Mars crustal magnetism, plate tectonics, and more

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Mars has no global magnetic field of internal origin, but must have had one in the past when the crust acquired intense magnetization, presumably by cooling in the presence of an Earth-like magnetic field (thermoremanent magnetization or TRM). The Mars crust is at least an order of magnitude more intensely magnetized than that of the Earth. The apparent lack of magnetization associated with major impact basins suggests that the crust acquired magnetic remanence early in its history, about 4 billion years ago. A new map of the magnetic field of Mars, compiled at $\sim$ 400 km mapping altitude by Mars Global Surveyor, is presented here. The spatial resolution and sensitivity of this global map is unprecedented, inviting geologic interpretation heretofor reserved for aeromagnetic and ship surveys on Earth. These data provide new insight into the origin and evolution of the Mars crust. The apparent lack of magnetization associated with volcanic provinces may indicate that the magnetic layer resides within a few km of the surface, requiring magnetization intensity of order few 100 A/m, almost unthinkable. Two parallel great faults are identified in Terra Meridiani by offset magnetic field contours. They appear similar to transform faults that occur in oceanic crust on Earth, and describe the relative motion of two ancient Mars plates on the surface of a sphere. The magnetic imprint in Meridiani is consistent with that observed above a mid-ocean ridge on Earth. It is a relic of an era of plate tectonics on Mars, an era of crustal spreading, rifting, plate motions, and widespread volcanism following the demise of the dynamo. We present this new data in the context of the early development of plate tectonics on Earth, as advanced by the Vine-Matthews hypothesis and the work of W. Jason Morgan and others. Finally, we discuss the next logical steps in Mars exploration: magnetic surveys on global and regional scales.