Early Differentiation and Dynamic Evolution of Mars - the Geodynamical approach

DORIS BREUER[1], ANA-CATALINA PLESA[1], MATTHIAS GROTT[1], NICOLA TOSI[1,2], MAXIME MAURICE [1]AND THOMAS RUEDAS[1,3]

[1]DLR, Institute of Planetary Research, Berlin, Germany (doris.breuer@dlr.de)
[2]Department of Astronomy and Astrophysics, TU Berlin
[3]Institute of Planetology, University of Münster

Isotopic anomalies in the Martian meteorites suggest the existence of several distinct geochemical reservoirs in the Martian interior that formed early and did not mix thereafter. Furthermore, petrological analysis of the meteorites suggests that rheologically significant amounts of water are present in the interior. We discuss the dynamical consequences of different thermo-chemical evolution scenarios, whether they can lead to the formation and preservation of mantle reservoirs, and what they tell us about the volatile distribution in the Martian interior. Reservoirs can form as a result of partial melting that induces a density change in the depleted mantle with respect to its primordial composition. However, efficient mantle mixing prevents these reservoirs from being preserved unless they are located in the stagnant lid or in the lower volatile-rich mantle. Alternatively, reservoirs could be formed during fractional crystallization of a magma ocean. In this case, however, the mantle would likely end up being stably stratified as a result of the global overturn of the unstable density distribution attained at the end of the crystallization sequence. This effect could be reduced if convection and mixing starts during magma ocean solidification. Depending on the resulting density contrast, little secondary crust would be produced and the lithosphere would be cool and dry, in contrast to observations. Therefore, reservoir formation by partial melting seems to be best compatible with current constraints, although survival of primordial reservoirs continues to be problematic.