Ancient Monuments Laboratory
Report 60/91

ARCHAEOMAGNETIC DATING: NORWICH CASTLE MALL, NORFOLK

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Summary

The clay lining of a pottery kiln from an excavation at the Castle Mall site in Norwich was sampled for archaeomagnetic dating. It was thought to be of Late Saxon (11th century) date. Unfortunately, it was not possible to produce a date for the feature due to the poor statistical correlation of the measured directions of remanent magnetisation. Conditions at the site suggested post-depositional disturbance as the most likely explanation for this failure.

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Archaeomagnetic Dating: Norwich Castle Mall, Norfolk

Introduction

The burnt clay lining from a heavily waterlogged kiln feature excavated at Norwich Castle Mall in Norfolk was sampled for archaeomagnetic dating. The feature was located on the site of the Castle Mall shopping development and is believed to be an eleventh century, Saxon pottery kiln.

The feature, context number 22367, was sampled on 22nd November 1990 by Andrew David and Paul Linford of the Ancient Monuments Laboratory and given the AML reference code NCM.

Method

Sampling and dating followed the standard procedures outlined in the Appendix. The samples from the feature were collected using the disc method (see Appendix, 1a) and orientated to true north with a gyro-theodolite.

Results

The feature, apparently the burnt clay lining of a pottery kiln was composed primarily of a dark grey, hardened clay distinct from the underlying natural clay. It is uncertain as to whether the feature represents a deliberate kiln lining or the consolidation of the natural clay due to the intense heat from the operation of the kiln. The floor of the kiln (Context No: 22285) produced a rich fill of pottery finds and evidence of deliberate firing. Both features were severely waterlogged leading to the possibility of leaching of ferrimagnetic minerals and the plastic deformation of the material during the sampling procedure. The fifteen samples recovered are described below:

Samples 1 to 9; composed of blackened clay taken from the northern edge of the feature.

Samples 10 to 14; composed of very soft burnt clay from the southern edge of the feature.

Samples 15; composed of possibly unsTable burnt sand.

Measurements of the directions of natural remanent magnetisation (NRM) of these samples are tabulated in Table 1; the corrections discussed in notes 3b and 3c of the Appendix have been applied. In almost all cases the intensity of magnetisation was acceptable, well above the level of measurement noise. However the thermoremanent directions are highly anomalous and appear to be randomly scattered. Samples 1 to 6 and 8 to 12 were eliminated from further consideration as they were so far removed from any historically recorded magnetic direction that they were assumed to be outliers. The distribution of the NRM directions of samples 7, 13, 14 and 15 are represented graphically in Figure 1. Owing to the anomalous scattering of the NRM directions, no statistically valid mean direction could be calculated. Three probable causes may be advanced for this effect:

1) The feature has been disturbed since it was last fired.

2) Leaching of ferrimagnetic minerals may have occurred in the waterlogged conditions described above.

3) An unsTable, viscous, component may be present in the magnetisation of the samples.

Sample NCM13 was partially demagnetised in 2mT increments to investigate the stability of the remanent magnetisation. The resulting measurements are tabulated in Table 2 and the decline in the intensity of magnetisation with increasing partial demagnetisation for the sample is plotted in Figure 2. The shape of the curve demonstrates that the magnetisation of the sample was sTable except for a small degree of viscous remanence indicated by the steepening of the curve in Figure 2 at low demagnetisation values.

The variation of the direction of remanent magnetisation for sample NCM13 is plotted in Figure 3 and has been corrected as discussed in notes 3b and 3c of the Appendix. Two positions of convergence occur on the graph the first at a partial demagnetisation of between 6 and 10mT and the second between 20 and 24mT; neither convergence varies considerably from the normal remanent magnetisation direction.

These results demonstrate that viscous remanent magnetism was not the primary cause of scatter in the angles of declination, and that partial demagnetisation of all samples would not significantly improve the mean direction of remanent magnetisation obtained.

Conclusion

It was not possible to obtain a date for feature 22367 due to the anomalous scatter of the measured directions of remanent magnetisation. The evidence of the site suggested that non-rigid collapse of the feature had occurred and that the thermoremanent directions had been further corrupted by the waterlogged conditions. This would provide the most likely explanation of both the failure of the archaeomagnetic date and the attempt to determine the direction of slump from the excavators records of site levels.

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Table 1; Corrected NRM measurements for all samples.

Sample	Declination (deg)	Inclination (deg)	Intensity ($Am^2 x10^{-8}$)
NCM01	53.698	82.791	55.320
NCM02	77.303	78.927	225.128
NCM03	61.262	79.967	5636.342
NCM04	20.774	83.646	1731.812
NCM05	73.076	82.000	341.827
NCM06	27.048	82.465	9.277
NCM07	13.055	78.632	125.707
NCM08	55.560	73.992	544.169
NCM09	6.505	81.262	1797.839
NCM10	54.107	70.172	59.392
NCM11	52.422	69.648	667.997
NCM12	60.383	73.049	611.309
NCM13	49.594	71.439	545.872
NCM14	26.948	67.243	571.956
NCM15	25.544	68.408	2.007

Table 2; Variation of remanent field with increasing partial demagnetisation for sample NCM13.

Demagnetisation (mT)	Declination (deg)	Inclination (deg)	Intensity (M/M_o)
0	53.973	71.164	1.000
2	50.297	71.070	0.952
4	49.527	71.299	0.893
6	48.575	71.609	0.816
8	47.320	71.493	0.734
10	48.899	71.332	0.634
12	49.421	71.428	0.520
14	49.759	71.857	0.409
16	49.812	71.888	0.319
18	48.142	72.098	0.252
20	46.304	73.319	0.189
22	46.529	73.538	0.152
24	47.372	73.356	0.132
26	44.559	73.382	0.114
28	43.030	73.350	0.102
30	42.074	73.483	0.092

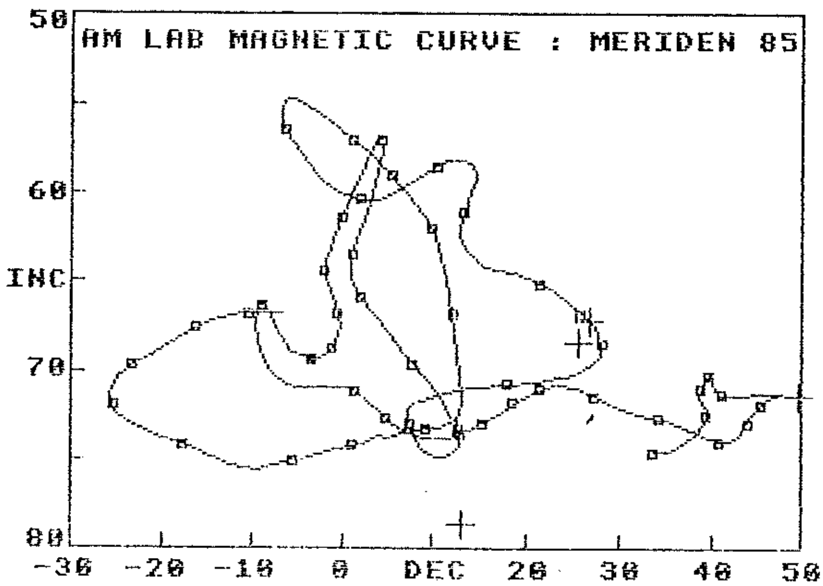

Figure 1; Distribution of NRM results for feature 22367, (NCM).

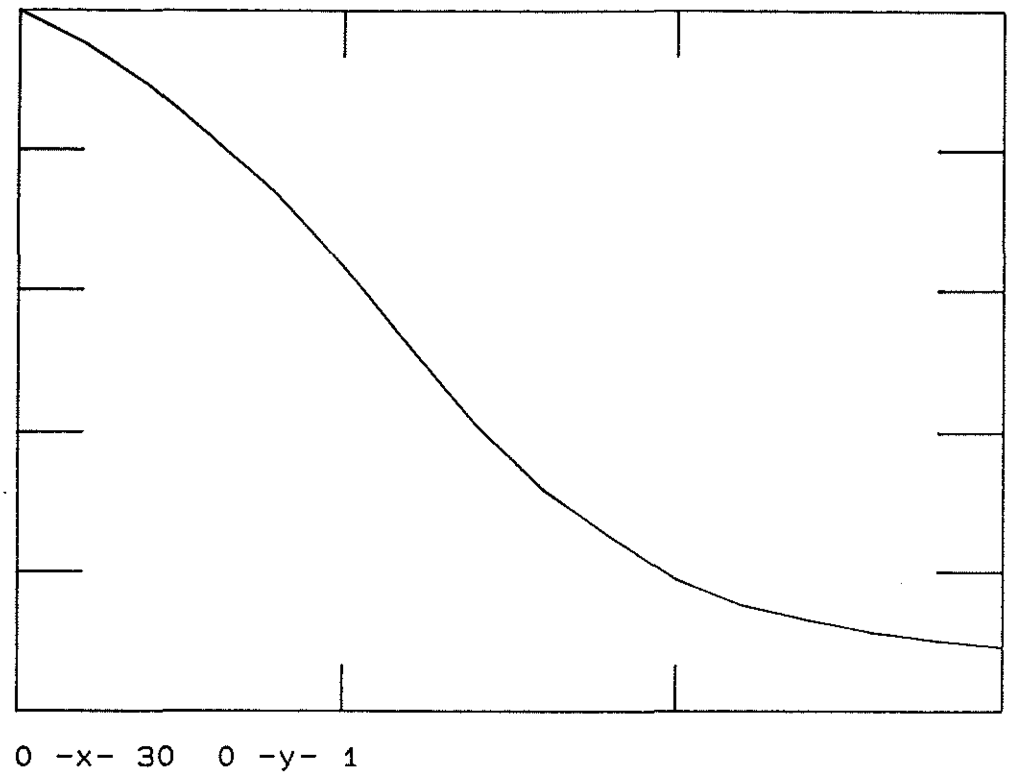

Figure 2; Variation of remanence intensity M/M_o (y axis), with increasing partial demagnetisation in mT (x axis), for sample NCM13.

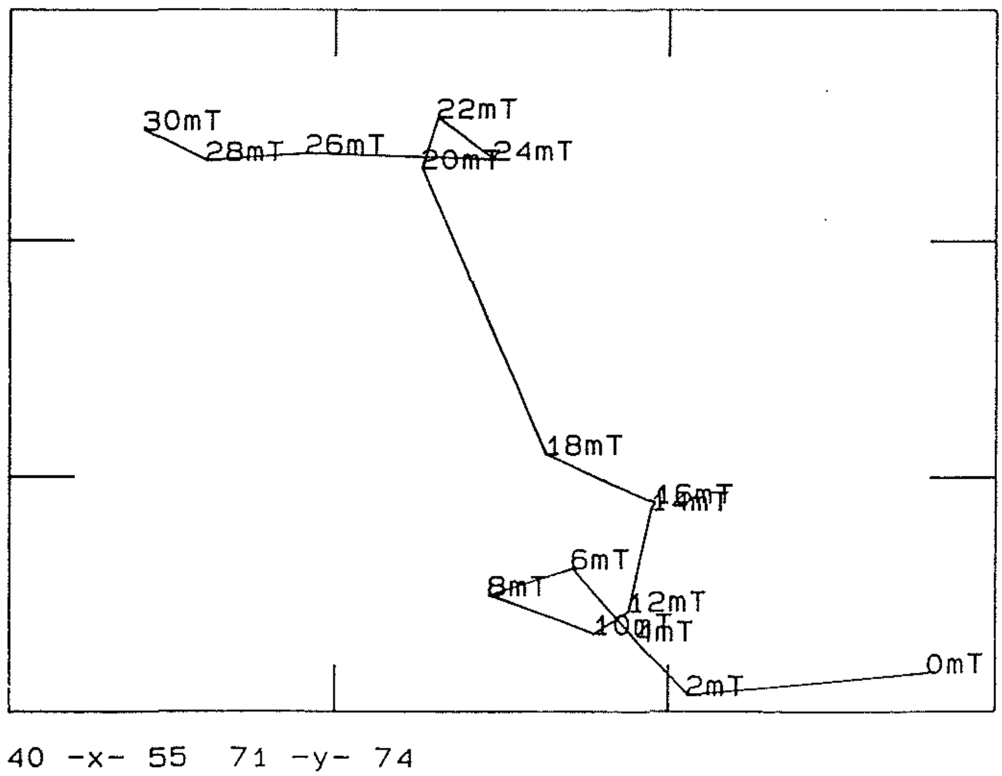

Figure 3; Variation of Dec (x axis) and Inc (y axis) with increasing partial demagnetisation, for sample NCM13.

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).

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