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Insights into KREEP-free volcanism on the Moon from Lunar Meteorites

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Returned lunar samples by the Apollo, Luna, and Chang'E 5 missions have provided valuable insight into the chemical and thermal history of the Moon [1]. A general understanding is that mare basalts were formed by partial melting of the lunar mantle in part due to radioactive heating from KREEP while mixing with it [2]. Alternatively, some lunar basalts may have a KREEP-free origin [3,4]. In this study, we examined lunar basaltic meteorite Asuka-881757 and other ~3.9 Ga KREEP-free meteorites to understand the early magmatic evolution of the Moon. These KREEP-free basaltic meteorites are coarse grained and Fe-rich (Mg# ~40-36) with pyroxene and plagioclase as primary constituents. Using the presence of stable phase fields of different minerals at variable *P-T* along with petrographic observations, we constrain the minimum depth of emplacement of KREEP-free parental magmas within a magma chamber between 60-100 km. KREEP-free basalts away from the PKT region, e.g., A-881757 vis-à-vis YAMM, underwent fractional crystallization, and later erupted near the surface forming coarsest crystals at a slow cooling rate, in comparison to that of Apollo mare basalts. The applied thermodynamic modeling suggests these older KREEP-free basalts were generated through low degree partial melting of a shallow pyroxene-rich mantle, distinct from later (3-8-3.3 Ga) KREEP-bearing Apollo mare basalts, suggesting a fundamental change in lunar melting processes [5]. Our study provides insights into the early thermo-chemical evolution of the Moon, and highlights the importance of KREEP-free basalts in understanding partial melt mechanisms in the lunar interior. Crystallization of the KREEP-free YAMM meteorites seem consistent with the hidden cryptomare basalts close to the Moon's surface, which are yet to be chemically explored.

References:

[1] Shearer, C. K. et al., (2006), *Rev. Mineral. Geochem.***60**, 365–518.

[2] Neal, C. R. & Taylor, L., (1992), *Geochim. Cosmochim. Acta* **56**, 2177–2211

[3] Borg, L. E. et al., (2009), *Geochim. Cosmochim. Acta* **73**, 3963–3980.

[4] Tian, H. C. et al., (2021), *Nature* **600**, 59–63

[5] Srivastava, Y. et al., (2022), *Nat. Comm.* **13**, 7594