Modeling the geophysical history of very large impact basins: The gravity anomalies of the Orientale basin

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Introduction

The gravity anomalies of lunar impact basins form via a combination of syn- and post-impact processes [1]. Modeling the formation of these anomalies therefore allows us to learn more about both the parameters of the impact and the geophysical environment in which the basin evolved. In this study, we look at the lunar Orientale Basin, which, at a diameter of ~960 km, is large enough that the curvature of the Moon may have affected its formation and evolution.

Observational Constraints

We use free-air and Bouguer gravity anomaly maps from NASA's dual Gravity Recovery And Interior Laboratory (GRAIL) spacecraft [3], and topography from the Lunar Orbital Laser Altimeter instrument aboard NASA's Lunar Reconnaissance Orbiter (LRO/LOLA) [4]. Our crustal thickness data comes from an inversion of GRAIL data [5]. All data is azimuthally averaged along small circles centered on Orientale (at 266.0ºE, 19.4ºS). We report both the mean and 2σ error in the plots below; the error arises from real asymmetry in the basin.

Modeling & Results

The entire history of the Orientale basin from the moment of impact through geophysical evolution can be explored by using a multi-stage modeling approach [1, 6, 7], shown below.

First, we simulate the basin-forming impact using the iSALE hydrocode [1, 6, 7], varying the pre-impact crustal thickness, subsurface thermal gradient, and the kinetic energy of the impactor as required. We then model the cooling and isostatic relaxation of the basin using the Abaqus finite-element modeling program, using the end state of the hydrocode model as the initial conditions for our model.

The models shown at left are a work in progress; we do not yet have a model that matches all of the constraints.

References & Acknowledgements