THE MAGNETIC FIELD AT THE CORE-MANTLE BOUNDARY

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Models of the geomagnetic field are, in general, produced from a least-squares fit of the coefficients in a truncated spherical harmonic expansion to the available data. Downward continuation of such models to the core-mantle boundary (CMB) is an unstable process: the results are found to be critically dependent on the choice of truncation level (Benton, 1982). Modern techniques allow this fundamental difficulty to be circumvented (Shure, et al., 1982, Gubbins, 1983).

The method of stochastic inversion is applied to modeling the geomagnetic field. Prior information is introduced by requiring that the spectrum of spherical harmonic coefficients to fall-off in a particular manner which is consistent with the Ohmic heating in the core having a finite lower bound. This results in models with finite errors in the radial field at the CMB. Curves of zero radial field can then be determined and integrals of the radial field over patches on the CMB bounded by these null-flux curves calculated. With the assumption of negligible magnetic diffusion in the core - the frozen-flux hypothesis - these integrals are time-invariant.

Results are shown below for the field at 1970 and 1980.

Several important results emerge from these models:

1) The magnetic field at the CMB is very much more complicated than previously supposed. The error estimate for the radial field is about 50 μT, so even the smallest features seen in the models are 'real'.

2) The models are consistent with the frozen-flux hypothesis. Previously, the validity of this hypothesis had been doubted even on a time-scale of just ten years, as the hypothesis seemed inconsistent with the decay of the dipole (Booker, 1969).

3) Some of the features seem to indicate the existence of magneto-hydrodynamic waves in the core. MHD waves have long been proposed as an explanation of the secular variation, but have not previously been observed.

The frozen-flux hypothesis can be incorporated into the inversion as an additional constraint. Because the position of the null-flux curves changes with time, the constraint is non-linear and so has to be satisfied iteratively. Great care has to be taken, however, to ensure the procedure is convergent.

With the assumption of frozen-flux it should be possible to calculate certain components of the fluid motion at the top of the core. However, the models suggest that significant changes are occurring in high order terms (out to, say, degree 11) for which the secular variation is hard to determine accurately.

More data of the quality of the MAGSAT mission will be necessary to determine the secular variation, or, possibly, data covering a much longer time-interval.

References

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Booker, J.R., 1969, Proc. R. Soc. A., 309, 27-40.

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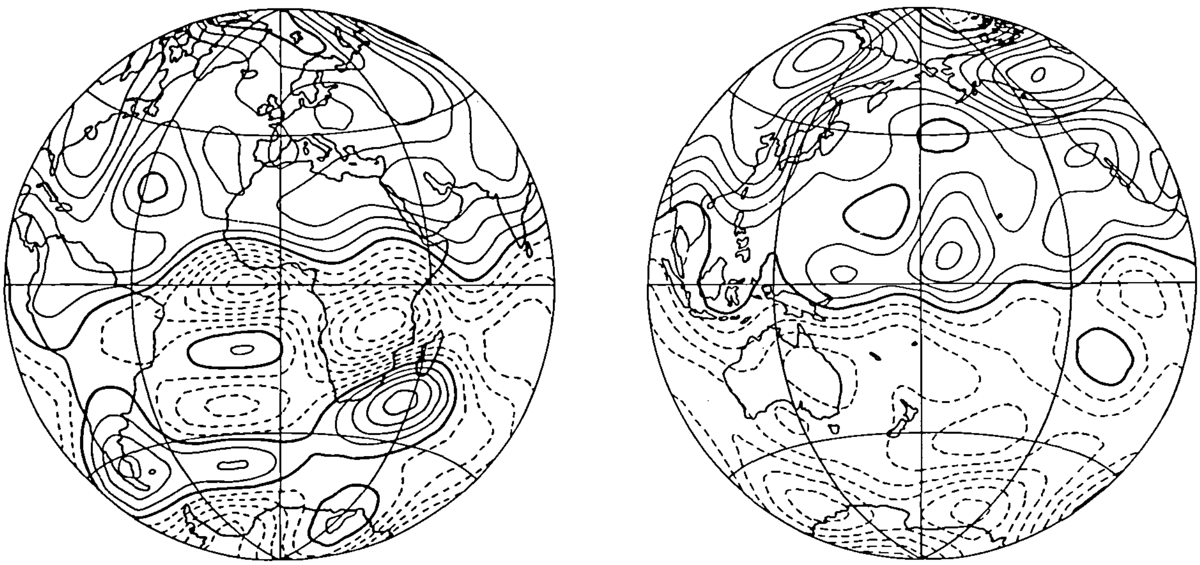
Shure, L., Parker, R.L. and Backus, G.E., 1982, Phys. Earth Planet Inter., 28, 215-229.

Contour maps of the radial field at the core-mantle boundary. The contour interval is 100 μT. The bold lines represent zero radial field, the continuous lines nagative radial field and the broken lines positive radial field.

1970



1980