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A preliminary magnetisation model for the lunar crust

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Abstract

Lunar Prospector vector magnetometer data have been used to produce a global magnetisation model for the lunar crust. In the absence of orientated and magnetically reliable sample returns, a magnetisation model provides valuable information on the amplitude and direction of crustal magnetisation, offering insight into the origins of the lunar magnetic fields. This model can also be used to predict the crustal magnetic field at any point above the lunar surface.

Crustal magnetic field data

The internal magnetic field of the Moon results from remanent magnetisation of the lunar crust. These fields have been globally mapped by Lunar Prospector's Magnetometer (MAG) and Electron Reflectometer (ER). This study utilises MAG data from lunar wake and geotail times, with a simple model of the external field removed to leave the internal (crustal) field. These data have been used to produce a degree 150 spherical harmonic model of the lunar crustal magnetic field [1].

The model

Unlike previous models for lunar crustal magnetisation which employ geometric shapes or single dipoles [2,3], this model makes no assumption about magnetisation direction or source shape. Using techniques developed for terrestrial and Martian data sets [4,5], the spatial distribution of magnetisation within a magnetised layer is expressed as a linear combination of Green's functions relating magnetic field data to model parameters. A unique magnetisation solution is found by minimising the root-mean-square (RMS) magnetisation amplitude for a given fit to the data. This is a trade-off controlled by a damping parameter, with the final solution chosen to best minimise both the misfit and the RMS magnetisation, while still having magnitudes sufficient to produce the observed fields (based on ideal body analysis [6]). The thickness of the layer was varied between 5 and 50 km to find the best fit for different regions of the Moon, using an initial thickness estimate calculated from a theoretical fit to the power spectra [7] of the MAG data [1].

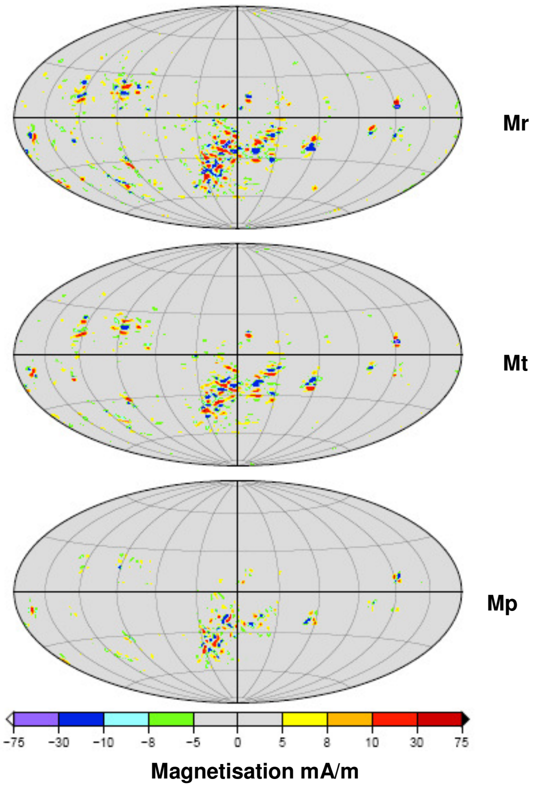

Figure 1: Three components (radial, theta, phi) of surface crustal magnetisation for a 30 km thick layer (Hammer projection centred on the farside).

Results

The best fit models for most layer thicknesses give magnetisations of up to 75 mA/m (Figure 1).

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These magnetisations are 200 times weaker than those for Mars [3]. As with the lunar crustal magnetic fields [1,8,9], the largest concentrations of strongly magnetised crust are located antipodal to the youngest large impact basins, and show some isolated features. The strongest magnetisations are in the Descartes and Reiner Gamma formations associated with the strongest crustal magnetic fields.

Outlook

These models show the spatial distribution of magnetisation of the lunar crust and place constraints on the depth of the magnetised sources. The inferred depths and strengths of these sources from this model can be further improved by including the ER data [9] as a surface magnetic field strength constraint. Magnetisation models with details of amplitude and direction are vital for the interpretation of the magnetic features observed on the Moon and will contribute to the resolution of some of the issues surrounding lunar magnetism.

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