THERMO-REMANENT MAGNETIZATION OF MARTIAN LITHOSPHERE. Jafar Arkani-Hamed, Earth & Planetary Sciences , McGill University , Montreal , Quebec , Canada.

Introduction: There is evidence for moderate temperatures in the deep Martian lithosphere in the last ~4 Gyr, suggesting the possibility of deeper magnetic source bodies magnetized by the magnetic field of the upper lithosphere in the absence of the core field. The support of large shield volcanos on Mars requires a thick and strong lithosphere, about 100-300 km [e.g., Zuber et al. , 2000]. Arkani-Hamed and Reindler [2002] showed that stresses of up to ~100 MPa have existed in the upper 200 km of Mars since the formation of Olympus and the Tharsis mountains. The temperature at the base of the elastic lithosphere is suggested to be ~650 C [Zuber et al., 2000]. The elastic lithosphere thickness estimates suggest that the lithosphere has cooled below the Curie temperature (assumed 600C) down to 100- 200 km in the last 4 Gyr. I assume that the upper lithosphere was magnetized by the core field in the early history of the planet, whereas the lower lithosphere was magnetized gradually as it cooled below the Curie temperature in the presence of the magnetic field of the upper lithosphere. The present day observed magnetic field arises from the magnetization of that portion of the lithosphere which is presently below the Curie temperature, hereafter refered to as the magnetic lithosphere.

Thermo-remanent magnetization of the lithosphere: I determine the thermo-remanent magnetization (TRM) models of the Martian lithosphere, assumed to be responsible for the present magnetic field of Mars. I divide the magnetic lithosphere into two layers and assume that the upper layer was magnetized by the core field, whereas the lower layer has gradually acquired TRM as it cooled below the Curie temperature in the presence of the magnetic field of the upper layer, after the core dynamo ceased to exist. I use the 50-degree magnetic potential model of Arkani-Hamed [2001]. Using the 90-degree spherical harmonic model of Cain et al.'s [2002] resulted in an unrealistically strong enhancement of the short wavelength components, demonstrating the fact that these components are not of crustal origin.

A conservative thickness of 100 km is adopted for the magnetic lithosphere at present. The thickness of the magnetic lithosphere is decided on the basis of the thermal evolution models calculated using parameterizedconvection calculations. I consider a chondritic Mars model that is differentiated during or shortly after accretion and produced a buoyant initial crust overlying the mantle. The low Hf/W ratio of the SNC meteorites compared to the terrestrial values suggests that chemical differentiation and core formation in Mars occurred within 20-30 Myr. of the planet's history [Halliday et al., 2001]. The thermal evolution models start after magma ocean solidification and core formation. 40% or 60% of the radioactive elements are concentrated in the crust. As Mars cools a stagnant lid atop the convecting mantle thickens [e.g., Schubert et al., 1992]. The lid in the early stages of the thermal evolution consists of the upper, cold and rigid part of the crust. The lid grows to include part of the upper mantle at later stages as the mantle cools and becomes rigid. The thickness of the potentially magnetic lithosphere at present is between 150 and 200 km, regardless of which model is considered.

The magnetization of the lower layer of the magnetic lithosphere strongly depends on the magnetization factor δ. The magnetization factor of the freshly produced oceanic extrusive basalt of Earth is about 0.00004 A/m nT. The Martian lithosphere is probably more magnetic than the Earth's. Many different value of δ and the thickness of the upper layer of the magnetic lithosphere are considered. It is assumed for simplicity that δ is constant throughout the lithosphere for a given model, but varies from one model to the other. For the terrestrial δ value the lower layer of the magnetic lithosphere has weak magnetization and the upper layer is the main source of the observed magnetic anomalies. On the other hand, at the higher δ value the magnetization of the lower parts of the magnetic lithosphere is quite appreciable. There is a distinct difference between the radial component of the magnetization and the tangential components. The radial component of the magnetization of the lower layer correlates positively with that of the upper layer, whereas the tangential components of the magnetization of the lower layer are in the opposite direction of those of the upper layer.

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