Ancient Monuments Laboratory
Report 27/90

ARCHAEOMAGNETIC DATING: THE NATIONAL GALLERY EXTENSION, ORANGE ST, LONDON.

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Summary

A clay hearth, discovered during excavations on the site of the National Gallery extension in London, was sampled for archaeomagnetic dating. Measurements suggest a date range in the twelfth century AD which compliments other available dating evidence.

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Archaeomagnetic Dating: The National Gallery Extension, Orange Street, London.

Introduction

During excavations by the Museum of London in advance of the proposed extension to the National Gallery, two superimposed clay hearths were discovered in the fill of a Saxon quarry pit. The upper hearth was sampled for archaeomagnetic dating to contribute to the construction of a chronological sequence for the pit fill (Cowie 1988).

The hearth was sampled on the 27th July 1987 by A David of the Ancient Monuments Laboratory and by D Shiel, then at the Laboratory, who also made initial laboratory measurements. Final tests, measurements and evaluation were undertaken by the author.

Method

Sampling and dating followed the standard procedures outlined in the Appendix. The samples were collected using the disc method and orientated using a compass. Measured declinations were subsequently corrected to take account of the variation between the direction of the magnetic pole and true north. Initially fifteen samples were taken, although six of these disintegrated owing to their friable nature. All the samples were composed of a red-orange clay with occasional small earthy inclusions.

Results

The results of the Natural Remanent Magnetisation (NRM) measurements of the nine surviving samples are tabulated in Table 1. The inclination and declination values in this table have been corrected for magnetic refraction (see Appendix, 3b) and to Meriden (see Appendix, 3c). The scatter of their thermoremanent directions is represented in Figure 1. The samples were, in general, strongly magnetised, NAG05 and NAG09 having the only noticably low intensities. Furthermore, the thermoremanent directions form a consistent group with no anomalous values.

On the strength of the above observations the ten results were combined to calculate the mean thermoremanent direction:

Dec = 15.711 +/- 3.014°E; Inc = 64.789 +/- 1.284°; Alpha-95 = 2.451°

The low Alpha-95 value suggests that the precision of this mean is acceptable. The result is represented graphically, superimposed on the calibration curve, in Figure 2; the derived date range is:

1120 - 1180 cal AD; at the 68% confidence level.

Since the mean thermoremanent direction did not fall precisely on the curve, it was decided to partially demagnetise a pilot sample, to determine whether viscous remanent magnetism had corrupted the NRM results. Sample NAG04 was chosen and the changes in its thermoremanent field with increasing AF demagnetisation are tabulated in Table 2. The decline in magnetic intensity with increasing demagnetisation is plotted in Figure 3 and the variation of the remanent field direction in Figure 4.

The results show that the sample is reasonably magnetically stable. However, the intensity of its remanence when demagnetised in a 20mT AF field was slightly greater than the NRM intensity, indicating a viscous component orientated in almost the opposite direction to the thermoremanent field and cancelling it to a slight extent. The sample exhibited only a small variation in remanent field direction with increasing demagnetisation (see figure 4).

Nevertheless, it was decided to partially demagnetise all the samples in a 4mT AF field to remove this viscous component in case its effect on the field directions of the more weakly magnetised samples was more pronounced. The results of these new measurements are tabulated in table 3, corrected in the same way as those in table 1. The distribution of remanent field directions is illustrated in figure 5. It is clear from this figure that the grouping has slightly improved, hence the mean remanent direction was once again calculated:

Dec = 16.841 +/- 2.421°E; Inc = 63.976 +/- 1.062°;
Alpha-95 = 2.027°

This result is represented graphically, superimposed on the calibration curve in figure 6. The alpha-95 statistic for this new mean direction is smaller, indicating greater precision; the mean also falls almost exactly on the calibration curve. The revised date range for this mean is:

1120 - 1155 cal AD; at the 68% confidence level.

Conclusions

Since the mean NRM field direction did not coincide with any point on the calibration curve, it is clear that the measurements of the thermoremanent field directions of the samples were being slightly distorted. The results of the partial demagnetisation of the pilot sample suggest that this was caused by a small viscous component in the remanent field. The revised mean remanent field direction both coincided exactly with the calibration curve and was of greater precision, implying that partial demagnetisation of the samples in a 4mT AF field successfully removed this viscosity.

There is thus no inherent reason to doubt then revised date range of 1120-1155 AD, which also is in good agreement with the pottery sequence for the pit fill.

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Table 1; Corrected NRM measurements for all samples.

Sample	Declination (deg)	Inclination (deg)	Intensity (mA/m)
NAG02	12.949	59.965	411.26
NAG03	16.299	62.817	374.10
NAG04	16.070	61.159	448.50
NAG05	19.903	69.930	161.63
NAG06	14.563	63.260	2012.39
NAG08	11.932	65.967	1795.01
NAG09	8.722	69.103	127.84
NAG13	23.518	63.961	1121.78
NAG15	17.282	66.451	307.13

Table 2; Variation of remanent field with increasing partial demagnetisation for sample NAG04.

Demagnetisation (mT)	Declination (deg)	Inclination (deg)	Intensity (mA/m)
0	23.797	57.975	429.93
2	24.096	57.693	432.90
4	25.149	57.488	414.57
6	25.717	57.462	381.89
8	26.609	57.348	339.28
10	26.875	56.974	297.16
12	24.821	57.668	248.03
14	24.344	56.623	203.61
16	23.947	56.995	146.74
18	22.562	57.512	114.57
20	22.554	57.406	90.16
22	19.008	58.387	72.99

Table 3; Corrected measurements for all samples after 4mT AF partial demagnetisation.

Sample	Declination (deg)	Inclination (deg)	Intensity (mA/m)
NAG02	10.914	61.708	334.40
NAG03	16.672	63.527	357.71
NAG04	18.637	60.390	414.57
NAG05	25.896	64.782	122.56
NAG06	15.445	62.326	1876.72
NAG08	13.409	65.939	1575.30
NAG09	11.048	67.979	71.70
NAG13	21.373	62.807	984.31
NAG15	17.559	65.690	274.97

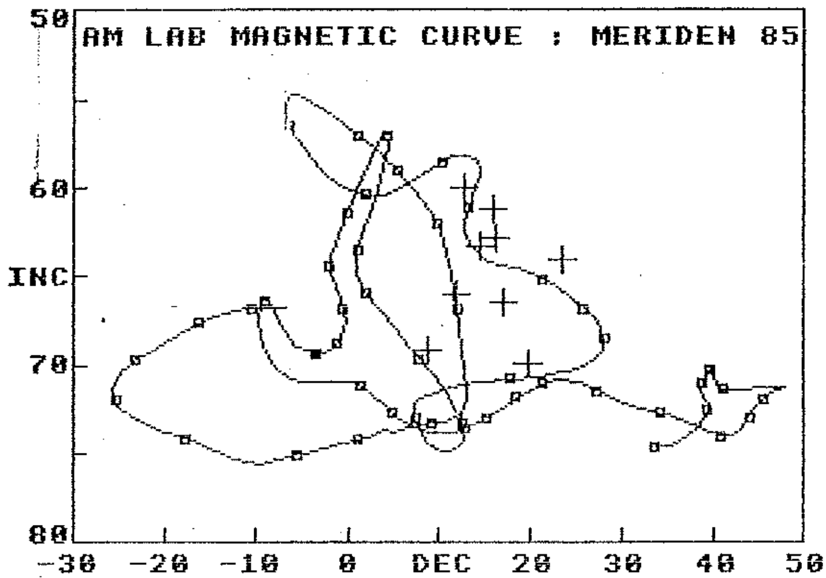

Figure 1; Distribution of NRM results.

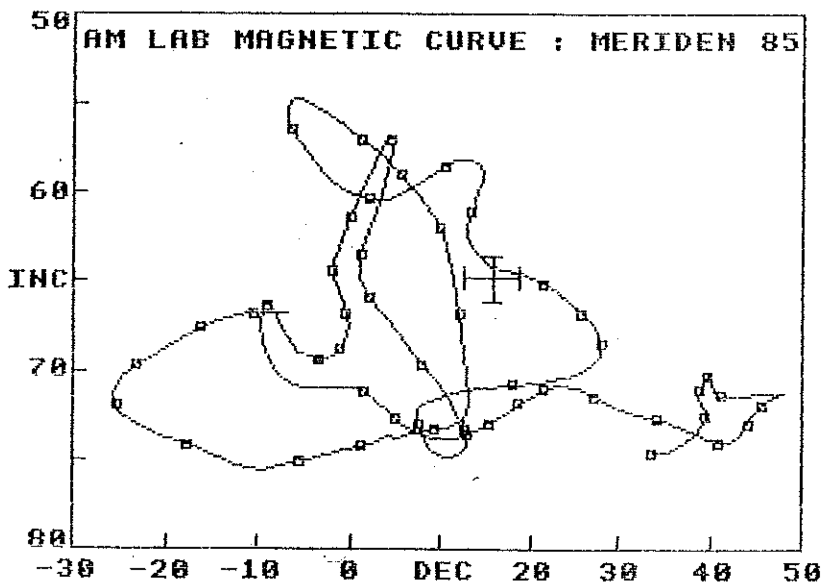

Figure 2; Mean of NRM results with 68% confidence limits.

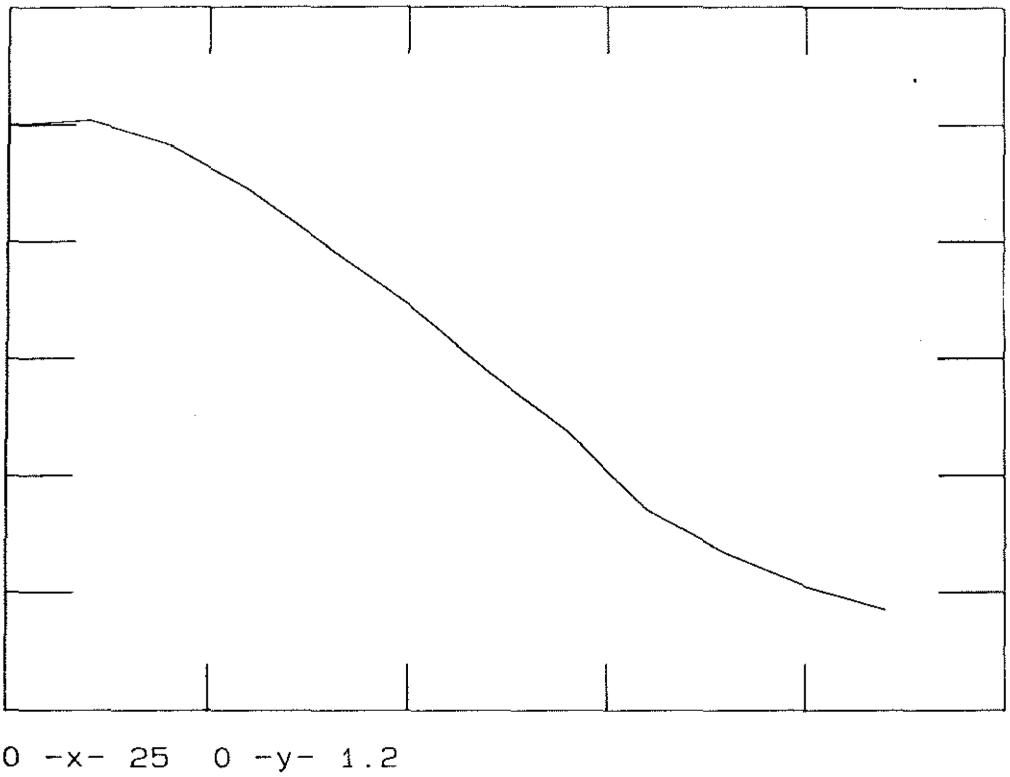

Figure 3; Variation of remanence intensity (y axis), M/M_o, with increasing partial demagnetisation in mT (x axis), for sample NAG04.

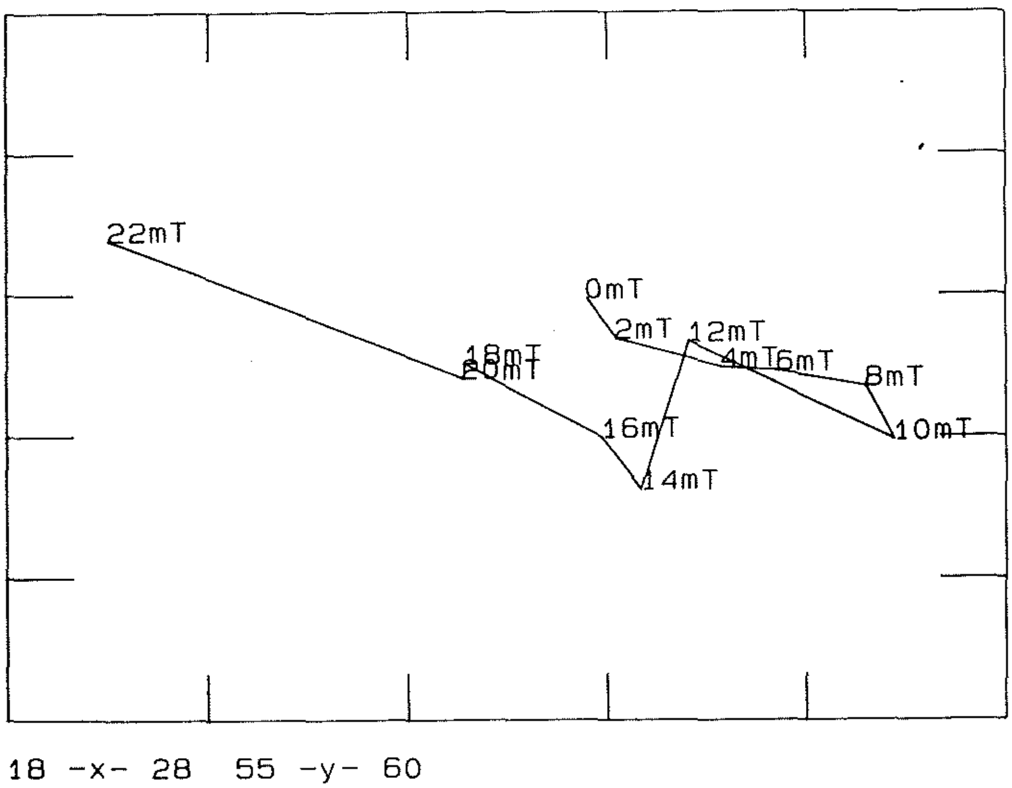

Figure 4; Variation of Dec (x axis) and Inc (y axis) with increasing partial demagnetisation, for sample NAG04.

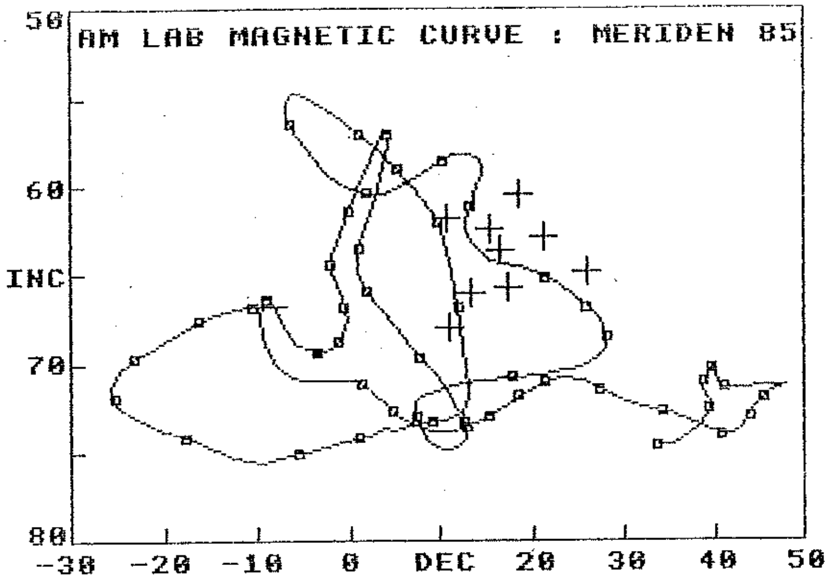

Figure 5; Distribution of partially demagnetised results

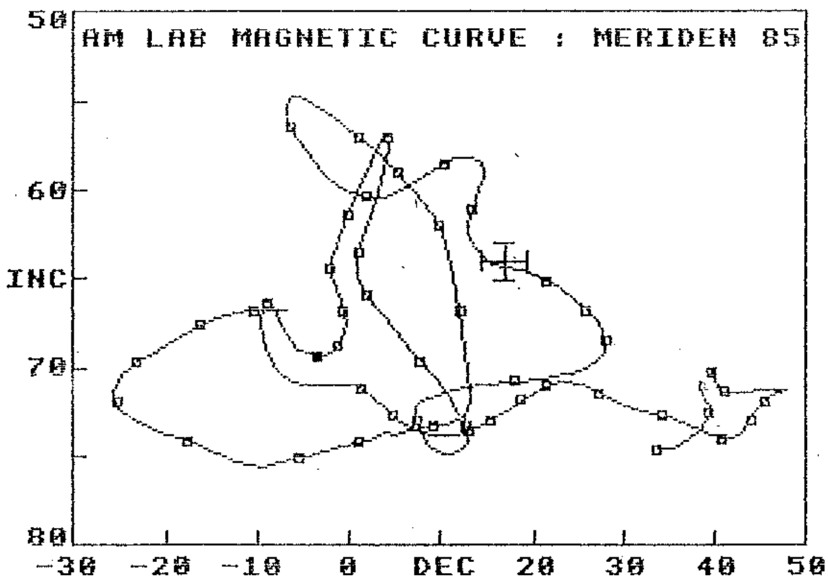

Figure 6; Mean of Partially demagnetised results with 68% confidence limits

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 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; the smaller its value, the better the precision.

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 varve data compiled by Turner and Thompson (1982).

c) Dates are normally given at the 68% confidence level. However, both the quality of the measurement and the estimated reliability of the calibration curve for the period in question are 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).

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