MAGNETOMETER DATA TESTS MODELS FOR THE ORIGIN OF THE MARTIAN CRUSTAL DICHOTOMY; DICHOTOMY MODELS CONSTRAIN TIMING OF MARTIAN MAGNETIC FIELD. M. S. Gilmore, Jet Propulsion Laboratory, MS 183-335, 4800 Oak Grove Drive, Pasadena, CA 91109, msg@pop.jpl.nasa.gov.

Introduction: Measurements recently supplied by the MGS Magnetometer/Electron Reflectometer (MAG/ER) on MGS can be applied to test theories of the origin of the martian crustal dichotomy. Strong (± 1500 nT) magnetic anomalies are observed in the Martian crust. The observations can be summarized as follows [1,2]: 1) strong crustal magnetic sources are generally confined to the southern highlands, although weaker (~40 nT) anomalies were observed during close periapsis; 2) strong magnetic anomalies are absent in the vicinity of Hellas and Argyre; 3) the anomalies in the region 0° to 90° S, 120° to 240° west have a linear geometry, strike generally east west for 1000s km, and show several reversals. This latter point has led to the suggestion that some form of lateral plate tectonics may have been operative in the southern highlands of Mars [1,2].

These observations have led previous workers [1] to hypothesize that the magnetic anomalies were present prior to and were destroyed by the formation of Hellas and Argyre. As such large impacts are confined to the era of heavy bombardment, this places the time of formation of large magnetic anomalies prior to ~3.9 Ga [1]. One obvious extension of this is that the northern lowlands lack significant anomalies because they were erased by impacts and/or the northern lowlands represent crust completely reheated above the Curie temperature.

Preliminary observations of the distributions of the large crustal magnetic anomalies show that many of them extend continuously over the highland lowland boundary. This occurs particularly north of the boundary between 30°W and 270°W, corresponding to northern Arabia, but also occurs in southern Elysium (~10°S, 200°) and the SW portion of Tharsis (~15°S, 140°). This suggests that, in these areas, Noachian crust containing the >3.9 Ga magnetic signature, lies beneath the northern highlands. This geometry can be used to test models for the formation of the martian crustal dichotomy.

Timing. Two models argue for the formation of the northern lowlands by impact. This first involves a single huge impact where the lowlands are the basin of that impact [the “Borealis Basin”, 3]. A second model calls for the formation of the lowlands by multiple overlapping impact basins [4]. The scale of both of these events requires formation of the northern lowlands very early during the heavy bombardment, ca. 4.55 Ga for Borealis [5]. If the northern magnetic anomalies were destroyed by impacts of this magnitude, this puts the formation of the anomalies prior to this event. The maintenance of a dynamo and its cessation (at least enough to prohibit formation of 1500nT anomalies) would have occurred within a relatively short period of time (~ few 100 Ma), which requires that if the southern linear anomalies are formed by plate tectonics, the crustal spreading would have to happen relatively quickly as well. This argues against the idea that slow reversals could accommodate the cooling of large packages of crust that may be required to produce such strong anomalies [2].

Endogenic processes such as the thinning of the lowlands by subcrustal erosion [6] or over a mantle plume [7] may serve to heat up primordial crust above the Curie temperature. In this scenario, thinning events would have had to occur subsequent to the cessation of the (strong) dynamo in order not to record the anomalies. Deepseated anomalies would be preferentially destroyed from below, and may allow the maintenance of anomaly-free Noachian kipukas (presumably the surface layer) within the northern lowlands.

The Surface vs. What is at Depth. The overlap of the magnetic anomalies into the northern lowlands may correspond to areas where the ancient crust is present beneath the lowlands. This implies that this ancient crust is at a deep level beneath both the highland and lowland areas, at least 3 km below the present topography of the highlands. Perhaps this 3 km represents a megaregolith within the southern highlands. This observation does not support differential movement along the present day boundary. If the topography of the lowlands was lowered relative to the highlands (and the ancient crust lowered within it), you may expect a lessening of the magnetic field over the boundary, which is not seen at the surface. Higher order gravity and topography data expected from MOLA will undoubtedly shed light on crustal thickness variations such as these.

A geomorphic study of a specific area where a magnetic anomaly crosses the dichotomy is currently underway. The area of focus is centered on ~10°S, 202°W and extends from ~5°S to 15°S. A positive magnetic anomaly correlates with the extensive Noachian cratered unit (N_{pl1}, 8) and dissected unit (N_{pld}). The anomaly becomes negative northward, still within N_{pl1}, changes to positive values and crosses the dichotomy into knobby plains material (A_{pk}). Preliminary analysis of Viking data show no morphologies indicative of variations in composition, flow boundaries, or topography correlative with the geometry of the magnetic anomaly.

References: [1] Acuña M. H. et al., (1999) *Science 284*, 790-793. [2] Connerney J. E. P. et al., (1999) *Science 284*, 794-798. [3] Wilhelms D. E. and Sqyures S. W. (1984) *Nature 309*, 138-149. [4] Frey H. and Schultz R. A. (1988) *GRL 15*, 229-232; ---- (1990) *JGR 95*, 14203-14213. [5] McGill G. E. and Squyres S. W. (1991) *Icarus 93*, 386-393. [6] Wise D. U. et al. (1979a) *Icarus 38*, 456-472; --- (1979b) *JGR 84*, 7934-7939. [7] McGill G. E. and Dimitriou A. M. (1990) *JGR 95*, 12595-12605. [8] Scott D. H. and Tanaka K. L. (1986) *ibid., I-1802-A*.