EXPERIMENTAL DETERMINATION OF TRACE ELEMENT PARTITIONING DURING LUNAR MAGMA OCEAN CRYSTALLIZATION. L. T. Andrews and S. M. Elardo. The Florida Planets Lab, Department of Geological Sciences, University of Florida, Gainesville, FL 32611, USA. selardo@ufl.edu

Introduction: The study of the samples returned by Apollo 11 extended our understanding of the formation of the Moon and helped establish the lunar magma ocean (LMO) hypothesis [1]. Since that time, differentiation of the Moon via the LMO has been extensively studied both numerically and experimentally [e.g., 2-5, amongst many others]. The focus of many studies of LMO crystallization has been the major element evolution of the mantle and residual melt. Although attempts have been made to model the trace element evolution of the LMO, experimental studies of trace element partitioning directly relevant to LMO compositions and P-T conditions are lacking in comparison. Observing the evolution of the trace element abundances and ratios at lunar conditions is important as it can lead to a better overall understanding of the lunar mantle, such as identifying source regions when major elements do not display significant heterogeneity.

Here we present the preliminary results of a study designed to quantify the partitioning of a suite of trace elements during crystallization of the LMO. For this study, we adopt the experimentally-determined LMO fractional crystallization sequence from Charlier et al. [2] based on the lunar primitive upper mantle (LPUM) bulk Moon composition from Longhi [6], assuming a wholly molten Moon.

Experimental and Analytical Methods: Five experimental starting compositions corresponding to five stages of LMO crystallization in the study of Charlier et al. [2] were produced by mixing reagent-grade oxides and fayalite under ethanol in a mortar and pestle. Synthetic fayalite was used as an Fe reagent to ensure that all Fe present in the mixtures was divalent. Once the starting materials were homogenous and dry, each mix was spiked with trace elements using HNO_3 plasma standard solutions at a concentration of ~500 ppm each. Trace elements added to each mix include La, Ce, Nd, Sm, Eu, Gd, Dy, Er, Yb, Lu, Rb, Sr, Sc, Y, Ni, Co, Zn, W, Hf, Pb, U, and Th. Mixtures were left in a Teflon beaker on a warm hotplate to evaporate the weak HNO_3, after which the dry starting materials were stored in a desiccator until use.

Piston cylinder experiments were conducted in the Florida Planets Lab at UF using graphite capsules and $BaCO_3$ pressure media in a Rockland Research Corp. end-loaded piston cylinder. All MgO internal parts were dried at 900 °C before use to eliminate unwanted water. Experiments for each of the five LMO liquid compositions will be run at appropriate pressures between 0.5 and 3 GPa that correspond to the approximate depth of crystallization in a fractionating whole Moon LMO. The pressures and temperatures were calculated from corresponding depths of the LMO cumulate pile based on glass percentage left from the Charlier et al. [2] experiments. Equilibrium will be assessed in the experiments through the use of a time series and with phase homogeneity. Run products are then mounted in epoxy and polished flat for microbeam analyses. Glass and mineral compositions will be analyses with the Cameca SXFive FE electron microprobe at UF. Trace element partition coefficients will then be quantified using the Thermo Element2 magnetic sector ICP-MS equipped with a New Wave UP-213 solid state laser ablation system.

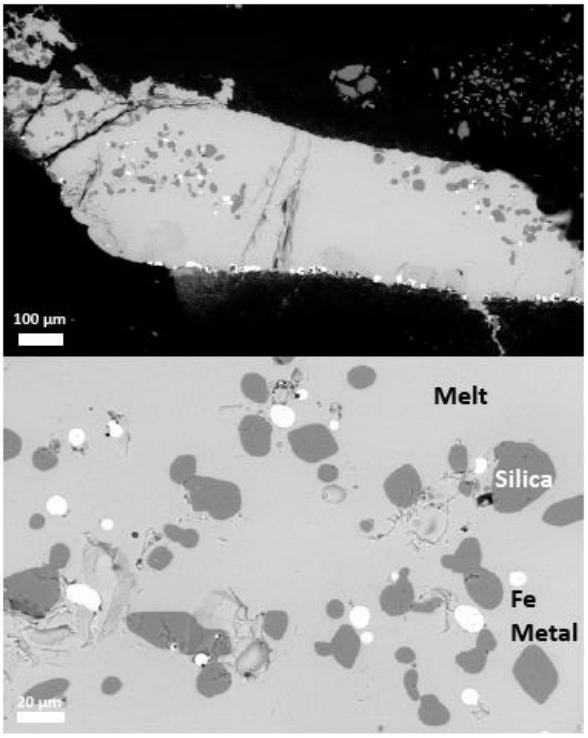

Figure 1: Backscattered electron images of a preliminary experiment on the most evolved of the five LMO liquid compositions from Charlier et al. [2]. Experiment conducted at 0.5 GPa and 1100 °C for ~72 hours. The experiment contains melt, a silica phase, and Fe metal.

An example of a preliminary experiment on a late-stage LMO composition is shown in Fig. 1. This experiment has a high melt fraction, and contains a silica phase, consistent with the Charlier et al. [2] results on this composition, and Fe metal likely due to some reduction of Fe from the graphite capsule at low pressure. Upon the completion of additional

experiments and the determination of partition coefficients using LA-ICP-MS, our results will be compared to existing trace element partitioning parameterizations [7-10] to assess consistency. We will also model the variation of these trace elements through LMO crystallization to construct a model of their abundances and ratios in pre-overturn mantle cumulate compositions. Importantly, our experiments also contain the parent and daughter elements (Sm-Nd, Rb-Sr, Lu-Hf, Pb-Th-U) for all of the major radiogenic isotope systems. As noted by Snape et al. [11], no study has yet quantified the partitioning of radiogenic parent-daughter elements at conditions relevant to the LMO. Therefore, our results will enable modelling of the isotopic evolution of the LMO as well.

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