PRELIMINARY SOUTH POLE-AITKEN BASIN RING RECONSTRUCTION USING MASSIFS

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Introduction: The South Pole-Aitken (SPA) basin is thought to be the largest and oldest impact basin on the Moon **[1]**. It underlies every impact basin near the south pole and extends north to Aitken Crater (16°S, 173°E). Due to its ancient age of 4.26 ± 0.03 Ga **[2]**, the rings of this ~2600 km basin are significantly degraded, and in the western half, they are almost entirely absent, making mapping the ring structures a challenge. Accurately reconstructing the SPA ring structures is key to understanding the basin's formation and the overall lunar history.

Previous work identified three possible ring structures for the SPA basin **[3]**; however, the western portions have remained ambiguous, with no significant elevation differences signifying basin rings. Two other studies attempted reconstruction of the ring structure, [**4**] with best-fit ellipses based on Clementine topography, iron, and thorium extents, and [**5**] best-fit ellipses using LOLA-derived topography. Here, we reconstruct the full extent of the SPA ring structures from massifs (i.e. Moon mountains), crustal thickness, and Bouguer gravity anomalies.

Data and Methods: We identified and characterized massif extents by measuring "Absolute Relief" (the difference between the summit to the lowest encompassing contour of the mountain and any mountain in the same complex), "Prominence Relief" (the difference between the mountain summit to the lowest encompassing 100 m contour interval that contains no other peak), and average, medium, and maximum relief for profiles drawn in the cardinal/ ordinal directions from the summit of the massif down to where the slope becomes <8°. These measurements were all collected using the Lunar Reconnaissance Orbiter Camera (LROC) Wide Angle Camera (WAC) GLD100 topographic map [**6**].

Since the terrestrial definition of a mountain includes sea level [**7**], which the Moon does not possess, we defined landforms that rose 457 m or more above neighboring landforms as massifs to match the 1500 ft elevation standard defined by [**7**].

Here we analyzed mountains with absolute relief greater than 1000 meters (**Fig 1.**). Since the lunar surface is littered with landforms across a broad range of ages with relief of 457 m - 1000 m, including these smaller massifs would produce a large but uninterpretable dataset.

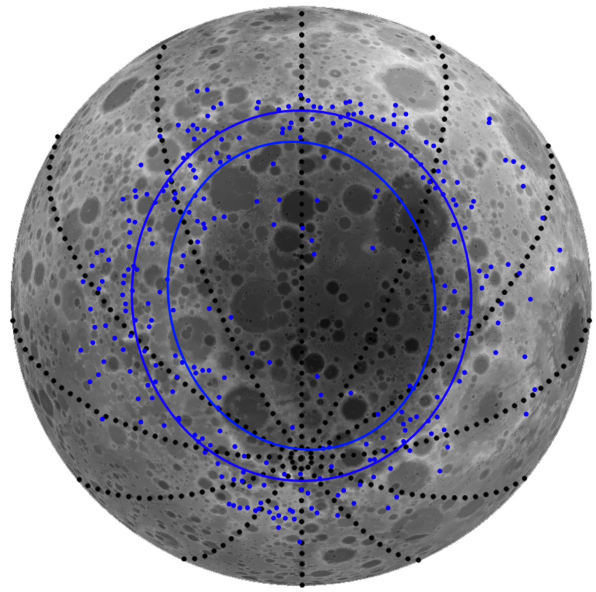

Figure 1. *SPA basin with best-fit ellipses for the inner and outer ring (blue rings) and massif locations (blue dots, n=300), overlain on the GLD100 (orthographic projection centered at 56°S,180°E)*

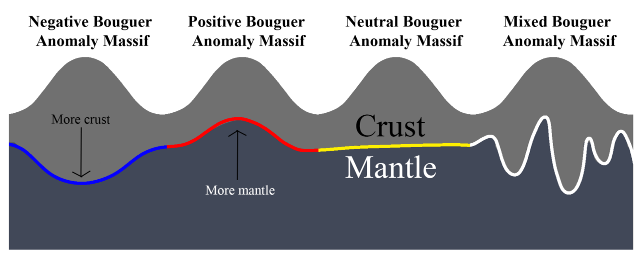

Figure 2. *Schematic representation of subsurface mass underneath massifs based on Bouguer anomalies.*

Each massif was also categorized based on the local Bouguer Gravity [**8**] expression. These categories include positive (25 mGal and higher), negative (-25 mGal and lower), neutral (-25 to 25 mGal), and mixed (containing both negative and positive anomalies within its perimeter). The purpose of this categorization is to distinguish whether the underlying material of the massif is composed primarily of mantle or crust and allow us to visualize the subsurface mass (**Fig. 2**). Alternating ring structures present different Bouguer gravity anomalies, as seen in Orientale [**9**]; therefore, we use this as an additional tool for ring reconstruction.

Discussion: On average, massifs appear to rise to greater *absolute relief* from the innermost part of the basin outward, with some of the tallest massifs reaching higher than 7 km. The inner ring in **Figure 1** was created using the innermost massif structures (defined by their location on the crustal thickness map between 20-40 km thickness) in the basin to create a best-fit ellipse [**10**], likely corresponding with Orientale's Inner Rook Ring (IRR). Further analysis of the inner massifs may reveal evidence of a corresponding Inner Depression Ring (ID).

The outer ring (**Fig. 1**) (corresponding with Outer Rook Ring, ORR) was created using massifs >7000 m in *absolute relief*. Note that this best-fit ellipse was similar in azimuthal direction, shape, and location as a best-fit ellipse created using massifs of >6000 m *absolute relief* & >4000 m *prominence relief*.

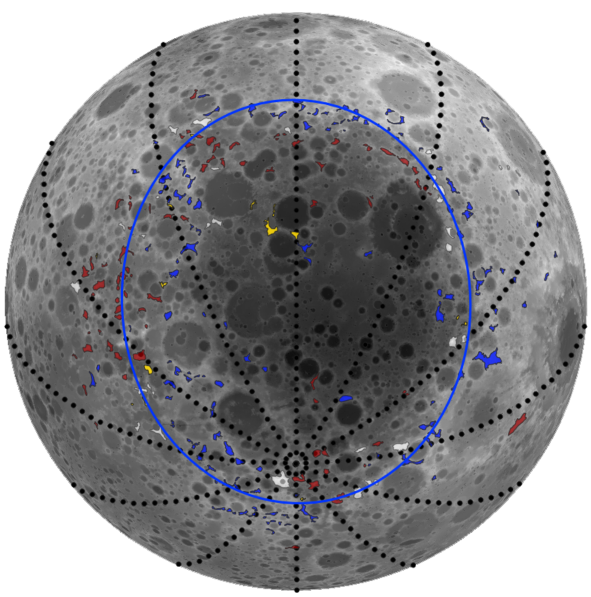

Figure 3. *SPA basin with a best-fit ellipse of negative Bouguer anomalous massifs (blue ring) and massif polygons (red=positive, blue=negative, yellow=neutral, and white=mixed) overlain on the GLD100 (orthographic projection centered at 56°S,180°E)*

If we concur with [**9**] and their conclusion that the transient crater does not correspond to a ring, but rather would sit in between the ID and the IRR, then the transient crater diameter may also be acquired from this massif work, given further analysis. Additionally, the existence of a ring corresponding to the Cordillera Ring (CR) might become evident with future work.

Figure 3 shows our best-fit ellipse based on the negative Bouguer massifs, which appears to be the dominant expression for massifs within the basin. The azimuthal direction of the semi-major axis of the ellipse seems to be consistent with the outer ring from both [**4,5**], however the exact placement of the structure differs slightly. Indeed, it would seem that our best-fit ellipse matches well with the outer ring from [**5**] in the eastern half of the basin, and with their identified "external scarp" in the western half.

Our best-fit ellipse created by negative Bouguer massifs lines up well with our ellipse created from the >7000 m *absolute relief* massifs and the ellipse made from >6000 m *absolute relief* & >4000 m *prominence relief* massifs in both the western and eastern halves of the basin. However, the Bouguer ellipse does extend slightly farther north and south.

Conclusions: Our reconstruction of SPA's significantly degraded ring structure and analysis of Bouguer gravity in the subsurface of the massifs is ongoing, and future work is expected to shed light on the transient cavity, an Inner Depression Ring, and possibly a fourth ring, corresponding to Orientale's Cordillera Ring.

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