CRYSTALLIZATION OF A MODEL SILICATE MOON E. Baker[1] (edward.baker@seh.ox.ac.uk), Dr. J Wade[1] and Prof. B Wood[1]. 1: (Department of Earth Sciences, University of Oxford)

The Moon is almost indistinguishable from the Earth in a number of refractory isotope systems (e.g. W, O, Cr etc), indicating a close genetic link between the two bodies [1], [2]. Although broadly similar to the terrestrial mantle, the silicate Moon's major element composition appears to differ in one key respect - the estimated iron content of silicate moon (up to 17 wt.% FeO) is significantly higher that of Earth (8 wt.% FeO). These elevated lunar FeO contents are, however, primarily based upon interpretations of lunar surface rocks, and dependent on models of the melting and crystallisation history of the silicate Moon.

Question: Given the established genetic link between silicate Earth and Moon, do lunar surface rocks require a mantle source that is significantly richer in Iron? Is the silicate Moon actually the same as the terrestrial mantle at the time of the giant impact?

Our experiments investigate a fractionally crystallizing lunar magma ocean of fertile pyrolite composition [3], with volatile elements (K and Na) reduced by 67 %. Experiments started at 80 % liquid with 20 % Olivine removed from the primitive composition. At each step the melt from the previous experiment was the bulk composition for the next step. Experiments lie between fO_2 of C-CO and IW+1 in graphite capsules and follow the lunar pressure gradient, from 2.5 GPa, 1675 °C for the primitive melts to 0.5 GPa, 850 °C for evolved melts.

The line of liquid descent (fig. 1), when re-mixed in various proportions, is able to explain most of the major element compositions of lunar rocks: Explicitly, a lunar mantle, of peridotitic composition, when crystallizing under lunar conditions is able to reproduce our observations of the surface of the Moon.

A 'Bow shaped' REE pattern with depletion in heavy and light REEs, is characteristic of mare basalts. KREEP, rich in LREEs can be the sink for the light REEs. On the Moon, low pressure precludes the formation of Garnet; another sink is therefore needed to explain the depletion of Mare basalts in the HREEs. A high temperature pyroxene is found in my experiments to accept large amounts of the HREEs. The stability of this pyroxene phase enables my model to reproduce the REE profile as well as the major element compositions found on the surface of the Moon.

Forward models of the REE evolution of the Moon suggest further differentiation of the late stage liquid is required to deplete iron and enrich in REEs to recreate the KREEP basalt composition (fig. 2). Remixing and recombination modelling to recreate the composition of mafic crystals, 'mafics', found in the ferroan anorthosite suite (fig. 3) find the mafics to best match with crystal phases, rather than melt, produced experimentally.

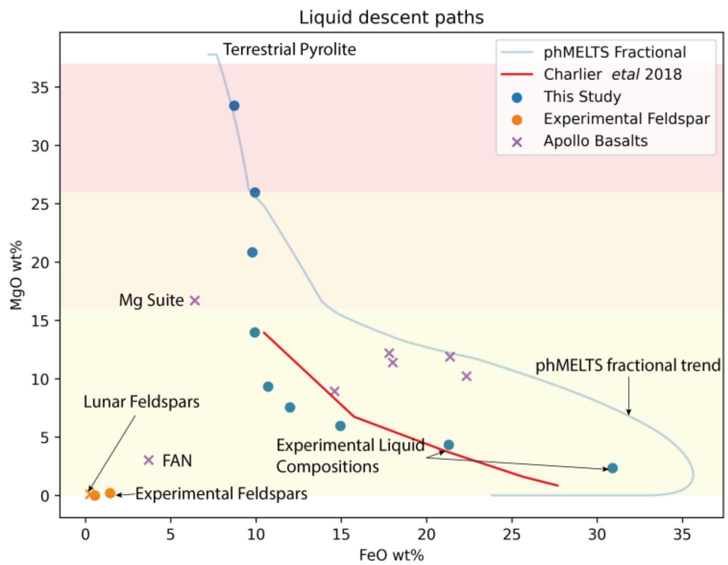

Figure 1: Evolution of fractional liquids in FeO-MgO space. Light blue line is liquid composition predicted by the phMELTS modelling program. phMELTS predicts large Fe enrichment early on, continuing to more than 35 wt. %. Solid red line is the evolution of the LPUM composition [4], discretised and evolved experimentally by [5]. Blue dots are the evolving bulk compositions from this work. Lunar bulk rock data plotted as purple crosses with average lunar FAS feldspars plotted as an orange cross. Experimentally produced feldspars plotted as orange dots.

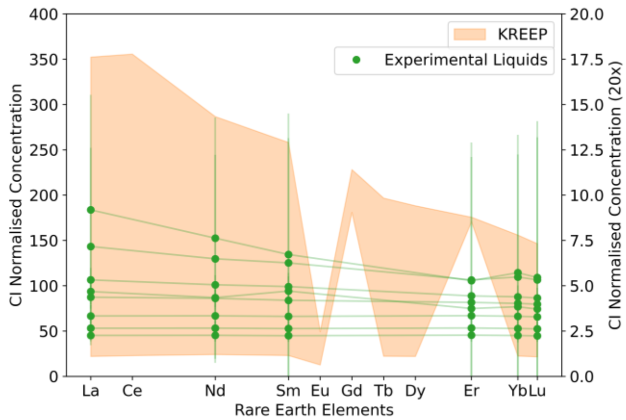

Figure 2: The evolution of REE profiles through the crystallisation of the lunar magma ocean. The ultimate predicted concentration of REEs is not sufficient to recreate the KREEP basalts; further crystallisation and concentration is required.

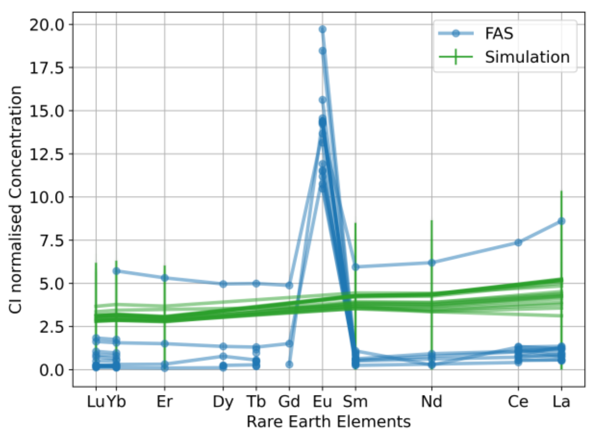

Figure 3: The modelled REE profiles of Ferroan Anorthosite rocks. Models recreate the correct flat profile.

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