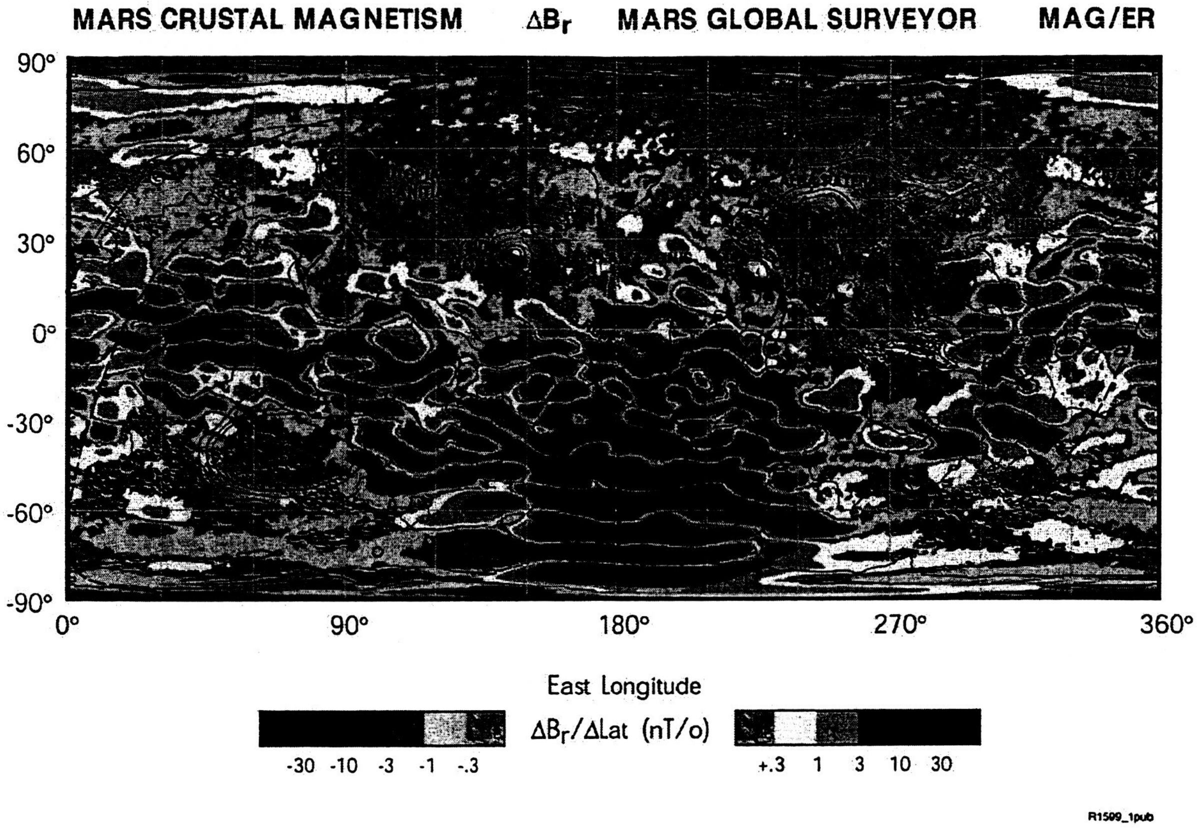
A MAGNETIC PERSPECTIVE ON THE MARTIAN CRUSTAL DICHOTOMY. J. E. P. Connerney[1], M. H. Acuna[1], N. F. Ness[2], D. L. Mitchell[3], R. P. Lin[3], and H. Reme[4], [1]NASA Goddard Space Flight Center, Code 695, Greenbelt, MD 20771; Connerney@gsfc.nasa.gov, [2]University of Delaware, Newark, DE 19716, [3]Space Science Laboratory and Physics Department, University of California, Berkeley, CA, 94720.



Introduction: The Mars Global Surveyor spacecraft has completed two Mars years in nearly circular polar orbit at a nominal altitude of 400 km. The Mars crust is at least an order of magnitude more intensely magnetized than that of the Earth [1], and intriguing in both its global distribution and geometric properties [2,3]. Measurements of the vector magnetic field have been used to map the magnetic field of crustal origin to high accuracy [4,5]. This most recent map is assembled from > 2 full years of MGS night-side observations, and uses along-track filtering to greatly reduce noise due to external field variations.

The map: The radial field component was averaged along-track and decimated to 1 sample per degree latitude traversed by MGS in its polar orbit. A simple 3-point non-recursive digital filter (differentiating Lanczos filter) is then applied to the time series to attenuate constant offsets and variations of larger spatial scale than those associated with variations of crustal magnetization. We then take the median value of all points falling in each 1 by 1 degree bin in latitude and longitude to create a global image of the field. The resulting map has about an order of magnitude greater sensitivity to crustal magnetic fields. This map of the *change* in radial field with latitude (dBr/dTheta) is closely related to a map of the theta component of the field, with the added advantage of superior removal of external fields.

Overview: The crustal demagnetization previously associated [2] with the large impact basins (Hellas, Argyre, Utopia, Isidis) is even more obvious in this new map, as is the crustal demagnetization associated with the large volcanic structures (Tharsis, Olympus Mons, Elysium). A number of geologic features previously identified in imagery and topography (Cerberus Rupes, Valles Marineris) now can be seen to have magnetic signatures as well. Lack of magnetization seems to be associated with emplacement of lavas.

Crustal magnetization extends well beyond the older Noachian southern highlands terrain. We suggest that the smooth, flat northern lowlands are underlain by much older crust, an extension of the southern highlands crust. This is consistent with the inferred Noachian age of the underlying crust based on the detection of "Quasi-circular depressions", thought to be buried craters [6]. Much of the crustal magnetization originally imprinted in the underlying crust may have been erased by thermal remagnetization in a weak field (after the demise of the dynamo) following the catastrophic widespread emplacement of a ~1 km thick volcanic layer throughout the northern lowlands [7]. If so, a low temperature magnetic mineralogy (titanomagnetite, magnetite) is implicated and the magnetic layer must be relatively thin, e.g., few km in thickness.

Plate tectonics: Another kind of fault, not previously recognized in imagery or topography, can be identified in the Meridiani region by inspection of the magnetic contours. Two long dashed lines are superposed on the map to identify the location of the proposed faults, along which the magnetic field pattern appears to shift. These lines are drawn by rotation of a vector about a common axis of rotation identified by a pole (marked with a cross) located at 23° S and 80.5° E, just north of Hellas. The magnetic imprint is best preserved near 0° latitude and 0° longitude, where the map shows a series of east-west trending features of alternating polarity extending from ~15° N to ~30° S. A similar pattern can be found on either side of the proposed fault lines. The magnetic imprint has been altered where the crust has been reworked by impacts (e.g., the multi-ring crater Ladon near 18° S, 331° E) and perhaps other events. The two proposed parallel great faults are separated by ~1400 km and a similar pattern in the magnetic field is found on both sides of the easternmost fault along ~2700 km of its length.

The magnetic imprint in Meridiani is consistent with crust formed by plate tectonics in the presence of a reversing dynamo. Essential characteristics: (1) a magnetic imprint aligned with the ridge axis or spreading center, (2) a comparable magnetic imprint observed at widely separated locations, and (3) the presence of transform faults, or great faults, along which relative plate motion has occurred. The relative motion of two rigid plates on the surface of a sphere may be described as a rotation about an axis. If two plates have as common boundaries a number of great faults, they must lie on small circles about the rotation pole. The great faults in Meridiani define an axis of rotation (23° S and 80.5° E) describing the relative motion of two ancient plates, north and south of the equator. The ~240 km offset of the putative ridge axis in Meridiani is comparable to that observed along ocean ridges on Earth.

The origin of the great Valles Marineris fault system is controversial, but it has been attributed to planetary rifting [8] and compared to terrestrial plate tectonic rifts, e.g., the east African rift zone. A rift structure of parallel grabens and troughs forms, often along an arc, where the crust is being pulled apart by tensile forces. The west-northwest trend of Valles Marineris is oriented nearly perpendicular to the direction of plate motion implied by the great faults in Meridiani (relative plate motion occurs along the strike of transform faults). The direction of tensile forces required to form Valles Marineris, if it is a rift structure, is consistent with the motions implied by the proposed transform faults in Meridiani.

The great volcanic edifices of the Tharsis Montes (Arsia Mons, Pavonis Mons, Ascraeus Mons, extended to include Ceraunius Tholus/Uranius Patera and volcanic cones in Tempe Terra) and the pair Olympus Mons, Alba Patera lie nearly on two small circles (short dashed lines) about a common axis (through 35.5° N and 152° E). The motion of a single plate over a pair of mantle hotspots in a direction parallel to the dashed lines could form a chain of volcanoes if the magma source periodically breached the crust (e.g., the Hawaiian island chain of volcanoes in the Pacific). The relative ages assigned to these volcanoes is consistent with plate motion northward over a pair of putative mantle hotspots, with Alba Patera and Uranius Patera forming early, Olympus Mons and Arsia Mons later.

Dichotomy boundary: The dichotomy boundary is a reflection of crustal evolution, following (from Isidis to Tharsis south of Elysium and Lucas Planum) a series of relic transform faults and spreading centers [9], elsewhere defined by catastrophic lava flows encroaching upon highlands terrain. The Mars crust reflects the end of an era of plate tectonics, a relic of crustal spreading, rifting, plate motions, and widespread volcanism following the demise of the dynamo.

References:

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