Magnetization of Arsia Mons, Mars. K.F. Sprenke[1] and L.L. Baker[2], [1]Dept of Geological Sciences, University of Idaho (Moscow, Idaho 83844-3022, ksprenke@uidaho.edu), [2]Rocky Mountain College (Billings, MT 59102, bakerl@rocky.edu).

Introduction: Prominent magnetic anomalies are absent over the major volcanic edifices of Mars. Apparently the martian global magnetic field ceased to exist long before the volcanism north of the dichotomy occurred [1]. However, Arsia Mons, the southernmost of the great shield volcanoes of Mars, is located adjacent to a large regional magnetic anomaly (Fig.1). This raises the question of whether the Arsia Mons lavas might have acquired a magnetization induced from the much older remanent magnetization in the adjacent crust. This magnetization, induced by local fields associated with magnetized regions of the crust, would have occurred in spite of the absence of a global field at the time of emplacement.

A data set giving the crustal martian magnetic field at mapping orbit altitude has recently been made available [1]. These data, collected over a period of 504 days at altitudes near 400 km, provide the best measurement to date of the martian field. The data set gives the vector field for each 1 degree by 1 degree area on Mars using only observations from the dark side of the planet. The binned values from which the final median value for each area was selected are thought to be statistically independent because the time between subsequent samples in each bin is large compared to variations in the external field. Accuracy of the crustal field (few nT) is limited primarily by residual external fields.

Upon analysis of this data set, we claim that Arsia Mons, does in fact have a very subtle magnetic anomaly associated with it. The radial component of the anomaly is shown in Fig. 2. The anomaly is at the very limit of the resolution of the MGS data.

Method: The processing we used to obtain this map was as follows:

1) A subset of the field model [1] at mapping orbit altitude covering Tharsis (Fig 1) was filtered to eliminate wavelengths shorter than about 480 km. Analytical modeling suggests that the volcano should produce anomalies at an altitude of 400 km with wavelengths longer than 480 km. To avoid any bias in the choice of low pass filter, the two-dimensional filter coefficients derived by Fuller [2] were employed.

2) Using the resulting smoothed data from the immediate area of Arsia Mons (Fig.2), the regional trend was approximated by a best-fit quadratic polynomial surface. This regional trend was removed to yield the residual anomaly map shown in Fig. 2.

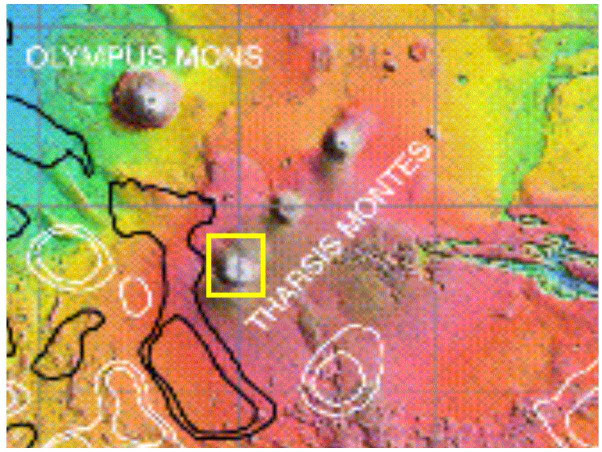

Fig. 1. Map of topography and crustal magnetic anomalies in the equatorial region of the eastern hemisphere of Mars. Arsia Mons is enclosed in the yellow square. The black contour lines are negative magnetic anomalies; the white contours are positive magnetic anomalies. The contour interval is 10 nT. The latitude and longitude lines are 30 degrees (~1770 km). Modified from [1].

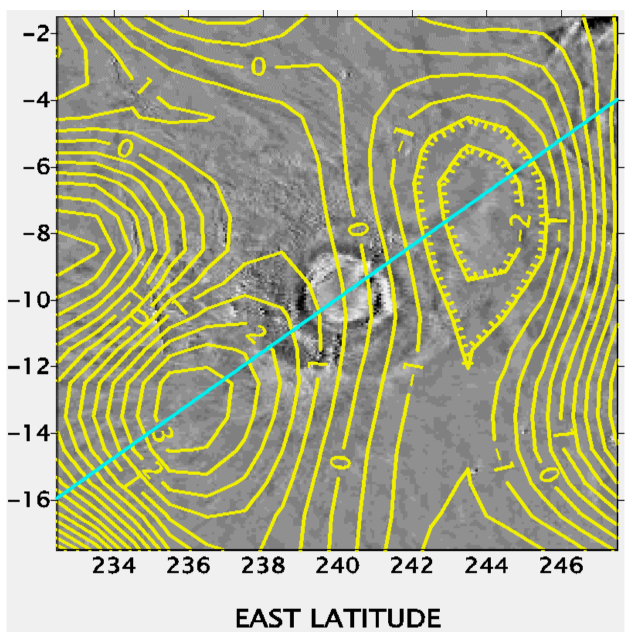

Figure 2. Radial magnetic residual anomaly map superimposed on Arsia Mons. The contour interval is 0.5 nT. Closed negative contours are hatched. The line of inferred magnetization is also shown.

The shape of the magnetic anomaly over Arsia Mons shows a positive radial anomaly to the southwest of the volcano and a negative anomaly to the northeast. This suggests a near horizontal magnetization directed southwest. A near horizontal magnetization vector of this direction should result in a magnetic field above the volcano oriented in the opposite direction (i.e. to the northeast). To test this hypothesis, we projected the tangential components of the magnetic field to the southwestward direction. The resulting tangential field (positive to the southwest) is shown in Fig.3. These data are low pass filtered to remove wavelengths shorter than 480 km, but no regional trend has been removed. The dominantly positive contours in the region are in fact interrupted in the immediate area of the volcano, indicating a local reversal of the tangential field as predicted by the modeling. The size of this anomaly is about -2.5 nT.

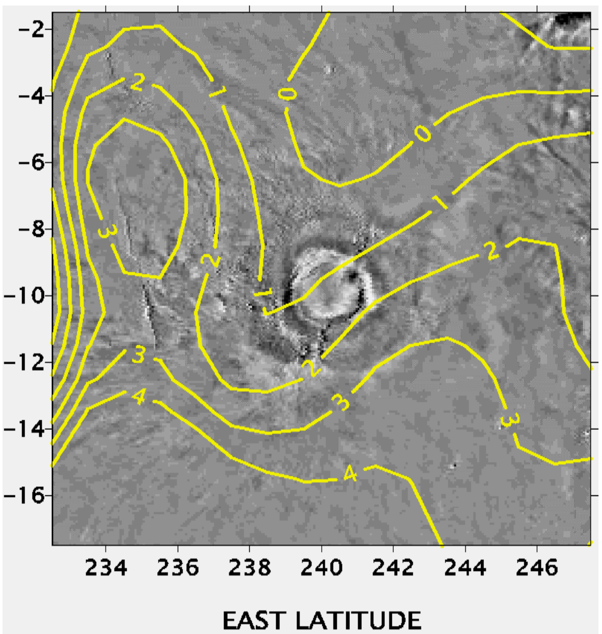

Figure 3 The tangential component of the magnetic field over Arsia Mons projected in the southeastern direction of inferred magnetization. The contour interval is 1 nT.

Interpretation: Magnetic modeling results (Fig.4) suggest that Arsia Mons lavas have a magnetic intensity of about 1 A/m inclined gently (about 10 degrees) to the southwest. The degree of magnetization suggested by the model (1 A/m) would be typical of terrestrial sea-floor basalts. However, because magnetization of Arsia Mons must have been induced by a relatively small crustal source, the Arsia Mons proclivity to be magnetized must be orders of magnitude greater than that of terrestrial sea-floor basalt. This result suggests that whatever geochemical phenomenon is responsible for the strong natural remanent magnetization (>20 A/m) in the crust of the ancient highlands may also be applicable in the younger extrusions north of the dichotomy. This would suggest that, if the strong magnetization results from petrological features of the rocks, that these features may be characteristic of Martian basalts overall, and not unique to older highlands rocks. Or, if the magnetization results from subsequent alteration of the rocks, that this alteration was ongoing throughout much of Martian history. An alternative explanation is that some of the deeper and older composite layers in Arsia Mons may date back to the age when the dynamo was active. If so, this may have implications for the age of the Tharsis construct and associated features.

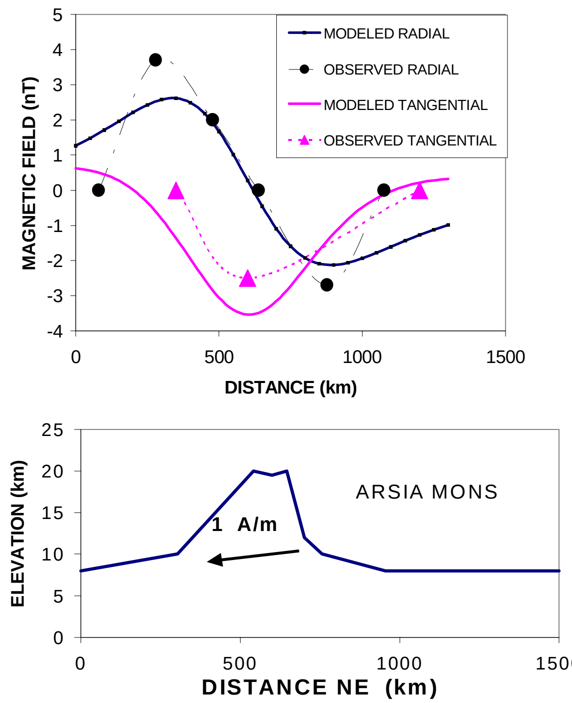

Figure 4. Modeled and observed magnetic field profiles 400 km above Arsia Mons along the profile line indicated in Fig.2. The observed radial values are directly from the the residual map (Fig.2). The observed tangential values of the residual anomaly were estimated by inspection of Fig. 3. The topography and magnetization vector used in the model is shown in the lower panel.

References:

[1] Connerney et al., Geophys. Res. Lett., 28, 4015-4018, 2001.

[2] Fuller, B.D., In Mining Geophysics, S.E.G., Vol II, 658-708.