LUNAR GEOLOGIC MAPPING: PRELIMINARY MAP OF THE SOUTHWEST QUADRANT OF LUNAR LQ-10 ("MARIUS") QUADRANGLE. P. F. Suter[1], T.K.P. Gregg[1], and R.A. Yingst[2] [1]Department of Geology, 126 Cooke Hall, University at Buffalo, Buffalo, NY 14260-3050 (pfsuter@buffalo.edu). [2]Planetary Science Institute, 1700 E Fort Lowell, Tucson, AZ 85719.

Introduction: Systematic lunar mapping by the U.S. Geological Survey Astrogeology branch began in 1960 with the chief purpose of creating a stratigraphic framework for exploration during the Apollo missions [1]. After a lengthy hiatus, new topographic, compositional and gravity datasets have become available. In response, a global geologic mapping program was jointly devised and executed by NASA and the USGS [2-4]. This program subdivides the Moon into 30 quadrangles to be mapped at 1:2.5M (Fig. 1).

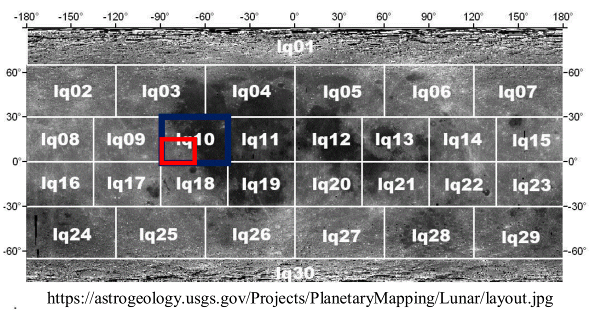

Figure 1. *Equidistant cylindrical projection of the Moon overlain by the new geologic mapping scheme at 1:2.5 M scale. Image base is Clementine 750-nm albedo global mosaic. LQ-10 is outlined in blue; the red rectangle highlights the mapping area for this study. (Modified from https://astrogeology.usgs.gov/Projects/PlanetaryMapping/Lunar/layout.jpg)*

Here, we provide an update on our efforts to determine the origin and timing sequence of geomorphic landforms within the southwest quadrant of Lunar Quadrangle 10 (LQ-10, "Marius"), as part of an ongoing effort to map all of LQ10 [5]. In accordance with recently published planetary mapping guidelines [6], this project synthesizes remote sensing data from multiple instruments to create a geologic map of the SW subquadrant of LQ 10. It is both a revision and a reinterpretation of Apollo-era mapping of this region [7,8]. The goals of this project are to: 1) determine the origin and timing sequence of geomorphic landforms; 2) constrain the extent of regolith mixing between highland and mare terrain; and 3) create a geologic map of the southwest quadrant of LQ-10.

Geologic Setting: LQ-10 contains mare associated with Oceanus Procellarum [e.g., 9 and references therein]. Notably, the area contains Marius Hills, an anomalous collection of domes and cones, and the geologically complex Aristarchus Plateau [10]. The SW quad of LQ10 in particular contains the contact between Oceanus Procellarum and the adjacent highlands. Within LQ10, the origin, age and emplacement history of the maria are poorly understood, particularly where mare material is dispersed throughout the highlands. In addition, Orientale basin impact ejecta (Hevelius Formation [8]) appears to have influenced the distribution of mare emplaced at the mare-highland boundary. Exposed highland material and remnants of partially buried craters (e.g. Cavalerius D) protrude above the mare surface, suggesting that the mare material along the mare-highland boundary is thin relative to embayed highland topography.

Mapping History: Apollo-era maps based on Lunar Orbiter data range in scale from local (1:5000) [11] to global (1:5 M) [1]. Among the most detailed maps are 44 1:1M Lunar Aeronautical Chart (LAC) series quadrangle maps that center around the equator. One of these maps [10] contains the Marius Hills and the easternmost periphery of the LQ10 SW quadrant, which contains Hevelius and Cavalerius craters and a portion of the mare-highland boundary. This map summarizes the earliest attempts to describe and map materials associated with the Orientale impact basin, known collectively as the Orientale Group. Named for its original type area on the floor of Hevelius crater, the Hevelius Formation includes myriad landforms and textures generated by widely distributed Orientale basin impact ejecta. Later maps subsequently expanded this definition to include the ring-shaped deposits encircling the Orientale impact basin interpreted as Orientale basin's ejecta blanket [7].

Methods: The map area is defined by the southwest quadrant of LQ-10 (0° to 15°N, -90° to -67.5°E) covering ~300,000 km^2, approximately the size of Arizona. The Global Morphology Mosaic from the Lunar Reconnaissance Orbiter Camera (LROC) Wide Angle Camera (WAC) aboard the satellite Lunar Reconnaissance Orbiter (LRO) [12] serves as the base map for digitizing and analysis. Supplemental Narrow Angle Camera images (0.5 m/pixel at 50 km alt) provide unprecedented detail of local textures and elucidate intricate cross-cutting relationships. Laser Altimeter generated topography (118 m/pixel) [13,14] serves as an effective way of observing morphology as well as providing necessary visual clues where the basemap is shadowed. Compositional data is provided by Clementine's UVVIS Warped Color Ratio Mosaic mineral map [15,16]. The "red" channel, which corresponds to the ratio of the 750/415 nm bands, is sensitive to low-titanium terrain (a characteristic of the highlands) while the "blue" channel, which corresponds to the ratio of the 415/750 nm bands, is sensitive to high-titanium terrain associated with mare basalt [17]. The "green" channel, which corresponds to the ratio of the 750/1000 nm bands, is sensitive to iron. It must be noted that these ratios are effected by soil maturity [18] and TiO_2 content [17]. For example, the highlands appear red because they have accumulated glassy agglutinates. Therefore, the Clementine color composite image reveals where the regolith from these terrains have mixed. Clementine color ratio images are used to help correlate units where visual information is ambiguous or misleading. In addition, Clementine's 750 nm band is used as a proxy for relative albedo within the map area. Digitizing takes place in ESRI's ArcGIS software environment. Contacts are first drawn as closed polylines at ~300 m vertical spacing then converted to polygons.

Preliminary Mapping Results: The map product is a work in progress (Fig. 2).

The northeastern portion of the map area, which contains the western boundary of Oceanus Procellarum, is dominated by smooth, flat-lying plains deposits interpreted to be maria. Plains material here is differentiated based on composition and stratigraphic relationship to other plains units. For example, 'rugged plains' are spectrally red and embayed by 'complex plains.' The southwestern portion contains NW-trending ridges and troughs, swirly or ropey textures and subdued craters interpreted to be part of Orientale basin ejecta. 'Radial ridges' and 'Swirly material' cover an area previously mapped as the continuous portion of Orientale's ejecta blanket. 'Radial ridges' grade into 'Swirly material to the north where the radial features gradually become less prominent.

Linear features are prominent in the eastern half, particularly to the southeast, which contains the floor-fractured craters Hedin and Hevelius. In the northeastern portion is a complex of lineaments and mare-embayed troughs that consists of both structural and volcanic elements.

References: [1] Wilhelms, D.E. and McCauley, J.F. (1971) USGS Misc. Invest. Series Map I-703. [2] Gaddis, L.R. et al. (2005) *LPSC XXXVI*, #2021. [3] Gaddis, L.R. et al. (2005) *Abst. Plan. Mappers Mtg.*, USGS OFR 2005-1271. [4] Gaddis, L.R. et al. (2005) *GSA Ann. Mtg., Abs.* 514-4. [5] Yingst, R.A. and Gregg, T.K.P. (2009) *LPSC XL*, #1319. [6] Skinner, J.A., Jr. et al. (2018), https://sservi.nasa.gov/wp-content/uploads/2018/09/PGM_Protocol_March2018.pdf. [7] Scott et al. (1977) USGS Mis. Invest. Series Map I-1034. [8] McCauley, J.F. (1967) USGS Misc. Invest. Series Map I-491. [9] Hiesinger, H. et al. (2003) *JGR*, *108*, 5065. [10] Chevrel, S.D. et al (2009) *Icarus, 199*, 9-24. [11] Cannon, P.J. and Rowan, L.C. (1971) USGS Misc. Invest. Series Map I-679. [12] Robinson, M.S. et al. (2010) *Space Sci Rev 150(1),* 81–124. [13] Zuber, M. et al. (2010) *Space Sci. Rev.*, *150,* 63–80. [14] Smith, D. et al. (2010) *Space Sci. Rev.*, *150,* 209–241. [15] Eliason E.C. et al. (1999) *PDS*, 4001-4078. [16] Hare T.M. et al. (2008) *LPSC XXXIX*, #2337. [17] Lucey, P.G. (2000) *JGR*, *105(E8),* 20377-20386. [18] C.M. Pieters et al. (2006) *Icarus, 184,* 83-101.

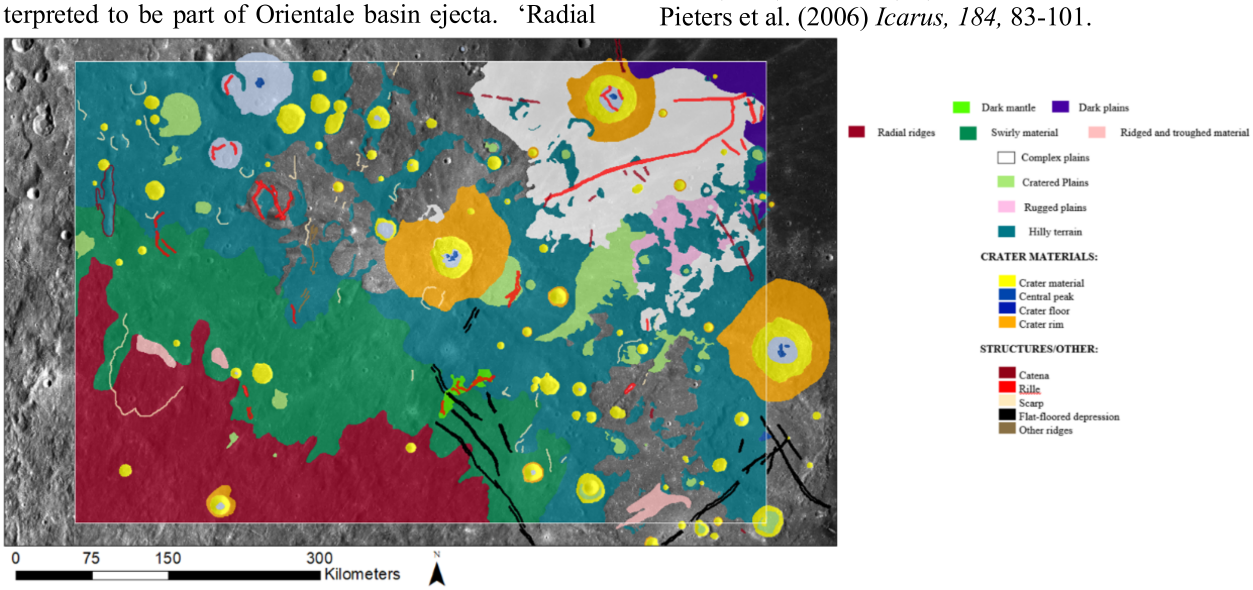

Figure 2. *A preliminary map of the SW quad. of LQ10. Unit names are not yet final.*