

**LRO TARGETING OF LUNAR PYROCLASTIC DEPOSITS.** L.R. Gaddis<sup>1</sup>, M.S. Robinson<sup>2</sup>, B.R. Hawke<sup>3</sup>, Tom Giguere<sup>3,6</sup>, Olaf Gustafson<sup>4</sup>, S.J. Lawrence<sup>2</sup>, J.D. Stopar<sup>2</sup>, B.L. Jolliff<sup>5</sup>, J.F. Bell III<sup>4</sup>, <sup>1</sup>Astrogeology Program, U.S. Geological Survey, Flagstaff, AZ; <sup>2</sup>School of Earth and Space Exploration, Arizona State University, Tempe, AZ; <sup>3</sup>University of Hawaii, Honolulu, HI; <sup>4</sup>Cornell University, Ithaca, NY; <sup>5</sup>Dept. Earth & Planetary Sciences, Washington University, St. Louis, Missouri 63130; <sup>6</sup>Intergraph Corp., P.O. Box 75330, Kapolei, HI 96707. (lgaddis@usgs.gov).

**Introduction:** Lunar pyroclastic deposits are high-priority targets for the Lunar Reconnaissance Orbiter (LRO) mission [e.g., 1]. Images from the Narrow Angle Camera (NAC; 0.5 m/pixel images and mosaics) and Wide Angle Camera (WAC; 7-band imager, 100 m/p VIS, 400 m/p UV) subsystems of the LRO Camera (LROC), supplemented by coordinated observations from the Mini-RF [2] and Diviner [3] instruments, will provide information about the lunar surface to address major questions about these deposits. In the first year, the LRO mission will address imaging targets that are of interest to the NASA Constellation (Cx) Program as potential landing sites and for exploration on the lunar surface. In the second year, LRO will move into a science phase that emphasizes scientific targets. Targeting for all sites is underway currently (see <http://ser-dev.ser.asu.edu/LSM/targeting.php>). This abstract describes the science rationale and status of LRO targets for pyroclastic deposits.

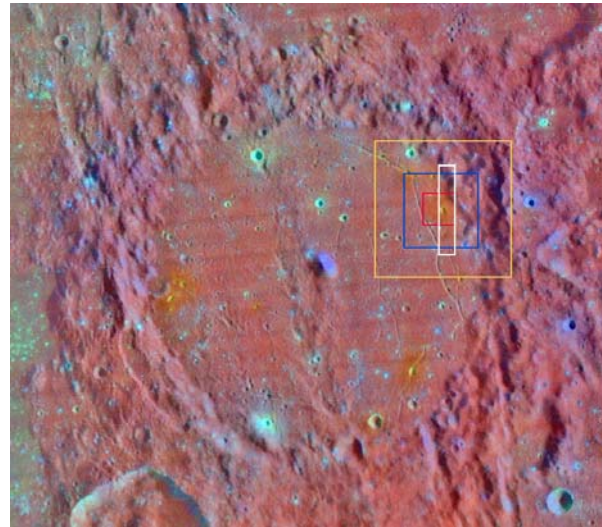
**Science Rationale:** As volatile- and metallic-element (e.g., S, Fe, Ti) enriched remnants of ancient lunar volcanic eruptions, pyroclastic deposits provide information on the early lunar interior [e.g., 4-6] and the distribution of possible resources [7, 8]. Earth-based telescopic studies of the Moon (0.4-2.4  $\mu\text{m}$ ) identified pyroclastic units on the basis of low albedo and absorptions due to iron-bearing volcanic glasses [e.g., 9-11]. These studies provided data on the compositional diversity, distribution, and stratigraphy of unsampled mare and pyroclastic deposits on the near side [e.g., 10, 12]. Recent analyses using Clementine color data demonstrated the compositional heterogeneity of these deposits and expanded our knowledge of pyroclastic deposit types beyond those represented in returned samples [e.g., 13-15].

**Exploration Objectives:** Several sites within major lunar pyroclastic deposits for the first year (exploration phase) of the LRO mission are included among the 50 'Priority-1' sites specified by Cx. These sites are a subset of possible landing sites from three reference target sets [16-19] that include 75 lunar sites identified as having high scientific, resource utilization, and operational merits and potential [1]. Lunar sites that feature pyroclastic volcanism in the Cx target list include: Alphonsus crater, Apollo 15 near Hadley Rille, Aristarchus Plateau, Rima Bode, Schrodinger crater, and Sulpicius Gallus. LROC coverage for such exploration targets includes (in order of priority): (1) a 10x10 km region of interest (ROI) for complete coverage, including geometric and photometric stereo; (2) a 20 x 20 km ROI 'best effort' target for stereo data products; and (3) a 40 x 40 km 'best effort' ROI for monoscopic mosaic coverage (Figure 1). Nominal exploration image sets will acquire photomosaics of high quality and resolution for hazard and safety assessment and construction of digital elevation models of potential landing sites. Imaging by LROC is subject to a variety of constraints that will determine final coverage and scheduling of image acquisition [20].

**Science Objectives:** Studies of lunar pyroclastic deposits with LRO data have the potential to address major questions concerning their distribution, composition, volume, eruptive styles, and role in early lunar volcanism. Objectives for LRO observations for lunar pyroclastic deposits include: (1) *Characterization of large, 'regional' deposits.* The presence of volatile elements in sampled pyroclastic glasses suggests that the Moon may not have been totally depleted in volatiles during its formation and magma-ocean phases. We have sampled only two pyroclas-

tic deposits directly (Apollo 15, Apollo 17) but we know from regolith samples that there are many other volcanic glasses for which we have not identified the source deposits [5]. Combined NAC (for mapping extent and thickness) and WAC data (for color and composition) will enable us to characterize the spatial extents, distributions, and compositions of pyroclastic deposits and thus relate them to other sampled glass types and possibly to their associated basalts. (2) *Determination of titanium contents.* The high titanium content of many of the largest lunar pyroclastic deposits (e.g., Rima Bode, Apollo 17/Taurus-Littrow, Mare Vaporum) increase their value as possible economic resources in part because of their association with concentrations of H- and He-rich materials [e.g., 8]. WAC color data will allow us to characterize titanium contents of pyroclastic deposits, to map the diversity of effusive and pyroclastic units with variable titanium contents that are currently not recognized, and to identify which pyroclastic deposits are the best sources of titanium and associated volatile elements. Using NAC stereo data, meter-scale topographic models of the surface will allow us to better constrain emplacement and distribution of possible juvenile materials, the geometry of small pyroclastic eruptions, and models of their eruption. (3) *Assessment of morphology and compositional variation.* Improved knowledge of the morphologic and color characteristics of the lunar pyroclastic deposits from NAC and WAC data will permit refinement of the existing classification of their compositions, with particular attention to intra-deposit compositional variations, identification of juvenile components and evaluation of the distributions and relative amounts of juvenile vs. host-rock components. For each deposit, LROC data will be used to search for small-scale morphologic and compositional variations such as those that might characterize separate eruptive episodes from the same vent, pulses of magma intrusions and/or crustal dikes, and possible changes in composition and volatility of source materials with time.

**Targeting Strategy:** Seventy-five globally distributed pyroclastic deposits [13] were the focus of our NAC targeting campaign. Additional sites that may feature pyroclastic volcanism have also been targeted, for a current total of ~350 ROIs. At most sites, both high- and low-sun targets (typically 5°-55° and 65°-85°, respectively) were identified, and many targets have been selected for coverage by photometric stereo data to facilitate detailed morphologic analyses.



**Figure 1.** Exploration Target image coverage for LROC superimposed on a merged Lunar Orbiter and Clementine color-ratio (R=750/415 nm; G=750/950; B=415/750) view of Alphonsus crater (80 km dia.); White outline=NAC footprint; red=10x10 'Priority 1' site; blue=20x20 km 'Priority 2' site; yellow=40x40 km 'Priority 3' site.

**References:** [1] Jolliff et al., 2009, LPS XXXX, abs. #2343. [2] Bussey et al., 2008, LPS XXIX, abs. #2389. [3] Greenhagen and Paige, 2009, LPS XXXX, abs. #2255. [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] Pieters, 1978, PLPSC 9th, 2825. [13] Gaddis et al., 2003, Icarus 161, 262. [14] Lucey et al., 2006, RMG 60, 83. [15] Wilcox et al., 2006, JGR 111, E09001. [16] ESAS, 2005, NASA TM 2005-214062, 750 p. [17] First Lunar Outpost (FLO) study, NASA Wkshp, Aug. 1990. [18] Taylor & Spudis, Eds., 1990, NASA Conf. Pub. 3070. [19] Ryder et al., 1988, EOS: Trans. AGU, 70, 1495. [20] Lawrence et al., LPS XXXX, abs. #2316.