**EVIDENCE FOR POLAR WANDER IN THE GRAVITY AND MAGNETIC FIELDS OF MARS.**
Kenneth. F. Sprenke[1], [1]Affiliation (Kenneth F. Sprenke, Dept. of Geological Sciences, University of Idaho, Moscow, Idaho, 83844, email: ksprenke@uidaho.edu).

**Introduction:** Evidence for polar wander on Mars can be found in the gravitational and magnetic fields of the planet. The gravity field of Mars when corrected for the geometry of Tharsis, shows a residual geoid that was apparently rotationally unstable prior to the rise of Tharsis. Stable spin axis positions on the non-hydrostatic residual figure of Mars are 15° to 90° from the present-day poles, suggesting a similar amount of polar wander with the rise of Tharsis. The most stable spin axis position on the residual geoid is at 30°E, 32°S and 210°E, 32°N. The magnetic field of Mars shows an alignment of magnetic doublet anomalies with the direction of magnetization. A geostatistical analysis of polarity alignments in the martian magnetic field reveals the general pattern of magnetization, and locates the paleopoles near 50°E, 40°S and 230°E, 40°N. This result, which is consistent with the gravitational result, suggests significant polar wander since the martian crust was magnetized.

**Evidence for Polar Wander in the Gravitational Field:** The Tharsis load and its global deformation of the lithosphere dominate the non-hydrostatic geoid of Mars. In this study, I investigated the non-hydrostatic figure of Mars prior to the rise of Tharsis by removing the effect of the Tharsis rise from the geoid. Then, assuming that the features that form the residual geoid without Tharsis predate the rise of Tharsis, the rotational stability of the resulting residual non-hydrostatic figure was evaluated in terms of possible polar wander. The long wavelength Tharsis effect on the geoid was estimated by first removing the hydrostatic component of the present-day flattening and then eliminating zonal spherical harmonics centered on Tharsis to degree 6. As shown by [1], the long-wavelength features associated with Tharsis are well modeled by this simple procedure. The non-hydrostatic component of the geoid was set at 6 % of the present flattening, a value deduced from the spin precession rate of Mars. The degree 2 residual geoid (Figure 1, next page) has a somewhat triaxial shape with broad lows west of Hellas and northwest of Olympus Mons and broad highs west of Elysium Mons and south of Valles Marineris. This figure is not rotationally stable at the present-day poles. The conversion of the planetary figure from that of Mars without Tharsis to Mars with Tharsis requires at least 15° up to as much as 90° of rotation of the planet relative to the spin axis (See [2] for details). The stable positions surround the axis of the best-fit oblate spheroid to the residual geoid centered at 30°E, 32°S and 210°E, 32°N, where the rotational stability is maximum. At this configuration, Mars without Tharsis would rotate at its lowest energy state with respect to its angular momentum.

**Evidence for Polar Wander in the Magnetic Field:** A semivariogram of the polarity of the radial magnetic field of Mars was constructed. Analysis of the semivariogram (Figure 2) shows that the polarities of the martian magnetic field have an interesting geostatistical structure.

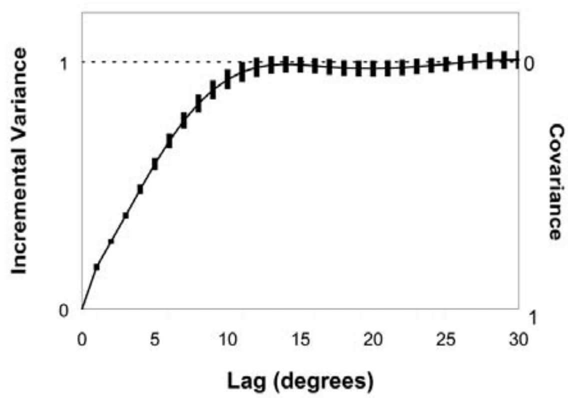


**Figure 2.** The geostatistical structure of the magnetic field polarities of Mars. The bars on the semi-variogram represent one standard deviation limits. Note the peak near 14° where some of the population is above the theoretical sill level, indicating negative covariance at this lag for many anomalies on Mars.

Polarities are well correlated out to a range of near 10° where the mean incremental variance approaches (but does not quite reach) its theoretical sill value of 1. At a lag of 14°, the first maximum of the incremental variance is reached. At a lag of 20°, a minimum occurs in the semivariogram. Finally at a lag of 30°, the theoretical sill value is reached. The minimum indicates a mean separation of 20° between anomalies of the same polarity. The first maximum suggests a mean separation of 14° between anomalies of opposite polarity. Because this lag is not simply half of the separation between anomalies of the same polarity, the incremental variance at this lag is interpreted to represent the effect of magnetic tails on the semivariogram. From the one standard deviation limits at lag 14°, it is apparent that some of the population at this lag exceeds the sill and is in fact negatively correlated. The next step was to determine if the polarity structure identified on the semivariogram is spatially correlated to specific paleopole locations on Mars. The mean autocovariance at lag 14° was compiled for each of the 2000 trial paleopole positions. The results, contoured on a map of Mars in Figure 3, show that the negative correlations at lag 14° are spatially segregated into the areas surrounding 50°E, 40°S and 230°E, 40°N. Paleopoles at these locations best explain the orientation of magnetic doublets in the magnetic field of Mars.

**Conclusion:** This study shows that both the magnetic and gravity field of Mars can be interpreted in a manner consistent with the hypothesis of polar wander on Mars. The consistency between the gravity and magnetic in so far as the location of paleopoles is striking.

**References:** [1] Zuber M.T. and Smith D.E. (1997) *JGR* 102, 28673-28685. [2] Sprenke, K.F., Baker, L.L., and Williams, A.F.(2005)*Icarus., in press*.

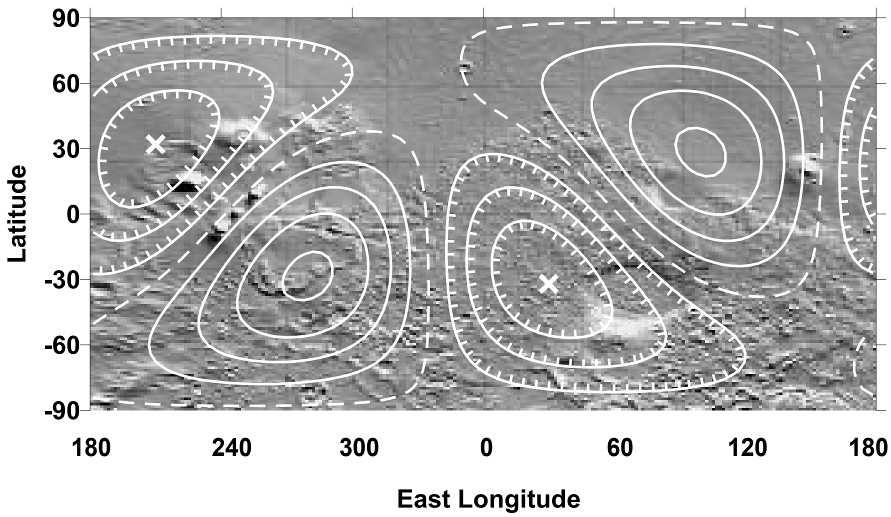


**Figure 1**. The spherical harmonic 2 residual geoid of Mars without Tharsis. The zero contour is dashed. Negative contours are hatched. The contour interval is 50 m. The X's mark the poles of the best fit oblate spheroid.

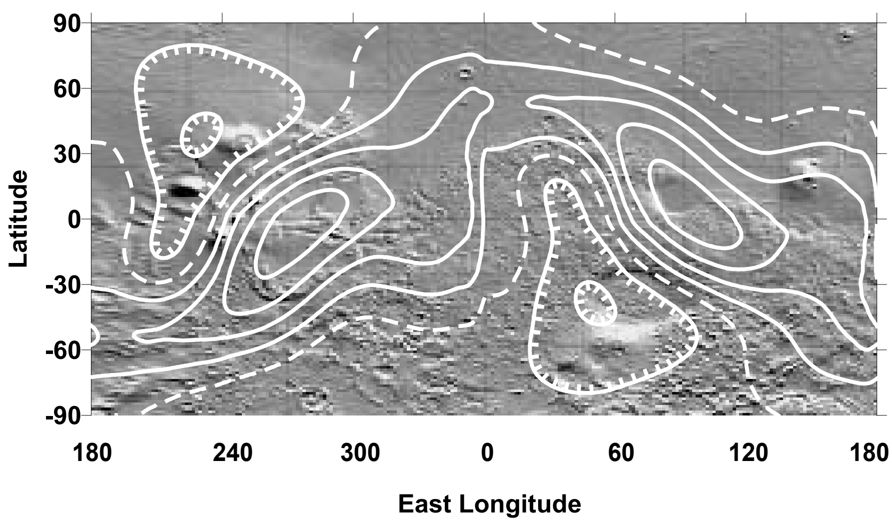


**Figure 3.** The mean magnetic north-south autocovariance of magnetic polarities at lag 14° for trial paleopole positions on Mars. Poles in the more negative areas best explain the geostatistical structure of the magnetic polarities on the planet. The zero contour is dashed. Negative contours are hatched. The contour interval is 0.02.