MODELLING THE SOUTH POLE-AITKEN BASIN IMPACT. G. S. Collins[1], R. W. K. Potter[1], D.A. Kring[2], W. S. Kiefer[2], P. J. McGovern[2], [1]Impacts and Astromaterials Research Centre, Dept. Earth Science and Engineering, Imperial College London, London, SW7 2AZ, UK, ross.potter04@imperial.ac.uk; [2]Lunar and Planetary Institute, 3600 Bay Area Blvd, Houston, TX, 77058, USA

Introduction: The 2500km diameter [1] South Pole-Aitken (SPA) basin is the largest and oldest impact structure on the Moon. The scale of the impact suggests that normally inaccessible lunar material, such as deep crust or mantle, was excavated or uplifted to the lunar surface, making SPA a strong candidate for possible sample return missions [2]. Analysis of originally deep-seated material would help further our understanding of planetary differentiation and early Solar System processes.

Crater scaling arguments [3] and previous numerical modeling of giant impacts on the Moon [4, 5, 6] suggest that an SPA-scale impact would bring impact-processed mantle material to the lunar surface either by ejection or by uplift as part of the rebounding crater floor. SPA-scale impact models also predict the production of a large melt pool underneath the central crater basin. Many spectroscopic studies of the basin have been undertaken [7, 8, 9], with [8] suggesting that the basin floor has a composition best described as a mixture of lower crustal and mantle material. Gravity data, tied to constraints on crustal structure from Apollo seismic data, suggest that the SPA basin is underlain by a ~10-30km-thick layer, less dense than the mantle, which thins toward the crater center [10]. Here, we use these observational constraints to refine hydrocode simulations of the SPA impact based on model predictions of the volume, dimensions and final location of the melt pool and crustal deformation.

Methods: We used the two-dimensional iSALE hydrocode [12,13] to simulate vertical impacts at 10-20 km/s of asteroids 100-200-km diameter into a spherical Moon with a resolution of 2.5-5 km per cell (20-80 CPPR). The Moon was modelled as a three-layer globe, 1750 km in radius (slightly larger than the true radius of 1737 km), consisting of a 50-km thick crust, a 1350-km thick mantle and a 350-km radius core. ANEOS-derived equation of state tables for dunite [14] and iron [15] were used to represent the mantle and core, respectively. A Tillotson equation of state, with parameters determined for gabbroic anorthosite [16], was used to model the crust. Dunite was also used to represent the impacting asteroid. Strength and thermal model parameters for both dunite and gabbroic anorthosite were derived from fits to experimental data [17, 18].

Self-consistent initial gravity, pressure, strength and density fields within the Moon were computed based on a prescribed radial thermal profile, representing lunar conditions at the time of impact. As a first approximation, the temperature in the Moon was assumed to increase with depth by 25K/km in the crust and upper mantle, and follow an adiabatic temperature gradient in the mantle and core, pinned at a temperature of 1740K at a depth of 560km.

Results: Numerical model results show two distinct zones created by the impact. The inner zone contains a deep pool of mantle material melted by shock heating and decompression melting. This zone is approximately equal in diameter to the transient crater and contains little, if any, crustal material. In the outer zone, which extends from the approximate location of the transient crater rim to the final crater rim, crustal material underlies mantle material heated above the solidus that is exhumed to the lunar surface by both ejection and run-off from the central uplift.

Discussion: The compositional anomaly at SPA is approximately equal to its topographic diameter (2500 km). Moreover, analysis of Clementine data suggests that later impacts in the outer part of the SPA basin have exposed buried upper crustal anorthosite; whereas, there is no evidence of upper crustal anorthosite exposures within an inner diameter of 1260 km. Assuming the compositional anomaly is related to the presence of (partially) molten upper mantle on the lunar surface, our numerical models are in best agreement with observations for an SPA impact energy of about $4\text{-}5 \times 10^{26}$ J.

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