MG-SPINEL EXPOSURES IN THE SOUTH-POLE AITKEN (SPA) BASIN: NEW INSIGHTS INTO THE STRATIGRAPHIC RELATIONSHIPS, SPATIAL DISTRIBUTION AND SPECTRAL VARIETIES Garima Sodha and Deepak Dhingra, Department of Earth Sciences, Indian Institute of Technology Kanpur, UP 208016, INDIA. (garimasd@iitk.ac.in, ddhingra@iitk.ac.in)

Introduction: The occurrence and distribution of Mg-Spinel bearing lithology, a new rock type on the Moon [1], represents a geological record that is yet to be completely documented and holds important clues to understanding the early phase of lunar geological evolution, including the origin of this lithology itself.

Here, we report several new insights from our systematic documentation of Mg-Spinel exposures within the South-Pole Aitken (SPA) basin, the largest and likely the most ancient impact basin on the Moon. We have identified multiple, new exposures of Mg-Spinel, obtained key stratigraphic information based on in-situ exposures and observed diversity in the spectral character of Mg-Spinel which has direct implications for its origin.

Study area: SPA basin is a key stratigraphic marker in the lunar geological history which can be used to understand the origin of Mg-Spinel lithology. We are therefore carrying out a basin wide identification and characterization of Mg-Spinel exposures, to understand the geological context of this new rock type at both regional and local scales. We have carried out detailed investigations in and around Thomson crater (32.3° S, 166° E; 117 km diameter), a key site of Mg-Spinel exposures [2]. In addition, we have evaluated the geological context of few other Mg-Spinel detections in the region reported by previous workers [3].

Data and Methods: We have integrated multi-mission, multi-resolution datasets to both identify and characterize the Mg-Spinel exposures. These include spectral reflectance data from Moon Mineralogy Mapper (M3) onboard Chandrayaan-1 [4-6], imaging data from Terrain Camera (TC) onboard SELENE mission [7], imaging data from Wide Angle Camera (WAC) and Narrow Angle Camera (NAC) onboard Lunar Reconnaissance Orbiter (LRO) [8] and topography data from Lunar Orbiter Laser Altimeter (LOLA) onboard LRO mission [9].

Results: Our detailed investigations have widely expanded the distribution of Mg-Spinel occurrences and provided rich information about their spectral character and stratigraphic association.

1. Mg-Spinel in the Ingenii-Thomson Region: We report much more extensive distribution of Mg-spinel beyond the previously reported Mg-Spinel occurrences which were restricted to Thomson crater. The new exposures have been identified at multiple locations within the Ingenii basin and outside of Thomson crater. The distribution of these new exposures suggest a more widespread occurrence of Mg-Spinel in the Ingenii-Thomson region and that numerous exposures lie buried underneath the mare in this region.

2. Potential OOS exposures: There is mounting evidence for the occurrence of an assemblage of Olivine, Orthopyroxene and Spinel (OOS) in the region. If true, it would make Ingenii-Thomson region as the third such location on the Moon, after Moscoviense [1] and Endymion [10]. Besides, this

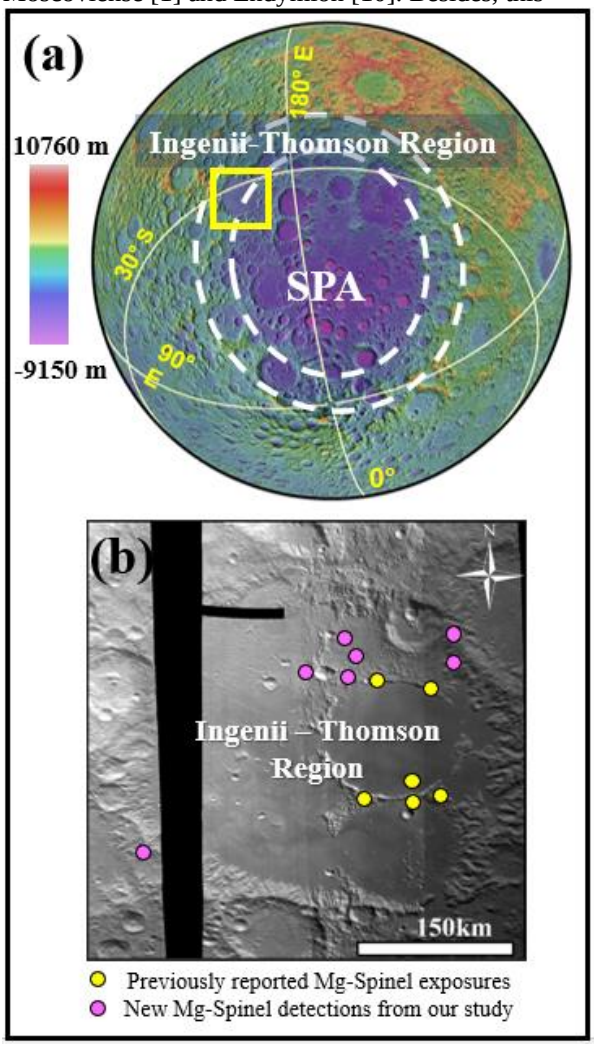

Figure 1. (a) LRO LOLA color shaded topography centered at SPA basin, Ingenii-Thomson region is situated on the inner ring of the SPA. **(b)** Spatial distribution of Mg-spinel in the Ingenii-Thomson region.

additional occurrence of OOS would help towards better characterization of this unusual assemblage and its geological relevance. The signatures of some of the potential olivine occurrences are relatively weak, making their identification challenging. Work is underway to further substantiate the identification of these interesting exposures.

3. Spectral diversity in the character of Mg-spinel exposures: Mg-spinel is characterized by a strong absorption band around 2-micron and an absence of 1-micron band [1]. In addition, there is no association with mafic minerals. However, our observations have clearly documented multiple flavors of Mg-Spinel in the region, exhibited by their distinctive spectral character. We have further augmented the spectral characterization with the detailed geologic context of the various Mg-Spinel flavors to obtain a comprehensive view of these exposures and to further evaluate their implication for the origin of Mg-Spinel. This assessment of different flavors benefitted from the large number of Mg-Spinel exposures in the Ingenii-Thomson region.

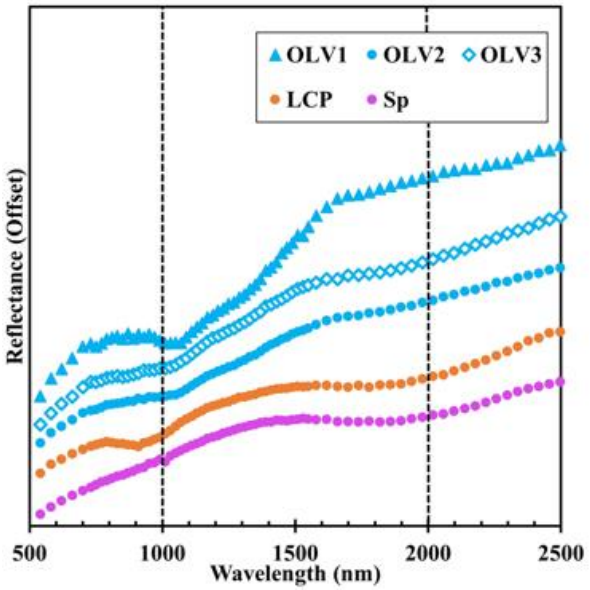

Figure 2 Spectral character of the OOS assemblage identified in the Ingenii-Thomson region.

4. Stratigraphic association of Mg-Spinel exposures: We have identified some stratigraphically well-constrained exposures of Mg-Spinel lithology to strongly tie the occurrence of these exposures in the broad timeline of events that happened in the SPA region but which could also pre-date the formation of SPA basin itself. We note that there are at least three broad regions of Mg-Spinel occurrences associated with the SPA basin: Ingenii-Thomson region, McKellar crater (50 km) and Hausen crater (167 km). Interestingly, all these occurrences are associated with the SPA basin rings. We are currently evaluating two key possibilities in this regard: a) Mg-Spinel lithology pre-dates SPA basin, formed at depth and is therefore preferentially exposed along SPA basin rings; b) Mg-Spinel lithology post-dates SPA formation and was formed along the ring regions due to later geological processes, possibly by later intrusions. We hope to investigate further by looking for any additional Mg-Spinel exposures in the SPA basin region.

Summary: The present work provides numerous new insights into the occurrence and distribution of Mg-Spinel lithology in the SPA basin region. It raises some interesting new possibilities including the potential occurrence of OOS deposits and presence of different spectral varieties of Mg-Spinel in the region. In addition, the study highlights the relevance of SPA in understanding the origin of Mg-Spinel on the Moon. The collective information available from this study would provide key insights into the understanding of this new rock type on the Moon.

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References: [1] Pieters C.M. et al., (2011) *JGR, 116, E00G08.* [2] Pieters et al. (2014) *American Mineralogist., 99(10), 1893-1910*. [3] Sun Y. et al., (2017) *EPSL, 465, 48-58.* [4] Pieters et al. (2009) Current Sci., 96, 500-505 [5] Green R.O. et al., (2011) JGR, [6] Goswami J.N. and Annadurai (2009) Curr.Sci., 96, 426-491 [7] Haruyama J. et al. (2008) Earth, Planet. Space, 60, 243-255 [8] Robinson M.S. et al. (2010) Space Science Review, 150, 81-124. [9] [10] Bhattacharya S. et al. (2013) Curr. Sci., 105, 685-691