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Detransformation of the British geomagnetic secular variation record for Holocene times

Gillian M. Turner* *Institute of Earth and Planetary Physics, University of Alberta, Edmonton, Alberta, Canada*

R. Thompson *Department of Geophysics, University of Edinburgh, Scotland*

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In this note we replot the British post-glacial secular variation curve in terms of actual values of declination and inclination, rather than the 'transformed' declination and inclination system used in our original paper (Turner & Thompson 1981). This should facilitate the comparison of our record with contemporaneous European archaeomagnetic data.

Our composite record was obtained by averaging the dated records from 10 cores of lake sediment. The sequence of unit vectors describing the magnetic direction record of each core was rotated so as to place its mean direction (the mean over the section of core dated between 0 and 7000 BP, the time span of the shortest core) at zero transformed declination and inclination ($\bar{D}_T = 0°$, $\bar{I}_T = 0°$). The transformed coordinate frame of each core is thus derived from its mean direction, assumed to represent the mean geomagnetic field direction over the 7000 yr period, rather than from the core tube and its orientation during coring. Hence the problem of not knowing the azimuthal orientation and inclination of the corer during core collection is avoided, and the 10 records can be averaged in this coordinate system.

Transformed coordinates then, provide a convenient, generalised method of plotting averaged sediment records. However, in the archaeomagnetic method, sample orientation is straightforward, and the results can readily be plotted as absolute declination and inclination values. So for consistency when comparing the two, we have attempted here to 'detransform' our record. The following procedures, assumptions and approximations were taken to produce the detransformed magnetograms and Bauer-type plots of Figs 1 and 2.

(1) Amplitude correction. Although the combination of 10 data sets produces a good estimate of the signature of the geomagnetic variations, the following factors contribute to an overall loss of amplitude in both declination and inclination.

(a) The quality of magnetic recording varies widely between different sediments, depending on the porosity of the sediment, the size and shape distributions and the nature of the magnetic carrier (Verosub 1979). The Loch Lomond sediments carry a good, high amplitude pattern of remanent directions, of which the most recent closely follow the London observatory records. The much wetter and less compacted sediments of Llyn Geirionydd, on the

*Present address: Department of Physics, Victoria University of Wellington, Private Bag, Wellington, New Zealand.

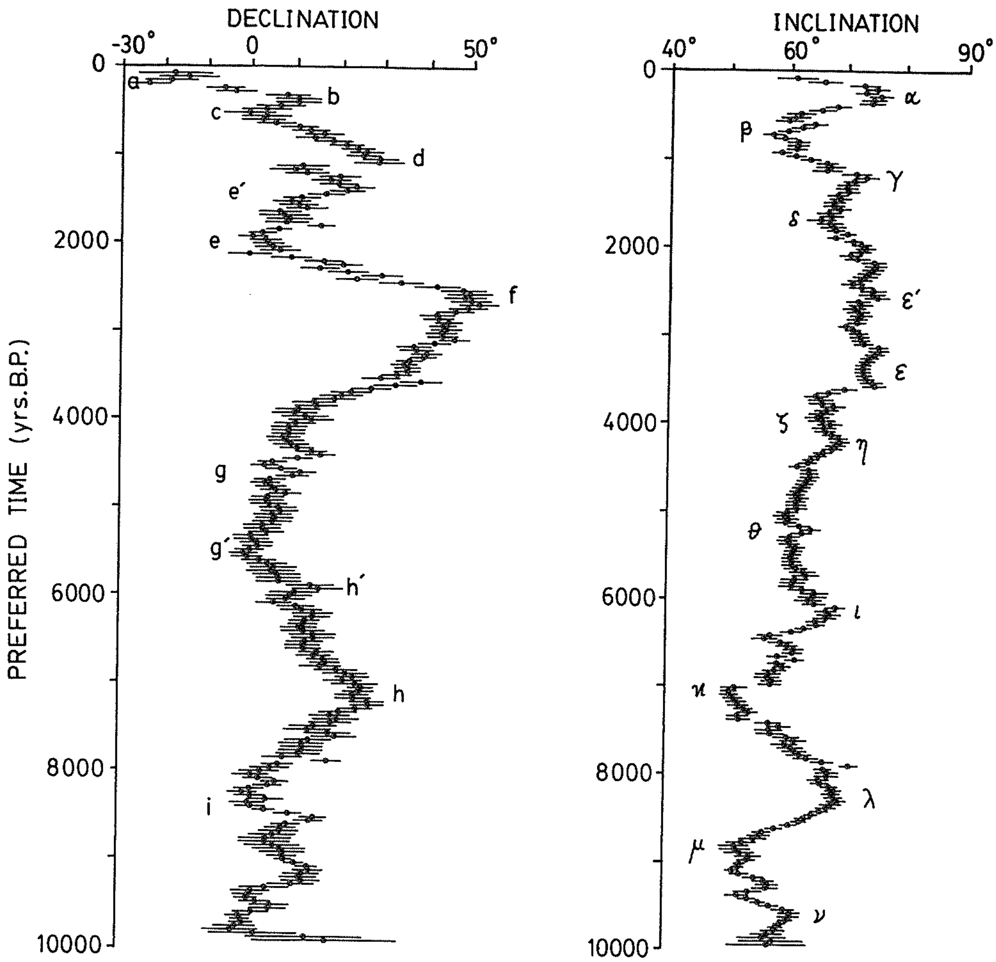

Figure 1. Averaged magnetograms of cores LLRD 1, 2, 3, LLRP 4, WIND 1, 2, 3 and GEIR 2, 3, 4, plotted against 'preferred time' at 40 yr intervals, 'detransformed' as described in the text. Alpha-95 confidence limits are shown at each horizon for an 80 yr window about the horizon. Declination and inclination features are labelled as in Turner & Thompson (1981).

other hand, while undoubtedly recording the same geomagnetic features, yield a much more scattered record of lower amplitude. The straightforward averaging procedure we have used thus inevitably reduces the amplitudes of the variations below their true values.

(b) The three lake sediments were dated independently, so between-core discrepancies in the dating of specific features also leads to a lower amplitude.

The best estimate of amplitude is probably given by the Loch Lomond cores. So by comparing the peak to peak amplitudes of several declination and inclination swings between individual Lomond records and the composite curve, we were able to estimate an overall reduction factor of 2.0. This correction was applied to the averaged record in the transformed coordinate frame, rather than to the individual records before averaging since: (i) the latter would involve estimating several correction factors on more scattered records, and (ii) amplification of the scatter in the final record, as in the former procedure the lower amplitude, more scattered records are suppressed compared with the better defined, higher amplitude ones.

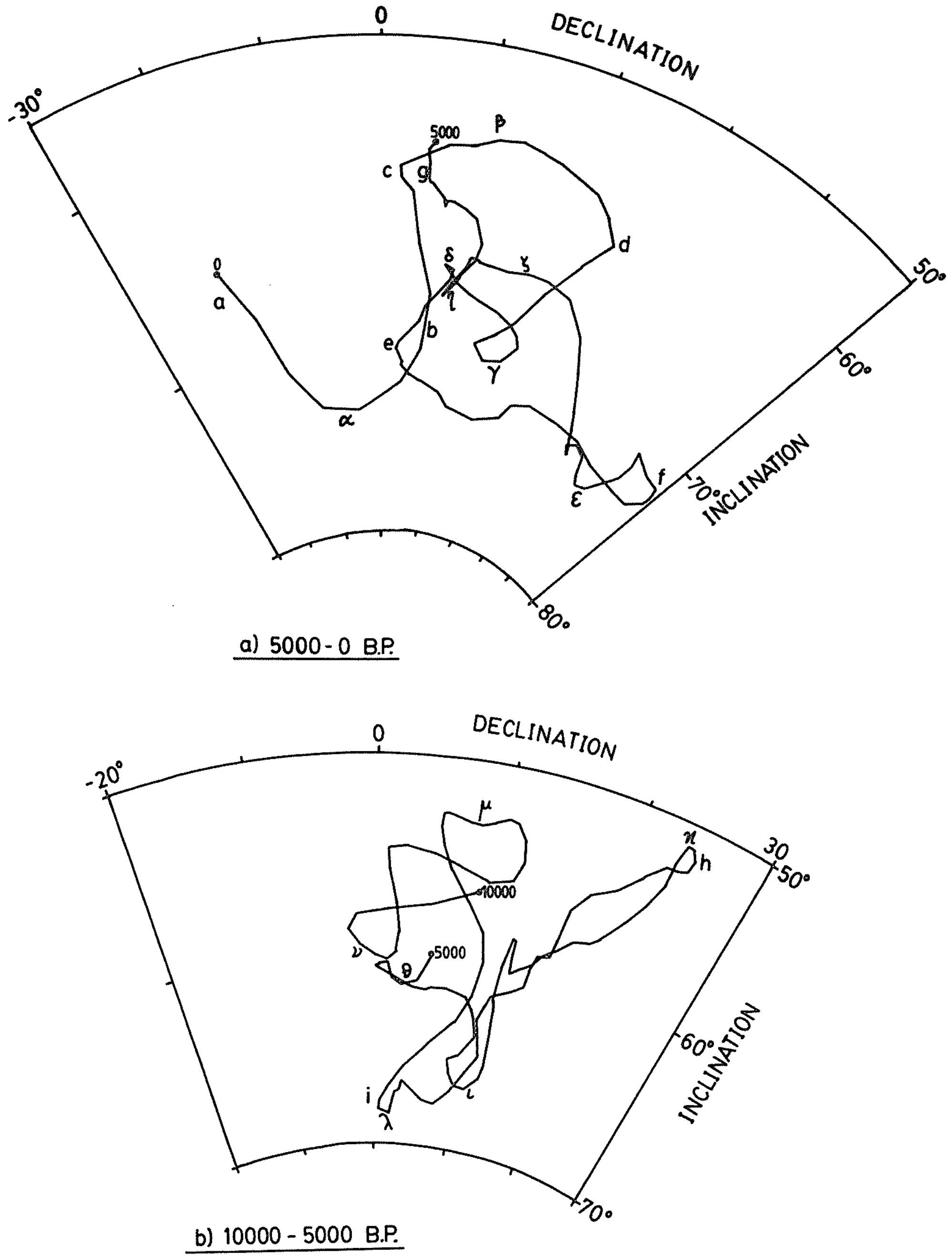

Figure 2. 'Bauer' plots – equal area projections of the results of Fig. 1, smoothed by passing a 3 point (80 yr) running mean along the data set. (a) 5000–0 BP. (b) 10 000–5000 BP. Labels are as in Fig. 1.

(2) Inclination correction. The whole record was rotated in the vertical plane containing its mean direction, so that the mean inclination was made equal to the average value of the inclination over all the cores. This value was chosen, rather than the inclination of an axial dipole at the site, as it cannot be assumed that, over only 10 000 yr the geomagnetic field averages to an axial dipole field.

(3) Declination correction. Until this stage it has been necessary to plot relative declinations, about a mean value. Since the cores were not oriented azimuthally, additional information is needed from another source to fix the scale absolutely. This was obtained from the London observatory record. The uppermost westerly swing of our record (b–a–present) was matched to the AD 1820 observatory swing which extends to 24°W, by shifting the whole of our record by 13.9° to the east.

(4) Confidence limits. Fig. 1 also shows estimates of the 95 per cent cones of confidence about each point. These were calculated on 80 yr sections of data about each age horizon, namely the 10 directions at each horizon, 10 from the horizon above and 10 from that below. This removes some of the effect of dating descrepancies without including a significant effect from the actual secular variation. All the major features noted by Turner & Thompson (1981) are shown to be significant at this level.

For brevity we have not shown any contemporaneous European archaeomagnetic results for comparison. However, the agreement between the results of Figs 1 and 2 and those of Thellier (1981) for France from AD 0 to the present, and Aitken (1970) and Clark (private communication) for Britain during the same period is good in terms of both the sense of looping of the geomagnetic vector and the absolute values of declination and inclination. Allowing for the difference in latitude and geographical separation, our results are also quite consistent with those of Kovacheva (1980) for south-east Europe for the last 8000 yr.

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