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Crystallising the Lunar Magma Ocean: insight from experimental petrology with a new composition derived from physical data.

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The crystallization of the Lunar Magma Ocean (LMO) and the resulting lunar mantle stratification are strongly dependant on the bulk composition of the Moon. Since the Apollo and Luna missions, several chemical compositions have been proposed, varying in their Al2O3 and FeO contents [1]. Recently, Khan and co-workers [2,3] inverted lunar seismic and gravity data for composition and temperature using a thermodynamic database for the system FeO-CaO-MgO-Al2O3-SiO2 (FCMAS). The resulting bulk lunar composition has a relatively low Al2O3 content (4.3 wt%) and high FeO content (12.5 wt%). This composition satisfies the seismic and gravity data of the Moon, which is not the case for other proposed compositions with higher Al2O3 content, like the Taylor Whole Moon (TWM) composition [4]. The Khan et al. preferred composition is also different from a Lunar Primitive Upper Mantle (LPUM) model derived from a terrestrial upper mantle [5] which has a lower FeO content.

We aim to experimentally constrain the crystallization sequence and mineral compositions in a lunar magma ocean with a starting composition based on the FCMAS composition proposed by Khan et al. [2]. Since ilmenite is a crucial mineral in late magma ocean crystallization and subsequent overturn (e.g. [6]) due to its high density, we add TiO2 as a component in our starting composition.

Experiments were performed both at room pressure in a high temperature furnace and with an end-loaded piston-cylinder at VU University Amsterdam. Pressures of 0, 1, 1.5, 2, 2.5 and 3 GPa and temperatures between 1000°C and 1600°C were applied. At this meeting we will present a phase diagram for this newly proposed lunar bulk composition, and discuss implications for the cooling of the Lunar Magma Ocean and subsequent dynamics of the lunar mantle.

[1] Shearer C. K. et al. (2006) in New Views of the Moon, 365-518. [2] Khan A. et al. (2006) EPSL 248, 579-598. [3] Khan A. et al. (2007) Geophys. J. Int. 168, 243-258. [4] Taylor S. R. (1982) Planetary Science, LPI, Houston TX, 322pp. [5] Hart S. R. and Zindler A. (1986) Chem. Geol., 57, 247-267. [6] De Vries J. et al. (2009) LPSC 40, abstract 1244.