Thermal and Chemical Consequences of Large Impacts on the Lunar Interior

#2180

Matt J. Jones[1] (matthew_jones@brown.edu) and Alexander J. Evans[1]
[1]Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, RI 02912

BROWN

Objective

Investigate interior effects of the lunar South Pole-Aitken (SPA) impact and its relationship with the origin of the antipodal Procellarum KREEP Terrane (PKT)[1] (Fig. 1).

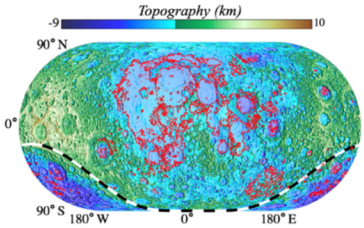

Figure 1: Lunar map of topography with surface volcanic deposits outlined in red[2]. The South Pole–Aitken (SPA) basin is delineated in black and white. Modified from [3].

Background

- The SPA impact likely occurred within 200 Myr after the possible global lunar magma ocean[3-5].
- The SPA impact is suggested to have induced migration of magma ocean residuum (urKREEP)[5-7] and caused antipodal seismic effects[8, 9], contributing to PKT formation.

Model

- CitcomS (a 3D thermochemical evolution code)[10, 11] is combined with a shock heating model from [12] to simulate an SPA-sized impact in a laterally homogeneous Moon. **Nominal lunar model parameters**[13] and **various initial thermal states** are used (Fig. 2).
- Mantle temperature is limited to 1850 K.

Results

- In all cases, the impact-heated mantle material rises and **spreads laterally beneath the surface**, which is accommodated by an upwelling beneath the impact site (Fig. 2).

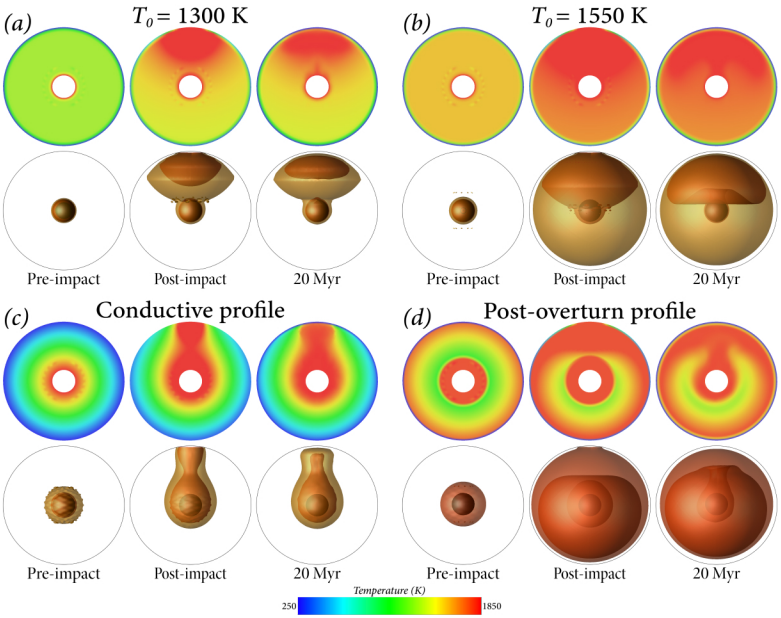

Figure 2: Thermal state of the lunar interior before, immediately after, and 20 Myr after simulating an SPA-sized impact. Irregularity near the core is an initial perturbation given to each thermal profile. Bottom of **(a-c)** shows temperature isosurfaces at 1600 K (outer) and 1800 K (inner) with a static sphere representing the core. Initial temperature profile in **(d)** is adapted from [4, 14] and all isosurfaces are at 1800 K.

Implications

- Post-impact lateral advection of subcrustal material from the region of SPA may provide a mechanism to **transport urKREEP**.
- Long-term behavior may **concentrate urKREEP in the PKT** by direct transport to the impact antipode or by redistribution of farside urKREEP deeper into the mantle.

Future Work

- Study long-term (200 Myr+) effects of impacts.
- Investigate effects of an Imbrium-sized impact and multiple consecutive impacts.
- Consider detailed profiles for temperature, density, viscosity, and radiogenic heating.
- Incorporate models to track migration of urKREEP.

References

[1] Jolliff, B. L., et al. (2000) *JGR, 105*, 4197–4216. [2] Hiesinger, H. et al. (2011) *LPSC XLV*, 2861. [3] Evans, A. J., et al. (2018) *JGR: Planets, 123*, 1596–1617. [4] Elkins-Tanton, L. T., et al. (2011) *Earth Planet. Sci. Lett., 304*, 326–336. [5] Warren, P. H. (1985) *Ann. Rev. Earth Planet. Sci., 13*, 201–240. [6] Arkani-Hamed, J., and Pentcovic, A. (2001) *JGR, 106*, 14,691–14,703. [7] Jutzi, M., and Asphaug, E. (2011) *Nature, 476*, 69–72. [8] Schultz, P. H., and Crawford, D. A. (2011) *GSA Special Paper 477*, 141–159. [9] Williams, D. A., and Greeley, R. (1994) *Icarus, 110*, 196–202. [10] Zhong, S., et al. (2000) *JGR, 105*, 11,063–11,082. [11] Tan, E., et al. (2006) *Geochem., Geophys., Geosyst., 7*, Q06001. [12] Watters, W. A. et al. (2009) *JGR, 114*, E02001. [13] Lemoueffle, M., et al. (2018) *JGR: Planets, 123*, 3144–3166. [14] Evans, A. J., et al. (2014) *JGR: Planets, 119*, E004694.