SHALLOW SUBSURFACE INVESTIGATIONS OF SCHRÖDINGER BASIN'S PEAK RING USING GRAIL GRAVITY FIELD

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Introduction: We present an interpretation of the near surface (<20 km depth) composition of the Schrödinger Basin Peak Ring formation from density models based on short wavelength (≈ 17-90 km) gravity anomalies from the GRAIL (Gravity Recovery and Interior Laboratory) satellite. Schrödinger basin provides a pristine and unique location to study the crust of the Moon. The peak ring material has been excavated from within the crust and therefore a traverse across the crater shows a cross-section of the material within the crust. However, the depth from which the peak ring material has been excavated remains largely undetermined. Although we can observe the mineralogy on the surface of the peak ring (mostly pristine anorthosite [1]) from M^3 (Moon Mineralogy Mapper) spectra, we cannot directly observe subsurface mineralogy trends. Using GRAIL data, however, we can test subsurface mineralogy distribution scenarios based on the fact that plagioclase-rich anorthosite has a lower density than the olivine-rich troctolites or dunites which are expected to compose deeper crustal material.

A simple method to calculate a region's density is to exploit the fact that gravity data is highly correlated to topography. Assuming that the true density of the Moon is constant, its gravity field will be a scalar multiple of its theoretical gravity from topography, and thus can be calculated as the linear regression of the two quantities. However, we demonstrate that the density of the peak ring is significantly different from its surroundings, which invalidates density results from the linear regression approach. Thus, we create 2D gravity forward models that account for heterogeneous subsurface density.

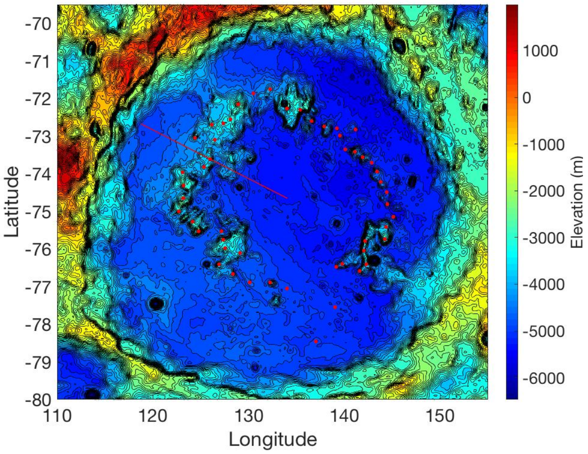


Figure 1: *LOLA topography data of Schrödinger Basin. The red dots indicate topographic high points along the 52 model profiles. The red line indicates the cross section displayed in Figure 3.*

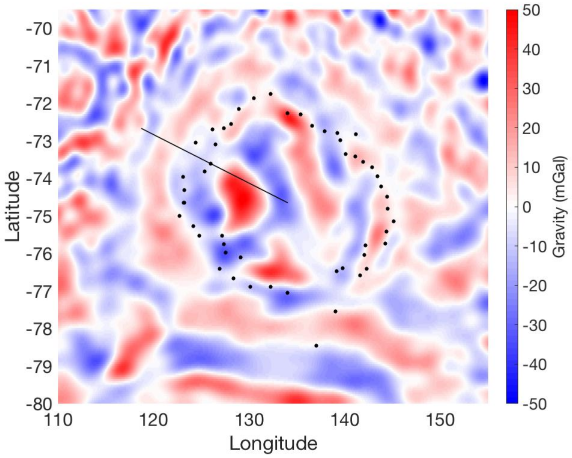
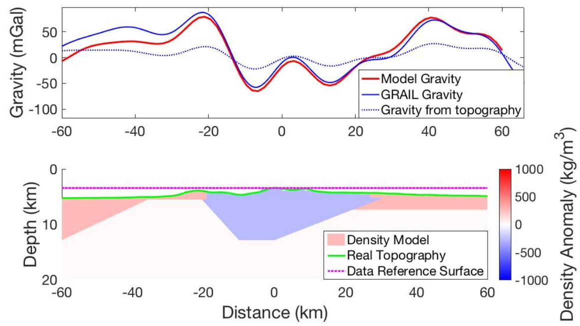


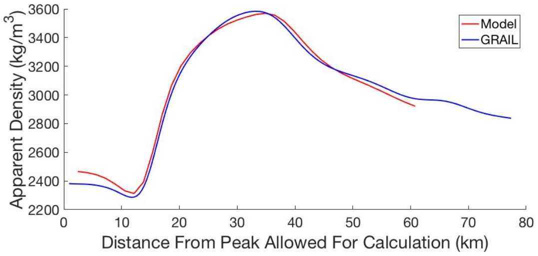
Figure 2: *Schrödinger Basin Bouguer gravity anomaly filtered for degrees 120-640 (≈ 17-90 km wavelength). The black dots indicate model profile centers and the line is the example profile shown in Figure 3*

Methods: To create the 2D models, we choose profiles crossing perpendicularly to the peak ring using topography data, shown in Figure 1, from LOLA (Lunar Orbiter Laser Altimeter). For each profile, we create a density map beneath the topography which consists of polygons and their corresponding density contrast values. An analytical solution to solve the gravity response from an arbitrary polygon can be found in [2]. To calculate the total gravity response of a model, the gravity from topography is multiplied by the average crustal density of the Moon, which is 2,550 kg/m^3 [3], and added to the sum of the response from each density contrast polygon. The best fitting density model for each profile after considering 23,000 different combinations of the polygons' shapes and density values are chosen based on minimizing the difference from the true and modeled gravity. An example model result is shown in Figure 3a. In total, 52 separate 120 km profiles were modeled, each radiating from a point near the center of Schrödinger basin. Their locations relative to the topography and filtered Bouguer gravity anomaly can be seen in Figures 1 and 2.

Results & Discussion: As predicted, the density values calculated from a linear regression of true gravity and gravity from topography are highly affected by subsurface density contrasts at this scale. The models showed that depending on the nature of the feature, the apparent density from a linear regression approach may



(a) *Density model relative to 2550 kg/m^3 and Gravity Response.*



(b) *Bulk density calculation considering increasing distance.*

Figure 3: *(a): Density model for a Schrödinger Basin peak ring cross section. The crater center is on the left. The red modeled gravity response closely matches the real gravity data in blue, suggesting that the peak ring in this location is less dense than the surroundings. (b): The calculated apparent density is is higher than any true density in the model, showing that a low density feature can cause a high apparent density in some circumstances.*

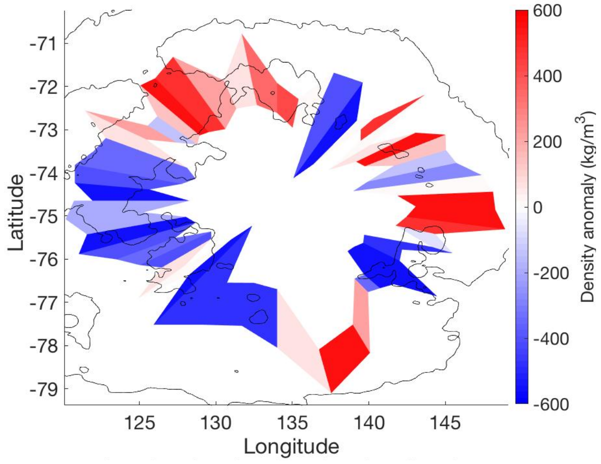


Figure 4: *Peak ring density values from best fitting models relative to 2,550 kg/m^3. The black line indicates a -4,500 m elevation contour to outline the peak ring's shape.*

be raised or lowered beyond reasonable values. Paradoxically, a low density anomaly can create a much higher apparent density than the surrounding high density material (see Figure 3b). Although the method is valid when abundant topographic variation is present and density contrast sizes are negligible compared to the total area in consideration, this is not the case for studying a localized feature such as the peak ring of Schrödinger basin. Thus we determined that gravity modeling is necessary to assess the peak ring's structure.

Figure 4 illustrates the shapes and density values for each of the 52 model profiles. On the west side, the peak ring material fits better if it is less dense than the surrounding material. For the 19 model profiles that covered the western portion of the peak ring, the average peak ring density is 2,335 kg/m^3 with a 95% confidence standard error of 132 kg/m^3. This is supported by visual interpretation of the Bouguer anomaly in Figure 2, where the peak ring on the west represents a band of low gravity. In contrast, the remaining 33 profiles have an average peak ring density of 2575 kg/m^3 with 95% confidence standard error of 140 kg/m^3.

The forward modeling results suggest the peak ring material has not been uplifted from a depth where a significant abundance of high density olivine or pyroxene was present. The grain density of a pristine anorthosite (≈2,750 kg/m^3) is less than deeper mantle rocks (≈3,000+ kg/m^3) [4], and when reasonable porosity is assumed ($< 20\%$ [5]), anorthosite must dominate the peak ring's composition to support our model results. This supports spectral observations from M^3 that show predominately pristine anorthosite at the peak ring formation's surface [1]. Of interest for future study, the lowest density region overlaps with the preexisting Amundsen-Ganswindt basin.

Conclusion: Our subsurface density analysis is consistent with past interpretations of M^3 spectra and impact simulation studies that suggest the peak ring of Schrödinger Basin has been uplifted from within a mid-crustal depth and is predominately plagioclase [6][1]. No high density anomalies were found within the peak ring that would be consistent with large quantities of higher density olivine or pyroxene that would indicate a mantle origin. In the future, more advanced 3D models and inversion techniques could recover higher resolution near surface density anomalies when combined with accurate geologic constraints [7].

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