FORMATION OF MARTIAN VOLCANIC PROVINCES BY LOWER MANTLE FLUSHING? P. van Thienen[1] and Ph. Lognonné[2], [1]Institut de Physique du Globe de Paris, Department of planetary and space geophysics, 4 av. de Neptune, 94100 Saint-Maur-des-Fossés, France, thienen@ipgp.jussieu.fr, [2]Institut de Physique du Globe de Paris, Department of planetary and space geophysics, 4 av. de Neptune, 94100 Saint-Maur-des-Fossés, France, lognonne@ipgp.jussieu.fr.

Introduction: The two main volcanic centres on Mars, Tharsis and Elysium, are often interpreted in terms of mantle plume hotspots. Several workers have tried to explain why there seem to be only two and not more plumes, invoking exothermic[1] and endothermic[2] phase transitions. Alternative explanations include an impact genesis [3] and the reduced thermal conductivity of the thick southern lithospere [4].

As the cooling of Mars after a possible magma ocean stage takes place in a top-down manner, a thermal boundary layer at the CMB takes some time to develop, unless one assumes the core to be initally superheated. Some workers have speculated on this.

Numerical models: We present results of 2D cylindrical shell numerical mantle convection experiments (EBA) in which we try to ascertain whether the flushing of the lower mantle (present if one assumes a small to intermediate size for the martian core, within uncertainties) could provide a mechanism for the generation of a small number of plume-like features, showing localized upwelling of hot material. This would remove the necessity of an initial/early TBL at the CMB. We investigate the effects of solid-state phase transitions, viscosity stratification in the mantle (related to solid-state phase transitions), and the presence of a thick southern hemisphere crust. Two different stratified viscosity models are applied. The first has a lower mantle which is a factor 10 stronger than the upper mantle, similar to the viscosity contrast inferred in the Earth's mantle, e.g. from glacial rebound studies [5]. The second model has a transition zone which is a factor 10 stronger than the upper and lower mantle, based on recent work by Walzer et al. [6].

Results: Figures 1, 2, and 3 show snapshots of the temperature, viscosity and lower mantle material for three different models. In the first, there is no insulating southern hemisphere crust, resulting in four hot upwellings from the CMB region, evenly distributed. In the second model, relative insulation of the southern hemisphere results in a convection pattern which drags two upwellings in northward direction. The third model, having a strong lower mantle and an insulating southern hemisphere crust, shows a single hot upwelling. Tests have shown these results to be qualitatively similar for varying Rayleigh numbers (5.10^5 and 5.10^6) and clapeyron slopes of the endothermic phase transition (-1.10^6 Pa/K and -3.10^6 Pa/K).

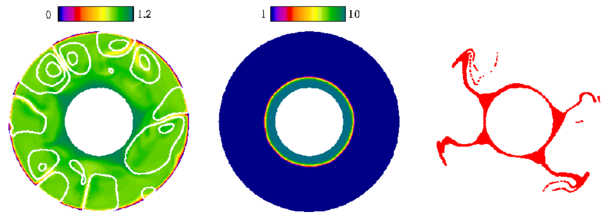

Figure 1: Snapshot of the temperature (left), viscosity (middle) and lower mantle material (right) for a model with a high viscosity lower mantle (factor 10 relative to upper mantle), a 1297 km core radius, and no thick southern hemisphere crust. The Rayleigh number is 5.10^6. t=228 Myr.

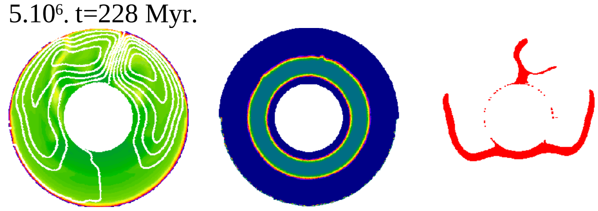

Figure 2: In this case, the transition zone is stronger than the upper and lower mantle. A thick southern hemisphere crust is included. The Rayleigh number is 5.10^5. t=114 Myr.

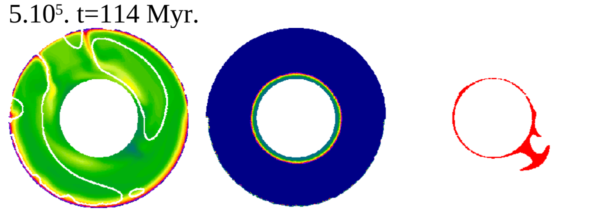

Figure 3: The combination of a strong lower mantle (core radius is 1497 km) and an insulating southern hemisphere crust results in the formation of a single hot upwelling, close to the boundary of the thick crust. The Rayleigh number is 5.10^5. t=801 Myr.

References:

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