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Eu anomalies in lunar plagioclase reflect secondary processing by subsolidus reequilibration and introduction of a KREEP component

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The anorthositic lunar crust, predominantly consisting of anorthites characterized by significant positive Eu anomalies, is an important product of lunar magma ocean (LMO) solidification. We calculated REE and Eu distributions in lunar anorthosites according to recent experimentally-determined fractional crystallization experiments [e.g., 1,2]. Applying the plagioclase-melt Eu and REE partitioning models of [3] and [4], and making lunar-relevant fO_2 and LMO bulk composition assumptions, we find that crystalized plagioclase exhibit lager Eu anomalies and flatter REE patterns (i.e., lower Ce/Sm) than Apollo samples [5]. In this study, we explore possible causes of this phenomenon.

We first considered remelting of the anorthosites. We calculated REE abundances of solid in equilibrium with instantaneous fractional melts. Although the recrystallized plagioclases show an elevated Ce/Sm, these scenarios exacerbate the Eu anomaly discrepancy. We explored *T*- and fO_2 dependent closed-system subsolidus reequilibration, which expands the space of Ce/Sm as well as Eu anomalies, however, the variation of Eu anomalies is still limited and cannot fit many natural samples under fO_2 conditions relevant to a reduced Moon. We then tested subsolidus reequilibration after addition of a chondritic component, which also failed to reproduce the natural distributions. Finally, we explored subsolidus reequilibration after addition of a KREEP component.

Addition of minor KREEP reduces Eu anomalies and elevates Ce/Sm ratios, reproducing variations in the natural samples. The proportion of KREEP required depends on the bulk LMO composition assumed. Addition of a KREEP component implies secondary magmatic processing of the lunar anorthosites, perhaps associated with Serial or Mg-suite Magmatism after a cumulate mantle overturn event.

[1] Rapp & Draper (2018) *MAPS* **53**, 1452-1455. [2] Charlier *et al* (2018) *GCA* **234**, 50-69. [3] Dygert *et al* (2020) *GCA* **279**, 258-280. [4] Sun *et al* (2017) *GCA* **206**, 273-295 [5] Pernet-Fisher *et al* (2019) *GCA* **266**, 109-130.