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Orientale Impact Basin: Topographic Characterization from Lunar Orbiter Laser Altimeter (LOLA) Data and Implications for Models of Basin Formation and Filling

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The 920 km diameter Orientale basin is the youngest and most well-preserved large multi-ringed impact basin on the Moon; it has not been significantly filled with mare basalts, as have other lunar impact basins, and thus the basin interior deposits and ring structures are very well-exposed and provide major insight into the formation and evolution of planetary multi-ringed impact basins. We report here on the acquisition of new altimetry data for the Orientale basin from the Lunar Orbiter Laser Altimeter (LOLA) on board the Lunar Reconnaissance Orbiter. Pre-basin structure had a major effect on the formation of Orientale; we have mapped dozens of impact craters underlying both the Orientale ejecta (Hevelius Formation-HF) and the unit between the basin rim (Cordillera ring-CR) and the Outer Rook ring (OR) (known as the Montes Rook Formation-MRF), ranging up in size to the 630 km diameter Mendel-Rydberg basin just to the south of Orientale; this crater-basin topography has influenced the topographic development of the basin rim (CR), sometimes causing the basin rim to lie at a topographically lower level than the inner basin rings (OR and Inner Rook-IR). In contrast to some previous interpretations, the distribution of these features supports the interpretation that the OR ring is the closest approximation to the basin excavation cavity. The total basin interior topography is highly variable and typically ranges $\sim$6-7 km below the surrounding pre-basin surface, with significant variations in different quadrants. The inner basin depression is about 2-4 km deep below the IR plateau. These data aid in the understanding of the transition from peak-ring to multi-ringed basins and permit the quantitative assessment of post-basin-formation thermal response to impact energy input and uplifted isotherms. The Maunder Formation (MF) consists of smooth plains (on the inner basin depression walls and floor) and corrugated deposits (on the IR plateau); also observed are depressions interpreted to be due to local drainage, and cracks related to cooling and solidification. This configuration supports the interpretation that the MF consists of different facies of impact melt. The location of vents, the altimetric distribution, and the slopes of mare basalts of different ages permit an assessment of basin controls on mare basalt emplacement. The inner depression is floored by tilted mare basalt deposits surrounding a central pre-mare high of several hundred meters elevation and deformed by wrinkle ridges with similar topographic heights; these data permit the assessment of basin loading by mare basalts and ongoing basin thermal evolution. LOLA data for the Orientale basin thus provide new insight into models of multi-ring basin formation, important information on their early thermal evolution, and new data on the initial stages of mare basalt flooding of multi-ringed basins.