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Expanding the REE partitioning database for lunar materials

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Positive europium anomalies are ubiquitous in the plagioclase-rich rocks of the lunar highlands, and complementary negative Eu anomalies are found in most lunar basalts. This is taken as evidence of a large-scale differentation event, with crystallization of a global-scale lunar magma ocean (LMO) resulting in a plagioclase flotation crust and a mafic lunar interior from which mare basalts were later derived. However, the extent of the Eu anomaly in lunar rocks is variable. Some plagioclase grains in a lunar impact rock (60635) have been reported to display a negative Eu anomaly, or in some cases single grains display both positive and neagtive anomalies [1]. Cathodoluminescence images reveal that some crystals have a negative anomaly in the core and positive at the rim, or vice versa, and the negative anomalies are not associated with crystal overgrowths. Oxygen fugacity is known to affect Eu partitioning into plagioclase, as under low fO_2 conditions Eu can be divalent, and has an ionic radius similar to Ca^{2+} - significant in lunar samples where plagioclase compositions are predominantly anorthitic. However, there are very few experimental studies of rare earth element (REE) partitioning in plagioclase relevant to lunar magmatism, with only two plagioclase D_{Eu} measurements from experiments using lunar materials [2,3], and little data in low fO_2 conditions relevant to the Moon.

We report on REE partitioning experiments on lunar compositions. We investigate two lunar basaltic compositions, high-alumina basalt 14072 and impact melt breccia 60635. These samples span a large range of lunar surface bulk compositions. The experiments are carried out at variable fO_2 in 1 bar gas mixing furnaces, and REE are analysed by and LA-ICP-MS. Our results not only greatly expand the existing plagioclase D_{REE} database for lunar compositions, but also investigate the significance of fO_2 in Eu partitioning, and in the interpretation of Eu anomalies in lunar materials.

[1] Fagan and Neal (2011), LPS 42, 2137; [2] McKay and Weill (1977), LPS 8, 2339 – 2355; [3] Weill and McKay (1975), LPS 6, 1143 – 1158.