EPSC Abstracts
Vol. 5, EPSC2010-393, 2010
European Planetary Science Congress 2010

An improved model of the magnetic lithospheric field of Mars using both MGS-MAG and MGS-ER measurements

B. Langlais (1), R. Lillis (2) and M. Purucker (3)
(1) Laboratoire de Planétologie et Géodynamique de Nantes, CNRS and University of Nantes, Nantes, France; (2) Space Sciences Lab, University of California, Berkeley, CA, USA; (3) Planetary Geodynamics Lab, Raytheon ITSS@NASA/GSFC, Greenbelt, MD, USA

Abstract

Mars Global Surveyor (MGS) returned very valuable measurements of the magnetic field, which convey crucial information regarding Mars' current state and past dynamics. In this study we report recent progress made on the incorporation of both MAG vector data and ER scalar data in a single magnetization model, and discuss the improvements in terms of correlation between geological features and magnetic signals. This more accurate crustal magnetic field model will be of significant use to those studying the aeronomy and space physics of the Mars-solar wind interaction.

1. Introduction

Mars' strong lithospheric magnetic field was discovered by the MGS mission [2]. The current magnetic figure of Mars is related to the magnetic minerals present in the lithosphere, to the pastdynamo-generated magnetic field, to the successive magnetization and demagnetization processes that affected the lithosphere, and to the interactions of the fields of internal origin with the induced Martian magnetosphere.

Modeling the Martian magnetic field using potential methods allows the separation of internal and external contributions. Existing global models are mostly based on measurements performed by the MAGnetometer experiment, i.e. direct measurements of the magnetic field vector [1]. These models use Spherical Harmonic [4, 3], Equivalent Source Dipole (ESD) [7, 5] or continuous magnetization solutions [9]. Only the two last modeling methods allow to infer a magnetization distribution, i.e. the physical properties of the Martian lithosphere.

The complementary ER measurements have been seldom used in that kind of models. These data come from the Electron Reflectometer experiment which measures the energy and angular distribution of the local electron population, and from which scalar crustal magnetic field magnitudes can be derived [6].

In this study we combine MGS MAG and ER measurements to model the Martian magnetic field and magnetization through an ESD scheme. We briefly present data and expected results.

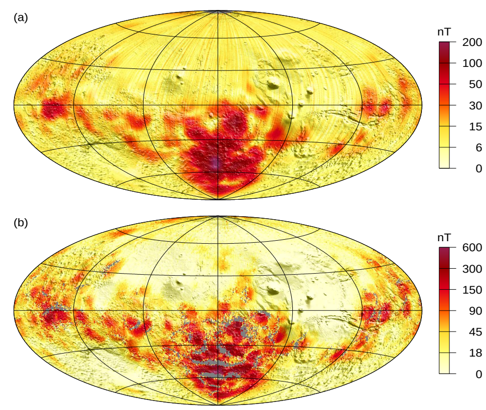

Figure 1: Magnetic field intensity above Mars' surface as it was (a) directly measured (MAG) between 360 and 430 km altitude in 2005-6, and (b) derived from the ER measurements at an altitude of 185 km.

2. MAG data

MGS MAG measurements were acquired during the repeated Mapping Orbit cycles at altitudes ranging from 360 km above the South pole to 430 km above the North pole. Night side measurements were treated using a correlative approach to reduce the external field contributions. The technique is a space domain approach using three adjacent passes separated in space by less than 1 degree of latitude, in a similar scheme to that developed for the Lunar Prospector dataset [8]. We show in Fig. 1a night side total field measurements prior to their pre-processing. Our approach allows to continue the data to a constant surface of 400 km above the mean Martian radius. In addition it provides a direct estimate of the uncertainty associated with the magnetic field intensity at this altitude.

3. ER data

ER magnetometry is based on the magnetic mirror effect, that is, the reflection of charged particles from regions of increased magnetic field strength. By comparing the pitch angle distribution of electrons moving toward the planetary surface with the distribution of those reflected from the surface, the increase in the magnetic field strength can be determined. Here ~ 3 million measurements have been combined to produce a map of the field magnitude due to crustal sources only, at 185 km altitude. It has an intrinsic resolution of ~ 200 km and a global detection threshold of ~ 3 nT [6]. It is sensitive to very weak crustal fields (e.g. the detection threshold is <1 nT over most of Tharsis), however no data can be collected where there exists a closed crustal field topology, leaving no coverage over $\sim 10\%$ of the Martian surface.

4. ESD modeling

The iterative modeling scheme is adapted from [7, 5]. The novelty comes from the use of ER data, equivalent to scalar measurements. The solution consists of equivalent magnetization intensity and directions associated with dipoles homogeneously distributed below the surface. The combined used of vector and scalar data requires a multiple step approach, as it is necessary to have an estimate of the field directions at the location of the ER data. Vector measurements are therefore used first, to produce an approached solution. Then this solution becomes an *a priori* model for the joint MAG+ER iterative inversion. Output model is chosen by investigating the evolution of the residuals between observations and model predictions. This output model then becomes a new *a priori* model. The inversion process stops whenever the misfit between the *a priori* and output models is satisfactory.

5. Expected outputs and conclusion

The joint use of MAG and ER data will lead to a consistent, significantly more accurate representation of the crustal magnetic field of Mars at 200 km altitude and above. The details of this new crustal field map will provide better constraints on the lateral variations of the magnetic field but also to those of the magnetization. This will provide us with a unique opportunity to remotely characterize Mars' interior and evolution, and will yield to important information about the interconnected histories of volcanism, magmatism, impacts and the ancient Martian Dynamo.

Acknowledgements

This study was supported by Agence Nationale de la Recherche (project ANR-08-JCJC-0126-01).

References

[1] Acuña, M. H. and 13 co-authors: Magnetic field of Mars: Summary of results from the aerobraking and mapping orbits, J. Geophys. Res., Vol. 106, doi: 10.1029/2000JE001404, 2001.

[2] Albee, A. L., Arvidson, R. E., Palluconi, F. and Thorpe, T.: Overview of the Mars Global Surveyor mission, J. Geophys. Res., Vol. 106, doi: 10.1029/2000JE001306, 2001.

[3] Arkani-Hamed, J.: A coherent model of the crustal magnetic field of Mars, J. Geophys. Res., Vol. 109, doi: 10.1029/2004JE002265, 2004.

[4] Cain, J. C., Ferguson, B. B. and Mozzoni, D.: An n = 90 internal potential function of the Martian crustal magnetic field, J. Geophys. Res., Vol. 108, doi: 10.1029/2000JE001487, 2003.

[5] Langlais, B., Purucker, M. E. and Mandea, M.: Crustal magnetic field of Mars, J. Geophys. Res., Vol. 109, doi: 10.1029/2003JE002048, 2004.

[6] Lillis, R. J., Frey, H. V., Manga, M., Mitchell, D. L., Lin, R. P., Acuña, M. H., and Bougher, S. W.: An improved crustal magnetic field map of Mars from electron reflectometry: Highland volcano magmatic history and the end of the martian dynamo, Icarus, Vol. 194, doi: 10.1016/j.icarus.2007.09.032, 2008.

[7] Purucker, M. E., Ravat, D., Frey, H., Voorhies, C., Sabaka, T. and Acuña, M. H.: An altitude-normalized magnetic map of Mars and its interpretation, Geophys. Res. Lett., Vol. 27., doi: 10.1029/2000GL000072, 2000.

[8] Purucker, M. E.: A global model of the internal magnetic field of the Moon based on Lunar Prospector magnetometer observations, Icarus, Vol. 197, doi: 10.1016/j.icarus.2008.03.016, 2008.

[9] Whaler, K. A. and Purucker, M. E.: A spatially continuous magnetization model for Mars, J. Geophys. Res., Vol. 110, doi: 10.1029/2004JE002393, 2005.