Goldschmidt2017 Abstract

The early thermal evolution and delamination of Mars' crust

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Recent re-evaluation of Mars' crustal composition and vertical extent indicates that the present-day martian crust may be denser and thicker than previously proposed [1]. As a consequence, the average crustal thickness would be significantly larger than the basalt-eclogite phase transition depth, which re-opens the question of crustal recycling on Early Mars, and throughout its history. While a thick crust is easily produced in thermal evolution models, such models are often discarded for satisfying the condition of separation of early geochemical reservoirs [2], though crustal recycling does not necessarily imply mixing.

We have therefore investigated the conditions under which a thick ancient crust with a denser (hence gravitationally unstable) eclogitic root could survive or peal off (delaminate) through the history of Mars, using numerical modeling. The efficiency of crustal delamination depends essentially on the density, viscosity, and temperature profiles, which suffer from uncertainties. We investigated the influence of these parameters by following the dynamic evolution of a three-layer system: basaltic & eclogitic crust, and mantle. We systematically varied the basalt-eclogite phase transition depth, the density contrasts between each material, and the viscous rheology, within plausible ranges. This allows the derivation of scaling laws for the timing of crustal delamination. To further constrain the temperature and viscosity profiles, we monitored the cooling of a martian magma ocean until its solidification, following [3]. Combining these constraints with our scaling laws allows us to determine the plausible range for average martian crustal thickness at early and late evolutionary stages.

[1] Baratoux, *et al.* (2014) *JGR*, **119**, 1707-1727.
[2] Morschhauser, *et al.* (2011) *Icarus*, **212,** 541–558.
[3] Monteux, *et al.* (2016) *EPSL*, **448**, 140-149.