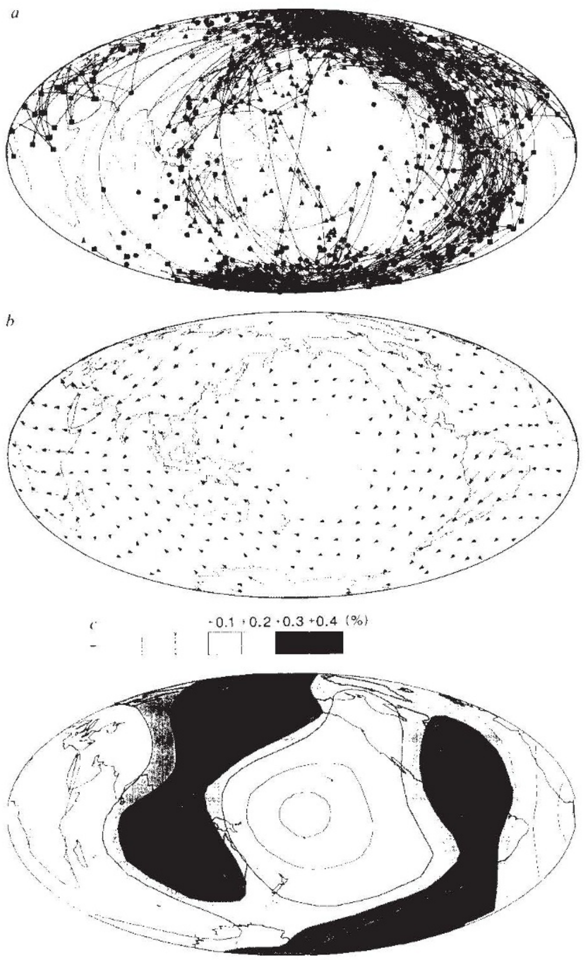
Geomagnetic reversal paths

SIR — New palaeomagnetic records of the transitional fields during geomagnetic reversals are bringing about a radical revision of ideas on the morphology of these fields. Recently, we and others have reported many new reversal records, a remarkable preponderance of which show the position of the virtual geomagnetic pole (VGP) moving along the longitude of the Americas or its antipode[1,2] as the reversal proceeds (*a* in the figure). The VGP is by convention the south magnetic pole of the dipole field that would give the observed declination and inclination at a site; hence, comparison of VGP paths from different sites yields information on the morphology of the field. The records include reversals ranging from 100,000 yr to at least 10 Myr in age; the persistence of the observed pattern may therefore reflect inherent characteristics of the geodynamo.

Here we point out that the same bands of longitude picked out by the transitional VGP paths prove to be important in other geophysical observations. For example, they have particular significance in models of the present magnetic field at the core/mantle boundary, as they mark the boundaries of the dominant non-dipole feature at low latitudes, between 90° E and 90° W[3]. In the frozen flux approximation, this feature reflects the pattern of fluid motion in the outer core — specifically, a strong westward toroidal flow from 90° E to 90° W at low latitudes (part *b* of figure). The source of the flow appears to be partly influx of fluid from higher latitudes and partly upwelling from depth; there is a similar but weaker flow eastward from 90° E to 90° W. The longitude bands preferred by the VGP paths are thus those along which north–south flow is seen in the core models.

The preferred longitudes also represent regions of fast seismic-wave propagation (and therefore low temperature) in the lower mantle, possibly related to subducted lithospheric plates (part *c* of figure)[4]. The VGP paths therefore link the morphology of the transitional fields not only to features of the present-day field and core flow patterns, but also to temperature anomalies in the mantle.



a, VGP trajectories for the Blake event (115,000–120,000 yr before present), the Upper Olduvai reversal, (~1.8 Myr) and two reversals at ~6.5 and ~11 Myr. *b*, Fluid motion at the top of the core (from ref. 3). *c*, Seismic P-wave velocity of the lower mantle, at a depth of 2,300 km (adapted from ref. 6). Velocities given as deviations from the mean. (See cover for colour version.)

Although we do not yet understand the nature of these links, we can suggest some possibilities. As the poles of the dipole field are the foci of radial flux lines entering and emerging from the core, the VGP paths during reversals should tell us something about the behaviour of the flux bundles. The flux bundles are reduced in strength compared with times when the field is not reversing, but the VGP paths suggest that some vestige remains throughout the reversal. Given the core flow pattern, it seems likely that flux bundles will, at least initially, move towards the Equator at those longitudes where there is flow towards the Equator. Similarly, during the recovery phase, flux bundles should be transported poleward at longitudes where there is poleward flow. The longitudes of north–south flow are at 90° W and 90° E, which are indeed the preferred longitudes of the VGP paths.

The degree to which the field is dipolar during the reversal, or displays some more complicated geometry, with paths dependent on the observation site, will depend on the details of the radial flux bundles. It is not at all clear how intact the flux bundles will remain, nor how important diffusion will be. For example, does some of the radial flux get swept into the toroidal flow? Do the flux bundles remain antipodal during the reversal? We think that it is not simply a coincidence that the longitudes of north–south core flow are those preferred by the VGP paths.

The link between reversal paths, the present magnetic field, flow in the core and temperature in the mantle, if confirmed by further work, will have profound implications. Because the time constants of mantle convection are orders of magnitude longer than those of the core, the persistence of the VGP bands over tens of millions of years suggests that fluid flow in the core is controlled, or at least modulated, by the temperature at the core/mantle boundary, which is determined by the pattern of mantle convection[5]. Thus, the engine of the planet appears to manifest itself in related internal motions from the core to the lithosphere, and geomagnetic phenomena in the core are ultimately related to plate tectonics.

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Triple helix stabilization?

SIR — There is an error in the interpretation of the data in the recent paper by Reaban and Griffin[1]. They demonstrate that when a plasmid containing a 2.3-kb segment of IgA switch tandem repeats is transcribed *in vitro* in the same direction as it is *in vivo*, the synthesized RNA forms a heteroduplex with the plasmid DNA, which results in a reduction of the supercoiling of the plasmid. This does not occur when the same sequences are transcribed in the antisense direction.

The authors interpret this to suggest that the switch sequence forms a triple-stranded DNA structure, which is stabilized by the RNA. But the RNA transcribed in this direction from the plasmid and also *in vivo* would be purine-rich, and not pyrimidine-rich, as they suggest, and therefore would probably