Impact Processing of Planetary Crusts

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Recent high-resolution mapping of the Moon's gravity field by NASA's GRAIL spacecraft reveals that the lunar crust has surprisingly high bulk porosity [1]. The correlation of strong lateral variations in porosity with impact craters [Fig. 1] suggests that impact bombardment has pervasively fractured the Moon's crust [2]. As porosity has a large effect on thermal conductivity and permeability, understanding why and when the Moon acquired its crustal porosity and how this porosity evolved is crucial to unravelling the Moon's thermal and magmatic evolution.

The aim of this project is to use a recently developed numerical model for the generation of impact-related porosity [3] to characterise the porosity signature of lunar impact craters, at a range of scales, as a function of preimpact target properties. Model results will be tested against GRAIL gravity data and then used to develop a statistical model of lunar crustal porosity evolution via sequential impacts that replicate the Moon's crater size-frequency distribution. The final model output will be compared with GRAIL-derived porosity maps (e.g., Fig. 1) to constrain the evolution of porosity in the lunar crust.

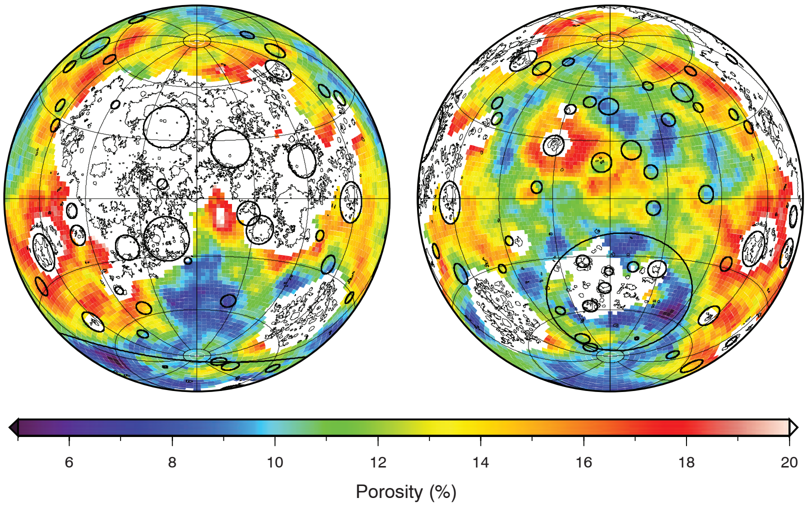

Figure 1 *Porosity of the lunar crust, using bulk density from GRAIL and grain density from sample and remote sensing analyses [1].*

Impact cratering is a fundamental solar system process that shapes, modifies and redistributes the crust of all planetary surfaces, not just the Moon. We will also examine the efficiency of porosity generation on other planetary surfaces with different gravities and thermal states to constrain likely interplanetary variations in crustal porosity. As porosity and permeability modulate groundwater flow, as well as chemical and mechanical reaction rates that drive many geological and ecological processes, impact-related fragmentation during epochs dominated by impact bombardment may have important consequences for hydrological, chemical and biological evolution of the primitive crusts of Earth and Mars.

The successful candidate will join, and be supported by, a vibrant and dynamic research group with world-class expertise modelling geophysical flows. They will be trained in state-of-the-art numerical methods for simulating hypervelocity impact, impact physics and high-performance computing. The candidate will have the opportunity to develop their career and profile by presenting at international conferences and publishing in high impact journals. Candidates for PhD positions should have a good mathematical background and a good degree in an appropriate field such as earth science, physics, mathematics, computer science or engineering.

[1] Wieczorek, M.A., et al., 2013. The Crust of the Moon as Seen by GRAIL. Science 339, 671–675. http://dx.doi.org/10.1126/science.1231530

[2] Soderblom, J.M., et al., 2015. The fractured Moon: Production and saturation of porosity in the lunar highlands from impact cratering. Geophys. Res. Lett. 42, 2015GL065022. http://dx.doi.org/10.1002/2015GL065022

[3] Collins, G.S., 2014. Numerical simulations of impact crater formation with dilatancy. J. Geophys. Res. Planets 2014JE004708. http://dx.doi.org/10.1002/2014JE004708

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