New constraints on the thermal and volatile evolution of Mars

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The preservation of 3-kms of elevation between the north and south and the thickening of the elastic lithospere (Te) from 0-20 km [1] to 300 km [2] from the Noachian age till the present suggests rapid cooling of the planet. We show that the content of water in the crust and mantle has an equal or larger effect on the strength of the lithosphere as that of temperature. Volatile history is thus key to Mars' evolution.

We use 3 thermal evolution models along with volatile evolution as inputs to a numerical model of topographic relaxation to predict dichotomy topography and Te over time. Present day topography and estimates of Te over the 1st b.y. of Mars' history provide constraints (Fig. 1).

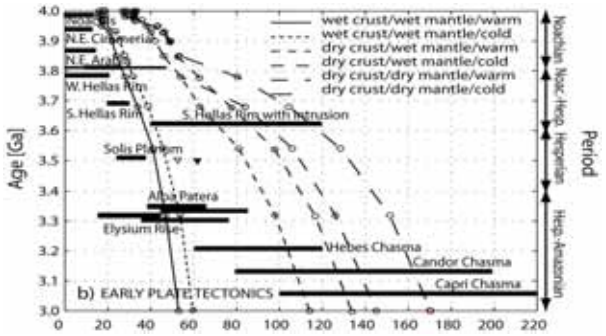

Figure 1: Fit of the numerical models (vertical lines) to the estimates of the elastic thickness (horizontal bars).

Our results are consitent with a Noachian lower crust that was either wet, and cold (~1500 K), or dry and hot (~2000 K). The convection model prefers an early wet crust followed by drying during the Hesperian; early plate-tectonics followed by mantle convection implies dry crust and mantle, and the mantle overturn model fits best with dry southern and wet northern hemispheres. Note, dry conditions on Mars disagree with results from SNC meteorites [3] and the presence of weakened faults [4] near the dichotomy boundary.

[1] McGovern *et al.* (2004) *JGR* **109**, doi, 10.1029/ 2004 JE002286. [2] Phillips *et al*. (2008) *LPSC* **2008,** Abstr. # 1493. [3] McSween *et al.* (2001) *Nature* **409**, 487-490. [4] Grott *et al.* (2005) *GRL* **32**, doi, 10.1029/2005GL023894.

Dissolved noble gases and stable isotopes as tracers of groundwater dynamics in the Lower Rhine Embayment, Germany

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A multiple environmental tracer approach has been applied to achieve an improved understanding of groundwater dynamics in the Lower Rhine Embayment, Germany. The main emphasis has been to utilise dissolved noble gas and noble gas determined excess air concentrations in addition to the stable isotopes of hydrogen, oxygen, carbon and strontium. It is hypothesised that a relationship between noble gas excess air concentrations and the magnitude and frequency of water table fluctuations, both natural and as a result of large scale water abstraction can be quantified and used as an indicator of groundwater recharge, flow rate and residence times. The research has also provided further insight into the role of fault zones on local and regional groundwater dynamics.

The hydrogeology of the Lower Rhine Embayment is complex and dynamic, and consists of unconsolidated sedimentary deposits with a number of laterally continuous lignite seams. Large scale open pit mining has a significant impact on the regional groundwater system primarily due to water abstraction and subsequent lowering of the water table. The layered aquifer system is intersected by numerous NW-SE striking fault zones that have been shown to have the potential to act as both barriers to groundwater flow and as preferential flow paths.

Groundwater samples taken from observation boreholes in close proximity to fault zones have provided preliminary results that indicate hydrogen and oxygen isotope anomalies and extremely high helium-4 concentrations in the shallow aquifer layers. Groundwater exchange between the lower and upper aquifer systems is impeded by confining clay layers and a continuous lignite seam of very low permeability. This suggests that palaeowater from depth is mixing with modern water of meteoric origin in the upper aquifer as a result of conduit flow from depth towards the upper aquifer layer within the fault zone.