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Viscous topographic relaxation on Mercury revisited - Implications for crustal thickness

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Only little data on Mercury's topography and gravity field is available and its crustal thickness D_c is therefore poorly constrained. Mercury's mean density implies a thickness of mantle plus crust of 600 km and the observed center of mass - center of figure offset constrains D_c to 100-300 km.

Another way to constrain Mercury's crustal thickness consists in forward modeling of the viscous relaxation of isostatically supported topography: Crustal thickness variations induce lateral pressure gradients which can drive flow in the lower crust if the temperatures there are sufficient, thus relaxing topography. The observed absence of large scale topographic relaxation of impact basins may then be used to constrain the thickness of the crust, and maximum allowable thickness values of 100-200 km have thus been obtained. However, so far models considering crustal flow have used simple thermal models for the crust, ignoring contributions from secular cooling and inner core growth. Furthermore, the assumed crustal thermal conductivities k are generally fairly large, ignoring the effects of a brecciated upper crust as well as the dependence of k on temperature and composition.

We have used one-dimensional thermal evolution models to construct more realistic thermal models of Mercury's lithosphere, thus improving the bounds on the maximum allowable crustal thickness. We choose a conservative estimate for the bulk concentration of radiogenic elements which yields surface heat flows consistent with faulting observations and imply near surface thermal gradients of 3-11 K km^{-1} at 4 Gyr b.p. If the mean crustal thermal conductivity is assumed to be $\sim$2 W m^{-1} K^{-1} and Mercury's crust is mainly composed of plagioclase, we infer that D_c is probably no larger than 100 km. If the composition is more basaltic and a diabase rheology is appropriate, this bound needs to be relaxed to $\sim$130 km.