Geomagnetic excursions and climate change

KENT[1] has demonstrated rather convincingly that the intensity of natural remanent magnetism (NRM) in deep-sea sediments is sensitive to changes in sediment type, and hence is not an accurate indicator of the true strength of the geomagnetic field. Thus, reported correlations between NRM intensity and climatic parameters in deep-sea cores may be largely or entirely a function of climatically induced changes in core lithology.

This explanation is not, however, directly relevant to suggested correlations between climate change and other aspects of the geomagnetic field. For example, excursions of the Earth's magnetic field, as recorded in sediments, have been correlated with climate fluctuations and with variations in the eccentricity of the Earth's orbit[2-4]. These excursions appear to represent changes in magnetic inclination and/or declination and do not necessarily involve variations of NRM intensity. The recorded excursions are not readily explained by changes in lithology and magnetic mineral content, although some workers have suggested that excursions in sediment cores are the result of disturbances of the deposits before, during or after sampling[5,6]. The discovery of several of the excursions in non-sedimentary materials, such as lava-flow sequences and ocean-floor magnetic striping, lends support to the idea that these events were real fluctuations of the geomagnetic field[7-9].

The proposed connection between geomagnetic excursions and climate may come about through a direct cause and effect relationship involving fluctuations in field strength that can accompany reversals and excursions[2,10], atmospheric effects of variations in geomagnetic pole position[11], or perhaps some other mechanism[12]. It is possible that excursions and climate are only secondarily related and that orbital variations are the driving force for both phenomena. Seven of the reported excursions during the last 700,000 yr seem to correspond to peaks in the approximately 100,000-yr eccentricity cycle[13]. These excursions are sometimes, but not always, correlated with changes in NRM intensity in cores[2]. Therefore, although Kent's work casts doubt on the significance of correlations of climate with NRM measurements of field strength, it does not offer an alternative explanation for the proposed connections between excursions, climate and orbital parameters.

MICHAEL R. RAMPINO

NASA, Goddard Institute for Space Studies, New York 10025, USA

1. Kent, D. V. *Nature* **299**, 538–539 (1982).
2. Wollin, G., Ericson, D. B., Ryan, W. B. F. & Foster, J. H. *Earth planet. Sci. Lett.* **12**, 175–183 (1971).
3. Fairbridge, R. W. *Nature* **265**, 430–431 (1977).
4. Rampino, M. R. *Geology* **7**, 584–587 (1979).
5. Amerigian, C. *Earth planet. Sci. Lett.* **21**, 321–326 (1974).
6. Opdyke, N. D. *Earth planet. Sci. Lett.* **29**, 238–239 (1976).
7. Wilson, D. S. & Hey, R. N. *Geophys. Res. Lett.* **8**, 1051–1054 (1981).
8. Champion, D. E., Dalrymple, G. B. & Kuntz, M. *Geophys. Res. Lett.* **8**, 1055–1058 (1981).
9. Barbetti, M. & McElhinny, M. *Nature* **239**, 327–330 (1972).
10. Harrison, C. G. A. & Prospero, J. M. *Nature* **250**, 563–565 (1974).
11. Bucha, V. *Studia geophys. geod.* **20**, 149–167 (1976).
12. Reid, G. C., Isaksen, I. S. A., Holzer, T. E. & Crutzen, P. J. *Nature* **259**, 177–179 (1976).
13. Rampino, M. R. *Geophys. Res. Lett.* **8**, 1047–1050 (1981).

KENT REPLIES—Rampino is correct in stating that, unlike NRM intensity fluctuations observed in some cores[1], anomalous NRM directions interpreted as geomagnetic excursions are not readily explained by changes in lithology and magnetic mineral content. The question of excursions, particularly their temporal and spatial distribution, can be argued at length (see, for example, ref. 2). Here I will simply illustrate some of the associated problems by considering the record of purported excursions in a single critical core, V20-108, which provides an important basis for several contributions seeking a link between geomagnetism and climate[3-5].

Although Wollin *et al.*[5] are sometimes cited[3,4] for the palaeomagnetic record of V20-108, the original data were published in an early and now classic paper on magnetic stratigraphy by Ninkovich *et al.*[6]. Comparison of the original inclination record[6] with later versions of the same data[3-5] shows some important discrepancies relevant to this discussion—for example, there are only three intervals of anomalous negative inclination, all in the upper 300 cm of the core (see Fig. 7 of ref. 6), rather than five intervals, extending to 500 cm (for example, Fig. 1 of ref. 4).

A closer look at the original data reveals that the inclinations below 300 cm in the 1,671-cm long core fall close to the expected dipole value of 63.5°, positive for normal and negative for reversed polarity. This indicates that the geomagnetic field is accurately recorded in this section of the core and supports the correlation of the reversals to the geomagnetic polarity time scale (for example, the 0.73-Myr Brunhes/Matuyama at 792 cm)[6]. In contrast, within the upper 300 cm, representing about 40% of the Brunhes, the inclinations are anomalous in two respects: first, regardless of sign, the inclinations are invariably shallower than the dipole value; and second, intervals of negative inclination occur. These intervals of anomalous negative inclination (or their facsimiles in ref. 5) have been seized upon as records of geomagnetic excursions and as such used to make various correlations with the Earth's climate or eccentricity of orbit[3-5].

I argue that these intervals, and in fact the magnetic data from the entire upper 300 cm of V20-108, are unlikely to be a representation of the geomagnetic field. In two nearby cores—V20-107 taken 227 km to the south and V20-109 taken only 208 km to the north of V20-108—the magnetic data are of high internal consistency and no such anomalous inclinations are observed in the Brunhes[6]. Such localized occurrence of large departures from an axial dipole field direction is difficult to explain with sources in the Earth's core and is more likely attributable to a distorted record. Indeed, analysis of the Lamont coring and curatorial logs for V20-108 reveals that at least the upper 300 cm of the sediment was drawn through a bent pipe during coring, a condition that could easily lead to disturbance of the sediment and the magnetic record. The same logs moreover show that the sediment core was broken in several places on board the ship, in particular at 298 cm to facilitate transport and at 460 cm where coring pipes were uncoupled; single-sample measurements of anomalous magnetic inclination closely correspond to these levels. In view of these observations, the interpretation of anomalous inclinations in V20-108 as records of geomagnetic field excursions and their correlation to global phenomena is highly dubious.

This illustration is not meant to imply that all geomagnetic excursions or short-polarity intervals reported in the literature are artefacts of poor or distorted records; several, such as the Mono Lake excursion recorded in sediments[7,8] and the Cobb Mt microchron in lavas[9,10], appear to be well documented. Rather, this unfortunate choice of data suggests that a more critical and conservative attitude should be taken in the documentation of geomagnetic field behaviour, considering the numerous and more mundane sources of anomalous palaeomagnetic data. A much improved knowledge of geomagnetic excursions and short-polarity intervals is required not only to provide a legitimate basis for comparison with the far better established record of Pleistocene climate change but also to gain a more fundamental understanding of the entire spectrum of geomagnetic phenomena[11].

This work was supported by grant OCE 81-19695. Lamont-Doherty Geological Observatory contribution 3452.

D. V. KENT

Lamont-Doherty Geological Observatory and Department of Geological Sciences, Columbia University, Palisades, New York 10964, USA

1. Kent, D. V. *Nature* **299**, 538–539 (1982).
2. Verosub, K. L. & Banerjee, S. K. *Rev. Geophys. Space Phys.* **15**, 145–155 (1977).
3. Rampino, M. R. *Geology* **7**, 584–587 (1979).
4. Rampino, M. R. *Geophys. Res. Lett.* **8**, 1047–1050 (1981).

0028-0836/83/130455—02$01.00