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Ancient Monuments Laboratory
Report 66/91

ARCHAEOMAGNETIC DATING: 26-27 SOUTHAMPTON STREET, COVENT GARDEN, LONDON

P Linford

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Summary

Burnt brickearth from an excavation at 26-27 Southampton Street, Covent Garden, London was sampled for archaeomagnetic dating. The site was known to date from the Saxon period but the archaeomagnetic evidence suggests, instead, a date within the Iron Age. Measurements suggest that the material was not heated sufficiently during firing, leading to predominantly viscous magnetisation. This has subsequently realigned towards the present field direction corrupting the date range deduced.

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Archaeomagnetic Dating: 26-27 Southampton Street, Covent Garden, London.

Introduction

An archaeological excavation was carried out at 26-27 Southampton Street, Covent Garden, prior to the redevelopment of the property. During this excavation three areas of burnt brickearth and sand were discovered that were thought to date from the Saxon period.

This material, context number 149, was sampled for archaeomagnetic dating to help establish a chronology for the site. The samples were given the collective sample number 17, and the AML code CG. Sampling was carried out on the 23rd of May 1989 by the author and A David of the Ancient Monuments Laboratory.

Method

Samples were collected using the disc method (see appendix, section 1a) and orientated to True North with a gyro-theodolite. Twenty-two samples were recovered with the following composition:

CG01-CG04, CG21, CG22: Compact red-yellow sand.

CG05-CG10: Reddened soil.

CG11, CG12, CG14, CG16, CG20: Burnt red-yellow clay.

CG13, CG15, CG17-CG19: Compact burnt red sand.

Results

All the measurements discussed below were made using the equipment described in section 2 of the appendix. Measurements of the directions of Natural Remanent Magnetisation (NRM) of the samples are tabulated in Table 1; the corrections discussed in sections 3b and 3c of the appendix have been applied. A graphical representation of the distribution of these directions is depicted in Figure 1.

It can be seen from the this figure that the directions fall into two main groups, one of which is centred about a declination of 5 degrees, the other with a central declination of -13 degrees. However, no correlation could be observed between this distribution and sample position. Inspection of the intensities of magnetisation in Table 1 shows a variation over three orders of magnitude. Whilst this may be partially accounted for by differences in sample size and composition, it also suggests that the samples may not all have been heated to a uniform temperature, above the blocking temperature, during the firing event.

The mean thermoremanent direction (see appendix section 3d) was calculated from these results and is depicted graphically, superimposed on the calibration curve (see appendix, section 4a), in Figure 2. This mean direction is:

Dec = -4.902 +/- 4.265°; Inc = 72.652 +/- 1.272°;
Alpha-95 = 2.290°;

Whilst the precision of this mean, as indicated by the alpha-95 statistic, is acceptable, the mean direction does not correspond with any point on the calibration curve; so no date range can be derived. Three possible causes of this problem may be considered:

1) The feature has been disturbed since the firing event.

2) An unstable viscous component in the magnetisation is corrupting the NRM direction.

3) As mentioned above, it is possible that the material was not heated to a sufficiently high temperature, hence the realignment of magnetic domains was not complete.

To investigate the stability of the remanence, a pilot sample, CG06, was partially demagnetised in 2mT increments, to a maximum value of 30mT (see appendix, section 2b). Measurements of the remaining remanent magnetisation at each stage are tabulated in Table 2. The decline in intensity of magnetisation with increasing AF demagnetisation is plotted in Figure 3; the variation in the remanent direction is depicted in Figure 4.

The decline of remanent intensity with increasing demagnetisation, depicted in Figure 3, forms an almost inverse exponential curve. A sample with stable magnetisation would have a demagnetisation curve approximating an inverse "S" shape, suggesting in this case the magnetisation was unstable. The steep decline in magnetisation in low AF fields shows that domains with higher coercivity were not aligned by the firing event. Examination of Figure 4, showing the change in direction of magnetisation with increasing partial demagnetisation, supports this conclusion. Below 10mT the direction is stable but at higher demagnetisations wanders at an increasing rate.

Since the behaviour of the direction of magnetisation at low demagnetisation values is obscured by the large changes mentioned above, a second plot, showing only measurements up to 10mT, is included as Figure 5. Inspection of this plot suggests that the thermoremanent direction is most stable between 4mT and 8mT; it was thus decided to partially demagnetise the remaining samples in a 6mT field, the centre of this range. Measurements of the remaining thermoremanent magnetisation in each sample after this treatment are tabulated in Table 3, corrected according to sections 3b and 3c of the appendix; their distribution is depicted in Figure 6.

Examination of this figure shows that the distribution of thermoremanent directions is now a single, loosely scattered, group. The directions of two samples, CG11 and CG21, now fall outside the graph area and the large drop in their intensity of magnetisation, as a proportion of the NRM value, suggests that they were not heated sufficiently during the firing event to acquire a stable remanence. For this reason they were excluded from the recalculation of the mean thermoremanent direction:

Dec = -1.203 +/- 3.846°; Inc = 71.925 +/- 1.193°;
Alpha-95 = 2.156°;

This mean, depicted graphically in Figure 7, is in a slightly different position to the mean NRM direction. A segment of the calibration curve passes within its 68% ellipse of confidence and the date range derived from it is:

133 - 81 cal BC at the 68% confidence level.
209 - 69 cal BC at the 95% confidence level.

Conclusions

Whilst the mean direction calculated above is of reasonable precision, as indicated by its alpha-95 statistic, the date range derived from it is unlikely to be correct, given the Saxon archaeological evidence from the site. The pilot demagnetisation results showed that the samples were not stably magnetised with very little alignment of the high coercivity domains. It is thus likely that the material sampled was not heated sufficiently during the firing event, so that the magnetisation acquired was entirely in viscous domains. This viscous magnetisation has slowly realigned its direction with time towards the present field direction, hence pulling the mean remanent direction away from the Saxon segment of the calibration curve.

Given the insubstantial nature of the material sampled, the possibility that it has been disturbed since it was fired must also be considered.

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Table 1; Corrected NRM measurements for all samples.

Sample	Declination (deg)	Inclination (deg)	Intensity (Am^2x10^{-8})
CG01	24.499	74.752	6679.977
CG02	2.702	75.390	1905.453
CG03	10.797	73.559	182.795
CG04	-4.207	79.373	76.289
CG05	-12.203	72.769	325.618
CG06	-9.657	70.444	330.125
CG07	3.130	71.059	509.488
CG08	-12.387	78.560	208.593
CG09	-28.371	71.933	124.693
CG10	-0.061	70.660	156.038
CG11	-6.191	64.056	12.960
CG12	-31.038	64.467	38.301
CG13	-14.633	71.364	1962.777
CG14	2.792	72.071	112.889
CG15	-4.680	66.202	2948.964
CG16	0.143	70.622	69.645
CG17	0.676	69.506	1849.075
CG18	-14.724	70.797	978.190
CG19	-15.166	72.830	386.685
CG20	5.522	72.795	2159.776
CG21	37.391	78.805	40.670
CG22	-11.088	75.190	12.925

Table 2; Variation of remanent field with increasing partial demagnetisation for sample CG06.

Demagnetisation (mT)	Declination (deg)	Inclination (deg)	Intensity (M/M_o)
0	-17.745	68.146	1.000
2	-15.962	67.555	0.900
4	-16.637	68.247	0.780
6	-16.581	67.854	0.659
8	-16.649	66.938	0.491
10	-18.478	65.347	0.348
12	-22.312	64.746	0.257
14	-23.994	61.110	0.157
16	-26.197	60.166	0.108
18	-29.541	58.078	0.084
20	-34.083	56.770	0.066
22	-38.426	57.725	0.047
24	-49.191	55.129	0.046
26	-46.579	45.683	0.040
28	-36.502	38.400	0.028
30	-44.653	41.208	0.026

Table 3; Corrected measurements for all samples after 6mT AF partial demagnetisation.

Sample	Declination (deg)	Inclination (deg)	Intensity ($Am^2 x10^{-8}$)
CG01	26.747	75.131	6235.811
CG02	4.017	75.386	1724.735
CG03	15.543	77.184	134.437
CG04	7.470	77.779	60.820
CG05	-3.465	69.272	208.477
CG06	-16.581	67.854	216.163
CG07	5.373	71.119	449.686
CG08	-5.063	76.507	136.864
CG09	-13.464	67.556	81.468
CG10	19.792	77.647	88.730
CG11	-4.035	24.301	2.678
CG12	-6.972	68.337	28.288
CG13	-13.955	71.341	1821.124
CG14	-0.133	68.863	94.617
CG15	-3.953	65.679	2748.026
CG16	-3.162	72.508	43.917
CG17	3.201	68.991	1770.562
CG18	-13.262	70.304	909.149
CG19	-14.888	73.271	357.049
CG20	6.776	72.476	2013.163
CG21	58.739	67.900	27.600
CG22	6.697	64.963	9.346

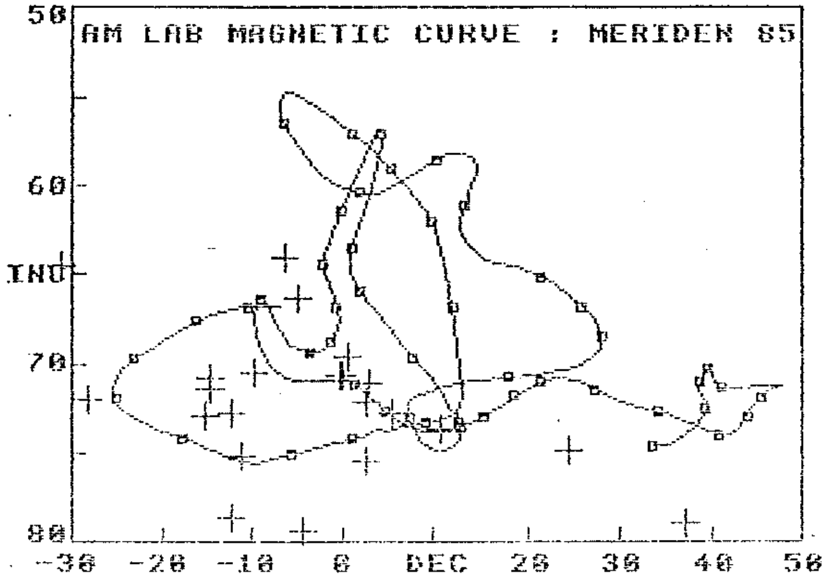


Figure 1; Distribution of NRM results.

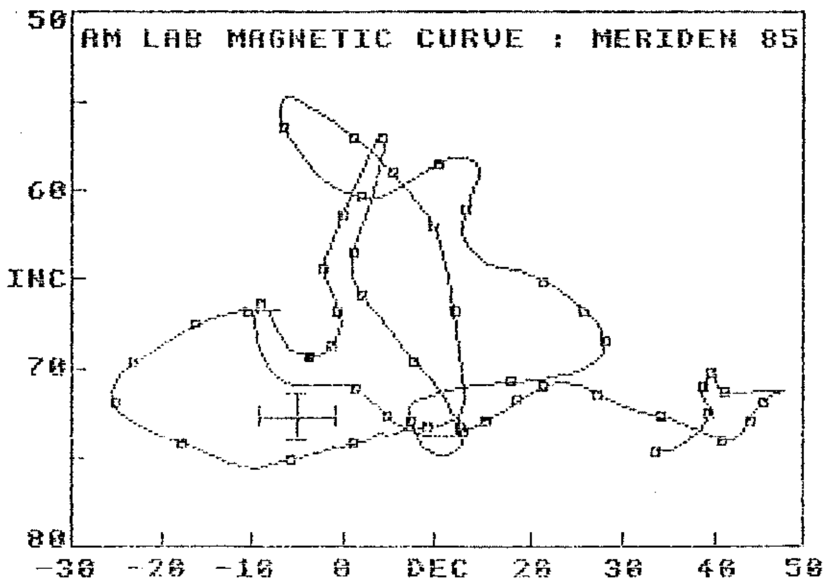
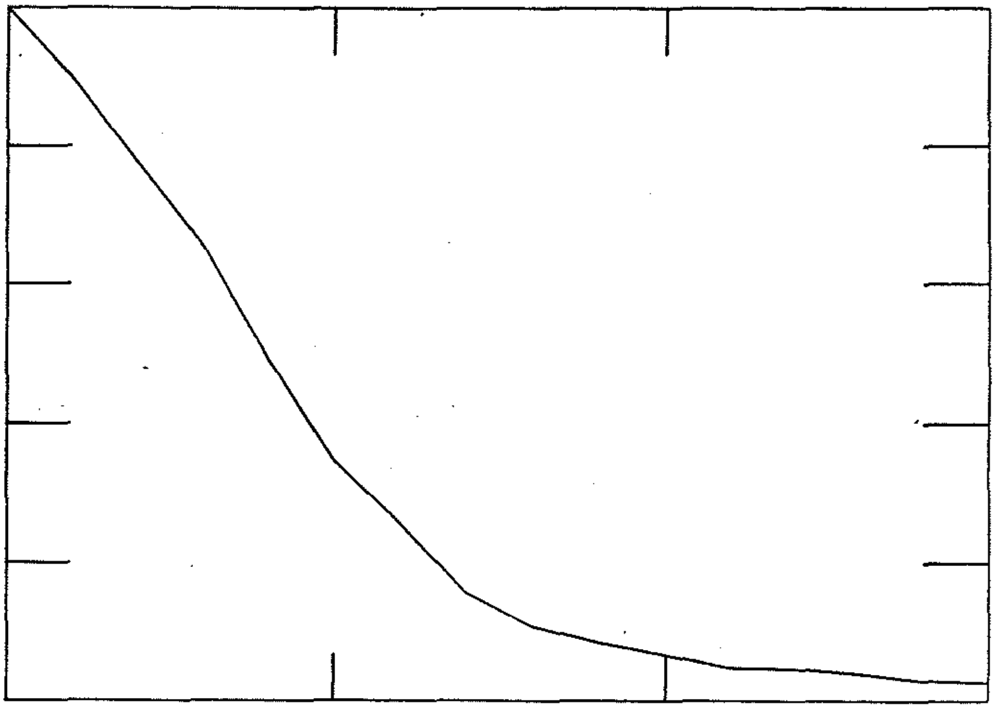
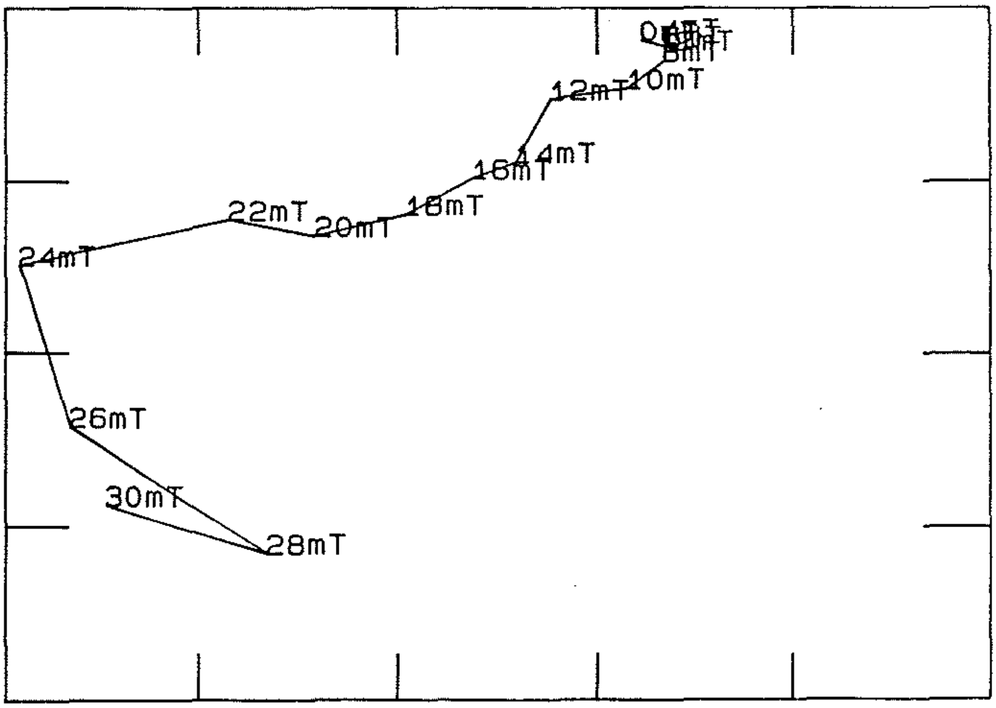


Figure 2; Mean of NRM results with 68% confidence limits.



0 -x- 30   0 -y- 1

Figure 3; Variation of remanence intensity (y axis), M/M_o, with increasing partial demagnetisation in mT (x axis), for sample CG06.



-50 -x- 0   30 -y- 70

Figure 4; Variation of Dec (x axis) and Inc (y axis) with increasing partial demagnetisation for sample CG06.

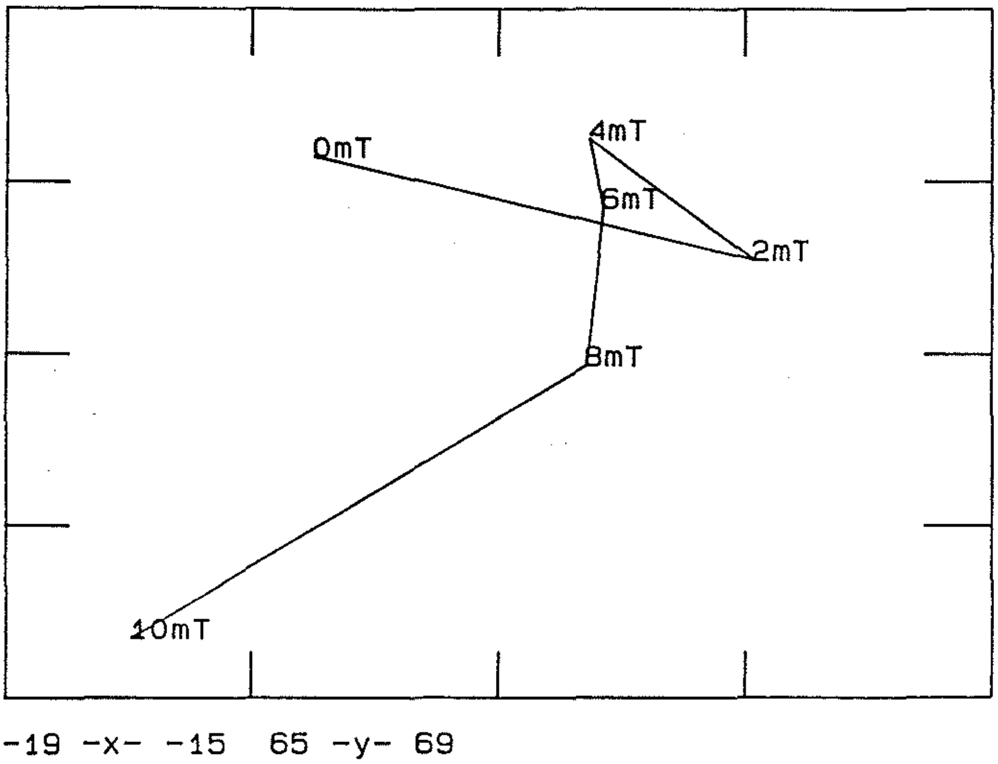


Figure 5; Variation of Dec (x axis) and Inc (y axis) with partial demagnetisations up to 10mT for sample CG06.

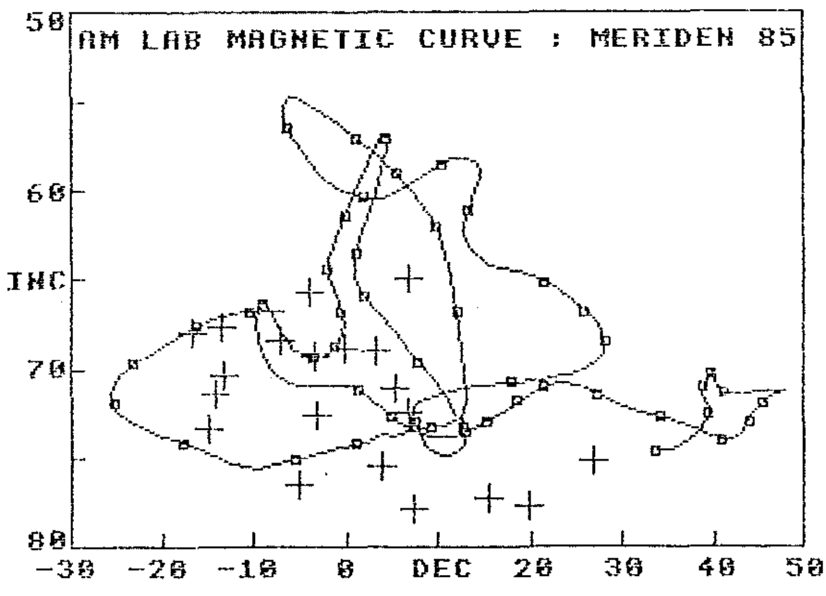


Figure 6; Distribution of partially demagnetised results.

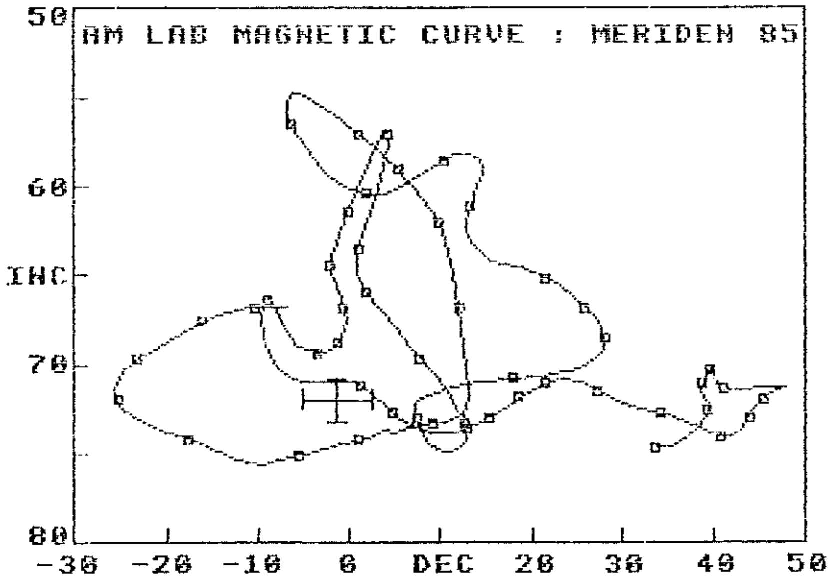


Figure 7; Mean of partially demagnetised results with 68% confidence limits.

Appendix: Standard Procedures for Sampling and Measurement

1) Sampling

One of three sampling techniques is employed depending on the consistency of the material (Clark, Tarling and Noel 1988):

a) Consolidated materials: Rock and fired clay samples are collected by the disc method. Several small levelled plastic discs are glued to the feature, marked with an orientation line related to True North, then removed with a small piece of the material attached.

b) Unconsolidated materials: Sediments are collected by the tube method. Small pillars of the material are carved out from a prepared platform, then encapsulated in levelled plastic tubes using plaster of Paris. The orientation line is then marked on top of the plaster.

c) Plastic materials: Waterlogged clays and muds are sampled in a similar manner to method 1b) above; however, the levelled plastic tubes are pressed directly into the material to be sampled.

2) Physical Analysis

a) Magnetic remanences are measured using a slow speed spinner fluxgate magnetometer (Molyneux *et al*. 1972; see also Tarling 1983, p84; Thompson and Oldfield 1986, p52).

b) Partial demagnetisation is achieved using the alternating magnetic field method (As 1967; Creer 1959; see also Tarling 1983, p91; Thompson and Oldfield 1986, p59), to remove viscous magnetic components if necessary. Demagnetising fields are measured in milli-Tesla (mT), figures quoted being for the peak value of the field.

3) Remanent Field Direction

a) The remanent field direction of a sample is expressed as two angles, declination (Dec) and inclination (Inc), both quoted in degrees. Declination represents the bearing of the field relative to true north, angles to the east being positive; inclination represents the angle of dip of this field.

b) Aitken and Hawley (1971) have shown that the angle of inclination in measured samples is likely to be distorted owing to magnetic refraction. The phenomenon is not well understood but is known to depend on the position the samples occupied within the structure. The corrections recommended by Aitken and Hawley are routinely applied to measured inclinations, in keeping with the practise of Clark, Tarling and Noel (1988).

c) Remanent field directions are adjusted to the values they would have had if the feature had been located at Meriden, a standard reference point. The adjustment is done using the method suggested by Noel (Tarling 1983, p116), and allows the remanent directions to be compared with standardised calibration data.

d) Individual remanent field directions are combined to produce the mean remanent field direction using the statistical method developed by R. A. Fisher (1953). The quantity "alpha-95" is quoted with mean field directions and is a measure of the precision of the determination (see Aitken 1990, p247). It is analogous to the standard error statistic for scalar quantities; hence the smaller its value, the better the precision of the date.

4) Calibration

a) Material less than 3000 years old is dated using the archaeomagnetic calibration curve compiled by Clark, Tarling and Noel (1988).

b) Older material is dated using the lake sediment data compiled by Turner and Thompson (1982).

c) Dates are normally given at the 68% confidence level. However, the quality of the measurement and the estimated reliability of the calibration curve for the period in question are not taken into account, so this figure is only approximate. Owing to crossovers and contiguities in the curve, alternative dates are sometimes given. It may be possible to select the correct alternative using independent dating evidence.

d) As the thermoremanent effect is reset at each heating, all dates for fired material refer to the final heating.

e) Dates are prefixed by "cal", for consistency with the new convention for calibrated radiocarbon dates (Mook 1986).

References

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