THE EFFECT OF POROSITY AND DILATANCY ON THE GRAVITY SIGNATURE OF CRATERS ON THE MOON.

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Introduction and Background: NASA's dual Gravity Recovery and Interior Laboratory (GRAIL) [1] spacecraft have, for the first time, globally mapped the lunar gravity field at high-resolution; this has enabled the study of craters of all sizes and ages. Soderblom et al. [2] calculated the residual Bouguer anomaly (interior to the crater floor) for ~2700 craters 27-184 km in diameter (*D*). They found that craters smaller than ~100 km have a residual Bouguer anomaly that is essentially 0±50 mGal, there is a transition for *D*~100–150 km, and craters larger than 184 km have a positive residual Bouguer anomaly. We note that there is a morphological transition from complex crater to peak-ring basin that occurs at *D* ~140–170 km [3,4].

Porosity is a measure of void space in a material, and dilatancy is the creation of pore space during shear deformation of rock material. A large variation in porosity is observed globally for the Moon [5], and both porosity and dilatancy affect the gravity signature of craters. In this study, we use the iSALE hydrocode [6] with a new approach to include dilatancy [7] to investigate the dependence of crater morphology and gravity signature on impactor size and pre-impact target porosity.

Modeling and Methods: We use the following model parameters in our simulations: an equation of state for granite in the crust and for dunite in the mantle, a melt temperature of 1373 K, an impact velocity of 15 km/s, a surface gravity of 1.62 m/s^2, and a thermal gradient of 5 K/km. We use the strength parameters for gabbroic anorthosite for the crust and dunite for the mantle [8]. The impactor sizes range from 6–30 km, and produce craters that are between 86–450 km in diameter for porosities of 0, 6.8, and 13.6%. The free-air and Bouguer gravity anomalies associated with these craters are calculated from our models and are compared to gravity data from GRAIL [1,2].

Results and Conclusions: We find that porosity has the greatest effect on the gravity signature of lunar craters and can explain the observed ±50 mGal scatter in the residual Bouguer anomaly. We investigated variations of impact velocity, crustal thickness, and dilatancy angle; we found that these do not affect the gravity as significantly as porosity does. We find that the crater diameter at which mantle uplift dominates the crater gravity is dependent on porosity, and that it occurs at a crater *D* that is close to the complex crater to peak-ring basin transition.

References: [1] Zuber M. T. et al. 2013, *Science* 339**,** doi: 10.1126/science.1231507. [2] Soderblom J. M. et al. 2014. Abstract #1777. 45th Lunar & Planetary Science Conference. [3] Baker D. M. H. et al. 2012. *Journal of Geophysical Research* 117:E00H16, doi:10.1029/2011JE004021. [4] Bray V. J. et al. 2012. *Geophysical Research Letters* 39:L21201. [5] Wieczorek M. A. et al. 2013. *Science* 339**,** doi: 10.1126/science.1231530. [6] Wünnemann K. et al. 2006. *Icarus* 180:514-527. [7] Collins G. S. 2013. Abstract #2917. 44th Lunar & Planetary Science Conference. [8] Potter R. W. K. et al. 2013. *Journal of Geophysical Research* 118:963-979.