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Formation of martian volcanic provinces by flushing of the deep mantle?

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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 and endothermic phase transitions. Alternative explanations which have been proposed include an impact genesis, the reduced thermal conductivity of the thick southern lithospere, and a focussing effect of variable thermal conductivity on hot mantle upwellings. As the cooling of Mars after a possible magma ocean stage takes place in a top-down manner, a thermal boundary layer at the core-mantle boundary takes some time to develop, unless one assumes the core to be initally superheated. Some workers have speculated on this. If there is no TBL at the CMB, mantle dynamics are probably initiated in a top-down manner as well. We present results of 2D cylindrical shell numerical mantle convection experiments in which we try to ascertain whether flushing of the hot deep mantle (lower mantle if present) could provide a mechanism for the generation of a small number of plume-like features, i.e. localized upwelling of hot material. In this scenario the formation is driven from the top by cold downwellings rather than from a hot thermal boundary layer at the CMB. We investigate the effects of solid-state phase transitions, different stratified and temperature-dependent viscosity models, and the presence of a thick southern hemisphere crust. Our results show that it is possible to generate hot strong localized upwellings from top-down dynamics if the lithosphere is thin or actively involved in the convective pattern. The presence of a thick, immobile, insulating southern hemisphere crust reduces the number of upwellings, as does a stratified viscosity model with a high viscosity deep mantle.