



## **Crystallization of an iron-rich and aluminium-poor Lunar Magma Ocean.**

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The presence of a global magma ocean early in the Moon's history is widely accepted, but its composition remains uncertain. During the 40 years following the Apollo sample return missions, several lunar bulk compositions have been suggested. Their Al<sub>2</sub>O<sub>3</sub> content varies from 3.7 to 7.5 and their FeO content from 7.7 to 13.6wt% [1]. In 2006, Khan et al. [2] inverted lunar physical data using a thermodynamic database for the system FeO-CaO-MgO-Al<sub>2</sub>O<sub>3</sub>-SiO<sub>2</sub> (FCMAS), and inferred a composition with a relatively low Al<sub>2</sub>O<sub>3</sub> content (4.3 wt%). Their composition satisfies the seismic and gravity data of the Moon, which is not the case for compositions with higher Al<sub>2</sub>O<sub>3</sub> content, such as the widely used Taylor Whole Moon (TWM) composition [3]. The starting composition used in this study is also different from the Lunar Primitive Upper Mantle (LPUM) derived from a terrestrial upper mantle [4]. We aim to constrain experimentally the crystallization sequence in a lunar magma ocean with a starting composition based on the FCMAS composition proposed by Khan et al. [2]. Since ilmenite is important for late magma ocean crystallization and subsequent overturn due to its high density, we add Ti to this composition. Trace elements were also added to constrain mineral-melt partitioning during crystallization.

Two sets of high-pressure experiments have been performed using an end-loaded piston-cylinder. The first set put constraints on the crystallization sequence until 60% of crystallization of the Lunar Magma Ocean, and a second set simulated the rest crystallization up to complete solidification. The starting materials were finely ground glass+olivine for the first step and glass for the second step. Pressures of 1-3 GPa and temperatures between 1000°C and 1650°C were applied during 6 to 104h. Experimental charges were analyzed with an electron microprobe. Olivine and orthopyroxene forming during the first step of crystallization are heavier than the residual liquid. Hence they sink down, forming very thick cumulate layers at the bottom of the magma ocean. The bulk composition for the second step was calculated from the composition of the residual liquid after 60% crystallization of the starting material from the first step. Lower pressures and temperatures were applied for this second step to simulate the final stages of lunar magma ocean crystallization. We will discuss the implications of our results for the mineralogy and geochemistry of the interior of the Moon upon cooling of the Lunar Magma Ocean.

References: [1] Shearer C. K. et al. (2006) in *New Views of the Moon*, 365-518. [2] Khan A. et al. (2006) *Geophys. J. Int.*, 168, 243-258. [3] Taylor S. R. (1982) *LPI*. [4] Hart S. R. and Zindler A. (1986) *Chem. Geol.*, 57, 247-267.