



Pre-impact crustal porosity and its effect on the gravity signature of lunar craters

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NASA's dual Gravity Recovery and Interior Laboratory (GRAIL) spacecraft have globally mapped the lunar gravity field at unprecedented resolution. Soderblom et al. [2015] made a comprehensive analysis of the residual and central uplift Bouguer gravity anomalies associated with more than 5200 lunar craters. There were two main observations that are related to the work presented here: 1) craters less than ~ 150 km in diameter (D) have a residual Bouguer anomaly (BA) that is near zero on average (although a negative trend is observed), but have both positive and negative anomalies that vary by approximately ± 25 mGal about the mean, and, 2) there is a transition at which the central uplift BA becomes positive and increases with D . Craters that are located in the maria and South Pole-Aitken (SPA) basin were excluded from the analysis because they tend to have more negative signatures than highlands craters. These gravitational signatures contrast with the invariably negative gravity anomalies associated with terrestrial craters. In this study, we investigate pre-impact porosity by modeling crater formation using the iSALE hydrocode, including a new approach to include dilatancy, to determine their effects on the gravity signature of craters. We calculated the BA for the simulations, but due to mantle uplift alone. We find that the magnitude of the BA increases with increasing porosity, and that variable initial porosity of the lunar crust can explain why craters on the Moon exhibit both positive and negative Bouguer anomalies. This can also explain the observed negative residual BA associated with craters formed in the lunar maria and SPA (and associated melt sheet) because they are typically less porous than the highlands crust. Gravity anomalies due to mantle uplift reproduce the observed transition from zero to a positive central uplift BA , which coincides with the morphological transition from complex craters to peak-ring basins.