GRAIL-IDENTIFIED GRAVITY ANOMALIES IN PROCELLARUM: INSIGHT INTO SUBSURFACE IMPACT AND VOLCANIC/MAGMATIC STRUCTURES ON THE MOON.

Ariel N. Deutsch[1], Gregory A. Neumann[2], James W. Head[1], and Lionel Wilson[1,3], [1]Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, RI 02912, USA, [2]NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA, [3]Lancaster Environment Centre, Lancaster University, Lancaster LA1 4YQ, UK (ariel_deutsch@brown.edu).

Introduction: Oceanus Procellarum on the Moon hosts four positive Bouguer gravity anomalies (PBGAs) that are similar in diameter (~100–120 km), gravitational amplitude (>100 mGal contrast), and shape (approximately circular in planform) (***Fig. 1***). However, these spatially associated PBGAs are characterized by distinct surface geologies. These four PBGAs are important in understanding the impact and volcanic/plutonic history of the Moon, in a region of elevated temperatures due to the Procellarum KREEP Terrane [1].

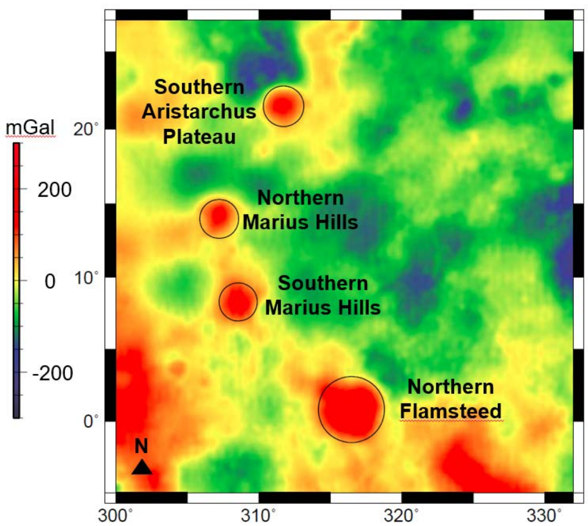

Fig. 1. *Four positive Bouguer gravity anomalies in Oceanus Procellarum. GRAIL-derived GRGM900c [2] Bouguer spherical harmonic solution to degree 660.*

The objective of our study is to constrain the subsurface structures that contribute to these four PBGAs through combined analysis of high-resolution GRAIL gravity data [3] and geologic analyses [e.g., 4].

Methodology: To obtain Bouguer anomalies, we remove the attraction of surface topography assuming a crustal density of 2800 kg/m^3 [5] that is characteristic of the nearside mare region. We use a bulk density of 3150 kg/m^3 for the maria, as was suggested for basalts of intermediate Ti-content [6]. We remove the longest wavelength variations in crustal structure, windowing the anomalies to spherical harmonic degrees 6-660, and explore a range of infill and intrusion density contrasts between 150 and 600 kg/m^3 to model the anomalies.

Gravitational modeling results: *Dike swarms:* The *Marius Hills* anomalies are characterized by a variety of volcanic morphologies [e.g., 7], consistent with the presence of multiple subsurface dikes [4]. Here, we model the crust as being occupied by ~25% volume of dikes (density contrast of 150 kg/m^3) to correspond to the GRAIL-derived signal. Given the volume (10,000 m^3) of the Marius Hills complex, at least 10 large-volume dikes are required [4]. The presence of a deep mantle reservoir is necessary in our forward model to correlate with the magnitude of the anomalies. A long-lived source in the mantle feeding multiple dikes is also consistent with the generation, ascent, and eruption of magma on the Moon [4].

Mantle upwelling: Mare-filled craters are consistent with the circular shapes of the anomalies and the topographic expression of *Southern AP* [8] and *N. Flamsteed* [9]. Coupling ~4 km of mare infill with ~5–7 km of mantle uplift produces the required density contrast for the PBGAs. This region of Oceanus Procellarum is characterized by relatively thin crust [10], which may have resulted in preferential mantle uplift following impacts of a size slightly lower than typical peak-ring basins [11].

Conclusions: The GRAIL data [3] presented here permit higher resolution gravity modeling than in previous studies [e.g., 6]. Coupled with geologic analyses [4], we determine that the four PBGAs (***Fig. 1***) are due to surface mare fill, subsurface dikes, and a deep density contrast, caused by either a magmatic/volcanic mantle reservoir or impact-related mantle uplift. Future work will include (1) analysis of the size of craters associated with PBGAs in anomalously thinner crust to further explore mantle upwelling in the Procellarum KREEP Terrane, and (2) geological analyses of the *Marius Hills* anomalies using the results of our forward gravitational modeling presented here.

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