AN ANALYSIS OF ORIENTALE BASIN: INTEGRATION OF MINI-RF RADAR AND OPTICAL MAPPING PRODUCTS.

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Introduction: The Orientale basin and its immediate surroundings show a large diversity of physical processes and contrasting compositions [1]. In general, formation of this region is thought to have occurred with (1) solidification of a Feldspathic Highlands Crust (FHT) from a magma ocean, (2) emplacement of pre-Orientale impact mare basalts, (3) Orientale impact ejecta burial and mixing of mare basaltic units, (4) basaltic flooding of the Oceanus Procellarum basin region of the Procellarum KREEP Terrane (PKT), and (5) small-impact lateral mixing of FHT and PKT basalts [1-5]. Here, in an effort to further characterize this region, we use radar data recently acquired by NASA's Lunar Reconnaissance Orbiter (LRO) Miniature Radio Frequency (Mini-RF) payload.

Radar is a unique analysis tool as it is sensitive to surface and subsurface deposits at meter to decimeter scales [4, 6]. In this respect, we aim to build upon previous work of [4] to further characterize two aspects of this region: (1) the elevated radar backscatter of the Orientale basin and ejecta relative to most other FHT deposits [7], and (2) the detection and characterization of buried mare volcanism, or cryptomare deposits. Initial Earth-based radar surveys used the 70 cm radar facilities of Arecibo Observatory and Green Bank Telescope to characterize the Orientale-Oceanus Procellarum region [4]. This effort proved fruitful for detection of subsurface cryptomare deposits (at decimeter vertical depths); however, it was limited to observations of eastern Orientale at resolutions of 10-30 km. Mini-RF offers a new perspective as it is sensitive to depths greater than optical but less than Earth-based radar data sets, at significantly higher spatial resolutions. Mini-RF has also collected data beyond the western-limb of the Moon (as seen from Earth) allowing for a more comprehensive analysis of the area absent limb-darkening and foreshortening effects encountered in previous studies.

Instrument: Mini-RF is a hybrid-polarized, side-looking, synthetic aperture radar (SAR) onboard LRO. The instrument transmits both S-band (12.6 cm) and X-band (4.2 cm) wavelengths and operates in two modes: "baseline" at a resolution of 150 m and "zoom" at a resolution of 30 m [8, 9]. X-band is sensitive to at most 1-meter into the subsurface [4], whereas S-band is sensitive to 1-2 meters vertically. Here, we concentrate our analysis on S-band zoom data products.

Data Products: Mini-RF measures returned signals in two orthogonal polarizations allowing for the calculation of Stokes parameters [10]. A relevant product derived from Stokes parameters for this study is circular polarization ratio (CPR). CPR is defined as,

$$\mu_C = \frac{(S_1 - S_4)}{(S_1 + S_4)} \qquad (1)$$

where S_1 and S_4 represent the first and fourth Stokes parameters, respectively. Values of μ_c serve as quantitative estimates of surface roughness and composition and are very useful for differentiating independent geologic deposits [6]. Radar products are coregistered with Clementine ultraviolet, visible, and near-infrared (UVVIS-NIR) data and subsequently derived TiO_2 and

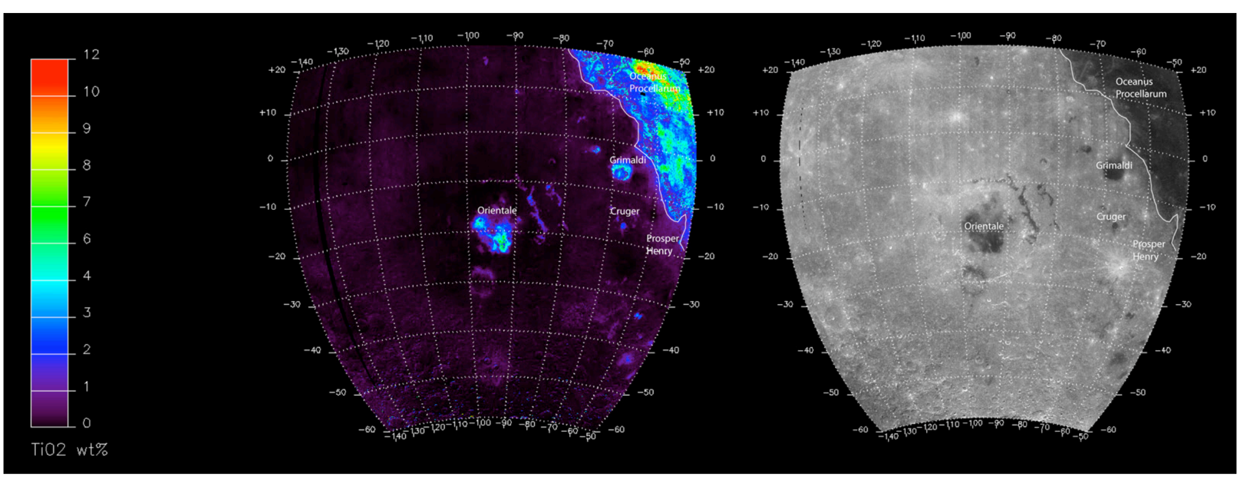

Fig. 1. (Left) Map of TiO_2 abundance estimates derived from Clementine UVVIS multi-spectral data. (Right) Clementine multi-spectral image (750 nm) of Orientale basin (30 pixels/degree; ~1 km/pixel).

FeO data products using the methods of [11, 12] (Fig. 1).

Results and Discussion: Orientale impact basin shows significant diversity in radar backscatter (Fig. 2). Mare basin deposits within Orientale basin floor show distinctly low radar returns in comparison with basin rings (μ_c ~0.45) and correlate well spatially with TiO_2 abundance. However, unlike Earth-based radar studies, mare deposits easily viewed in northern and eastern Orientale ring structures are not easily discerned with Mini-RF S_1 and μ_c mosaics displayed here, although μ_c values are lower. In general, the western region of Orientale shows higher average radar backscatter than the eastern side (~0.9 and ~0.75, respectively). The western edge of Montes Rook (inner-ring), which in Earth-based radar is affected by limb-darkening or not imaged at all, shows highly diffuse scattering with some of the highest μ_c values (~1.2) in the region [4]. Consistent with previous studies, Mini-RF also shows the Orientale-Oceanus Procellarum region to be predominantly radar-dark, perhaps moreso than previously reported. More specifically, deposits beneath Cruger crater show lower backscatter than some regions of western Oceanus Procellarum and are consistent with high proportions of ilmenite and TiO_2 abundance (i.e., cryptomare) as suggested by [4]. Areas southeast of Orientale and northeast of Schickard also show low μ_c but data coverage is still incomplete in this region.

Summary: Here we show a preliminary analysis of Orientale basin and the surrounding region using LRO's Mini-RF radar and Clementine optical derived data products. To first order, an analysis of the Orientale-Oceanus Procellarum region of the Moon is consistent with previous Earth-based surveys [4]. Mini-RF is also in the process of creating a complete view of the western portion of Orientale, an area not previously imaged. While this region has higher average S_1 and μ_c values than the eastern region of Orientale, it is heterogeneous suggesting a complex history.

Future Work: In the near future, we will integrate mineral maps of [13, 14] into our analysis. Regions of interest will also be examined more closely with LRO Narrow and Wide Angle Cameras (NAC & WAC, respectively). Opportunities for more direct comparisons with Earth-based radar data sets will be explored.

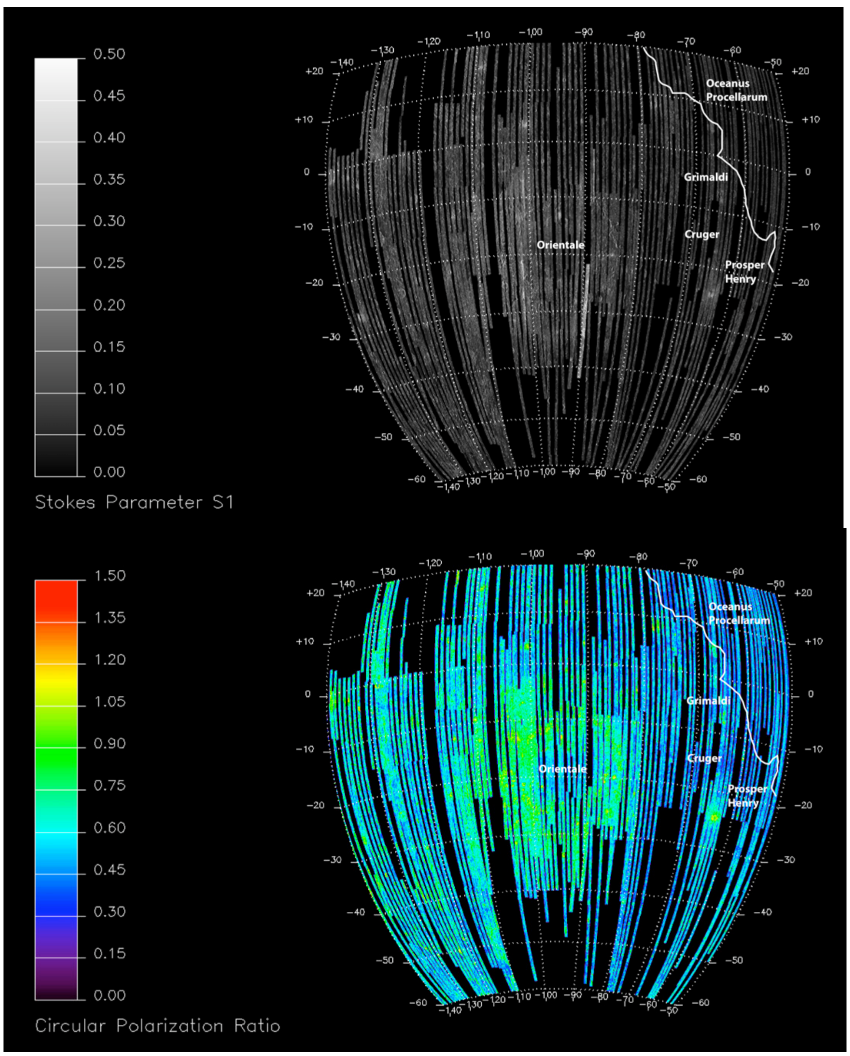

Fig. 2. Orthographic projections of Mini-RF radar products for Orientale basin and western Oceanus Procellarum (32 pixels/degree; ~1 km/pixel. (Top) Stokes parameter S_1 and (bottom) Circular polarization ratio (CPR).

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