Discovery of Small SPA Lunar Impact Basin

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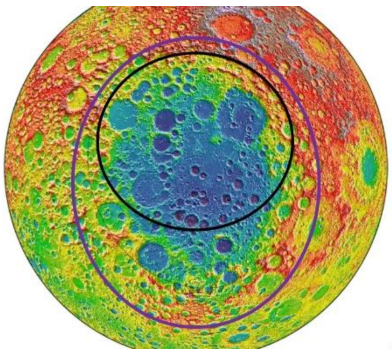
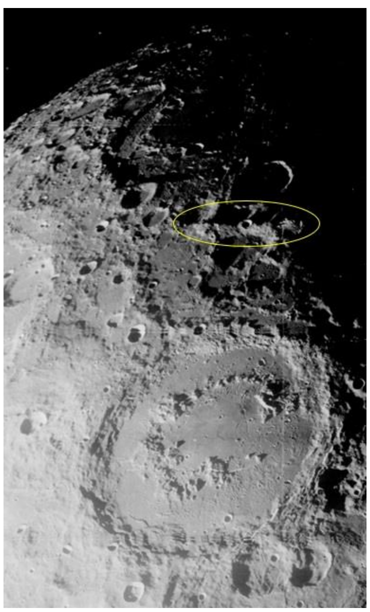
Images from Lunar Orbiters 4 and 5, as well as the GRAIL-A orbiter, have led to the discovery of an impact basin on the Moon's south-central Far Side. This basin is centered at 165W (195E) longitude, 45 degrees south latitude and is given the designation of Lyman-Langmuir. It has a diameter of 1,000 kilometers and occupies what was previously considered to be the northern sector of the South-Pole-Aitken (SPA) basin.

The Lyman-Langmuir (LL) basin is equal in extent to the Imbrium basin, but still significantly smaller than the SPA basin. In this diagram, the Lyman-Langmuir basin is outlined in black, while the SPA basin is outlined in purple. The LL basin may be slightly elliptical along an east-west axis.



A remnant of the southwest rim is preserved. These rim massifs were first observed by the Lunar Orbiter 4 spacecraft in May 1967 as shown here. The northern border of the Lyman-Langmuir basin is the same as the legacy SPA basin, namely the dual rim massifs located just north of the Apollo basin.

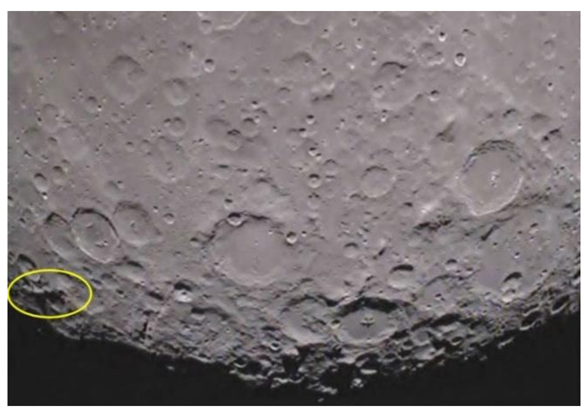


The existence of the Lyman-Langmuir (LL) basin resolves several geologic dilemmas. First, an extremely large impactor is no longer required for a gigantic SPA impact event. An asteroid, rather than a protoplanet, would be sufficient to form the LL basin.

A smaller impact event translates into a shallower excavation of the Moon's crust and mantle. This resolves the puzzling absence of a geochemical signature (i.e., olivine), of deep mantle rocks within the SPA basin (1). An impact-generated shockwave energetic enough to create a 2,500-km. wide basin should have transported rocks from the Moon's mantle. However, such "deep excavation [120 km] is inconsistent with observational data." (2)

Massifs of Lyman-Langmuir basin (Lunar Orbiter 4 image 4094-M; credit: LOIRP)

The Lyman-Langmuir (LL) basin has a radius of 500 kilometers, with one-half the area (or less), of an SPA basin. As a result, the energy of the LL basin impact event would be less than half of the standard SPA impact. This equates to a shallower impact cavity for Lyman-Langmuir. The seeming paradox of no mantle signature is thereby resolved.



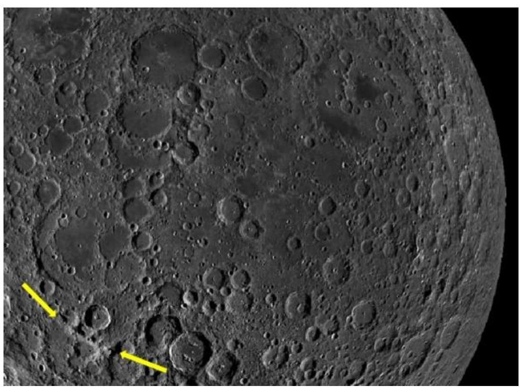
Several other lines of evidence lend support to the existence of the Lyman-Langmuir basin. First, the Thorium signature from the Lunar Prospector orbiter closely matches the location and dimensions of the LL basin. In addition, the SPA compositional anomaly (SPACA) lines up with the center of the proposed Lyman-Langmuir basin. (1)

Also, the Bouguer gravity map, generated by the GRAIL orbiters, displays a circular gravity signature that approximately outlines the LL basin.

Massifs south of Poincare (Lunar Orbiter 5 image 5065-M; credit: LOIRP)

There appear to be other ruined basins in the southern and eastern reaches of the of the legacy SPA basin. (3) Together, their existence can explain the topography of that sector without resort to the existence of a very large SPA basin. In the intervening billions of years since the formation of these basins many of the original rims and interior rings have foundered after being buried by lava flows or basin ejecta.

The detection of the Lyman basin hints at an impact history in the SPA region that is complex and intricate. Much of the unraveling of this sequence will require a global sampling campaign in the coming decades.



Lyman-Langmuir rim location (LRO mosaic; NASA)

References:
(1) The Character of South Pole-Aitken Basin: Patterns of Surface and Subsurface Composition
D.P. Moriarty III, C.M. Peiters
JGR; Volume 123, Issue 3; March 2018; Pages 729-747

(2) Constraining the size of the South Pole-Aitken basin impact
Potter, Kiefer, Kring et al; Icarus; August 2012

(3) Newly Detected Impact Basins within South-Pole-Aitken Basin; P. Horzempa; 2022; LPSC53