Geophysical Research Abstracts, Vol. 9, 11640, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-11640

Locking the Geodynamo to the Mantle and Implications for Core Dynamics

D. Gubbins (1), B. Sreenivasan (1), and A.P. Willis (2)

(1) School of Earth & Environment, University of Leeds, Leeds LS2 9JT, UK, (2) Department of Mathematics, University of Bristol, Bristol BS8 1TW, UK

Several observations suggest the geomagnetic field is affected by the lower mantle: the four main concentrations of flux lie close, on average, to regions of high seismic velocity; virtual geomagnetic poles circle the Pacific during polarity reversal, another indication of flux concentration on specific longitudes; and parts of the Pacific region have experienced low secular change for at least the past few thousand years. Lateral variations in heat flux across the core-mantle boundary can provide qualitative explanation of all these phenomena: high heat flux induces downwelling in the core that concentrates flux while low heat flux suppresses convection, notably in the Pacific. Heat flux may be inferred from lower mantle shear wave velocity by assuming the variations arise from variations in temperature in the lower mantle boundary layer. These qualitative ideas may be quantified, with difficulty, using numerical dynamo simulations with outer boundary heat flux prescribed to match a lower mantle seismic tomography model. Several studies have demonstrated a similarity between a time-average of the simulated field and the recent geomagnetic field but the simulations vary too rapidly to make a direct comparison. We have found a nearly stationary dynamo solution locked to lower mantle thermal anomalies; the magnetic field has four main flux concentrations lying within a few degrees of the corresponding four lobes of the present geomagnetic field. Moreover, two of the lobes are more stable than the other two in both the simulation and the historical record, suggesting a difference in size and strength of one or two of the lower mantle seismic anomalies. The locked regime requires weak advection at the top of the outer core, otherwise boundary effects cannot penetrate a significant depth into the core. We initially achieved this with a high thermal diffusivity (Roberts number) and low Rayleigh number with uniform heating, but a more plausible buoyancy profile for the Earth's core is for vigorous

compositional convection driving the dynamo at depth with weak thermal stratification operating in the upper regions, as could arise if the light component becomes immiscible at the lower pressures of the upper core. Further simulations have shown locking under this buoyancy regime. Lateral variations in heat flux across the inner core boundary are even greater than across the core-mantle boundary, and in some places may be negative, with the inner core melting. If the inner core is also gravitationally locked to the mantle, separate regions of melting and freezing of the surface could explain its complex seismic structure.