Early evolution and dynamics of the Moon from a molten initial stage

D.L. LOURENÇO[1]*, P.J. TACKLEY[1], C. LIEBSKE[2], G.J. GOLABEK[3], V.A. FERNANDES[4]

[1] Institute of Geophysics, Department of Earth Sciences, ETH Zürich, Switzerland (*correspondence: diogo.lourenco@erdw.ethz.ch)
[2] Institute of Geochemistry and Petrology, Department of Earth Sciences, ETH Zürich, Switzerland
[3] Bayerisches Geoinstitut, University of Bayreuth, Germany
[4] Museum für Naturkunde, Berlin, Germany

The formation of the Moon is thought to be the outcome of a collision between a Mars-sized object and proto-Earth at the end of Earth's accretion [1]. The energy released by this collision led to a partially or even completely molten early Moon [2]. The subsequent evolution of the Lunar Magma Ocean (LMO) is key to the present structure of the Moon. The crystallisation of the LMO led to the formation of a primary feldspar solid crust, constituting much of the lunar highlands [3]. At the bottom of the LMO a complementary layer of ultramafic composition formed and later became the source region for the basalts that compose the lunar maria.

The goal of our study is to understand and characterize the influence of melting on the long-term thermo-chemical evolution of the Moon, starting from a magma ocean. Our approach is to model the viscous creep of solid rock using the code StagYY [4], while parameterizing melt processes, as previously done in 1-D models [5, 6, 7]. It includes melt-solid separation at all melt fractions, the use of an effective diffusivity to parameterize turbulent mixing in largely molten regions, coupling to a parameterized core cooling model and a radiative surface boundary condition. Additionally a petrological model, based on pMELTS [8] results is incorporated into StagYY.

We present 2-D spherical annulus model results for the evolution of the Moon, while testing the effect of uncertainties in parameters such as surface heat loss, different petrological models and efficiency of turbulent mixing. We compare our results with observations, adressing questions regarding the present-day composition of the Moon's mantle and presence of partial melt in it.

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