GEOLOGIC ANALYSIS OF THE ORIENTALE ANNULAR PYROCLASTIC DEPOSIT. T. Gaither[1], L. Gaddis[1], T. Hare[1], and A. Garlant[2]. [1]Astrogeology Science Center, U.S. Geological Survey, Flagstaff, AZ. [2]Dept. of Physics and Astronomy, Northern Arizona University, Flagstaff, AZ. (tgaither@usgs.gov)

Introduction: The Orientale annular or ring-shaped dark mantle deposit (DMD) is a diffuse, low-albedo feature (29°S, 263°E, 154-km dia.) located southwest of Orientale basin and distributed around an elongate depression near the ring's center (***Figure 1***) [e.g., 1]. Here we report on a geologic analysis of the DMD, including examination of the spatial distribution of dark materials and estimation of deposit thickness. Thickness estimates for the Orientale DMD are based on the transient crater excavation depths of small, fresh lunar craters and the presence or absence of excavated, high albedo highlands ejecta. The goal of this work is to use new, high-spatial resolution imaging data and derived topographic products to examine the horizontal and vertical distribution of volcanic materials and to assess the influence of local topography on deposit emplacement. Results will help to constrain concurrent modeling of the emplacement of this unique, annular DMD [2, 3].

Background: Schultz and Spudis [4] interpreted the Orientale DMD and its unique circular nature as the result of a large number of individual pyroclastic deposits, produced by vents that marked the location of a pre-Orientale, 175-km-diameter impact crater. Weitz et al. [5] and Head et al. [1] used Clementine UV/VIS data to interpret the central depression as the source vent, and the annular pyroclastic deposit was modeled [1] as having been produced as an individual, ~2-m-thick deposit from a single, centralized vent. In this model, the Orientale DMD represents a 77-km annular deposit of sub-mm particles formed around an elongate, fissure vent 7.5x16-km in size, and the plume may have resembled the umbrella-shaped plumes seen on Io [e.g., 6].

Methods: We used imaging data from the Kaguya Terrain Camera (TC; ~10 m/pixel, [7]), the LRO Narrow Angle (NAC; 0.5 to 2.0 m/pixel) and Wide Angle Cameras (WAC; ~100 m/pixel, [8]), WAC stereo-derived topography [9], and Clementine color-ratio data [10] to characterize the geology of the DMD and to identify and measure diameters of small lunar craters (<1 km dia.) within the Orientale DMD. ArcScene 3D views of NAC frames draped over the LRO WAC DTM were also used to evaluate topography and aided our selection of craters with fresh, crisp rims from within areas of low topographic relief. Pyroclastic deposit thickness was constrained using the depth of excavation (H_{exc}) of these small craters according to the equations of Melosh [11], where D_t is the transient diameter, D_{rim} is the rim diameter, and H_t is the transient crater depth: $D_t = 0.84*D_{rim}$ and $H_{exc} \approx 1/3H_t \approx 1/10D_t$. Rim-to-rim diameters of 295 small craters were measured using the ArcGIS add-in Crater Helper Tools [12]. Three measurements were made for each crater (N/S, E/W, and SW/NE) and the average diameter was used to calculate the transient crater depth. In addition, craters were classified as "non-penetrating" (the crater did not penetrate deep enough to excavate through the LPD to expose the underlying bright-albedo highlands material) or "penetrating" (the crater did penetrate deep enough to excavate through the LPD to expose the underlying highlands material). The thickness of the LPD can be constrained to a depth between the deepest non-penetrating crater depth and the shallowest penetrating crater depth. Each point constraint for thickness of the deposit (LPD_{Th}) is derived from two crater measurements, the D_{exc} of one penetrating crater and one non-penetrating crater. In areas where there are no penetrating craters, D_{exc} of non-penetrating craters still provides a minimum thickness (***Figure 1***). Areas were selected for analysis based on their flat topography and a lack of hummocky terrain; in such rough areas, mantle deposits may have eroded downslope [1] and are therefore artificially thin, exposing underlying bright highlands material.

Geologic Analysis: *Regional geology of the DMD*. NAC images and Clementine data were used to search for the presence of additional volcanic vents, ponds, or rilles that may have been sources of pyroclastic material. Several small rilles were detected, typically in association with small, isolated mare units; these rilles appear covered by pyroclastic material several meters thick and are unlikely to be sources for the DMD. Our analyses confirm that the single, elongate central vent remains the likely source of the Orientale annular DMD.

Influence of topography. Evaluation of the relationship between local topography and deposit thickness using 3D rendering of NAC frames supports previous observations [1] that pyroclastic material covering the scarps and massifs of the Outer Rook mountain ring and the domes and massifs of local hummocky terrain have been shed off the higher elevation slopes and accumulated in the adjacent basins, with the thickest deposits at the bases of slopes. We have avoided such accumulation areas for our crater analyses. Also, the non-circularity of the Orientale DMD, the presence of the widest deposit on the lower-elevation side of the eruption, and the narrowest deposit across the mountain scarps where topography is steepest suggest that regional topography has influenced the emplacement of the Orientale DMD [2].

Pyroclastic deposit thickness. ***Figure 1*** shows representative pyroclastic deposit thicknesses of the Orientale DMD. Thickness estimates vary from 2.1-3.1 m to 12.0-18.4 m; minimum thickness estimates vary from as low as ~2 m to over 20 m. There does not appear to be a correlation between deposit thickness and distance from the vent, although mass-wasting and erosional processes that have thinned the deposits on high-elevation areas may have limited our ability to observe such a correlation.

Summary: Our results confirm the likely origin of the Orientale DMD as a single eruption from a fissure vent, suggest that both local and regional topography influenced the emplacement of the deposit, and suggest that the thickness of the Orientale DMD is up to ten times greater than previous estimates [1]. In further work, these thickness estimates will be compared to the results of eruption simulations [2] to further constrain the origin and emplacement of this unique lunar volcanic deposit.

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Figure 1. A) WAC mosaic centered on the DMD southwest of Orientale basin with estimated pyroclastic deposit thickness labeled, as determined from crater excavation depths. Circles (not scaled to crater size) represent minimum thicknesses where impact craters have not penetrated the deposit. Stars represent thicknesses constrained by excavation depths of a pair of craters, one that has penetrated the deposit and one that has not. B) NAC image of a penetrating crater. C) NAC image of a non-penetrating crater.