MARS MAGNETIC DATA: THE IMPACT OF NOISE ON THE VERTICAL EXTRAPOLATION OF FIELDS AND METHODS OF SUPPRESSION. Donna M. Jurdy, Michael Stefanick, *Department of Geological Sciences, Northwestern University, Evanston IL 60208-2150, USA, 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. This implies either very strongly magnetic rocks, or magnetization through a large section of the crust, possibly to a depth of 30 km [1]. Most startling is the preservation in the southern hemisphere of ten or more magnetic bands, possibly reversals, 100-200 km wide, extending up to 2000 km in length [2]. The magnetic lineations centered at 180° ± 30°, are concentrated in the more heavily cratered hemisphere. The disturbance near large impact craters suggests that magnetization came before the impacts [3] in the Noachian epoch of Mars' history at about 4 Ga.

Connerney et al. [4] have binned and made available data from the mapping phase of MGS. MAG/ER in the mapping phase observed the magnetic field at an altitude of 404 km ± 34 km. The data used in this analysis was from [4], (website: http://mgs-mager.gsfc.nasa.gov/publications/grl_28_connerney/data/) where the magnetic data are sorted and binned into latitude and longitude boxes by degree, and the value of the field is given for the radial, theta and phi components.

Along longitude 175°E the eastward component is small compared with the radial, and southward components and the field is especially strong. This is ideal for doing a one-dimensional Fourier analysis. Because polar data are absent, we have selected the segment from 80° S to 0° along longitude 180.

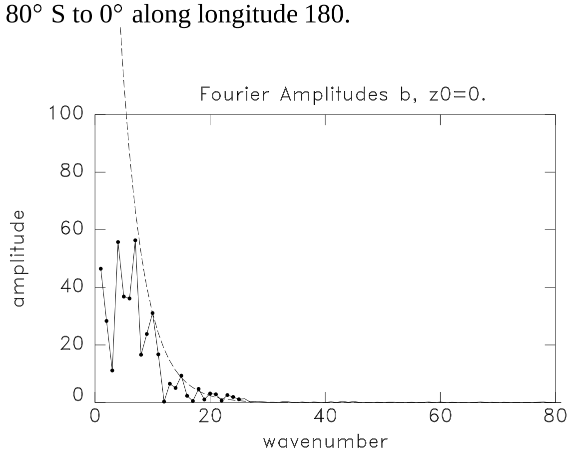

Figure 1: The Fourier spectrum of the vertical component of the magnetic field along the 180° meridian showing the exponential decay with increasing wave number. The dashed curve is the decay that would be expected from surface sources.

Fourier Analysis: The horizontal and vertical magnetic field components h_x and h_z, where x is the latitude, when Fourier analyzed both show an exponentially decreasing amplitude which would be expected from sources at or near the surface of Mars (Fig. 1). The smooth curves are exponential and estimate the Fourier amplitudes.

The field components satisfy Laplace's equation, so we can extrapolate the field downward [6, pp. 92-94]. The noise component [8, pp. 66-88] quickly increases (Fig. 2) even for a modest extrapolation from 400 to 280 km and we see that Fourier components beyond k=25 (wave length 360 km) must be dropped. We have used a simple truncation at k=25. (Because there is a transition between wavenumbers 20-30, one might use signal and noise estimates to create a Wiener optimal filter [5, pp.539-542] which would make a gentle transition from signal to noise. We did not use it.)

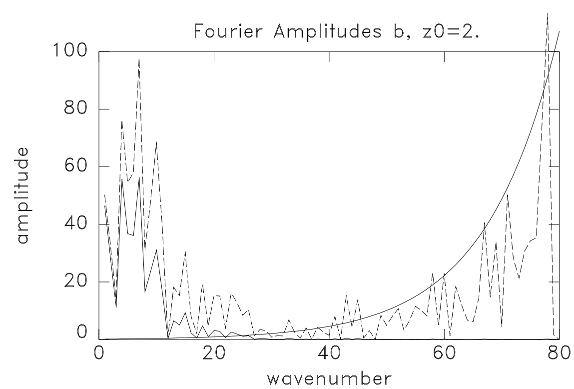

Figure 2: The Fourier spectrum of the vertical component of the magnetic field extrapolated downward about 120 km. The amplification of the noise components and the minimum in the spectrum near wavenumbers k=25-30 are evident. The smooth curve is a fit to white noise extrapolated downward.

Magnetic Potentials: If we integrate the vertical magnetic component with respect to latitude and remove the trend line (Fig. 3), we generate the magnetic potential [7, p.70]. Signal components will be shifted 90° in phase and the noise when integrated becomes a random walk which is reduced by the trend line removal. This allows us to continue farther downward. Integrating the horizontal magnetic component and manipulating the Fourier amplitudes [8, pp.61-62] gives us a second estimate of the same magnetic potential. The two estimates of the potential are nearly identical (Fig. 4). We believe that this is due to the fact that the magnetic field is nearly two-dimensional in this region, and we made a fortunate choice for taking a cross-section. This also explains why

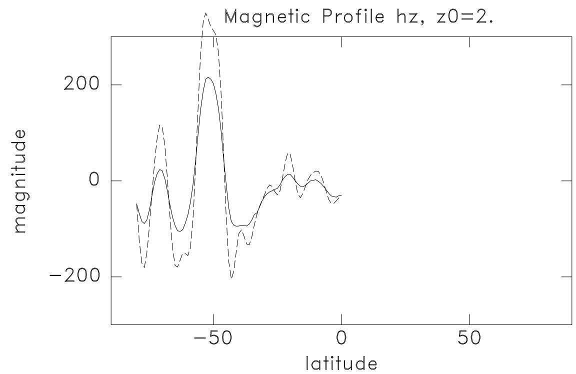

Figure 3: The vertical component of the magnetic field at MGS altitude (solid) and extrapolated downward about 120 km (dashed).

the horizontal and vertical components of the magnetic field are nearly 90° phase shifts of each other. The magnetization pattern does not require reversed lineations, but does not exclude them either.

Conclusion: Removal of noise and vertical extrapolation [9, pp. 151-157] suggests the presence of a major magnetic source on Mars near 50°S along the 180° meridian. Using a two-dimensional region centered here with corresponding two-dimensional Fourier analysis will be informative [6, pp. 44-47; 9, pp. 140-145].

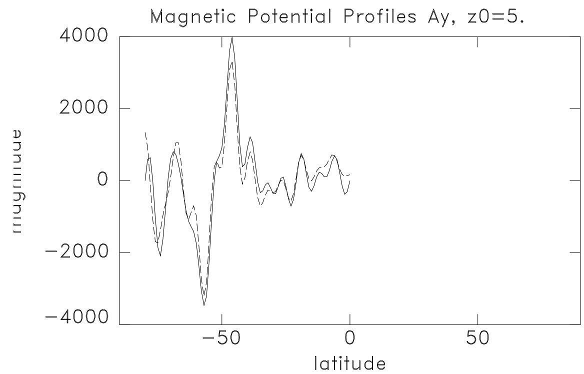

Figure 4: The magnetic potentials generated by integrating the horizontal (dashed) and vertical (solid) magnetic fields along latitude. They are nearly identical, i.e. the magnetic field is nearly two-dimensional in this region.

References: [1] Connerney, J.E.P, et al., *Science* , 284,794-798, 1999. [2] Acuna M.H. et al., *Science* , 284, 790-793, 1999. [3] Gilmore, M.S. and Nimmo, F., *LPSC* , XXXI, 2003, 2000. [4] Connerney, J.E.P. et al., *GRL* , 28, 4015-4018, 2001. [5] Press, W.H. et al., Numerical recipes in FORTRAN, Cambridge Univ. Press, 963p., 1992. [6] Kanasewich, E.R., Time series analysis in geophysics, Univ. Alberta Press, 364p., 1975. [7] Blakely, R.J., Potential theory in gravity and magnetic applications, Cambridge Univ. Press, 441pp., 1996. [8] Claerbout, J.F., Fundamentals of geophysical data processing, McGraw-Hill, 274p., 1976. [9] Telford, W.M. et al., Applied geophysics, Cambridge Univ. Press, 1976.