PALEOMAGNETISM

If the Earth's magnetism originated in a dipole at the center of the planet with its axis pointing due south, the magnetic inclination I would be related to latitude λ by the equation

$$\tan I = 2 \tan \lambda,$$

and the magnetic declination (or azimuth) D would be zero everywhere. In the northern hemisphere λ is positive, as would be the inclination I: by convention $I > 0$ when the magnetic field vector points below the horizontal. A measurement of D then gives the direction to the "virtual geomagnetic pole" (VGP), and a measurement of I gives the angular distance θ from the VGP, where

$$\theta = 90° - \lambda = \tan^{-1}(2/\tan I).$$

Many rocks are permanently magnetised by the Earth's field at the time they form, and this magnetism may still be stable and measurable hundreds of millions of years later. A VGP for a past time can be found if the rocks can be dated, and if strata horizontal when formed are still horizontal now, or if the tilt can be found and allowed for. McElhinny (1973) and Cox and Hart (1986) give good introductions to the subject. Both describe how to avoid errors of many possible kinds.

The Earth's field is not in fact a dipole aligned with the rotation axis, but over periods of about 10^4 to 10^5 years it may be considered so, to a good approximation. That period is long enough to average out the secular variation. Fortunately, it is also a minute fraction of the 10^8 year time-scale for a continent to move to a significantly different position on the globe. For tectonic studies one thus estimates a mean VGP (called a paleomagnetic pole) for a given rock formation at a given locality, from numerous samples laid down over a time long enough for secular variation to be unimportant. By doing this for rocks of nearly the same age on different parts of the same continent one can check for tectonic stability (and show that the Earth's radius has changed very little in the last 4×10^8 years). By investigating rocks of different ages one can trace the movements of the paleomagnetic pole and obtain a polar wander path for that continent. The difference between the polar wander paths of Europe and North America provided the first geophysical evidence for continental drift (Runcorn 1956), though its statistical significance and geological reliability took some time to confirm.

People finding a polar wander path for the purpose of studying continental movements ignore geomagnetic polarity reversals (q.v.), in order to obtain curves which are smooth on a million-year time scale. People studying the reversal process itself, of course, do not, nor do they average out secular variation, as periods of a few thousand years are crucial for both phenomena.

J.F. HARPER

REFERENCES

Cox, Allan, and Robert Brian Hart. 1986. Plate Tectonics. Palo Alto: Blackwell.

McElhinny, M.W. 1973. Palaeomagnetism and plate tectonics. Cambridge: Cambridge University Press.

Runcorn, S.K. 1956. Paleomagnetic comparisons between Europe and North America. Proc. Geol. Assoc. Canada 8:77–85.