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Ancient Monuments Laboratory
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# ARCHAEOMAGNETIC DATING REPORT 1995: MORTON FEN, BOURNE, LINCOLNSHIRE

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Summary

A fired clay surface, thought to have formed part of a Roman pottery kiln, was discovered during excavations at Morton Fen in Lincolnshire. The feature was sampled for archaeomagnetic dating and two possible dates were advanced for its last firing, during either the second or fourth century AD.



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**MORTON FEN, Bourne, Lincolnshire.**

**Archaeomagnetic Dating Report, 1995**

## Introduction

During excavations at Morton Fen in Lincolnshire (TF 1646 2328) a burnt clay surface was discovered; it was thought to be the remains of a kiln, dating from the Roman period, when it was used to manufacture the pottery found in the vicinity. The surface had few cracks and showed no evidence of disturbance or slumping since it was last fired, thus it was sampled for archaeomagnetic dating to help establish a chronology for the site. Sampling was carried out on the 6th of July 1993 by the author and N. Linford of the Ancient Monuments Laboratory, subsequent measurement and evaluation was performed by the author.

## Method

Samples were collected using the disc method (see appendix, section 1a) and orientated to true north using a gyro-theodolite. Eighteen samples were recovered, all orange-red in coloration. All the laboratory measurements were made using the equipment described in section 2 of the appendix.

## Results

The Natural Remanent Magnetisation (NRM) measurements for all samples, corrected according to the procedures described in section 3 of the appendix, are listed in table 1. Their mean direction of thermoremanent magnetisation was calculated to be:

$$\mathbf{Dec = 0.750 \pm 2.794^\circ; \quad Inc = 64.154 \pm 1.218^\circ; \quad \alpha_{95} = 2.211^\circ}$$

Two provisional date ranges may be derived that are consistent with this mean direction, subject to the qualifications listed in section 4 of the appendix, and using the calibration data referred to in note 4a:

**150-190 cal AD or 295-350 cal AD at the 68% confidence level.**

Both ranges are later than the first century AD date suggested by the initial pottery assessment for sherds found at the site.

Sample 11 was partially demagnetised in 2mT intervals to a maximum field of 30mT to investigate the stability of the remanent magnetisation within the feature. The results are listed in table 2 and depicted graphically in figure 1. The graph on the left shows the proportional decrease in intensity of magnetisation whilst the variation in the direction of remanence is plotted on a Bauer graph on the right.

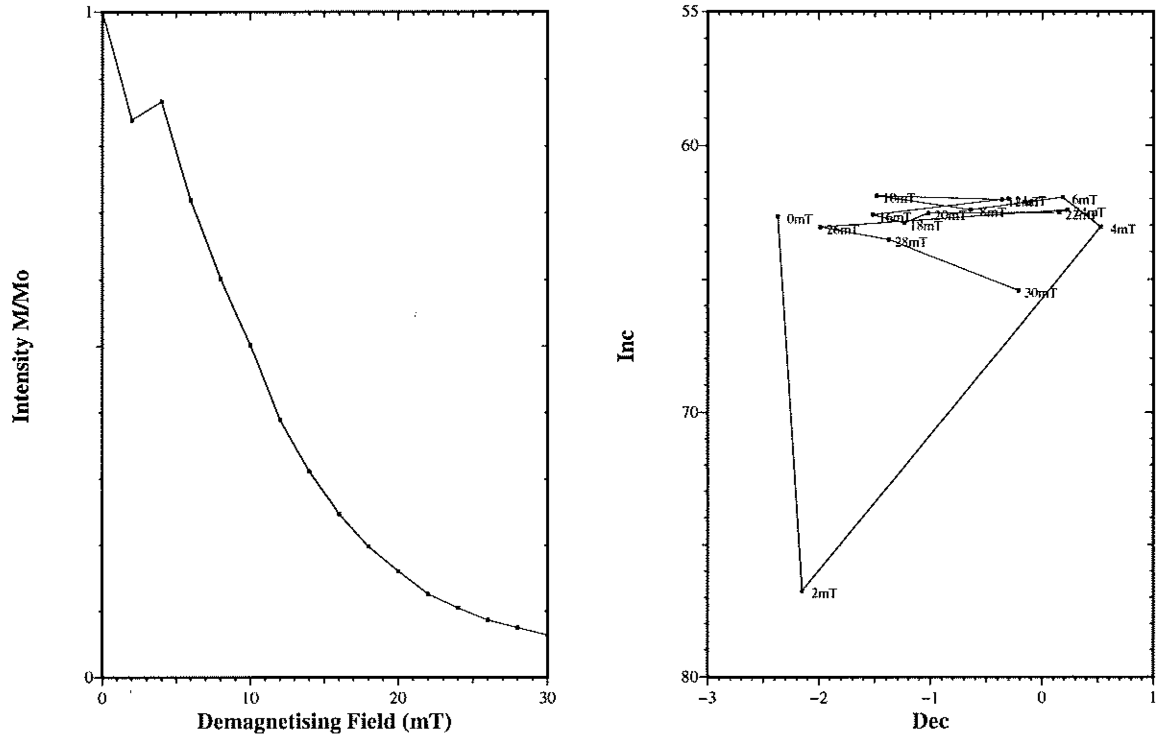


*Figure 1; Variation of isothermal remanent magnetisation with increasing AF demagnetisation.*

A distinct viscous component to the magnetisation was identified from these results. It was decided to remeasure the remanent directions of all samples, after partial demagnetisation in a 12mT AF field, to be certain that the final mean thermoremanent direction was free of the influence of this viscosity. These remeasured magnetisations are listed in table 1 and depicted in a Bauer plot, superimposed on the calibration curve of section 4a of the appendix, in figure 2. The revised mean direction of thermoremanent magnetisation was calculated to be:

$$\mathbf{Dec = 0.739 \pm 2.778^\circ;\quad Inc = 63.701 \pm 1.231^\circ;\quad \alpha_{95} = 2.234^\circ}$$

This direction is depicted on a Bauer plot, including error bars and superimposed on the calibration curve, in figure 3.

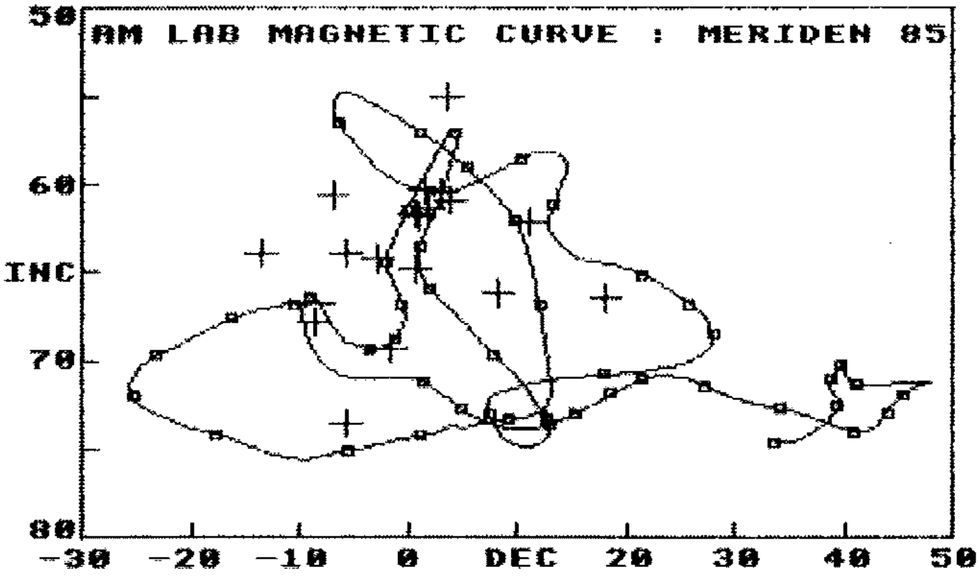


*Figure 2; Distribution of remanent directions of all samples superimposed on the calibration curve.*

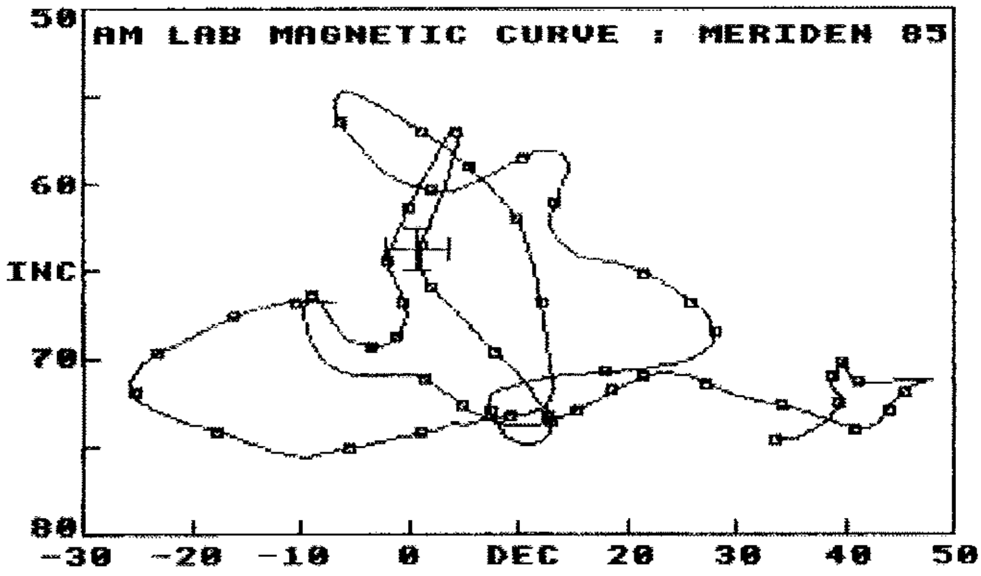


*Figure 3; Final mean thermoremanent direction of magnetisation superimposed on the calibration curve.*

## Conclusion

The date range corresponding to the segment of the calibration curve in figure 3 that coincides with the mean thermoremanent direction may be determined as:

**294-375 cal AD at the 68% confidence level.**

However a second range is also possible, as the mean direction overlaps an earlier segment of the calibration curve when the 68% confidence limits are considered. This earlier range is:

**125-188 cal AD at the 68% confidence level.**

Whilst the later date might be preferred as the mean direction falls exactly on this segment of the calibration curve, no definitive choice can be made without considering independent chronological evidence. In archaeomagnetic terms, confidence in the dating is good; the samples were highly magnetised and the distribution of their thermoremanent directions of magnetisation is in no way anomalous. Thus, it may be postulated that the last firing of the structure occurred during one of two periods defined above.

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| Sample Number | NRM Measurements | | | After 12mT Partial Demagnetisation | | |
|---|---|---|---|---|---|---|
| | Dec ° | Inc ° | M (Am² x $10^{-5}$) | Dec ° | Inc ° | M (Am² x $10^{-5}$) |
| **01** | 1.21 | 60.01 | 5.47 | 2.99 | 60.38 | 2.99 |
| **02** | 3.44 | 60.05 | 6.57 | 3.95 | 60.94 | 3.66 |
| **03** | -5.09 | 76.35 | 0.11 | -5.60 | 73.54 | 0.07 |
| **04** | -11.32 | 65.27 | 0.19 | -13.33 | 63.64 | 0.12 |
| **05** | 0.56 | 62.85 | 0.31 | 1.10 | 61.81 | 0.10 |
| **06** | 4.33 | 57.00 | 13.91 | 3.60 | 54.99 | 10.77 |
| **07** | 3.16 | 61.29 | 7.93 | 1.66 | 60.22 | 4.82 |
| **08** | -1.15 | 69.57 | 1.05 | -1.52 | 69.27 | 0.56 |
| **09** | 18.60 | 65.42 | 2.13 | 18.18 | 66.38 | 1.62 |
| **10** | -6.24 | 60.55 | 2.57 | -6.77 | 60.57 | 0.62 |
| **11** | 2.08 | 62.94 | 4.09 | 1.85 | 61.38 | 1.58 |
| **12** | -1.65 | 61.91 | 0.16 | 0.82 | 61.56 | 48.21 |
| **13** | -6.65 | 67.88 | 13.99 | -8.53 | 67.78 | 8.99 |
| **14** | 6.58 | 62.04 | 10.14 | 11.17 | 62.13 | 5.31 |
| **15** | -2.01 | 65.02 | 12.56 | -2.78 | 64.17 | 7.50 |
| **16** | 7.24 | 65.80 | 0.80 | 8.22 | 66.09 | 0.21 |
| **17** | -5.35 | 64.36 | 9.31 | -5.67 | 63.85 | 6.43 |
| **18** | 1.42 | 64.06 | 6.45 | 0.71 | 64.71 | 3.85 |

***Table 1; Thermoremanent magnetisations of samples from Morton Fen (Dec = Declination, Inc = Inclination, M = Total intensity of remanent magnetisation).***

| **Partial Demagnetisation (mT)** | **Declination °** | **Inclination °** | **Remaining Fraction of Initial Magnetisation ($M/M_0$)** |
|---|---|---|---|
| **0** | -2.372 | 62.645 | 1.000 |
| **2** | -2.150 | 76.733 | 0.839 |
| **4** | 0.526 | 63.033 | 0.866 |
| **6** | 0.181 | 61.931 | 0.719 |
| **8** | -0.641 | 62.400 | 0.601 |
| **10** | -1.483 | 61.872 | 0.502 |
| **12** | -0.363 | 62.017 | 0.389 |
| **14** | -0.308 | 61.984 | 0.311 |
| **16** | -1.517 | 62.584 | 0.247 |
| **18** | -1.240 | 62.894 | 0.198 |
| **20** | -1.021 | 62.521 | 0.161 |
| **22** | 0.152 | 62.498 | 0.126 |
| **24** | 0.226 | 62.398 | 0.105 |
| **26** | -1.988 | 63.043 | 0.087 |
| **28** | -1.375 | 63.514 | 0.075 |
| **30** | -0.213 | 65.422 | 0.064 |

***Table 2; Variation of magnetisation vector for sample MOR11 with increasing partial demagnetisation.***

## 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 $\alpha_{95}$, "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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