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A lower mantle origin for the young mare basalts returned by Chang'e-5

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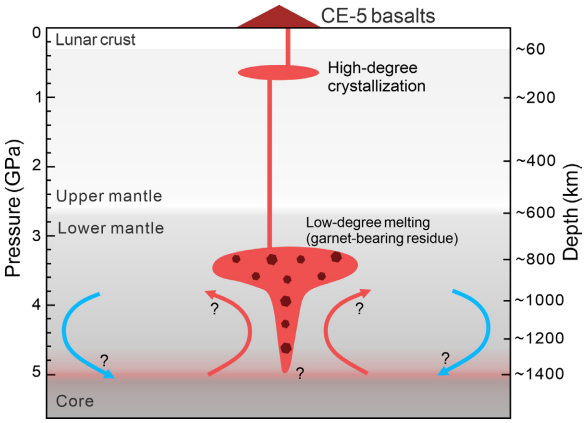

The samples returned by the recent Chang'e-5 (CE-5) mission confirmed active lunar magmatism at least two billion years ago [1, 2], which challenged the long-held view of an inactive Moon through much of its lifespan. However, the origin of this extended lunar magmatism remains mysterious. To understand the generation of these young mare basalts on the cooling Moon, various mantle source models have been proposed for CE-5 basalts. These include orthopyroxene-rich cumulates with contributions from ilmenite-bearing cumulates (IBC), and clinopyroxene-rich cumulates, either with or without contributions from IBC. Notably, estimates for the CE-5 mantle melting depth, though variable, generally fall in the upper mantle, ranging from ~4 kbar (<100 km) to ~2.5 GPa (~550 km) [3-5]. However, we note that the CE-5 samples show substantial fractionation between middle and heavy rare earth elements, which is rarely observed in the Apollo samples. We confirm this fractionation as a primary magmatic signature with measurements of the pyroxenes. By coupling phase equilibria modeling and element partitioning calculations, we show that this fractionation can only be produced if the magma source contained ~5-10 wt.% garnet, at a minimum depth of ~700 km (Fig. 1). We suggest the primary CE-5 magma originated from the lunar lower mantle. One possibility is that convection may have been sustained in the deep lunar mantle until at least two billion years ago. Alternatively, the CE-5 magma may have tapped the melt-bearing layer near the core indicated by recent seismic observations.

References:

[1] Q.-L. Li *et al.*, Two-billion-year-old volcanism on the Moon from Chang'e-5 basalts. *Nature* **600**, 54-58 (2021).

[2] X. Che *et al.*, Age and composition of young basalts on the Moon, measured from samples returned by Chang'e-5. *Science* **374**, 887-890 (2021).

[3] B. Su *et al.*, Fusible mantle cumulates trigger young mare volcanism on the cooling Moon. *Science Advances* **8**, eabn2103 (2022).

[4] B. Luo *et al.*, The magmatic architecture and evolution of the Chang'e-5 lunar basalts. *Nature Geoscience* **16**, 301-308 (2023).

[5] C. Wang *et al.*, A shallow (<100 km) ilmenite-bearing pyroxenitic source for young lunar volcanism. *Earth and Planetary Science Letters* **639**, 118770 (2024).