MARE DEPOSITS IN THE AUSTRALE REGION: EXTENT, TOPOGRAPHY, AND STRATIGRAPHY.

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Introduction: Mare Australe is an irregular quasicircular collection of mare basalt deposits centered at approximately 38.9°S, 93.0°E (Fig. 1). Somewhat atypically for lunar mare basalt deposits, the basalts in Mare Australe are discontinuous and compositionally heterogeneous. Whitford-Stark[1] mapped the mare basalts in the Australe region and postulated four periods of mare eruptive activity from the late Nectarian to the Eratosthenian. More recent efforts have shown the distribution of buried mare deposits (or "cryptomare") [2], characterized the composition of the mare basalts using Clementine data [3,4], and produced age estimates crater-density based age estimates [5].

Mare Australe was proposed to lie within a pre-Nectarian impact basin [3,6,7]. Previous workers have identified two poorly preserved ring structures in the Australe region ~880 and 600 km diameter [8,9]. However, Australe is one of several mare basalt deposits with no well-defined topographic rim boundaries [10]. Regardless, despite repeated episodes of significant mare volcanism, basalts did not completely fill the Australe region, thus the discrete Australe basalt deposits preserve fundamental information about the early stages of the mare formation process and possibly the relationship between impact basins and mare volcanism (assuming that there is an Australe impact basin).

New observations from the NASA Lunar Reconnaissance Orbiter (LRO) allow detailed spectral mapping of the Australe basalt units and the means to quantify the topographic characteristics (particularly the equipotential surfaces) of each of the mapped mare deposits. The goals of this effort: (1) Identify and characterize the discrete basalt deposits in the Australe region using new planetary data products, (2) identify possible volcanic source vents, (3) provide new information on the distribution of buried mare basalts, and (4) compare these results to other lunar geologic features.

Methods: This study relies heavily on Lunar Reconnaissance Orbiter Camera (LROC) Wide Angle Camera (WAC) observations, which provide global imaging

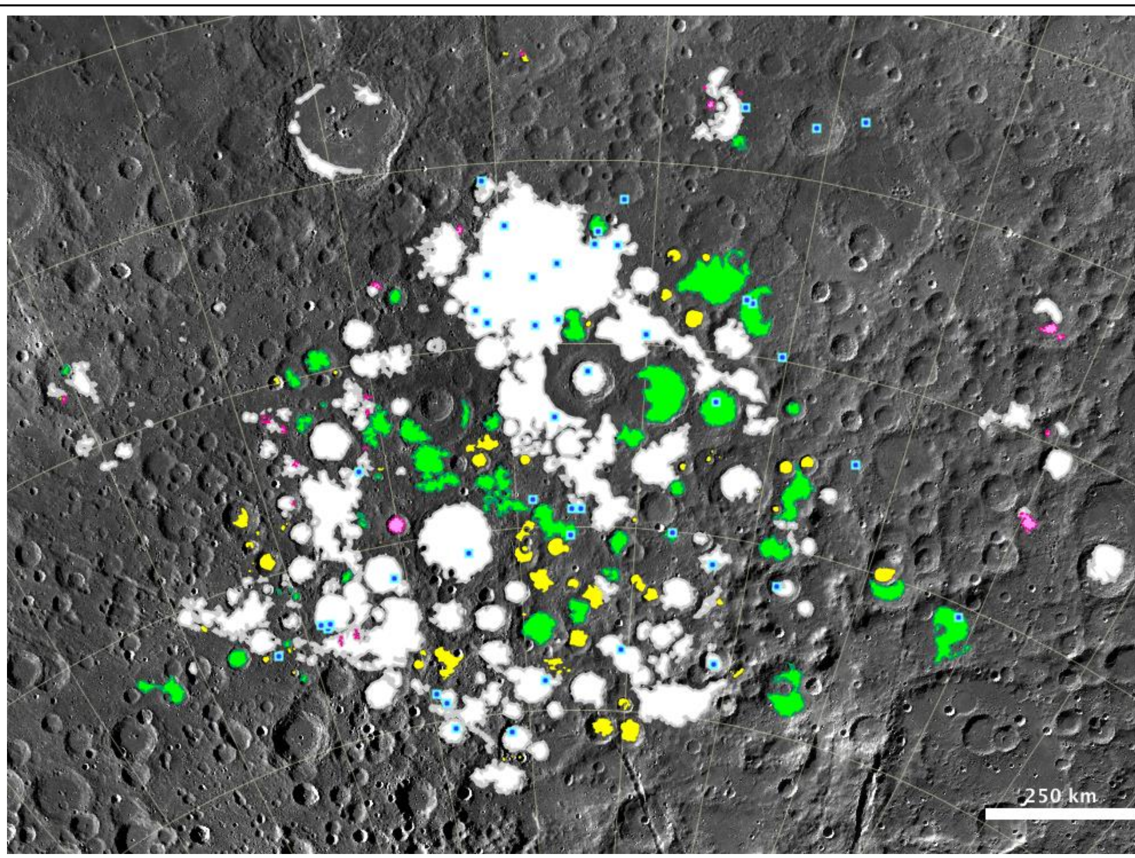

Figure 1. Sketch map of geologic features in the Mare Australe region. White areas are mare, yellow areas are possible cryptomare, green areas are degraded mare, pink areas are endogenically modified impact craters, blue markers denote dark-haloed craters (north is up, centered at 45°S, 95°E, latitude/longitude in 10° increments, WAC basemap).

Table 1. Elevations of basalt age units within Mare Australe

Age Unit	Min. Unit Elev. [m]	Max. Unit Elev. [m]	Discrete Unit Avg. [m]	Std. Dev.	Areal Weighted Avg. [m]
Eratosthe-nian	-3443	-363	-1877	889	-2126
Upper Imbrian	-4563	-417	-1759	895	-1833
Lower-Mid Imbrian	-3773	18	-1617	874	-1222
Nectarian-Lower Imbrian	-2329	-588	-1234	466	-1442

of the Moon with pixel scales of ~100 m/pixel. The WAC is a push-frame camera capturing seven color bands (321, 360, 415, 566, 604, 643, and 689 nm) with a 57-km swath width in color mode and a 105-km swath width in monochrome mode from the 50-km altitude [11,12]. The WAC monochrome low-sun morphology data product was used as a base map. Mare basalt unit boundaries were determined using a seven-band color product produced using the empirical photometric correction techniques of [13] as well as Clementine FeO and TiO_2 maps produced using the techniques of [14]. Topographic measurements were made using the GLD100 topographic product, spatial resolution sampling of 100 m and a vertical accuracy of 10 m [15].

Results and Discussion: Using WAC data, general boundaries of significant mare basalt deposits in the Australe region were distinguished. In addition, dark halo craters (including some not previously noted) were identified. The mare basalt units mapped in this study (Fig. 1) are generally consistent with the units mapped previously by [1-3, 16]. Several new cryptomare units were identified, and previously identified cryptomare were re-examined. The cryptomare deposits suggest that volcanic activity was more pronounced in the early period of mare deposition, potentially including pre-Nectarian examples, a similar history to that proposed for Balmer Basin [17].

The GLD100 dataset was used to systematically analyze the topography of the Australe region and determine the average elevation of each mare surface. Similar to previous studies, no well-defined topographic basin rim is observed for the putative Australe basin. When the elevations of the discrete mare basalt units are correlated to the age-stratigraphic relationships determined by previous investigators (Table 1) [1], a clear trend emerges: the equipotential surfaces of the youngest mare deposits are found at consistently lower elevations (weighted average: -2125 m) than the oldest Australe mare deposits (weighted average:-1440 m), consistent with [4].

Recent results from the GRAIL mission [18] suggest that the crustal thickness in the Australe region is not significantly different from other nearside mare basalt deposits, so crustal thickness alone cannot account for the fact that Australe has a lower erupted volume of mare basalts. The younger basalts are enriched in FeO, Ti, and Th [4]. The discrete basalt units distributed throughout the basin and separated by topographic barriers suggests multiple eruption centers accessing several mantle source regions. Some of the eruption centers remained volcanically active throughout the Imbrian to Eratosthenian, while others only experienced eruptions only during a limited time.

Conclusions: The extensive cryptomare in Australe suggests volcanism was more abundant in the Nectarian and waned in the Eratosthenian. The wide range of basalt ages indicates sustained, but intermittent, volcanism in the Australe region. The discrete clusters of mare units separated by regions of high topography and limited age ranges indicate that some regions of the basin were only volcanically active for a limited time, whereas other portions of the basin experienced extended volcanism from the Imbrian to Eratosthenian, indicating multiple eruption centers throughout the basin. Since Australe preserves a record of initial mare basalt eruption processes, these observations and conclusions imply that multiple eruption centers tapping a range of magma centers are normal for mare basalt formation across the whole Moon.

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