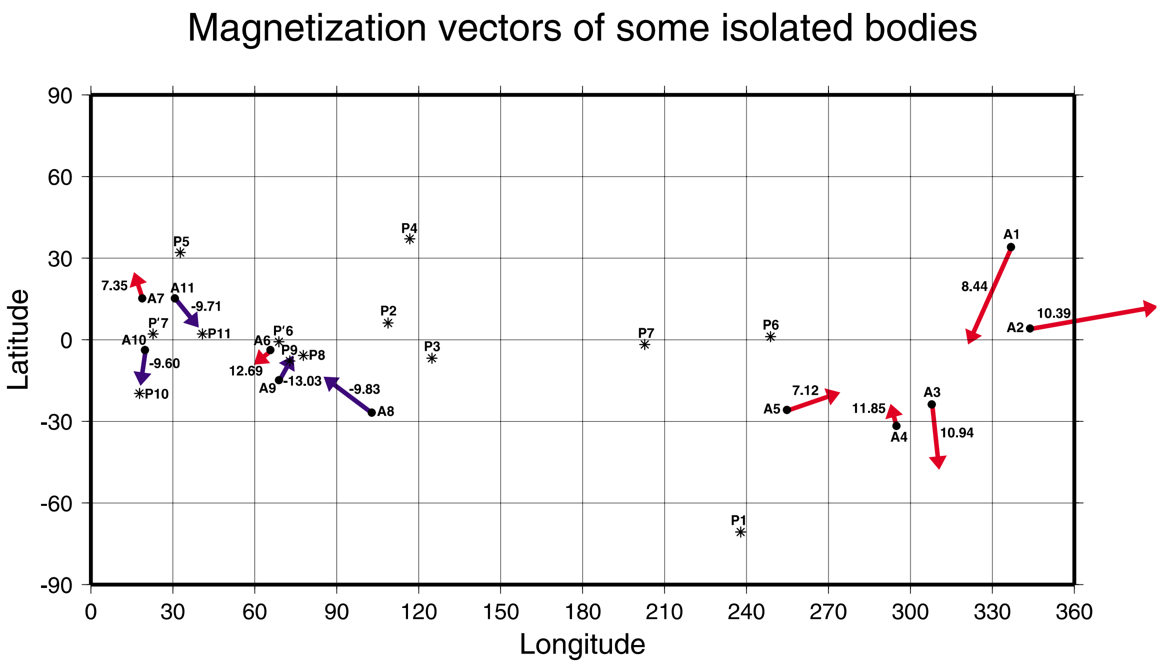
PALEOMAGNETIC POLE POSITIONS AND REVERSALS OF MARS. J. Arkani-Hamed, Department of Earth and Planetary Sciences, McGill University, Montreal, Canada, H3A 2A7, jafar@eps.mcgill.ca

Introduction: The magnetic map of Mars derived from the Mars Global Surveyor data shows that an extensive part of the southern hemisphere is highly magnetized [1]. The lack of appreciable magnetic anomalies in the north suggests that a strong core field existed in the early history of Mars that ceased around 4 Gyr. ago. Connerney et al. [2] modeled the magnetic anomalies over Terra Cimmeria in terms of seafloor spreading type magnetization of Martian crust, implying plate tectonics and magnetic pole reversals in the early history of Mars. Although details of their model failed some diagnostic tests of reversibility [3], and the downward continuation of the anomalies to Mars's surface [4] showed that major parts of the anomalies arise from nearby almost equidimensional bodies, the core field reversal hypothesis seems quite plausible. The strong magnetic anomalies of Cimmeria arise from large and closely placed complex magnetic bodies. It is impossible to determine the direction of magnetization of these bodies uniquely. However, there are a few very small and isolated anomalies that can be modeled by simple bodies of constant magnetization. The direction of magnetization of these bodies should reflect the orientation of the paleomagnetic field. In this paper I determine the paleomagnetic pole positions by modeling these isolated anomalies in terms of vertical prisms of elliptical cross section and show that the core field had most likely reversed it polarity, and the rotation axis has displaced in the last 4 Gyr.

Modeling Isolated Anomalies: The 50 degree spherical harmonic model of the Martian magnetic field derived by Arkani-Hamed [4] at 120 km altitude from the vector components acquired within 80-200 km altitude range is first upward continued to 380 km. The comparison of this upward continued model with the recent high-altitude night time magnetic data showed no appreciable external field contribution to the small isolated anomalies. The anomalies are entirely of crustal origin, they are modeled by iterative forward modeling as follows.

The magnetic potential of a given isolated anomaly, determined from the spherical harmonic model, was first mapped on an equal distance grid with an interval of 15 km. A two dimensional circular filter, with its center visually placed at the top of the potential anomaly, is applied to minimize the magnetic field of nearby bodies. The filter set to zero the anomalies outside a radial distance R, and left unchanged those inside R`. The data between R` and R were gradually tapered by the Hanning function. The magnetic body is assumed to be a vertical prism of 10 km thickness and an elliptical cross section with a semimajor axis **a** and a semiminor axis **b**, oriented at a given direction. The magnetization vector of the body was calculated by fitting its magnetic potential to the filtered observed potential. To obtain the best fitted model, **a** was incrementally increased from 60 to 500 km at a 15 km increment, the **b/a** changed from 0.5 to 1, with an increment of 0.1, and the orientation angle increased from 0 to 180 degree with an increment of 10 degrees. Also, the center of the prism is moved within a circle of 100 km radius, at 15 km increments, with respect to the potential anomaly to minimize the possible initial misplacement. The best model had a minimum misfit value. Figure 1 shows the location and the magnetization of 11 model bodies, A1-A11. The vectors show the horizontal component of the magnetization and the numbers are the vertical components (positive upward). A6 and A9, and A7 and A11, are pairs of near by bodies with an almost 180 degree difference in their magnetization direction, implying that the core field likely had reversed in between the time these bodies were magnetized.



Paleomagnetic pole Positions: Also included in the figure are the locations of the paleomagnetic north pole, P1-P11, determined for each magnetic body assuming that the body was magnetized in a north-to-south oriented dipole core field. P'6 and P'7 are antipoles of P6 and P7, i.e., the north pole positions prior to the field reversal. The clustering of a large number of poles, 7 out of 11, within a circle of about 25 degree radius centered at about 5 degree latitude and 45 degree longitude is quite encouraging. Hood and Zakharian [5] modeled the magnetic anomalies near the north pole by circular disks and determined the magnetic poles at about 40 and 60 degree latitude and 135 degree longitude. The low altitude magnetic data to be acquired in the Spring 2001 will provide an excellent opportunity to further evaluate these preliminary results.

Assuming that the magnetic dipole was approximately aligned with the rotation axis of Mars, as for many other planets, the figure suggests that the rotation axis of Mars has displaced considerably in the last 4 Gyr., possibly in response to emplacement of Tharsis bulge, sheild volcanoes, and giant impact basins. Murray and Malin [6] suggested that the present location of the shield volcanoes is a consequence of a secular motion of the rotation axis by 10-20 degrees in the last 100 m.yr. The location of the rotation axis prior to the emplacement of Tharsis bulge determined by Melosh [7] indicated that the axis has moved northward by about 25 degrees. Recent studies by Spada et al. [8] showed that due to the thick lithosphere, surface loads on Mars are extremely effective in driving the rotation axis, and that the axis has escaped from the positive mass loads of Tharsis bulge and shield volcanoes by 20-70 degrees.

References: [1] Acuna M.H., et al.(1999) *Science,284,*790-793. [2] Connerney J.E.P., et al. (1999*), Science, 284*, 794-798. [3] Harrison C.G.A. (2000), *Science, 287*, 547a. [4] Arkani-Hamed J. (2000) EOS, 81, no 48, F775. [5] Hood L.L. and Zakharian A. (2000), *JGR*, submitted. [6] Murray B.C. and Malin M.C. (1973), *Science, 179*, 997-1000. [7] Melosh H.J. (1980), *Icarus, 44*, 745-751. [8] Spada G. et al. (1996), *JGR, 101*, 2253-2266.