MAGNETIC ANOMALIES IN THE TERRA CIMMERIA / SIRENUM REGION OF MARS: A MAGNETIZATION MODEL AND POSSIBLE SOURCES, L. L. Hood[1], N. C. Richmond[1,2], K. Harrison[3]; [1]Lunar and Planetary Lab, University of Arizona, Tucson, AZ 85721, lon@lpl.arizona.edu; [2]Planetary Science Institute, Tucson, AZ 85719, [3]Southwest Research Institute, Boulder, CO 80309.

Introduction: In this paper, we first attempt to develop a more self-consistent magnetization model for the strongly magnetized Terra Cimmeria / Sirenum region. To reduce the non-uniqueness of the problem, improved constraints on the direction of magnetization in the region are used. More detailed maps of the local vector crustal magnetic field produced using data from both the MGS mapping phase (~ 360-380 km altitude) and the MGS aerobraking phase (~ 90-150 km altitude) are employed. We then consider possible sources for the anomalies that are consistent with observed geology and with other constraints imposed by the global distribution of anomalies.

Crustal Field Mapping: Figure 1 is a map of the radial field component at the mapping altitude. East-west trends are evident in this field component as well as in the north component but are not present in the east component or in the field magnitude [1]. Figure 2 is a similar map produced at the aerobraking altitude. The mean altitude is much more variable in Figure 2 than in Figure 1. Nevertheless, it is evident that the broad radial field anomalies in Figure 1 are resolved into a number of smaller anomalies in Figure 2. Also, the strong east-west trends in the radial component in Figure 1 are greatly lessened in Figure 2. A similar comparison for the north component shows that the east-west trends are less prominent at the aerobraking altitude as well.

Maps constructed in the same way as those in Figures 1 and 2, but using artificial data for various source geometries, indicate no evidence in the MGS data for highly elongated sources. Specifically, highly elongated sources with reasonably constant (within a factor of ~ 5) magnetization intensities invariably produce elongated anomalies in the field magnitude, which are not observed. More detailed comparisons of this type lead to the conclusion that crustal sources in this region have maximum lengths of ~ 500 km and maximum aspect ratios of ~2.

Magnetization Source Models: Without additional constraints on the magnetization distribution or direction, it is essentially impossible to invert a complex crustal magnetic field such as that in the Terra Cimmeria / Sirenum region to infer source body characteristics. In order to reduce the non-uniqueness of the problem, independent constraints on the direction of magnetization in the region are needed. For this purpose, we have modeled two rela-

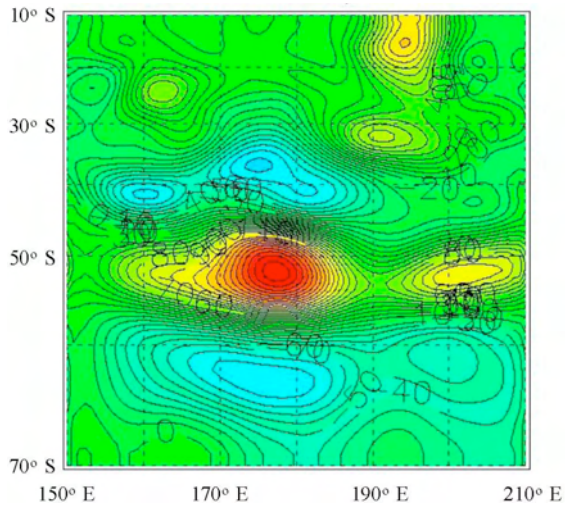

Fig. 1. B-Radial at mapping altitude. C.I. 10 nT.

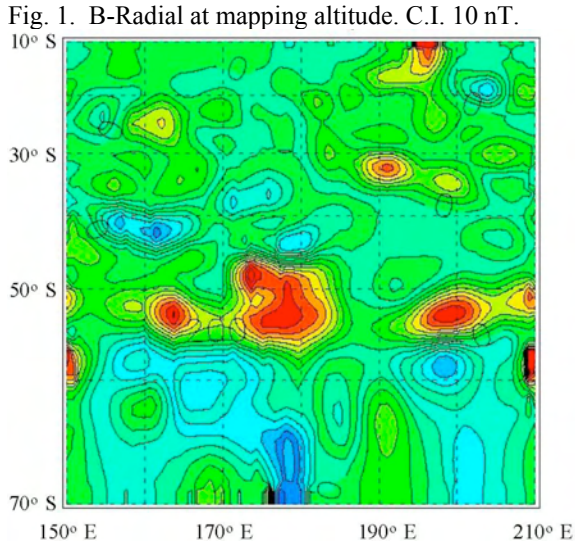

Fig. 2. B-Radial at aerobraking altitude. C.I. 100 nT.

tively isolated, higher-amplitude anomalies on the aerobraking map centered at ~ 56S, 198E and 33S, 191E. Using forward modeling methods described previously [1], the directions of magnetization of the two sources were estimated and were found to be mainly northward in both cases. The corresponding paleomagnetic pole positions were approximately consistent with those estimated in earlier work using mapping phase and science phasing orbit data [1,2; see also ref. 3]. On this basis, it is inferred that

sources in the region are most probably magnetized mainly in northward or southward directions. Using this additional constraint, iterative forward modeling was then applied to determine a magnetization distribution that is consistent with data at both the aerobraking and mapping altitudes. The model magnetization distribution, which includes 41 discrete sources, is summarized schematically in Figure 3. Again, no highly elongated sources are indicated. The main cause of strong east-west trends of anomalies seen on some radial and north field component maps of this region is a merger of these field components, especially at higher altitudes, due to separate sources being magnetized mainly northward or southward and lying roughly to the east or west of one another.

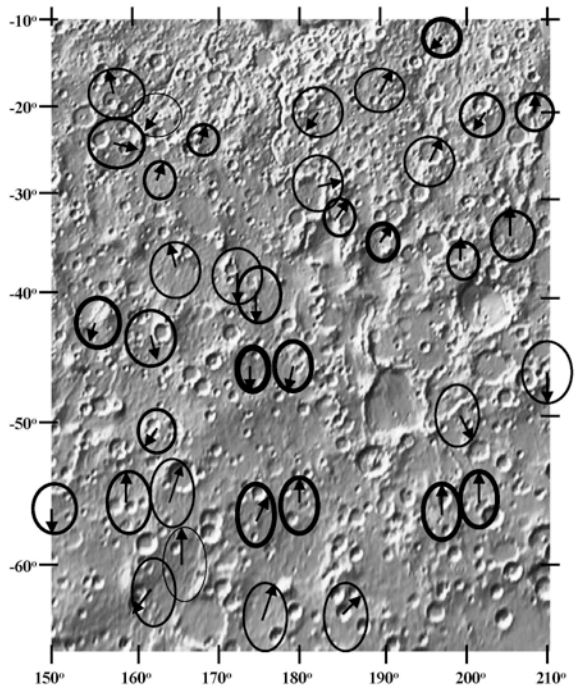

Fig. 3. Ovals indicate locations of circular disk model sources. Thicker lines indicate larger dipole moments per unit area. Horizontal projections of estimated magnetization vectors are shown.

Possible Sources of the Anomalies: Figure 3 indicates that the sources of the Terra Cimmeria / Sirenum anomalies have a fairly random distribution and are not elongated by more than ~ 500 km in any direction. These results therefore do not support earlier interpretations involving either spreading centers or accretion of terranes at converging plate boundaries [4,5,6]. Geologic units in the region include Noachian-aged cratered plateau material and, to a lesser extent, hilly and cratered material [7]. The plateau material is characterized by flat and smooth intercrater terrain, interpreted as being caused by volcanic lava flows and aeolian resurfacing. A number of grabens and faults are often present in the plateau material with a tendency for an east-northeast / west-southwest orientation [8]. Most of these grabens are probably underlain by sheet-like dike intrusions [9]. However, many radiate from Tharsis and most or all probably post-date the dynamo epoch. Nevertheless, dike swarms beneath pre-existing grabens overlain by the plateau volcanic lava flows and aeolian deposits could be the anomaly sources.

It has previously been suggested that dike intrusions are the sources of the anomalies [10]. This suggestion was motivated, in part, by the need for narrow, sheet-like intrusions (< 2 km wide) in order to provide cooling rates sufficiently rapid to produce magnetically stable single-domain magnetite grains (assumed to be the main carrier). An additional constraint on the sources of the anomalies is the global distribution of martian crustal fields. As discussed previously [1,11], this distribution appears to be characterized by a concentration toward the location of the paleomagnetic equator, which passes nearly through the Terra Cimmeria / Sirenum region. One hypothesis for explaining this distribution is that (a) hydrothermal processes were involved in producing the strong anomalies; and (b) near-surface water was more abundant at low latitudes where surface ice may have been most stable during the dynamo era (in contrast to the present era). Crystallization of a basaltic magma in the presence of water can significantly increase the formation rate of magnetite [12]. The presence of water can also increase the cooling rate of a magmatic intrusion with consequences for magnetization acquisition. Further numerical simulations along the lines reported by Nimmo [10] but accounting also for the presence of water in the upper crust are therefore motivated to constrain the origin of the magnetic sources.

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