

Material Migration in Early Moon Constrained by Petrogenesis of KREEP Basalts

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The last vestiges of the lunar magma ocean differentiation, KREEP (also known as urKREEP), were extremely enriched in potassium (K), rare earth elements (REE), phosphorus (P), and radioactive heat-producing elements such as thorium (Th) and uranium (U). KREEP-rich lunar samples show unique geochemical signatures and provide critical clues to trace the materials migration inside the Moon. However, the petrogenesis of KREEP-rich lunar samples, particularly the timing and the mechanism that their parent magma acquires KREEP components remains enigmatic. Here, we present the geochemical characteristics and formation mechanism of KREEP-rich materials found in Chang'e-5 regolith. The source rock is constrained to be the KREEP basalt located at the northwestern rim of the Imbrium basin and was transferred to the sampling location approximately 3.3 billion years ago. Thermodynamic modelling on their parent magma petrogenesis indicates that a minimum proportion of 1–5 wt% KREEP was incorporated into the lunar mantle cumulates down to ~200 km depth. The distribution of KREEP-rich basaltic samples along both the rim of Imbrium basin and the border of Procellarum KREEP Terrane supports a strong correlation between the KREEP related magmatic activities and the tectonic movements. This investigation reveals that KREEP component has descended deep into the mantle before being recycled back to the lithosphere during the early history of the Moon. The redistribution and heterogeneous preservation of heat-producing elements contained within KREEP-rich materials may elucidate the various thermal states and diverse crustal building-modification processes of the Moon.