LUNAR PYROCLASTIC VOLCANISM AT ATLAS CRATER AS VIEWED BY LROC.

L. Gaddis[1], M.S. Robinson[2], B.R. Hawke[3], T. Giguere[3,5], L. Keszthelyi[1], J.O. Gustafson[4], J.F. Bell III[4] and the LROC Science Team. [1]Astrogeology Science Center, U.S. Geological Survey, Flagstaff, AZ; [2]School of Earth & Space Exploration, Arizona State Univ., Tempe, AZ; [3]Univ. Hawaii, Honolulu, HI; [4]Cornell Univ., Ithaca, NY; [5]Intergraph Corp., P.O. Box 75330, Kapolei, HI 96707. (lgaddis@usgs.gov).

Overview: Observations of the lunar crater Atlas (46.7°N, 44.4°E, 87 km dia.) by the Narrow Angle Camera (NAC; 0.5 to 2.0 m/pixel) and Wide Angle Camera (WAC; 100 m/p, 5 VIS channels) subsystems of the Lunar Reconnaissance Orbiter (LRO) Camera [e.g., 1] reveal a strikingly different character between two pyroclastic vents in the crater floor. Evidence for different eruption styles between the southern and northern deposits and possible multiple eruptive episodes within the southern deposit is presented.

Introduction: Lunar pyroclastic deposits are high-priority targets for the LRO mission [e.g., 2-4], in part because they are thought to be volatile- and metallic-element (e.g., S, Fe, Ti) enriched remnants of ancient lunar volcanic eruptions. Their compositions and distributions provide information on the early lunar interior [e.g., 4-6] and the distribution of possible resource materials [7, 8]. Studies of pyroclastic deposits with telescopic and Clementine color (ultraviolet, visible or UVVIS) data demonstrated their compositional heterogeneity and expanded our knowledge of deposit types [e.g., 9-14].

Atlas Pyroclastics: Two small pyroclastic deposits were previously identified in the floor of the Upper Imbrian Atlas crater [15], including those associated with north and south vents (*Figure 1*). The northern deposit was thought to be smaller (~100 km^2) than the southern deposit (~250 km^2) [12], and both were believed to have been emplaced by explosive, vulcanian-style eruptions. Spectra of both Atlas deposits indicate the presence of feldspar-bearing mafic mineral assemblages dominated by orthopyroxene. Although resembling highlands compositionally, Group 1 deposits may also contain clinopyroxene, glass, and/or olivine [15].

LROC WAC images (Figure 1) confirm that the northern deposit has a higher reflectance (~10% brighter) than the southern deposit and reveal that the northern deposit is more widely distributed (~40 km dia.) than previously thought. Both deposits are associated with fractures that ring the crater floor; in both areas wider segments of the fractures were previously identified as likely source vents.

LROC NAC images of the putative vent (X in *Figure 2*) for the northern deposit show no strong evidence for the presence of a pyroclastic mantle. Within the northern deposit, a local concentration of the lowest reflectance material, and the presence of a low positive-relief feature, a nearby shallow, semicircular depression, and northward trending lobes of material suggests that a possible vent is located along the margin of intersecting floor fractures at a site east of the earlier vent.

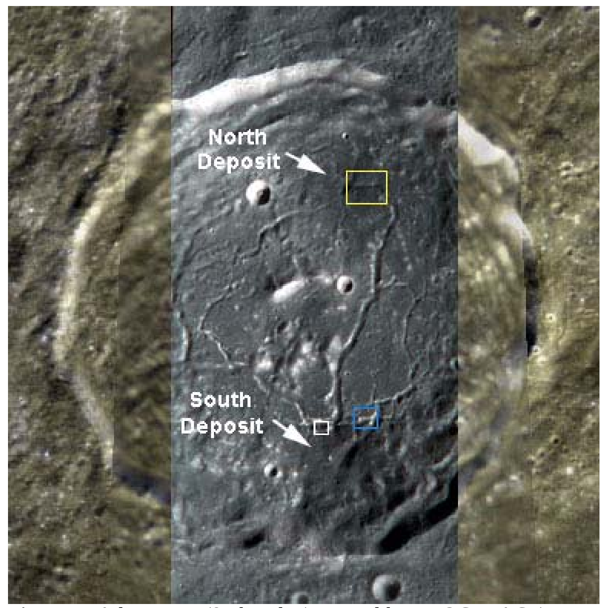

Figure 1. Atlas crater (87 km dia.) viewed by LROC WAC (center, frame M113662900CE; VIS bands, red=3, green=2, blue=1) on Clementine 'natural' color (UVVIS bands, red=5, green=4, blue=1). Image resolution is 100 m/pixel, north is toward the top.

Portions of fracture walls within the southern deposit are mantled with smooth, very low reflectance material that has adhered to ~steep slopes and may have been somewhat plastic when emplaced (*Figure 3*). Here the fracture itself may have been the vent for local erupted materials. Further evidence for such plastic material is observed as cracks in low-reflectance veneer draping over the edge of a fracture (*Figure 4*); here boulder tracks are seen in the underlying lighter materials but not in the dark veneer. The dark veneer may have formed as a late-stage eruption of liquid magma that coalesced and cooled on the surface to form a crust on older, more friable material. Such a deposit suggests emplacement by a strombolian rather than a vulcanian explosive eruption; the latter is thought to involve fragmented debris rather than magma [16]. Also, the southern deposit may have been emplaced by multiple episodes of explosive volcanism.

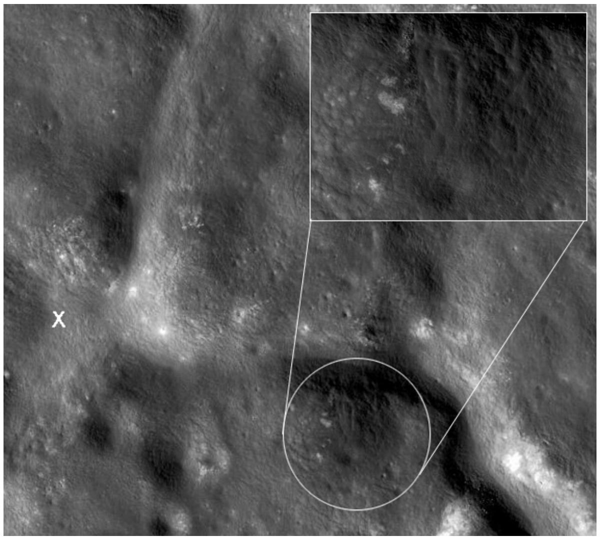

Figure 2. LROC NAC views (frame M104218117R, 1.6 m/pixel, inc. 67°) of the northeast floor of Atlas crater (yellow box, Figure 1). A possible vent is circled. The depression previously identified as the vent for this deposit is marked with an X at left. Inset at upper right is a close-up of the encircled area. Base image is ~1.4 km across.

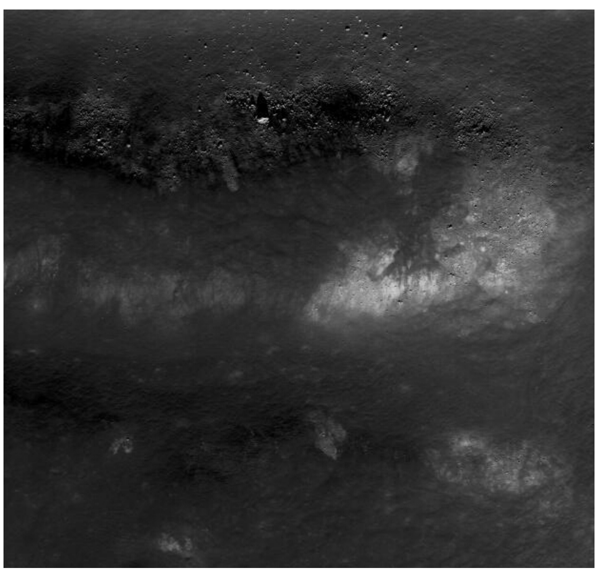

Figure 3. LROC NAC view (frame M108943582R, 0.5 m/pixel, 48° inc.) of mantled fracture on south floor of Atlas crater (blue box, Figure 1; image is ~1.6 km across).

The distribution of dark veneer within the southern deposit is widespread and the sources are unclear. It seems unlikely that a single source vent is responsible, especially if the fracture in the eastern portion of the deposit (*Figure 3*) is a primary vent. LROC image coverage is not yet complete for the southern deposit; additional images and topographic data will help to identify the source vents and determine whether multiple vents are present.

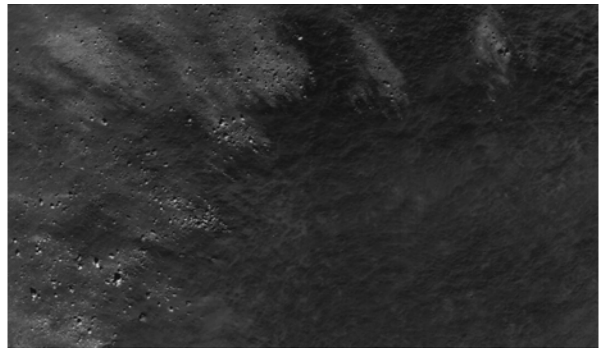

Figure 4. LROC NAC views (M108936787, 0.5 m/pixel, 47° inc.) of northeast floor of Atlas crater (white box, Figure 1). Image is ~500 m across.

Summary: LROC data reveal that pyroclastic vents and deposits within the floor of Atlas crater are larger and more complex than previously thought. The character of the southern pyroclastic deposit in Atlas crater is quite different than that of the northern deposit. Evidence is compelling for different eruption styles between the southern and northern deposits, and there may have been multiple eruptive episodes within the southern deposit. Further analyses of existing and newer data from LROC and other LRO instruments (e.g., Mini-RF S- and X-band radar data [17] and Diviner [18] reflected solar and emitted thermal data) will enable us to examine these and other pyroclastic deposits on the basis of topography, composition, surface roughness, and thermal inertia. These data will allow us to address fundamental questions about lunar pyroclastic deposits, including whether they commonly have multiple vents, whether earth-like Hawaiian or vulcanian eruptive styles are common, and how often primitive or juvenile materials are present.

References: [1] Robinson et al., 2009, Space Sci. Rev, in press. [2] ESAS, 2005, NASA TM 2005-214062, 750 p. [3] Jolliff et al., 2009, LPS XL, #2343. [4] Gaddis et al., 2009, LRO Sci. Targ. Mtg., #6025. [4] Heiken et al. 1974, GCA 38, 1703. [5] Delano, 1986, JGR 91, D201. [6] Shearer et al., 2006, RMG 60, 365. [7] Hawke et al., 1990, PLPSC 20th, 249. [8] Duke et al., 2006, RMG 60, 597. [9] Pieters et al., 1973, JGR 78, 5867. [10] Gaddis et al., 1985, Icarus 61, 461. [11] Hawke et al., 1989, PLPSC 19th, 255. [12] Gaddis et al., 2003, Icarus 161, 262. [13] Lucey et al., 2006, RMG 60, 83. [14] Wilcox et al., 2006, JGR 111, E09001. [15] Hawke et al., 1989, PLPSC 19th, 255. [16] Head and Wilson, 1979, PLPSC 10th, 2861. [17] Nozette et al., 2009, LRO Sci. Targ. Mtg., #6041. [18] Paige et al., 2009, Space Sci. Rev, DOI 10.1007/s11214-009-9529-2.