A GLOBAL MAP OF MARS' CRUSTAL MAGNETIC FIELD BASED ON ELECTRON REFLECTO-METRY.

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Introduction: One of the great surprises of the Mars Global Surveyor mission was the discovery of intensely magnetized crust [1, 2]. Magnetic sources on Mars are at least ten times stronger than their terrestrial counterparts, probably requiring large volumes of co-herently magnetized material, very strong remanence, or both [3]. Although much of the attention so far has been placed on the strong crustal fields in the southern highlands, magnetic sources do exist in the younger low-lying plains. The strength and morphology of these sources could yield clues to the thermal and magnetic history of the northern plains.

Low altitude (~100 km) Magnetometer (MAG) data obtained during aerobraking have the greatest spatial resolution and sensitivity for identifying crustal magnetic sources from orbit, but those data are sparse and therefore limit the ability to discern morphology. Fully sampled MAG data obtained in the 400-km-altitude mapping orbit have been differenced with re-spect to latitude ($\Delta B_r/\Delta Lat$) to minimize the influence of induced fields from the solar wind interaction and thus enhance the sensitivity to weak crustal sources [4]. Here we describe independent results from the Electron Reflectometer (ER), which remotely meas-ures the magnetic field intensity at ~170 km altitude, and is roughly seven times more sensitive to crustal magnetic sources than measurements of B_r from the mapping orbit.

Data Analysis: Electron reflectometry is based on the magnetic mirror effect, or the reflection of charged particles from increasing magnetic field strength. So-lar wind electrons incident on Mars' night hemisphere reflect from crustal magnetic fields. The flux of re-flected electrons exhibits an attenuation, caused by absorption in the atmosphere, that depends sensitively on the angle between the particle velocity and mag-netic field (pitch angle), which is measured by the ER. We have developed a model of an electron's interac-tion with the neutral atmosphere [5], which includes both elastic and inelastic scattering. Measured pitch angle distributions are modeled to constrain the mag-netic field at 170 km altitude (B_{170}).

The data used to construct the ER map consist of least-squares fits to 2×10^6 pitch angle distributions, each yielding an estimate of B_{170}. These are mapped from the spacecraft altitude of 400 km down to 170 km by following the local magnetic field direction in a straight line. The mean and standard deviation of B_{170}

are calculated within a 150-km-diameter circle that is scanned over the entire planet. This resolution should be sufficient to follow variations in the crustal mag-netic field strength, which we expect to occur on scale lengths comparable to or greater than the reference altitude of 170 km.

Results: Figure 1 shows B_{170} as color superim-posed on a shaded relief map derived from MOLA topography. The maximum field strength shown is 100 nT, although peak values of B_{170} exceed 1000 nT. This was done to highlight relatively weak fields and because stronger fields are well mapped by the MAG at 400 km altitude [2, 8]. Regions without superim-posed color are composed of cells with good sampling but for which the average value of B_{170} is less than 10 nT. Black regions are composed of cells with insuffi-cient sampling, which occur where crustal field lines are rarely or never connected to the IMF, even though the field strength may be significant.

The higher sensitivity of the ER map reveals addi-tional structure in equatorial and mid-latitude regions previously mapped by the MAG. Many of the mag-netic sources along the dichotomy boundary are seen to extend northward. In particular, weak magnetic sources extend northward to ~50° latitude on both the eastern and western borders of the Tharsis rise. In addition, the demagnetization signatures of Hellas, Argyre, and Isidis are more clearly defined with higher dynamic range, supporting the impact origin of the magnetic features.

The B_{170} map shows a partial ring of enhanced val-ues surrounding the Utopia basin, which coincides with a ring of increased crustal thickness derived from MGS gravity and altimetry [9]. The southeastern part of the ring is missing. The Utopia basin has been iden-tified as an impact structure on the basis of geologic [10] and topographic evidence [11, 12]. The distribu-tion of quasi-circular depressions (QCD's), interpreted as buried craters, within the basin suggests that it dates from the early Noachian [13], while the basin mor-phology and gravity signature indicates that it post-dates the formation of the crustal dichotomy [9].

One possible interpretation is that the ring of mag-netic sources around Utopia was formed by impact demagnetization of some preexisting distribution of magnetized crust. The southeastern part of the ring, if it ever existed, could have been thermally demagnet-ized by the Elysium volcanic region. This would im-
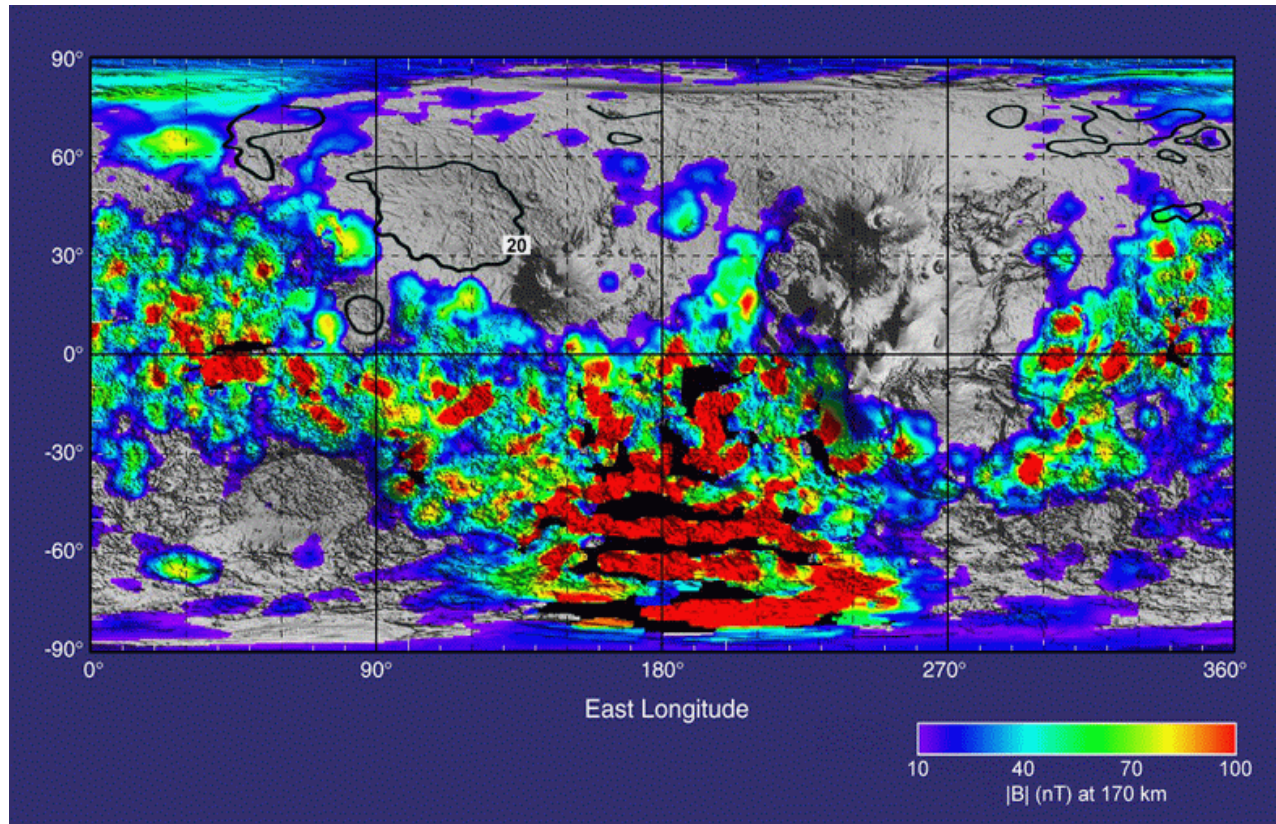
Figure 1: The crustal magnetic field amplitude at an altitude of 170 km (B_{170}), as inferred from electron reflectometry, is represented as colors superimposed on a shaded relief map of MGS-MOLA topography. Grayscale regions have $B_{170} < 10$ nT. White regions contain no data. Regions with thin crust in the northern hemisphere are bounded by a 20-km crustal thickness contour (from [9]).

ply the presence of magnetized early Noachian crust in the northern lowlands beneath a much younger surface. This is compatible with the interpretation that the northern lowlands preserve numerous buried impact craters, and that the smooth, young surface is only a thin (few km) veneer covering crust that is nearly as old as the southern highlands [14].

The correlation of the B_{170} ring surrounding Utopia with crustal thickness suggests that this parameter could limit the strength of magnetic sources in the northern plains. The huge magnetic moments associated with the strongest magnetic fields in the southern hemisphere [3] probably require volumes of magnetized crust that are tens of kilometers thick. The generally weaker magnetic fields in the northern lowlands could then be partially explained by a thinner crust (~30 km compared with ~60 km in the highlands; [9]), while variations in crustal thickness could result in observable magnetic signatures. This interpretation is supported by a correlation of B_{170} with crustal thickness in areas of the northern lowlands that are not as-

sociated with known impact sites. Where the crust is thinner than 20 km, B_{170} is generally below our 10-nT mapping threshold (Fig. 1).

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