THE SOURCE OF THE INTERMEDIATE WAVELENGTH COMPONENT OF THE EARTH'S MAGNETIC FIELD

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The intermediate wavelength component of the Earth's magnetic field has been well documented by observations made by MAGSAT. It has been shown that some significant fraction of this component is likely to be caused within the core of the Earth. Evidence for this comes from analysis of the intermediate wavelength component revealed by spherical harmonics between degrees 14 and 23, in which it is shown that it is unlikely that all of this signal is crustal. Firstly, there is no difference between average continental source strength and average oceanic source strength, which is unlikely to be the case if the anomalies reside within the crust, taking into account the very different nature and thickness of continental and oceanic crust. Secondly, there is almost no latitudinal variation in the source strength, which is puzzling if the sources are within the crust and have been formed by present or past magnetic fields with a factor of two difference in intensity between the equator and the poles. If however most of the sources for this field reside within the core, then these observations are not very surprising.

It is believed that most of the core sources are subject to some form of secular variation. This means that after a period of time, the spherical harmonic coefficients which produce these changes should change. In contrast, sources produced by remanent or induced magnetization within the crust would not be expected to change in any significant way, except for the small decrease in source strength of induced sources as the dipole field of the Earth decays with time (this decay is at a rate of 0.082% per year). Recent compilations of the field have calculated secular variation (SV) of coefficients up to degree eight. Using SV and models of the field at previous epochs it is possible to show that the relative change of amplitude increases with the degree of the harmonic. For instance the degree three harmonics change at a rate of 0.53% per year. This relative change increases in a fairly regular manner until at degree eight the relative change is 3.8% per year. This suggests that at higher degrees of harmonic it should be possible to see changes in coefficients if they indeed are caused by sources within the core of the Earth. Various models have been produced of the Earth's magnetic field at epoch 1980.0, based mainly on MAGSAT data. A comparison between these models shows that in general there is a fairly high correlation between individual spherical harmonic coefficients. This means that, given another accurate measurement of the Earth's magnetic field provided by GRM or MFE, it should be possible to detect changes in the higher degree coefficients (greater than 14) if the sources for these fields do indeed reside within the core of the Earth.

The increase in the resolution provided by GRM will also be of considerable use. It will be easier to tie individual anomalies to crustal structures if indeed they are caused by crustal field sources. To given an idea of the increase in resolution, the RMS field for a typical sea floor spreading situation was calculated (spreading rate 50 km/my, reversal rate 2/my, magnetization 1.0 A/m, thickness 6 km). For a height of 400 km the RMS field was 0.58 nT, whereas for a height of 160 km the RMS field was 2.5 nT. More importantly, there is much more power at larger wavenumbers. The wavenumber band between 0.014 and 0.032 (wavelength between 200 and 450 km) contains an RMS signal of 1 nT. At this wavenumber band the data from MAGSAT do not have any correlatable signals. For a dipolar source within the crust, the RMS field at the satellite altitude increases by a factor of 4.0 if the satellite altitude changes from 400 km to 160 km.