VERTICAL EXTRAPOLATION OF MARS MAGNETIC POTENTIALS. Donna M. Jurdy, Michael Stefanick, *Department of Geological Sciences, Northwestern University, Evanston IL 60208-2150, donna@earth.northwestern.edu.*

Introduction: Mars Global Surveyor MAG/ER measured strongly magnetized crust; despite Mars' weak field at present, the intensity reaches about 10 times that of Earth's magnetic lineations. We analyze the magnetic lineations in an octant centered at 40°S, 180°W ±40°, concentrated in the more heavily cratered Southern hemisphere. Data was used from the mapping phase of Mars Global Surveyor, MAG/ER magnetic measurements at altitudes of 404 ±34 km (made available by Connerney conveniently binned into degree boxes [1]).

Using a rotated spherical co-ordinate system centered at 40°S,180°W, we perform a two-dimensional Fourier analysis over this region, the area with strongest magnetic lineations.This can be shown to be a good approximation: results can be used to reconstruct the original components as a check on the co-ordinate transformation. The advantage of this co-ordinate system is the lack of distortion; it extends 40 degrees in each direction about the center. The vertical component, B_r, shown in Fig. 1 has been extrapolated from satellite level to 100 km by downward continuation. The results agree very nicely with the more sparse data from the initial aerobraking phase of MGS at about 100 km altitude [2], and the more complete, mapping-phase coverage fills in the data gaps. The magnetic field components can be described by the curl of a vector potential or the gradient of a scalar potential.

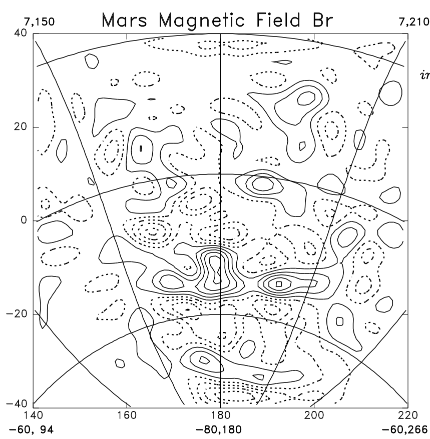

Figure 1: The vertical component of the magnetic field Br extrapolated downwards from 400 km to 100 km using a fourier transform. The result agrees very well with aerobraking data at 100 km [1] and also fills in data gaps. Map is centered at 40°S,180°W ±40°, extending 40° in each direction. Latitude and longitude lines are shown for reference; the geographical coordinates of each of the corners is given.

Analysis: The scalar potential is constructed from the vertical component, taking the Fourier transform and dividing by the vertical wavenumber [3]. This potential shown in Fig. 2 has also been extrapolated to 100 km. The vector potential, though more challenging to present, is more intuitive in the sense that it represents the field as a swirl around an axis rather than a flow from a (non-existent) monopole to another opposite monopole as the scalar potential does. The vector potential (Fig. 3) shows abrupt changes in direction which suggest different ages of magnetization or demagnetization for adjacent regions. The scalar potential does not hint at this. Finally, the vector potential enters directly in Shroedinger's equation [4, pp. 74-79; 310-315] and would cause energy and angular momentum transitions and so magnetic realignments for capturing a thermal event. The scalar potential does not appear in this equation and so seems just a convenient mathematical device: from a single scalar field the 3 components of the magnetic field are easily derived as gradient components. Cain [5] has constructed a 90 degree and order global spherical harmonic model of the scalar potential, but does not specifically discuss this region. Another planetary model, a 50 degree spherical harmonic analysis, [6] for Mars' magnetic field finds a equidimensional pattern of the magnetization rather than lineations characteristic of reversals.

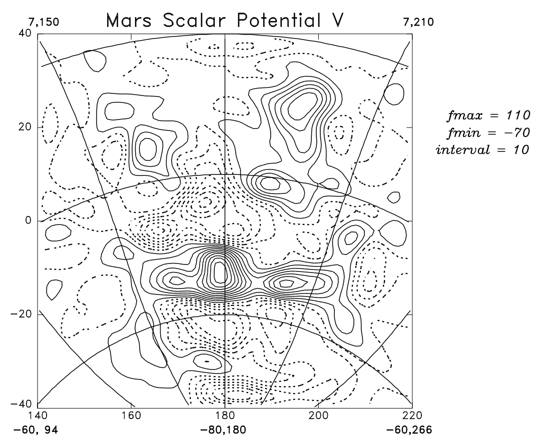

Figure 2: The magnetic scalar potential obtained from the vertical component of the magnetic field using a fourier transform and extrapolated downwards from 400 to 100 km. The gradient components of this field replicates the horizontal components of the magnetic field almost perfectly. Map projection as in Fig. 1

Magnetic Potentials: The magnetic potentials (as well as the original magnetic fields) are extrapolated downward from satellite level at 400 km to 100 km and to the surface. The scalar potential is especially attractive as it can be obtained from the Fourier transform of the vertical magnetic component, B_r. The gradient of scalar potential generates the horizontal magnetic components which can be compared with the origi-

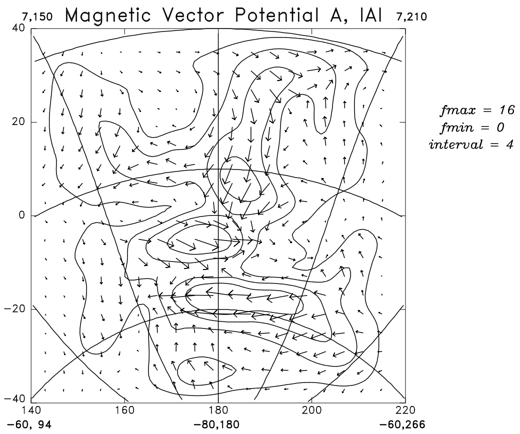

Figure 3: The magnetic vector potential plotted as a two-dimensional vector field and its magnitude contoured. For simplicity, the field is shown at satellite altitude of 400 km. Map projection as in Fig. 1.

nal horizontal components rotated into this co-ordinate system. The corresponding fields are nearly identical, thus an independent check as the horizontal components of the magnetic field were not used to construct the scalar potential. In addition, this confirms the internal consistency of the components of the magnetic field.

Models: We model the magnetic field using the observed scalar potential. With vertical dipoles we determine depths and magnitudes for selected centers and average surroundings, and find that 8 sources account for >80% of the variance. (Only 4 sources already account for >60% of the variance.) These sources range in depth 260 $\pm$130 km, but the source magnitudes range over a factor of 4. Using the autocorrelation of the scalar potential, we estimate that there are only 20-30 independent components of the field (which corresponds to a resolution of 4x5 or 5x6). The scalar potential, extrapolated to the planet's surface from satellite level can be compared with surface features (Fig. 4). Of particular interest are the location of ancient craters; these eroded features no longer retain the topographic signature of fresh craters, but instead are identified by concentric basins and outflow channels [8]. Generally, impact craters larger than 300 km disrupt magnetization [6,7] even out to several radii [9]. However, in the southern hemisphere region modification of the surface magnetization is not present around, indeed, some of the strongest scalar potential lies adjacent to the rings of the ancient craters. Possibly, then, magnetization here in the southern hemisphere post-dated the impacts causing these large basins like Sirenum (Fig. 4).

Conclusion: The magnetic potential, while more difficult to display, is more fundamental than the scalar potential, and suggests a much simpler interpretation of magnetic patterns in the region near 40°S,180°W $\pm$40°. This region encompasses the most strongly magnetized arear concentrated in the older, more heavily cratered Southern hemisphere, and shows no disruption due to ancient craters. The patterns of magnetization in this region are shown to be more equidimensional than linear.

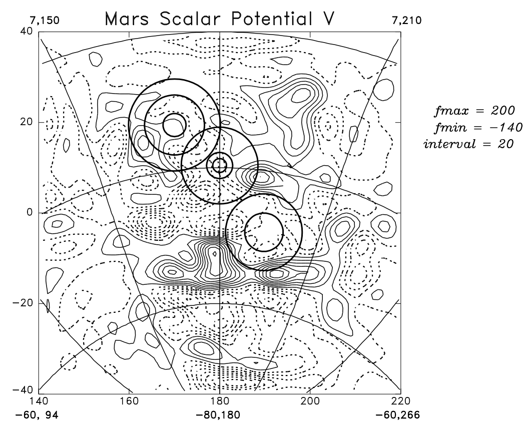

Figure 4: The magnetic scalar potential extrapolated downward to the surface of Mars. Also shown as concentric circles are ancient impact basins [8]. Multiringed basins, from N to S: Al Qahira, S. of Hephaestus Fossae, Sirenum. Map projection as in Fig. 1.

References: [1] Connerney, J.E.P. et al. (2001), *GRL, 28*, 4015-4018. [2] Acuna M.H. et al. (1999), *Science, 284*, 790-793. [3] Blakely, R.J. (1996), Potential theory in gravity and magnetic applications, Cambridge Univ. Press, 441pp. [4] Baym, G. (1969), Lectures on Quantum Mechanics, W. A. Benjamin, 594pp. [5] Cain, J.C., et al. (2003), *JGR, 108*, 5008. [6] Arkani-Hamed, J. (2001), *JGR 106*, 23197. [7] Langlais, B. et al. (2003), *JGR 10*, in press. [8] Schultz, P.H. et al. (1982), *JGR 8*, 9803. [9] Mitchell, D.L. et al. (2003), *EOS*, AGU Spring meeting abstract GP22A-08.