Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.17472

Degree-one convection pattern during the lunar magma ocean solidification

LINE COLIN[1], CHLOÉ MICHAUT[1], STÉPHANE LABROSSE[1] AND ADRIEN MORISON[2]

[1]Ecole Normale Supérieure de Lyon

[2]Univ. Exeter

Presenting Author: line.colin@ens-lyon.fr

Although the classical scenario for the solidification of the lunar magma ocean elegantly explains the formation of an anorthosite crust by flotation of anorthite minerals, it does not explain the observed degree-one variation in crustal thickness of the Moon. The lunar crust is indeed significantly thinner on the near side (~20-30 km) than on the far side (~50-60km).

One suggestion is that a degree-one convection settles in the solid cumulates before the end of the solidification of the lunar magma ocean. Because, the phase change boundary between the cumulates and the ocean can allow matter to flow-through by melting and freezing, solid convection may indeed be facilitated and a degree-one pattern of convection could be favoured (Morison et al, 2019).

Here we construct a model of solidification of the lunar magma ocean based on a simple anorthite-olivine phase diagram. In a first stage, lasting hundreds of years, cumulates form at the base of the ocean. In a second stage, simultaneous crystallisation of anorthite and cumulates leads to the formation of a flotation lid which significantly slows down the cooling of the magma ocean. The total crystallisation timescale is of the order of 100 million years.

Using a linear stability analysis on the convection equations accounting for material exchange at the solid-liquid interface, we show that convection has time to set up in both the solid cumulates and possibly in the anorthosite crust before the end of the second stage of crystallisation.

We also show that a degree-one convection pattern is favoured in the solid cumulates, which can explain the observed nearside-farside difference in crust thickness.