Electromagnetic Core-Mantle Coupling and Preferred Geomagnetic Reversal Paths

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We compute the electromagnetic torques acting on the mantle and core during geomagnetic polarity reversals using models of the transition magnetic field and seismic models of lower mantle structure. The interaction between an inclined poloidal magnetic field and electric currents in the mantle generates electromagnetic couples between the core and mantle that depend on the heterogeneity in electrical conductance in the D''-layer at the base of the mantle. These couples are capable of locking the geomagnetic field to lower mantle structure, producing preferred paths for the pole during magnetic polarity reversals. Using global models of seismic velocity variation at the base of the mantle to represent the variation in D''-layer thickness, we compute core-mantle electromagnetic couples as a function of magnetic pole position for several models of the transition field, including inclined dipoles, inclined quadrupoles and a model consisting of an inclined dipole plus the present-day nondipole field. All models yield preferred pole paths. Most of the models yield two longitudinally-confined paths, one close to the Americas and the other through East Asia, similar to the clusters of virtual geomagnetic pole (VGP) paths seen in paleomagnetic data from deep sea sediments. We also compute the time variation of this torque due to variations in the historical field since 1700. Although small in magnitude, the torque oscillates on a centuary timescale.