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Depth to the magnetic sources of Mars

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The magnetic sources of the strong magnetic anomalies over Cimmeria and Sirenum Terrae of Mars must have acquired magnetization during the active period of the core dynamo. The bottom of the potentially magnetic layer has been constrained by the depth to the Curie temperature of its magnetic carriers. The uppermost part of the layer has been significantly demagnetized by the impacts that have created a huge amount of craters overlapping these regions. A total of 24 thermal evolution models of Mars are examined to determine the effects of 8 major physical parameters on the thermal state of the Martian crust. The parameters include: 1) The thickness of the initial crust created by chemical differentiation of a magma ocean; 2) The elastic to ductile transition temperature of the lithosphere; 3) The initial temperature in the upper mantle immediately after the creation of the initial crust; 4) The possible super heated core; 5) The total radioactive content at present and different Th/U and K/U ratios; 6) The total radioactive elements concentrated in the crust; 7) The total Potassium concentrated in the core; and 8) The pressure dependence of the thermal expansion coefficient. The thermal evolution models are based on parameterized convection calculations with a stagnant lid on the convecting mantle. It is shown that among the 8 major physical parameters the initial upper mantle temperature and total radioactive content of Mars have substantial effects on the thermal state of the crust in the first 1 Gyr of the planet's history. The magnetic source bodies that have been magnetized by the core field during the first 500 Myr are located in the upper about 70-60, 60-50, or 35-30 km of the crust if hematite, magnetite, or pyrrhotite is the major magnetic carrier of the source bodies, respectively.

The shock pressures induced in the crust by impacts can demagnetize the uppermost part of the crust. A total of 14 different models are examined to assess effects of the crater diameter, the exponential decrease of shock pressure as a distance from the impact site, and the demagnetization threshold of the shock pressure. It is demonstrated that impacts that create 50-200 km diameter craters are capable of demagnetizing the upper 10-20 km of the crust.

Deeper parts of the crust cooled below the Curie temperatures of the magnetic minerals in later times, after the core dynamo ceased to exist. Detailed studies of the remanent magnetization acquired by the deeper parts of the crust are conducted through examining 9 different magnetic models of the lower crust. It is concluded that the magnetization acquired by the lower crust, in the absence of the core field but in the presence of the magnetic field of the upper crust, has minor effects on the observed magnetic anomalies of Mars. The major magnetic source bodies responsible for the observed strong magnetic anomalies of Cimmeria and Sirenum Terrae are most likely located in a thin layer, between 20 and 70, 20 and 60, and 20 and 35 km depths if hematite, magnetite, or pyrrhotite is the major magnetic carrier, respectively.