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Does the gravity signature of lunar basins correlate with their ages?

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Abstract

The high-resolution gravity data provided by Gravity Recovery and Interior Laboratory (GRAIL) mission enables detailed modeling of subsurface structures of the Moon. We investigated the coherence between gravity signature of lunar impact basins and their relative ages. Since various factors seem to have major influence on the gravity signature no direct correlation to age could be found.

1. Introduction

Lunar impact basins provide insights into the early formation of terrestrial planets. By investigating their characteristics, we are able to learn more about the distribution, mass, and timing of the late accretion flux, as well as the state of the Moon during this time. The high-resolution gravity field, provided by the Gravity Recovery and Interior Laboratory (GRAIL) mission opens up new perspectives on the lunar impact basins and their formation. In combination with the topography obtained by the laser altimeter (LOLA) on board of the Lunar Reconnaissance Orbiter (LRO) mission, the characteristics of the basins described in former studies [1] may be revised. Utilizing the most recent data, we will set up a new inventory.

2. Is there a correlation between gravity signature and the age of lunar basins?

Based on studies by Neumann et al. [2] we investigated the correlation between the gravity signature of lunar basins and their relative ages. Bouguer gravity anomalies of lunar impact basins reveal a center peak, similar in size to the inner most topographic ring. Further out, a negative anomaly is found, which extends up to the rim crest (Fig. 1). The difference between the maximum gravity signal in the center and the lowest decrease towards the rim crest is defined as the Bouguer anomaly contrast. A correlation between this contrast and the size of an impact basin has been demonstrated [2].

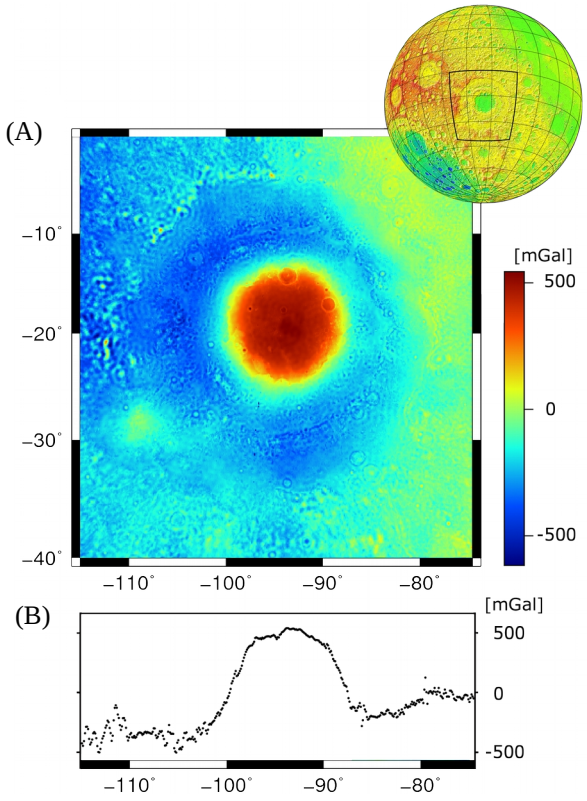

Figure 1: Orientale basin. (A) Top view of Bouguer gravity anomalies (B) Cross section of Bouguer gravity anomalies from west to east

We wish to test if the Bouguer anomaly contrast of impact basins correlates with their age: Since the

crust and the upper mantle of the Moon were much warmer in the past and thus less viscous, structures, formed during an impact, probably relaxed fast. For later events, when the interior was colder and therefore more viscous, these structures probably relaxed more slowly. We used the Bouguer anomaly contrast provided by Neumann et al. [2] and normalized them regarding the diameters of individual basins. Sorting the basins by the normalized contrast and comparing the order with basin ages determined from crater statistics [3] [4], no correlation could be found. In a next step, since the crustal thickness may have an influence on the thermal conditions and the speed of relaxation, we divide the basins in different groups, based on a crustal thickness map [5]. Also the separate groups did not show any correlation between gravity signature and the age of the impact basins.

3. Discussion and Outlook

We conclude that in addition to age, factors like a difference in thermal conditions or variations in thickness of mare fill must contribute to the gravity signature of lunar basins. Furthermore, the speed of relaxation is related to the basin dimension. The larger the diameter of an impact basin, the faster it relaxes [6]. All of these aspects proved the relaxation process to be more complex. Possible errors in estimated basin diameters, which were used for normalizing the Bouguer anomaly contrast, may also impact the outcome.

For a deeper understanding of the formation of lunar basins we will study basin candidates in more detail. We start our investigation with the working list of Wood [1]. Since the topography of lunar impact basins is often highly degraded due to subsequent cratering or erosion, especially older basins are difficult to recognize. The high-resolution gravity field offers new possibilities to identify lunar basins: besides the fact that subsurface structures mainly keep unaffected by processes occurring at the surface, during the basin formation mantle material was lifted up, causing a pattern of positive anomaly in the center, surrounded by a depression in gravity signature towards the rim crest (Fig. 1), where crustal material was removed [2]. This finding can be used for recognizing impact basins and defining their individual properties.

4. Conclusion

With the most recent data provided by GRAIL and LRO missions we are able to take a fresh look on lunar basins and their characteristics. High-resolution gravity data may help to identify basins and may give new constraints for impact simulations. No correlation is found between the gravity signatures of lunar basins and their relative ages.

Acknowledgments

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