Poster #146

The Effects of Porosity on Lunar Crater Formation and the Transition from Complex Crater to Peak Ring Basin Morphology

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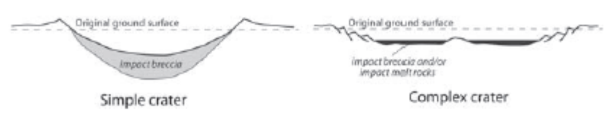


Figure 3 from Collins et al. [2012].

Introduction and Background

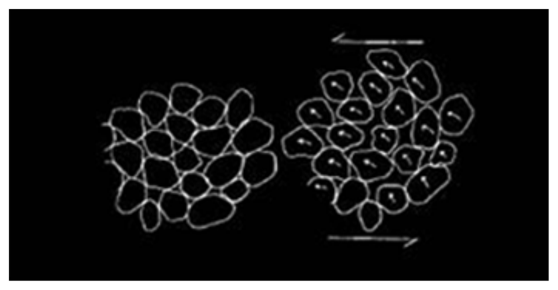
The observed transition from simple to complex crater morphology is driven by gravitational collapse of the transient crater. The mechanism that causes the transition from complex to peak-ring crater morphology is still debated.

Melosh [1979] was the first to put forward the idea of Acoustic Fluidization (AF), which is the temporary behavior of fractured rock as a viscous fluid.

It is triggered by intense, short-wavelength vibrations within the target and it occurs mostly within the crater collapse phase of the impact process.

We systematically investigate this change in crater morphology using the iSALE [Collins et al., 2004; Wünneman et al., 2006].

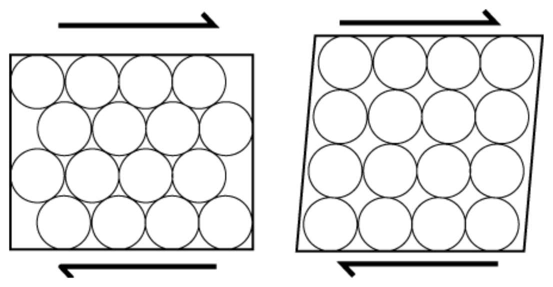
Porosity and Dilatancy



Porosity is a measure of the void spaces in a material. It is given by the following equation:

$$\phi = \frac{V_v}{V} = 1 - \frac{\rho_{bulk}}{\rho_{grain}}$$

Where ϕ is the density, V is total volume, V_v is void volume, and V_s is solid volume.



Dilatancy is the creation of pore space during shear deformation of rock material.

The distension is related to porosity by the following equation:

$$\alpha = \frac{1}{1-\phi} = \frac{V}{V_s}$$

Both of these will affect the gravity signature.

Methodology

We use ANEOS for a 35 km thick granite crust, a dunite mantle, a 6 km dunite impactor at 15 km/s, a temperature gradient of 5 K/km, and a melt temperature of 1373 K.

We systematically vary the AF parameters, γ_T and γ_η, to understand how they affect crater morphology.

γ_T is a scaling factor that controls the amount of time the target is subject to AF, and is related to the decay time by the following equation [Wünnemann & Ivanov, 2003]:

$$T_{dec} = \gamma_T (r/c_s)$$

γ_η is a scaling factor that is related to the viscosity by the following equation [Wünnemann & Ivanov, 2003]:

$$\eta = \gamma_\eta (c_s r \rho)$$

The results are compared with specific craters; we look at both topographic features and gravity data from NASA's Gravity Recovery And Interior Laboratory (GRAIL) mission.

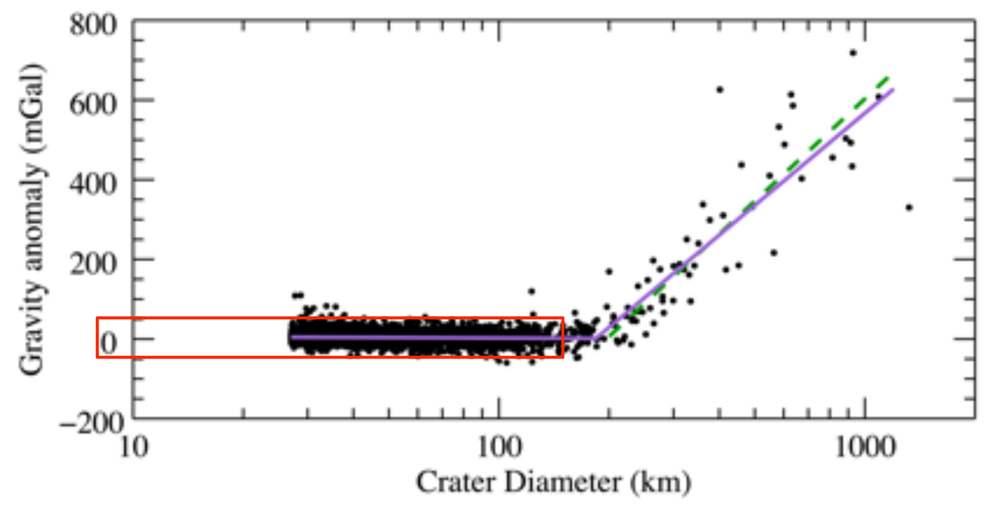
Results and Conclusions

The amplitude of the Bouguer anomaly decreases with decreasing porosity, and better matches the observed gravity for Tycho.

The effects of porosity and dilatancy on impact dynamics leads to a large variation in the gravity signature of complex craters.

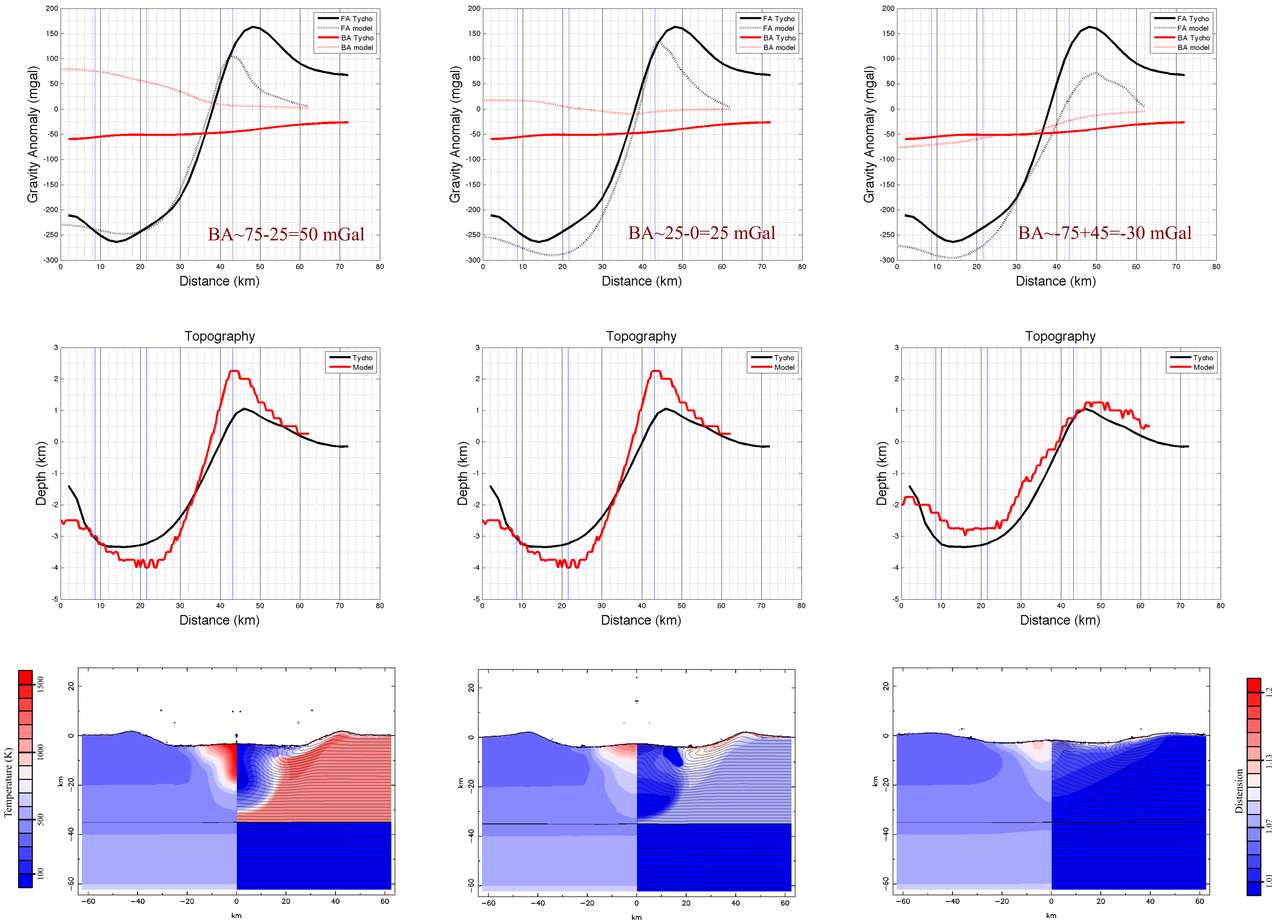
A variation of target porosity may explain the observed +/-50 mgal variation in the observed Bouguer anomaly for complex craters (see figure at right).

Mean Bouguer Anomaly

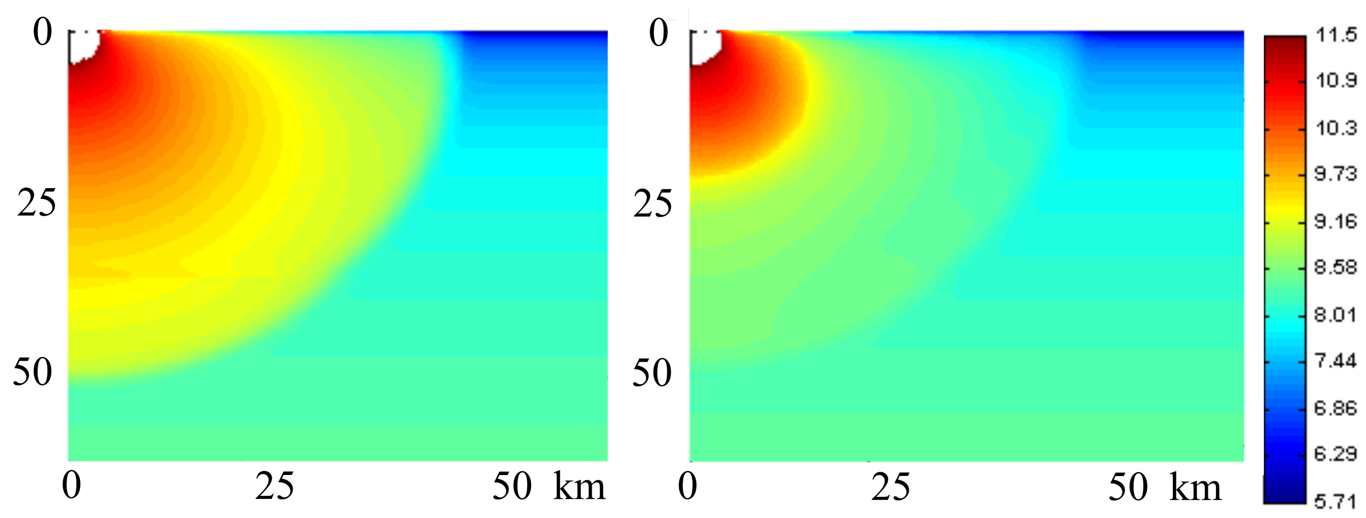


The mean Bouguer anomaly [Soderblum et al., 2014] is the mean from 0-0.2D minus the mean from 0.5-1D.

13.6% porosity | **6.8% porosity** | **No porosity**



Plots of free-air (black) and Bouguer (red) gravity anomalies (top), topography (middle), and temperature & distention (bottom) for porosities of 13.6% (left, γ_β=300, γ_η=0.02), 6.8% (center, γ_β=300, γ_η=0.02), and 0% (right, γ_β=350, γ_η=0.09).



Shock wave attenuation

Contour plots in the x-y plane of the peak shock pressure after 12 s at the position of the tracers after 0.5 after the impact for targets with nonporous (left) and porous (right). The color bar is in log(Pa).

Acknowledgements

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References: Morgan, J. V. et al (2000) EPSL, 183, 347-354. Collins, G. S. et al. (2002) Icarus, 157, 24-33. Collins et al. (2004) MPS 39, 217-231. Wünneman et al (2006), Icarus, 180, 514-527. Melosh (1979) JGR, 84, 7513-7520. Wünnemann K. and Ivanov B. A. (2003) PSS, 51, 831-845. Zuber et al. (2012), Science, doi:10.1126/science.1231507. Soderblum, J. M., et al. [2014] LPSC, abstract #1777.