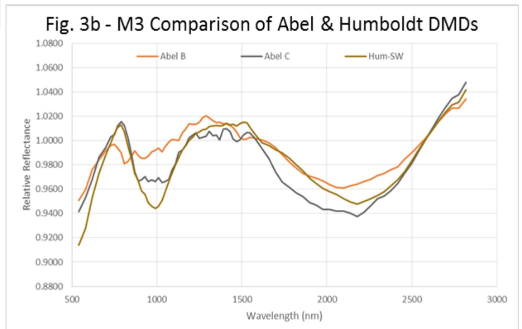
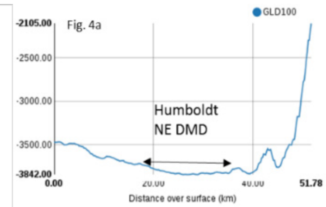
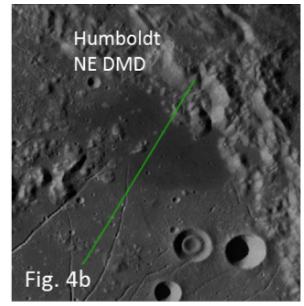


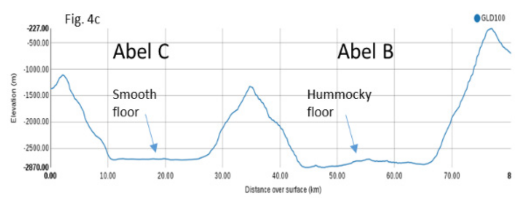
Fig. 2b – M3 coverage of Humboldt region shown over WAC global mosaic (ASU QuickMap)

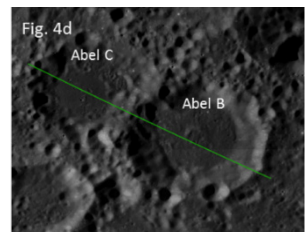












ate both compositional units and regolith maturity levels. Of particular interest in this image is the contrast between the Humboldt NE DMD and the other Humboldt deposits. In addition, both Abel B and C are somewhat subdued, exhibiting little contrast with surrounding units in contrast to the distinctive appearance of the Humboldt and Barnard DMDs. These same trends can be seen in the M3 near-infrared spectra (Fig. 3). While the Humboldt DMDs all have a similar 2 μm band position, the NE deposit has an asymmetric 1 μm band extending to longer wavelengths (Fig. 3a). When Abel B & C are compared to Humboldt, they both have a shorter 2 μm band center and weaker 1 μm band (Fig. 3b). Abel B in particular has a weaker mafic signature, suggesting that the DMD material may have mixed with highland components.

The topographic expression of DMDs is an important factor in understanding emplacement mechanisms. The Humboldt DMDs are generally smooth with low slopes, consistent with effusive emplacement; the NE deposit is typical (Fig. 4a, b). A comparison of Abel B & C reveals that the floor of Abel C is quite smooth and flat, consistent with effusive emplacement, while the floor of Abel B is hummocky and likely mantled with pyroclastic material (Fig. 4c, d).

Conclusions and Future Work: Preliminary results from our analysis of DMDs on the southeastern limb utilizing multispectral and topographic data confirms our earlier conclusion that these deposits are predominantly effusive (mare ponds), with relatively limited associated pyroclastic deposits. Analysis of the WAC and M3 multispectral data will continue with the goal of characterizing all the SE Limb DMDs and constraining the composition and mineralogy of the deposits. In particular, we intend to explore the utility of the M3 dataset to differentiate between glassy and crystalling deposits, using recently developed methods as described by Besse *et al.* [12] and Horgan *et al.* [13].

References: [1] Gaddis L.R. *et al*. (2003) *Icarus 161*, 262-280; [2] Head J.W. III (1974) *PLSC 5th*, 207-222; [3] Gaddis L.R. *et al*. (1985) *Icarus 61*, 461-488; [4] Hawke B.R. *et al*. (1989) *LPS 19th*, 255-268; [5] Gustafson J.O. et al. (2010) *LPS 41st* #1862; [6] Gustafson J.O. *et al.* (2013) *LPS 44th* #2723; [7] Robinson M.S. *et al.* (2010) *Space Sci. Rev. 150* (1-4), 81-124; [8] Scholten *et al.* (2011) *LPS 42nd* #2046; [9] Sato H. *et al.* (2014) *JGR 119*(8), 1775-1805; [10] Pieters *et al.* 2009 *Curr. Sci. 96*(4), 500-505; [11] Malaret *et al.* (2011) NASA PDS; [12] Besse *et al.* (2014) *JGR 119*(2), 355-372; [13] Horgan *et al.* (2014) *Icarus 234*, 132-154.