Unusual Pattern of Convection in a Thin Mantle Shell and the Connection to Tectonics on Mercury

Scott D. King, *Dept. of Geosciences, Virginia Tech, Blacksburg, VA*

Calculations of convection in a 3D spherical-shell geometry with temperature-dependent rheology and a cooling-core boundary condition applicable to Mercury's silicate mantle using *CitcomS* show an unusual pattern of convection. Regularly-spaced, linear upwellings are the characteristic planform of mantle convection in a thin spherical shell and, this differs significantly from the cylindrical upwellings seen in similar calculations for Earth, Venus, and Mars mantle geometries (Figure 1).

Linear rolls with a wavelength approximately two to three times the thickness of the shell are observed in the low latitude region. Near the poles the linear roll planform breaks down into a nearly hexagonal pattern, with a wavelength nearly equal to the thickness of the shell. This planform is consistent with the pattern of compressive features observed in the hemisphere imaged by Mariner 10 (Figure 2) suggesting that the compressive features record an ancient pattern of mantle convection. This pattern of convection may be observable in the gravity and topographic data returned from the upcoming MESSENGER mission.

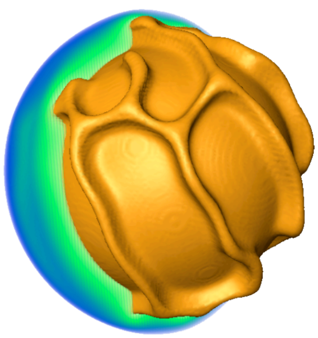

Figure 1: Temperature field after 750 million years of model evolution in a 2400 km radius sphere with an 1800 km radius core. The orange surface represents the 0.9 (1804 K) temperature isosurface. Note the transition between long, two-dimensional roll structures in the low latitudes to a more complicated hexagonal pattern in the high latitude.

The linear roll planform develops over a period of 300-500 million years. The planform of convection explains the orientation and timing of the compressive features, which would be random and continuous throughout the early history of Mercury if they were the result of contraction due to cooling alone. The stresses due to convection are order 500 MPa and when coupled with a global compressive stress field due to contraction of the same magnitude (necessary to offset the extensional stresses due to convection because extensional features are not observed outside Caloris basin) are sufficient to produce thrust faults that extend to depths of 25 km on Mercury, consistent with modeling of Discovery Rupes.

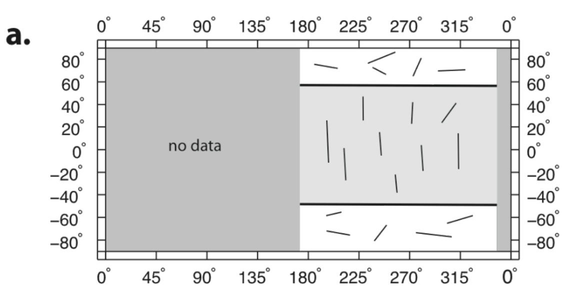

Figure 2: Schematic diagram of orientation of compressive features on Mercury’s surface from Mariner 10 imagery (after Watters et al., 2004).

King, S. D.,Pattern of Lobate Scarps on Mercury's Surface Reproduced by a Model of Mantle Convection, *Nature Geosciences* 1, 229-232, 2007.