# Heterogeneous lunar crust formation

MATTHIEU LANEUVILLE[1]

[1]Earth Life Science Institute (ELSI), Tokyo Institute of Technology, Tokyo, Japan (mlaneuville@elsi.jp).

The lunar magma ocean concept was developed shortly after the Apollo/Luna era in order to explain several converging observations (see [1] for a review). The existence of an almost global anorthositic crust with plagioclase content of 75-90% is consistent with crystallization from a global magma ocean. Extremely old ages for most of the non-mare rocks also support the argument for a primordial crust. Other lines of evidence concern the complementary Eu anomaly between mare basalts and the anorthositic crust, and the fact that the ratio of incompatible elements is uniform within the sampled portion of the Moon.

All of this, in addition to the giant impact formation scenario (see [2] for a review), made a strong case for an initially globally molten Moon from which the crust could have formed. However, there is now ample evidence for a heterogeneous lunar crust. On the one hand, the magnesium number (Mg#) distribution is significantly different between the two hemispheres (e.g., [3]). On the other hand, analysis of trace element partitioning in lunar meteorites, which are believed to have sampled a large fraction of the surface, also stress the existence of heterogeneities within the anorthositic part of the lunar crust (e.g., [4,5]).

These observations seriously weaken the arguments for such a global magma ocean. Here we tackle these issues by investigating how differential crystallization between hemispheres could have influenced the present day structure and composition. In particular we discuss the Mg# distribution and trace elements partitioning patterns. In order to do this, we consider the crystallization of the magma ocean using different boundary conditions and element partitioning behaviors on a 1-D thermal evolution model.

While we do not claim that such a model solves every conundrum, we want to make the first step and draw attention to the importance of finding early evolution models that are in agreement with the newly acquired data. This requires a combination of petrological data on element partitioning as well as integrative thermo-chemical evolution models of magma ocean crystallization.

[1] Warren (1985), Annu. Rev. Earth. Planet. Sci. [2] Hartmann (2014), Phil. Trans. R. Soc. A. [3] Ohtake, et al. (2012), Nat. Geosci. [4] Gross, Treiman & Mercer (2014), Earth Planet. Sci. Lett. [5] Russell, et al. (2014), Phil Trans. R. Soc. A.