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LOW FREQUENCY GEOMAGNETIC VARIATIONS AND INDUCTION STUDIES

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Introduction

Geomagnetic variations of external origin cover a wide frequency spectrum, from Pcl (or even Schumann radiation) to 11-year fluctuations. "Low frequency variations" as generally understood, include the diurnal variations with periods of 24, 12, 8 and 6 hours.

Diurnal variations have been studied intensively since their discovery in 1722. After the demonstration by Schuster in 1889 that they are of external origin, mechanisms were sought with varying success. The papers by Martyn and his co-workers make interesting reading. Both the fine detail of the analysis of Sq and L, and speculation about their mechanism, continues to this day. For instance, how much of the measured variation is due to water motions in the ocean?

Quite apart from what might be learnt from their origin, diurnal and other low frequency variations give a wealth of information about deep conductivity to those with the patience to measure them, either as a vector field or in conjunction with telluric potentials. Recording requires instrumental stability and control of temperature, while analysis is beset with difficulties such as low signal-to-noise ratio, non-stationarity of the time series and failure of the fundamental assumptions of magneto-tellurics. These can be overcome, but more difficult is the link between low frequency magnetic signals and tectonics. Perhaps the most significant barrier to a geological interpretation is the ignorance of the factors controlling conductivity. Coventionally, electrical conductivity at shallow depths is interpreted in terms of porosity in the presence of saline fluids, and, at greater depths, in terms of the effect of temperature on semi-conductors. However, the effect of conducting minerals, especially graphite and magnetite, is not known. Small quantities of such minerals could have a significant effect, but this depends on the extent of their continuity at grain boundaries.

One of the more neglected of the low frequency variations is the annual variation, having an amplitude of a few nanotesla. The semi-annual variation (like the 11-year variation) can be ascribed to fluctuations in the frequency and intensity of magnetic storms, but this explanation cannot be applied to the annual variation. Such small long period variations require careful analysis to avoid contamination from the much larger diurnal variation. Confining the analysis to night-time values is a device often used.

The study of low frequency geomagnetic variations is still an active field of research, partly because of efforts to unravel details of their origin, and partly because of their importance as a source field for probing the electrical conductivity of the earth.