TOPOGRAPHIC EVOLUTION OF THE LUNAR POLES: IMPLICATIONS FOR PERMANENTLY SHADOWED REGIONS (PSRs) AND VOLATILE DEPOSITS. Mishal K.T and Deepak Dhingra, Department of Earth Sciences, Indian Institute of Technology Kanpur, UP, India - 208016 (mishalkt@iitk.ac.in, ddhingra@iitk.ac.in).

Introduction: The near vertical axial tilt of the Moon (1.5^0) aids numerous topographic depressions at the lunar poles to host permanently shadowed regions (PSRs), which can harbor volatiles due to extremely low surface temperatures [1]. PSRs on the lunar poles have evolved with time [2], similar to the general evolution of the lunar terrain, in response to various geological processes such as impact cratering and volcanism. The formation of younger impact craters in the polar region generates topographic depressions, which could become PSR depending on their size and geographic location. Large scale geological events (ejecta from large craters/basins, volcanism) could smoothen the topography and erase/reduce or increase the extent of PSRs. This work primarily focuses on understanding the topographic modification of the lunar poles which has direct implications for the PSRs, and the potential volatiles deposited inside them.

Methodology: Averaged topographic profiles of the craters are obtained using digital elevation model from the Lunar Orbiter Laser Altimeter and SELENE Terrain Camera (SLDEM 2015) [3]. The polar crater profiles are then compared with similar sized younger (Eratosthenian and Copernican) craters [4] on the Moon. The average depth derived from multiple young craters is compared with the depth of polar craters to infer the approximate thickness of infilling. Here, the assumption is that the younger crater depths have been minimally affected by various geological processes. Since the depth variation within younger craters did not exceed 600m in the entire dataset, an error bar of ±300m has been assumed in our calculated infilling. The influence of target material, impact angle and crater floor alteration, which can affect the depth of younger craters, are not explicitly taken into account in the current study.

Results and Discussion: Our results show the extent of crater infilling in the polar craters and its influence on the PSRs and volatile deposits.

(1) Shallowing of the Polar craters: Craters on the lunar surface may become shallow due to a variety of geological processes such as ejecta deposition from crater formation, degradation of the crater (wall collapse), subsurface magmatic intrusion, and volcanic infilling. The nearside of the lunar north polar region has been topographically smoothened potentially by the depositions of plains material, which consists of ejecta from the Imbrium basin and other large craters [4,5]. These deposits have largely influenced the topographic

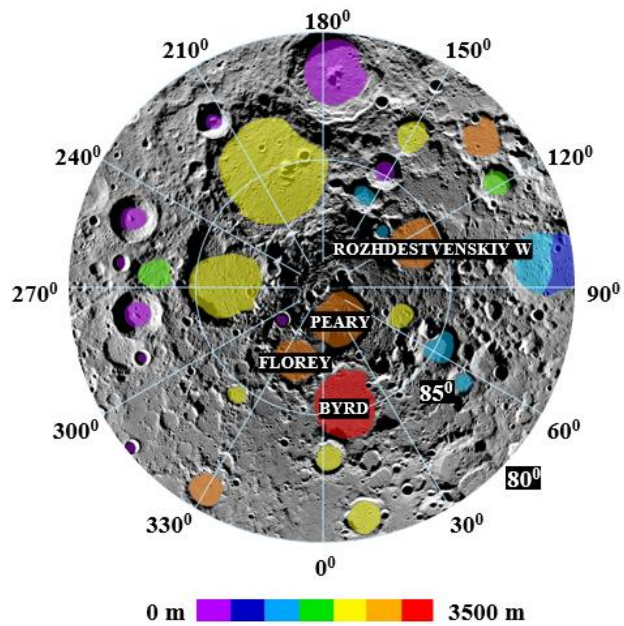

Fig 1: Map depicting the thickness of infilling in the north polar craters (80^0-90^0). Each color bar represents a range of 500m.

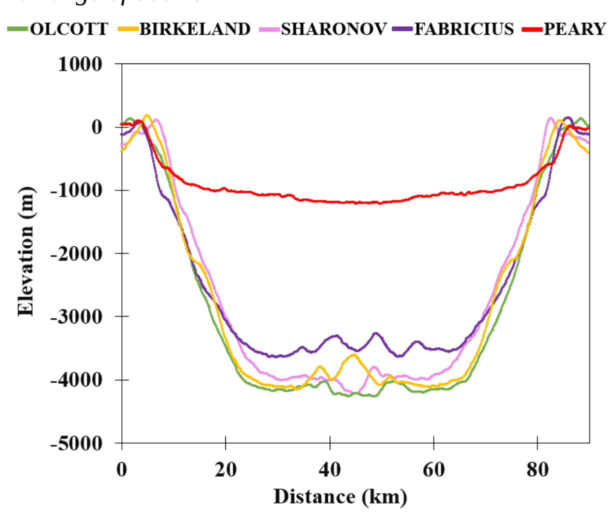

Fig 2: Averaged topographic profile of north polar pre-Imbrian crater Peary compared with similar sized younger non-polar craters to derive an estimate of the thickness of infilling.

lows by filling craters with kilometer scale thick deposits (Fig 2). The presence of crypto mare towards the north pole [6] also increases the possibility of the shallowing by the volcanic products. Our results show that multiple pre-Imbrian craters at the lunar poles (especially at the north pole) are filled with kilometer scale thick material. The thickness of deposits inside selected north polar craters is shown in Figure 1.

(2) Influence on Permanently Shadowed Regions: Infilling of material into the crater reduces the topographic contrast, affecting the Permanently Shadowed Regions. The analysis of PSR area [7] in the polar craters reveals that the older (Nectarian and Pre-Nectarian) craters host a lesser area of the crater as PSR, in contrast to the younger craters in the region.

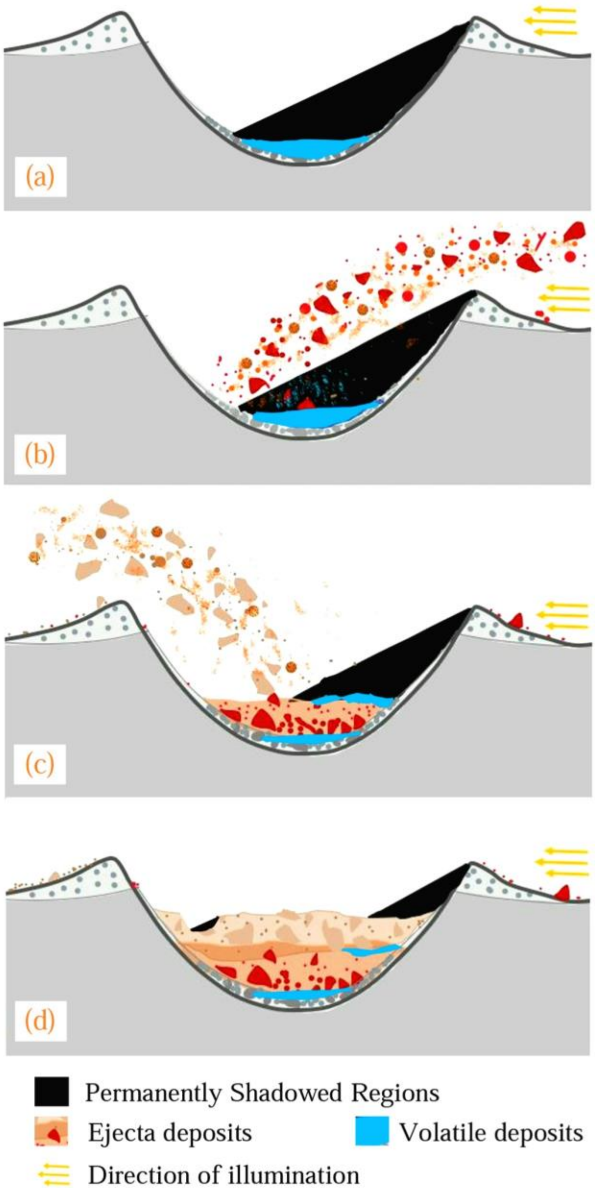

Fig 3: Scenarios of crater infilling via impact ejecta and their influence on PSRs and volatile deposits. (a) Crater with associated PSR and volatile deposit (b, c) Series of ejecta deposition from younger crater formations and associated burial of the volatile deposits (d) Evolved (modified) PSR with buried volatiles.

The south polar craters like Haworth, Shoemaker, and Faustini have remained exceptional as the craters do not appear to have been shallowed by large scale material deposition. Relatively large depths shown by these craters suggest their pristine character despite their old age (>4Ga [8]). The dominantly elevated topography surrounding Haworth, Shoemaker and Faustini might have possibly shielded the material movement into these craters, including volatiles (especially the movement of low angle ejecta) [9].

(3) Palaeo-PSRs and Buried Ices:
Large craters near the lunar poles which are currently filled to different extent might have hosted significantly large PSRs during the early lunar geological time. North polar craters such as Peary (Diameter: ~78 km, latitude: ~88.0) might have had a larger PSR than crater Shoemaker (Diameter: ~51 km, latitude: ~88.0), where the latter currently hosts one of the largest PSRs (1075 km^2) on the Moon [7]. Hence, we can expect Palaeo-PSR in crater Peary, which could have harbored significant amount of volatiles in the geological past. The volatiles delivered during the early lunar geological time could have got buried and preserved in these craters (Fig 3). Depending on the geological history of the region, these potential volatile deposits may occur in a variety of geological settings including near-surface deposits. It may be worth investigating the presence of such potentially hidden deposits in order to better constrain the polar volatile inventory of the Moon

Summary: Large scale depositional events may have strongly influenced the current distribution of PSRs on the lunar poles. The Palaeo-PSRs resulting from the evolution of PSRs are important regions to explore as they could potentially host ancient, buried volatile deposits.

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