

# IMPACT MELT LAVA INFLATION FRACTURES IN SCHOMBERGER-A CRATER, MOON: NEW PERMANENTLY SHADOWED REGIONS AND POSSIBLE CAVES NEAR THE LUNAR SOUTH POLE.

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**Introduction:** Concentric depressions on the floor of Schomberger A crater on the Moon are interpreted as impact melt lava inflation cracks, indicating lava surges during emplacement, a new form of permanently shadowed regions (PSR), and possible caves near the lunar south pole.

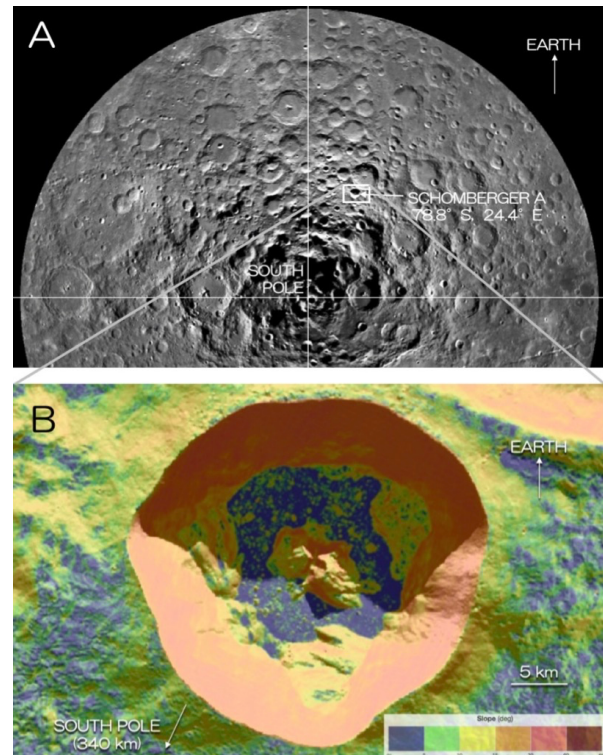
**Schomberger-A:** Schomberger A is a 31 km diameter impact crater located at 78.8°S, 24.4°E, 340 km from the lunar South Pole (Fig. 1A). It presents a fresh morphology and a ray system, and is estimated to be of Copernican age (<1.1 Ga old). Schomberger A is the highest latitude Copernican crater on the Moon large enough to have produced substantial impact melt.

Melt-producing Copernican age craters are of interest in the exploration of the lunar subsurface, as close to 86% of pits and caves identified on the Moon to date occur on the impact melt floors of Copernican age craters [1]. Prior to the present study, the highest latitude *candidate* pits and caves on the Moon are on the impact melt floors of Philolaus [2-4] and Anaxagoras [5] craters, two Copernican age impact structures located at 72.1°N and 73.5°N, respectively.

High latitude pits and caves on the Moon, while still only tentatively identified because of marginal lighting conditions, are a particularly intriguing possibility, as they would not only provide access to the lunar subsurface (like pits/caves anywhere on the Moon would), but would also be cold enough to cold-trap volatiles, much like permanently shadowed regions (PSRs) at the lunar poles do [6].

**Impact-Melt Lava Inflation:** The floor of Schomberger A is occupied by a sub-horizontal geologic unit edged by several lobate flow fronts (Fig. 2A+B). The lobate flows circumvent and embay large blocky masses on the crater floor (Fig. 2B). The unit is interpreted as an impact melt deposit, and the lobate flows as impact melt lava flows. The surface of this impact melt unit presents well-developed sets of sub-parallel and roughly equidistant curvilinear depressions, a majority of which conform to the edge of the convex lobate flows (Fig. 2C+D). These sets of curvilinear depressions are interpreted as lava flow surface fractures, specifically inflation cracks.

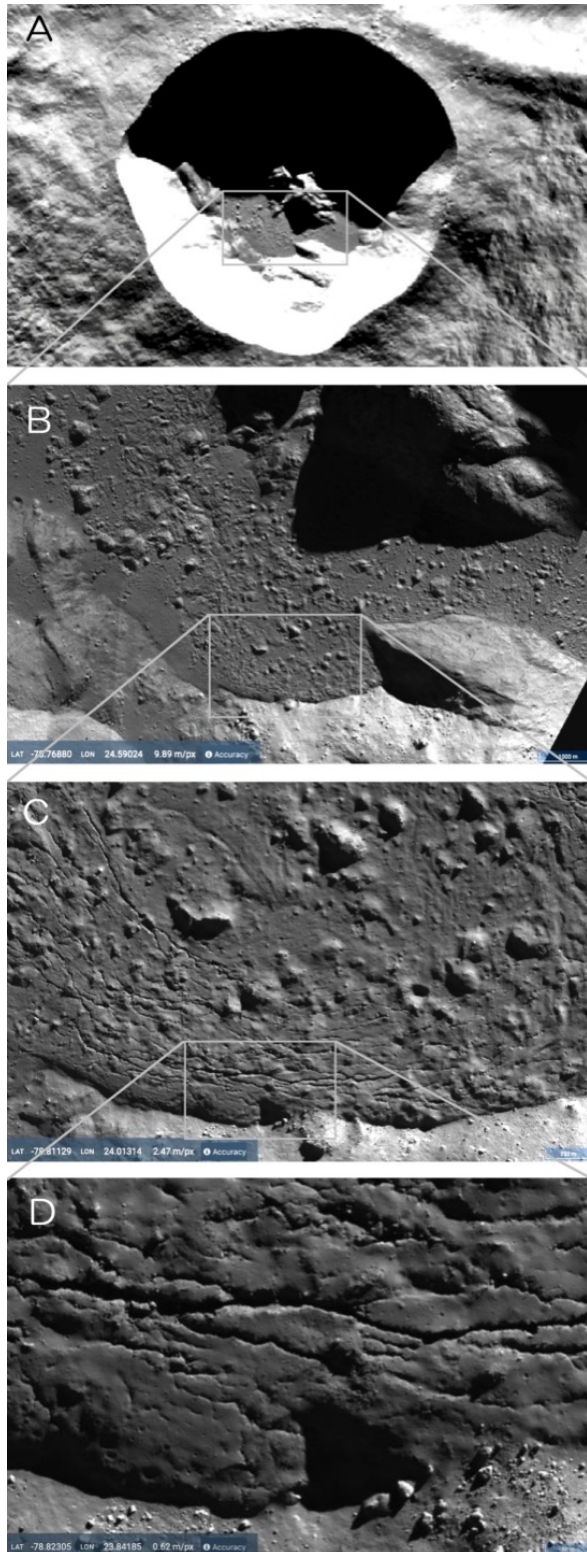
Inflation is a process in basaltic volcanism in which molten material is injected beneath the crust of an active lava flow and lifts it upwards. The swelling of the lava flow can result in fracturing of the crust's surface. Inflated lava flows have previously been interpreted on the Moon [7] and other planetary surfaces [8], but like terrestrial counterparts [9], only in association with



**Figure 1. Schomberger A crater and impact melt deposit.** A: Location map; B: Shaded relief and slopes (NASA LRO NAC imaging data + Chang'e 2 CCD slope data). Schomberger A presents steep (15-30°) slopes with mass wasting features, and a sub-horizontal impact melt sheet on its floor.

volcanic lava flows. The present interpretation suggests that impact melt lavas may also experience inflation, and display inflation fractures as a result.

Because impact melt lavas are, in contrast to volcanic lavas, produced in short-lived thermal pulse impact events with no sustained sources of lava, lava surges capable of producing significant inflation in impact melts are puzzling. Two hypotheses are proposed: a) surges resulting from runoff and incorporation of impact melt from steep, melt-splattered crater walls; b) surges produced by crater wall mass wasting, esp. megablock slumping. In both cases, the surges would be late crater modification stage events, particularly effective at mobilizing significant amounts of lavas as the crater floor area where impact melt is already ponding and crusting over is exiguous. Schomberger A presents a high depth to diameter ratio, steep walls, abundant evidence of crater wall mass wasting and aproning, and a relatively small ponding area on its floor (Fig 1.B).

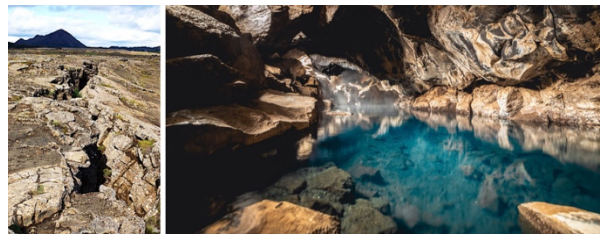


**Figure 2: Schomberger A Impact Melt Fractures, PSRs & Caves.** A: Schomberger A crater (D~31 km); B: Lobate impact melt lava flow edge; C: Sets of curvilinear depressions interpreted as impact melt lava inflation fractures; D: Inflation fracture PSRs & caves. (NASA LRO).

**Inflation Fractures New PSRs and Caves:** Impact melt lava fractures in Schomberger A range in width from 0.5 m (LRO NAC spatial resolution limit) to several tens of meters. Photometry indicates that many fractures exceed 5-10 m in depth, implying that their bottoms could be permanently shadowed. Thus, inflation fractures offer a new form of submeter to decameter scale PSRs on the Moon.

Lava flow fractures on Earth can be associated with subsurface caves. Those located in cold regions, such as the Grjótagjá lava fracture caves in Iceland, trap ice and snow, and may harbor seasonal meltwater ponds (Fig. 3). We speculate that the impact melt lava inflation fractures and PSRs at Schomberger A might be associated with caves, which would be cold enough to cold-trap volatiles, like PSRs at the lunar poles.

**Future Exploration:** The floor of Schomberger A is surrounded by steep slopes, and is difficult to access other than by landing directly onto the impact melt sheet on the crater floor, where slopes are typically  $< 5^\circ$  (Fig 1B). The impact melt fractures of Schomberger A could be targeted by a NASA CLPS (Commercial Lunar Payload Services)-class mission aiming to investigate cold, circumpolar PSRs and subsurface cavities for potential cold-trapped volatiles.



**Figure 3: Grjótagjá Lava Fracture Caves, Iceland.** L: Lava fracture at Grjótagjá near Lake Myvatn, Iceland; R: Seasonal meltwater pond from trapped ice and snow in a cave in the fracture. The Grjótagjá caves are an analog for possible impact melt lava fracture PSRs and caves at Schomberger A.

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**References:** [1] Wagner, R. V. & M. S. Robinson (2014). *Icarus*, 237, 52-60; [2] Lee, P. (2018a). *Lunar Sci. Landed Missions Wkshp 2018*, NASA/SSERVI, LLW2018-43; [3] Lee, P. (2018b). 49<sup>th</sup> LPSC, #2982; [4] Lee, P. (2018c). 6<sup>th</sup> European Lunar Symp. 2018, #024; [5] Avent II, W. & P. Lee (2021). 52<sup>nd</sup> LPSC 2021, #2733; [6] Lee, P. (2020). 3<sup>rd</sup> Planetary Caves Conf., #1066; [7] Garry *et al.* (2012). *JGR* 117, E00H31; [8] Hamilton, C. W. *et al.* (2020). *JGR Planets*, 125, e2019JE005975; [9] Elshaafi, A. & A. Gudmundsson (2019). *J. Volcanology Geothermal Res.*, 381, 284-301.