NEAR SURFACE EXPRESSION OF LINEAR GRAVITY ANOMALIES (LGAs): POTENTIAL CLUES AND IMPLICATIONS FOR EMPLACEMENT. Deepak Dhingra, Saket Patidar and Dibakar Ghosal, Department of Earth Sciences, Indian Institute of Technology Kanpur (IITK), Kanpur, UP 208016, India (Email: ddhingra@iitk.ac.in; deepdpes@gmail.com).

Introduction: Gravity Recovery and Interior Laboratory (GRAIL) mission has recently revealed evidence for large scale occurrence of magmatic intrusions in the form of linear gravity anomalies or LGAs [1]. The largest of these intrusions span several hundred kilometers in length and extend for several kilometers in width.

We report here potential near surface expressions of some of these geophysical anomalies which have direct implications for understanding the emplacement of these massive and spatially pervasive features.

Data and Methods: We have utilized coordinated imaging and spectral datasets from recent missions in conjunction with the reported gravity anomalies to evaluate spatial correlations. Imaging data from Wide Angle Camera (WAC) at 100 meter per pixel and Narrow Angle Camera (NAC) at 0.5-1 m per pixel from Lunar Reconnaissance Orbiter (LRO) mission and Terrain Camera (TC) at 10 meter per pixel from Seleneological and Engineering Explorer (SELENE) mission have been utilized to study the geomorphological character of the region around LGAs. Hyperspectral data from Moon Mineralogy Mapper (M3) on Chandrayaan-1 mission has been utilized to further evaluate the mineralogical signatures of geomorphologically interesting locations in the proximity of LGAs.

New Findings: We report the occurrence of floor fractured craters (FFCs) in proximity to some of the LGA segments. FFCs are known to have formed by the modification of impact craters by subsequent intrusive magmatic activity [e.g. 2, 3]. We describe here four such occurrences which seem to be linked to the nearby LGA segments and could therefore provide additional information about the associated LGA:

a) Crater Karpinskiy (91 km dia.): It is located in close proximity to the largest LGA in the northern high latitudes (Figure 1). The crater is separated from the LGA by ~50 km. Recent work by [4] reported the crater to have a feldspathic mineralogy along with strong hydration signatures. Karpinskiy is flanked by many large craters, similar to its size but none show evidence of any floor fractures.

b) Crater Montgolfier P (36 km dia.) and Unnamed Crater (31.2 km dia.): These two craters are located at mid-latitudes in the northern hemisphere, at the far southern end of the largest LGA (same as the one associated with Karpinskiy). Their spatial relations indicate that any association with LGA would be with a subsegment rather than the main segment. Interestingly, both craters exhibit a circular exposure of mafic material on the floor (Figure 2). With the surrounding region being largely feldspathic, the mafic

Figure 1 Spatial proximity of the crater Karpinskiy to the largest linear gravity anomaly (shown in yellow). Background image is LROC WAC polar mosaic.
exposures could potentially be the surface manifestation of the intrusive body. Two overlapping craters do not show any evidence of floor fractures.

d) Crater Chappell (74 km dia.): It is located S-SE of the largest LGA. Unlike the previous three craters, in the case of Chappell, it could be linked to multiple gravity anomalies in the region. But, it is largely located in the same region as Montgolfier P and J and could be related to the same magmatic source.

Implications: LGAs have been suggested to represent very early phase of magmatic activity on the Moon during the stage of thermal expansion. However, the detailed understanding of the emplacement of the LGAs as intrusions is still an area of active research [5]. Besides, the exact nature of these intrusions in terms of their geometry and spatial extent is also poorly constrained. The potential association of at least some of the LGA segments with floor fractured craters provides some interesting insights:

i) Extended lateral extent: Although the LGAs have largely been interpreted to be tabular in geometry, there is potential evidence for their significant lateral extent as highlighted by their spatial relationship with the floor fractured craters. In the case of Karpinskiy, it is located at least 50 km away from the LGA. The other three craters too are located at significant distances away from their linked LGA segments. In order to modify these craters via intrusive magmatic activity, some lateral movement of magma from the main body (trunk) is conceivable in the form of branching pattern of sills or sill-like morphologies.

ii) Near surface occurrence: The excavation depths of approximately 2.8 – 9 km for the floor fractured craters discussed here can be used to get a first-hand estimate of the vertical extent of the brecciated zone which must have been intruded by the later magmatic event. It is interesting to note that the smaller craters, namely, Montgolfier P and Unnamed crater, have exposure of mafic material on their floors (possibly along a weak zone from where magma may have leaked out). In contrast, the larger craters, Karpinskiy and Chappell, do not exhibit any distinct signatures of mafic material on their floors. These differences may be due to the different elevations of the pre-impact topography with a lower elevation region, allowing access to even smaller craters to magmatic zones while higher elevation regions may make it difficult for even larger craters to reach to the same zone.

Alternatively, it is conceivable that the intrusion depths of various magmatic bodies is variable across the lunar crust which would directly impact their sampling by craters. Shallow intrusions may be sampled by small craters. However, deeper intrusions may not be sampled by even large craters. Detailed evaluation of these various possibilities would provide key insights into the emplacement of these massive magmatic bodies in the lunar crust.

References:

Figure 2 Floor fractured crater Montgolfier P and an Unnamed crater located at the southern far end of the largest LGA. LROC WAC image.