

EXPERIMENTAL STUDY OF THE EVOLUTION OF THE ANCIENT LUNAR MANTLE  
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Basalts are key probes into the interiors of rocky parent bodies because they provide insights about various physicochemical processes and characteristics over time, including melting processes and temperatures, source region mineralogy, and mantle/crustal geochemistry. Lunar mare basalts have yielded a wealth of information on the thermochemical evolution of the Moon. The largest pulse of magma extrusion from the lunar interior occurred between 3.6 and 3.9 Ga, with a second, weaker pulse between 3.3 and 3.5 Ga (Borg et al., 2019). However, there is only minimal record preserved of lunar volcanism that occurred before ~3.8 Ga; thus, insights into the lunar mantle before this time are difficult to constrain. These pre-3.8 Ga basalts are referred to as cryptomare, and they are minimally recognized in our lunar sample collection, although numerous regions of cryptomare have been identified through remote sensing (e.g., Whitten and Head 2015). Further, pre-3.8 Ga magmatism consists of a variety of magmatic suites: Mg-suite, Alkali-suite, cryptomare, and felsites. The relationships among these pulses of magmatism and associated early mantle events (e.g., magma ocean cumulate overturn, giant impacts) are unknown.

In order to study the petrogenesis of ancient (pre-3.8 Ga) volcanism, we conducted melting and crystallization experiments using synthetic powdered mixtures with the bulk composition of a putative cryptomare clast from lunar meteorite Kalahari 009 to construct a phase diagram. The phase diagram will be completed up to 2 GPa and will map out the phase assemblage from the liquidus to the solidus. By comparing the resulting liquid lines of descent with other low-Ti and high-Ti basalt phase diagrams (e.g., Longhi, 1992), we will better understand how the petrogenesis of ancient basaltic compositions, as represented by Kalahari 009, compares with that of main-pulse mare basalts and what it means for early lunar volcanism. Furthermore, our results could provide important constraints for thermodynamic modeling of interactions between mantle melts and the ancient lunar crust during the first few hundred million years of lunar history.

Borg, L. E., Gaffney, A. M., Kruijer, T. S., Marks, N. A., Sio, C. K., & Wimpenny, J. (2019). Isotopic evidence for a young lunar magma ocean. *Earth and Planetary Science Letters*, 523, 115706. Longhi, J. (1992). Experimental petrology and petrogenesis of mare volcanics. *Geochimica et Cosmochimica Acta*, 56(6), 2235-2251. Whitten, J. L., & Head, J. W. (2015). Lunar cryptomaria: Physical characteristics, distribution, and implications for ancient volcanism. *Icarus*, 247, 150-171.