NEW VIEWS OF THE EMPLACEMENT OF THE ORIENTALE ANNULAR PYROCLASTIC DEPOSIT.

L. Gaddis[1], J. Laura[2], T. Hare[1], M. Milazzo, A. Garlant[1] and T. Gaither[1]. [1]Astrogeology Science Center, U.S. Geological Survey, Flagstaff, AZ; [2]Department of Geography, Arizona State University, Tempe, AZ. (lgaddis@usgs.gov).

Introduction: Recent observations by imaging instruments on the Lunar Reconnaissance Orbiter (LRO) [1] and SELENE/Kaguya missions [2] have revealed details of the only lunar ring-shaped or annular pyroclastic deposit, located on the southern margin of Orientale basin (***Figure 1***). Images from the Kaguya Terrain Camera (TC; ~10 m/pixel) and from the Wide Angle Camera (WAC; ~100 m/pixel) subsystem of the LRO Camera, along with WAC mosaics [3] and stereo-derived topography [4], were used to characterize the distribution and thickness of the deposit [5] and to model its eruption and emplacement (this work and [6]). The goal of our modeling is to re-examine earlier and possibly refine analyses of the eruption conditions that formed the annular pyroclastic deposit at Orientale.

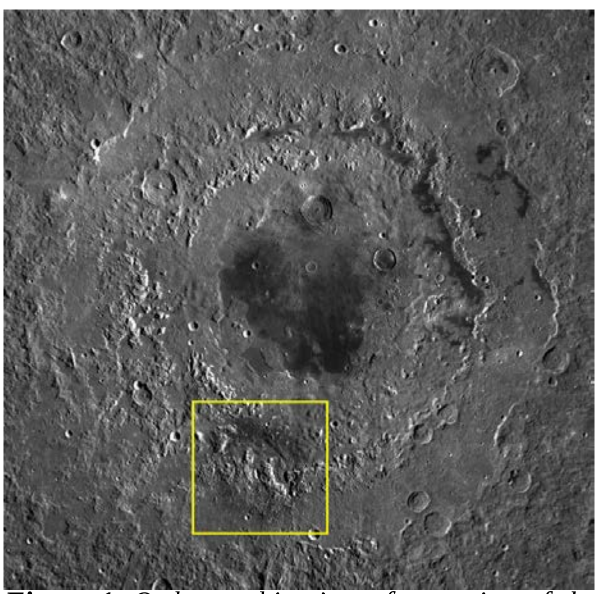

Figure 1. *Orthographic view of a portion of the WAC mosaic [3] centered on the Orientale multi-ringed basin (19.4°S, 92.8°W, ~1100 km dia.). The yellow box (100 km across) outlines the annular pyroclastic deposit to the southwest of the basin [NASA/GSFC/ASU].*

Background: The Orientale annular pyroclastic deposit is a diffuse, low-albedo feature located in the southwest part of the Orientale basin, distributed nearly symmetrically around an elongate depression near the ring's center at 29°S, 263°E. The annulus has an outer radius of ~77 km and an inner radius of ~45 km [e.g., 7, 8; ***Figures 1, 2***]. Previous workers [9, 10] identified the 7.5x16 km central depression as the only source vent. The emplacement and characteristics of the annular pyroclastic deposit were previously studied with a ballistic eruption model [10]. Model results suggested that the deposit formed as a ~2-m-thick layer produced by a single eruption from a fissure vent (fed by a dike stalled at ~3-4 km depth) lasting 1-2 weeks. The unique ring-shaped deposit, formed by a dike stalled at just the right depth, was reproduced when the ejection velocities of the sub-mm pyroclasts was between 350 and 420 m/s with the geometry of the eruption constraining the ejection angle to a value close to ~45° [10].

Modeling and Visualizing the Orientale Annular Pyroclastic Deposit: A ballistic model with similar physics as [10] but using the Python language [6] was used for modeling the flight of pyroclasts and visualizing the emplacement and distribution of particles in the resulting deposit. Model inputs are ejection angle, particle velocity, and number of particles. Although the model can emplace particles symmetrically almost anywhere near the vent outward (constrained largely by the currently observed depth and shape of the vent), the observed distribution of low-albedo material (e.g., the maximum and minimum extents of 77 and 45 km respectively) on the WAC mosaic [3] was used to identify ejection angles and velocities required to reproduce that pattern. Also, the model includes particle ejection from a random position within the linear vent and the flight stops where the ballistic trajectory intersects a digital elevation model [4]. Thus we account for the fact that local topography can cause particles to have either delayed or premature landing compared to flight over a smooth sphere. A point-density visualization showing the number and distribution of particle impacts is produced (***Figure 2***) to support future modeling of deposit thickness and volume.

Results: Our preliminary eruption simulations used 10000 pyroclasts launched sequentially at a range of velocities and ejection angles. We find that pyroclasts travel the correct distance for velocities of 450-480 m/s and ejection angles within ±25° of 45° degrees (***Figure 2***). The flight path is reduced the same amount as the ejection angle is increased or decreased from 45°, unless the shallow flight intersects a topographic feature the high flight would pass over. The results clearly show the effects of local topography on particle emplacement (***Figure 2***), the preferred deposition sites toward the outside of the annular ring, and indicates that significantly higher velocities than those of [10] are required to distribute particles in the observed pattern around the fissure vent.

Summary and Future Work: Although the model does not account for the effects of expanding gas, interactions between particles, etc., these preliminary results show that 3D modeling and visualization of the Orientale annular pyroclastic deposit can be accomplished and produces particle distribution roughly matching the observed annular deposit. Ejection velocities (but not angles) required are higher than those of earlier investigations [10]. In future work, we will use this model to further characterize the thickness and volume of the deposit, assess the influence of local and regional topography on emplacement, and to constrain the nature of the volatiles that may have been involved.

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References: [1] Robinson et al. (2010), Space Sci. Rev. 150, 81-124. [2] Haruyama et al. (2008), Adv. Sp. Res. 42, 310-316. [3] Speyerer et al. (2011), LPS 42, #2387. [4] Scholten et al. (2012), JGR, v. 117, E3. [5] Gaither et al., this volume. [6] Laura et al., this volume. [7] Gaddis et al. (2000), JGR, 105(E2), p. 4245-4262. [8] Gaddis et al., 2003, Icarus 161, 262. [9] Weitz et al. (1998), J. Geophys. Res., 103, E10, 22,725-22,759. [10] Head et al. (2002), J. Geophys. Res., 107, E1.

Figure 2. *Simulated emplacement of the Orientale annular pyroclastic deposit on topography with varying ejection velocities (450 to 480 m/s) and angles (20-70 degrees).*