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Present-day and early heat flows and the thermal evolution of Mars

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There is currently a very interesting and productive debate on the present-day heat flow and thermal state of Mars [1-4]. The very high (>300 km) effective elastic thickness deduced for the north polar region from the non significant flexure caused by loading due to the north pole cap [1], is related to a low surface heat flow at the present-time, hardly reconcilable with most of thermal history models. This low heat flow could be indicative of sub-chondritic heat-producing elements abundances [1], a limited influence of secular cooling [4], or simply a regional variability of surface heat flow [2,3].

Effective elastic thicknesses of Noachian-loaded regions are very low, typically ~15 km or lower [e.g., 5], indicating relatively high heat flows, which is expectable for a young planet: when a crustal thermal conductivity adequate for basaltic rock is used, heat flows in excess of ~30-40 mW m^{-2}, are obtained. However, the depth to the brittle-ductile transition (BDT) beneath Late Noachian-Early Hesperian lobate scarps (considered to be related with large thrust faults) is ~20-35 km [6-8]; these BDT depths can in turn be converted to heat flows of ~25-45 mW m^{-2} if crustal radioactive heat sources are included in the calculations. These heat flow values are lower than those predicted by thermal history models of Mars [e.g., 10], and than the heat flow equivalent to the total radioactive heat generation according to compositional models of Mars [e.g., 10,11].

The discrepancy between deduced and predicted Late Noachian-Early Hesperian heat flows could be explained by a limited contribution from secular cooling, as already proposed for explain the present-day heat flow in the north polar region [4]. However, it could also be explained by an early vigorous hydrothermal cooling of the upper crust, which was previously proposed to explain the preservation of large-scale crustal thickness variations observed in the southern highlands [12]. Thus, the comparison between heat flows estimated from both the effective elastic thicknesses of the lithosphere and the BDT depth, and those predicted by thermal history models, may serve to put constraints on the evolution of the efficiency of several ways of heat loss (including vigorous hydrothermal cooling) on Mars.

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