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Insights into the Mantle Source of the Chang'e 5 Lunar Basalts from Experiments and Modeling

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Despite its small size, the Moon produced basaltic magmas until as recently as 10's of millions of years ago. However, until the CNSA's Chang'e 5 mission returned basalts dated to ~1.96 Ga, the youngest sampled lunar igneous rocks were ~3 byr old, leaving most of the Moon's history out of reach for detailed petrology and geochemistry. Here we use high-P-T experiments and phase equilibrium modeling to investigate the mantle source region of the Chang'e 5 basalts to understand the types of mantle rocks and sources of heat that have contributed to sustained lunar igneous activity.

The Chang'e 5 basalts represent Fe-rich, moderate TiO_2 magmas. Based on the compositions of basaltic fragments and their constituent minerals that have been reported thus far by [1], we selected basalt fragment 103-001,005. The composition of this sample both reasonably approximates a liquid composition and is in equilibrium with the most Mg-rich olivine reported from any sample. The equilibrium P-T phase diagram for this composition was calculated using the Perple_X program, and a synthetic mix of this composition served as the starting composition for near-liquidus piston cylinder experiments between 0.5 and 2 GPa thus far.

Our initial results from both experiments and Perple_X indicate that the Chang'e 5 basalt has a near-liquidus region where olivine, ilmenite, plagioclase, and pyroxene saturate in close proximity at less than 1 GPa (~420 km) and likely close to 0.5 GPa (~200 km). Either CPX or ilmenite is the liquidus phase at 1 GPa and Perple_X, while over-predicting ilmenite stability, predicts garnet as the liquidus phase at 2 GPa, implying another multiple saturation point between 1 and 2 GPa. The low Mg# and LREE enrichment in the Chang'e 5 basalts could lead to the interpretation that these liquids have experienced low pressure fractional crystallization. However, given the isotopic indication of the lack of direct KREEP involvement, a shallow mantle source becomes equally plausible due to the ability of KREEP in the crust act as a shallow mantle heat source. Additional experiments will further constrain the possible source of the Chang'e 5 basalts.

[1] Tian et al. (2021) *Nature, 600, 59-63*