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Ancient Monuments Laboratory
Report 25/90

ARCHAEOMAGNETIC DATING: HOLLY TREE FARM, POTT ROW, GRIMSTON, NORFOLK.

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Summary

Two superimposed clay floors from a Medieval, multi-flued pottery kiln, discovered during excavations at Holly Tree Farm, Pott Row, near Grimston, Norfolk, were sampled for archaeomagnetic dating. The mean thermoremanent directions of both features were imprecise and the corresponding dates anomalously early. It was concluded that disturbance since the kiln was last fired was the most likely cause.

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Archaeomagnetic Dating: Holly Tree Farm, Pott Row, Grimston, Norfolk.

Introduction

The clay floor of a late Medieval multi-flued pottery kiln was discovered during excavations at Holly Tree Farm in Pott Row, near Grimston, Norfolk. The Grimston area is known to have been a centre for pottery production during the Medieval period and physical dating evidence would be a valuable aid in establishing its chronology.

The floor was sampled for archaeomagnetic dating during November 1988 and given the Laboratory code 1PR. A second clay surface, subsequently discovered beneath this floor, was also sampled during the same month and given the code 2PR. It is thought that this second surface represents the original floor of the kiln.

Method

Sampling and measurement followed the procedures outlined in the appendix. Samples from both features were collected using the disc method (Appendix, 1a), and orientated to true north with a gyro-theodolite.

For the purposes of archaeomagnetic dating, both features were in a poor state of preservation, the fired clay having a high water content and existing only in isolated patches. The samples from feature 1PR consisted of a red-orange clay with blackening visible of some samples. Samples from feature 2PR had a slightly pinker hue and a more sandy consistency. From feature 1PR, 14 samples were recovered, 13 were recovered from feature 2PR.

Results

Feature 1PR (upper surface)

Measurements of the directions of remanent magnetisation (NRM) within the samples from this feature, corrected as described in notes 3b and 3c of the Appendix, are listed in table 1. The distribution of remanent directions is depicted in figure 1.

The intensity of magnetisation within the samples was somewhat lower than usually expected for fired clay, the mean value being 1.5×10^{-6} Am^2. Also, it is clear from figure 1, that a high degree of scattering has occurred. Two of the samples, 1PR03 and 1PR13, do not even fall within the area of the diagram, and it is likely that they are outliers caused either by disturbance, or by sampling errors.

Nevertheless, some clustering of directions is evident, so the mean thermoremanent direction was calculated, excluding the outliers 1PR03 and 1PR13:

Dec = 6.804 +/- 3.675°; Inc = 68.594 +/- 1.341°; Alpha-95 = 2.495°;

This mean is depicted graphically, in figure 2, superimposed on the calibration curve (see Appendix, 4a). The mean direction coincides well with the curve and, despite the scattering mentioned above, the alpha-95 statistic suggests an acceptable precision. The date range derived from this mean was (see Appendix, 4):

440 - 505 cal AD at the 68% confidence level.

However, archaeological evidence rules out this date range as it has been established that the feature is of late Medieval origin. Thus, the coincidence of the mean direction with the calibration curve at this point must be by chance. It is possible that viscous remanent magnetism, acquired while the samples were in situ, has systematically deflected the remanent directions of all the samples. This would cause the mean direction to be shifted from its true position on the diagram, whilst still appearing to be of reasonable precision.

To ensure that this was not the case it was decided to remeasure the samples after partial demagnetisation. A pilot sample, 1PR10, was demagnetised in 2mT increments to a maximum of 30mT in an AF demagnetiser (Appendix, 2b), to establish the value at which the remanence was most stable. Measurements of the remanent field after each increment are tabulated in table 2. A graph of the decline in remanent intensity with increasing partial demagnetisation is depicted in figure 3 and the variation in remanent direction in figure 4.

The characteristic reverse 'S' shape of the graph in figure 3 shows that the magnetisation is stable. Furthermore, it can be seen in figure 4 that the remanent direction of magnetisation does not change significantly until the 18mT partial demagnetisation increment. This suggests that viscous remanent magnetisation is not a significant component of the overall magnetisation. Nevertheless, the remaining samples were partially demagnetised to ensure this result was not atypical.

The remanent direction of sample 1PR10 appeared to be most stable in the range between 4mT and 8mT. Hence the mid point of this range, 6mT, was chosen as the partial demagnetisation value to use for the rest of the samples. Measurements of the resulting remanent directions are tabulated in table 3 and depicted graphically in figure 5, corrected as discussed in notes 3b and 3c of the Appendix. An examination of figure 5 shows that the scatter of remanent directions has not significantly changed from that of the NRM directions in figure 1. Consequently the mean thermoremanent direction (Appendix, 3d), again calculated excluding 1PR03 and 1PR13, is little different:

Dec = 5.613 +/- 4.207°; Inc = 67.899 +/- 1.583°; Alpha-95 = 2.946o;

This mean direction is depicted in figure 6. The alpha-95 value has slightly increased, possibly since the samples, which originally had low intensities of magnetisation, are now partially demagnetised, making measurement errors more significant. Since this mean direction was so similar to the NRM mean direction, it is unlikely that the anomalous deflection is caused by viscous remanence in the samples. It must be concluded that disturbance since firing is the most probable cause of the anomalous mean thermoremanent direction, thus rendering the feature undatable by archaeomagnetic means.

Feature 2PR (original surface)

Corrected NRM measurements for the feature are tabulated in table 4 and the distribution of remanent directions is depicted in figure 7. The intensity of magnetisation of the samples was higher than that found in feature 1PR, the mean value being 8.0 x 10^{-6} Am^2.

Figure 7, exhibits similar traits to figure 1 which plotted the NRM directions for feature 1PR. Once again a high degree of scattering is evident, though there is a small cluster of directions in the centre of the diagram. Owing to the high degree of scattering, the mean thermoremanent direction, plotted on the calibration curve in figure 8, is imprecise (see Appendix, 3d and 4a):

Dec = 1.015 +/- 6.018°; Inc = 70.745 +/- 1.985°;
Alpha-95 = 3.678°;

Furthermore, whilst this direction again lies on part of the calibration curve, it would give an Iron Age date which can be discounted for the reason mentioned above.

As in the case of feature 1PR, partial demagnetisation of the samples was used to investigate the amount of viscous remanent magnetisation present. The pilot sample, 2PR13, was AF demagnetised in 2mT increments to 20mT, to investigate the stability of the remanence. The measurements recorded after each increment are tabulated in table 5. A graph of the decline in remanent intensity with increasing demagnetisation is depicted in figure 9, the variation in remanent direction in figure 10.

The unsmooth, almost linear, shape of the intensity curve in figure 9 suggests that magnetisation was not stable within the sample. This would account for the large, erratic changes in thermoremanent direction displayed in figure 10. Nevertheless, a region of stability of remanent direction is apparent at partial demagnetisations between 6mT and 12mT.

Based on the above, a partial demagnetisation field of 8mT was chosen to use on the rest of the samples. Corrected measurements of the direction of magnetisation after demagnetisation are tabulated in table 6; the distribution is plotted in figure 11. It is clear from this figure that degree of scattering has been reduced, suggesting that the magnetisation in these samples was indeed less stable than in those from feature 1PR and thus, more susceptible to viscous alteration.

The mean direction calculated from these results, plotted on the curve in figure 12, was calculated to be (see Appendix, 3d and 4a):

Dec = 3.559 +/- 4.500°; Inc = 67.687 +/- 1.709°;
Alpha-95 = 3.163°;

Whilst this mean is significantly different from its previous value, it is now close to mean of the samples from feature 1PR. Hence the magnetic remanence in feature 2PR also indicates a 5th century AD date, slightly earlier than that of feature 1PR. Since archaeological evidence shows that it is not possible for the feature to date from this period, it must again be concluded that disturbance since last firing has rendered it undatable archaeomagnetically.

Conclusions

Feature 1PR gives a 5th century AD date which is acceptable on archaeomagnetic evidence alone. Whilst less certain, the final results from feature 2PR indicate a similar, slightly earlier date range consistent with it being an older floor surface of the same kiln. Both dates are, however, ruled out when archaeological evidence is considered. It is thus most likely that disturbance since the kiln was last fired has corrupted the remanent magnetisations from their true values.

The high degree of scattering in both sets of results is a characteristic indicator of disturbance. Furthermore, the fact that both features have similar mean thermoremanent directions, suggests that the entire surviving kiln structure must have slumped. This is plausible since the feature was located near the surface on a site that had been ploughed. Further, more random disturbance may have been caused by frost damage when the surfaces were exposed. It should also be noted that the mean direction of feature 2PR was less precise than that from 1PR; this can be accounted for by the lower stability of magnetisation present in samples from this feature.

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26th March 1990

Table 1; Corrected NRM measurements for feature 1PR.

Sample	Declination (deg)	Inclination (deg)
PR01	15.721	66.825
PR02	7.215	72.652
PR03	-48.242	71.244
PR04	9.991	70.761
PR05	-8.240	68.063
PR06	24.329	64.399
PR07	6.569	69.516
PR08	7.677	72.799
PR09	11.155	65.410
PR10	7.728	67.868
PR11	-3.875	63.740
PR12	-5.250	66.985
PR13	-56.581	71.337
PR14	8.272	71.126

Table 2; Variation of remanent magnetisation with increasing partial demagnetisation for sample 1PR10.

Demagnetisation (mT)	Declination (deg)	Inclination (deg)	Intensity (M/M_o)
0	5.621	70.013	1.000
2	5.343	69.521	0.995
4	5.451	69.252	0.967
6	5.523	68.978	0.912
8	5.280	69.151	0.826
10	3.700	68.845	0.736
12	2.503	68.884	0.619
14	2.064	68.890	0.506
16	0.691	69.322	0.411
18	0.513	69.587	0.333
20	0.121	70.551	0.277
22	-3.045	71.443	0.222
24	-2.737	73.184	0.189
26	-6.091	72.262	0.172
28	-4.664	71.476	0.157
30	-10.307	70.547	0.139

Table 3; Corrected measurements for feature 1PR after 6mT AF partial demagnetisation.

Sample	Declination (deg)	Inclination (deg)
1PR01	18.183	65.796
1PR02	3.134	73.896
1PR03	-40.264	71.378
1PR04	17.645	72.710
1PR05	-18.118	65.004
1PR06	16.690	61.471
1PR07	2.469	68.752
1PR08	5.247	67.901
1PR09	12.321	63.548
1PR10	5.523	68.978
1PR11	1.565	65.344
1PR12	-5.218	66.723
1PR13	-39.897	66.338
1PR14	7.985	70.771

Table 4; Corrected NRM measurements for feature 2PR.

Sample	Declination (deg)	Inclination (deg)
2PR01	-7.954	67.085
2PR02	7.175	64.991
2PR03	1.991	79.167
2PR04	8.879	67.105
2PR06	-19.407	75.378
2PR07	-19.204	72.659
2PR08	16.786	59.862
2PR09	10.476	65.289
2PR10	-2.603	77.673
2PR11	-9.558	70.803
2PR12	2.108	76.224
2PR13	-9.014	74.305
2PR14	9.200	64.545

Table 5; Variation of remanent magnetisation with increasing partial demagnetisation for sample 2PR13.

Demagnetisation (mT)	Declination (deg)	Inclination (deg)	Intensity (M/M_O)
0	-12.677	73.550	1.000
2	-8.512	71.771	0.964
4	-3.556	71.263	0.904
6	-1.868	69.802	0.766
8	-1.840	69.281	0.671
10	-0.688	69.606	0.523
12	-1.216	69.144	0.443
14	-8.759	69.998	0.364
16	-2.828	68.968	0.254
18	-9.307	75.581	0.192
20	-7.483	65.756	0.173

Table 6; Corrected measurements for feature 2PR after 8mT AF partial demagnetisation.

Sample	Declination (deg)	Inclination (deg)
2PR01	-2.314	63.025
2PR02	10.937	65.260
2PR03	-0.947	73.066
2PR04	7.824	67.158
2PR06	-2.506	72.781
2PR07	-12.492	67.725
2PR08	7.637	55.416
2PR09	16.072	62.887
2PR10	-2.842	75.756
2PR11	-4.880	68.107
2PR12	6.697	68.270
2PR13	-1.839	69.281
2PR14	15.894	68.341

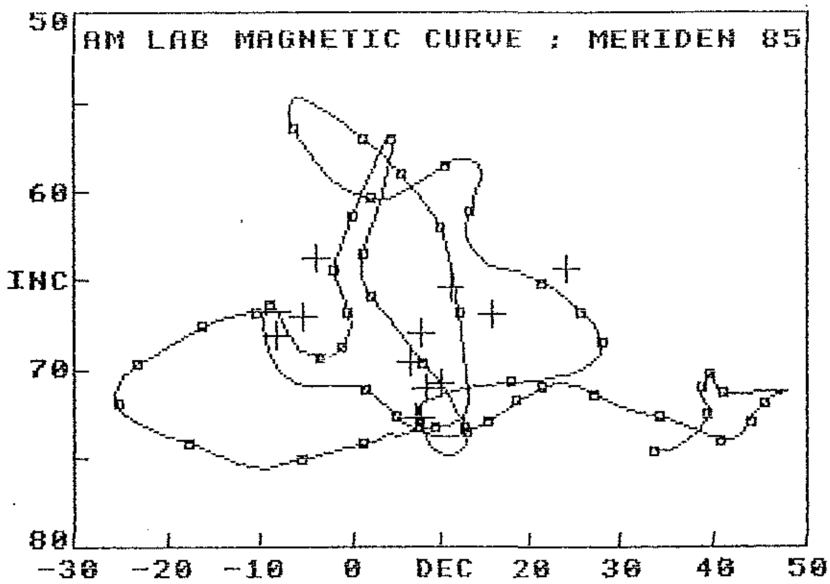

Figure 1; Distribution of NRM results for feature 1PR.

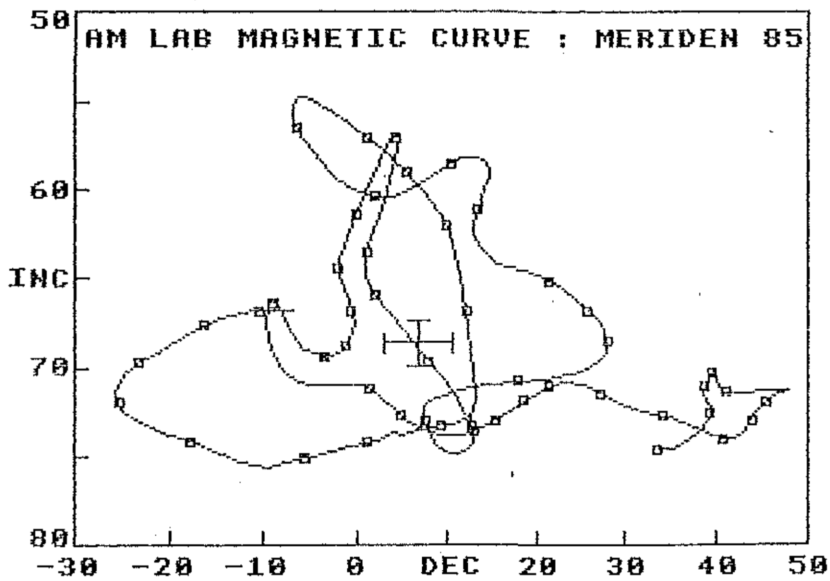

Figure 2; Mean of NRM results with 68% confidence limits for feature 1PR.

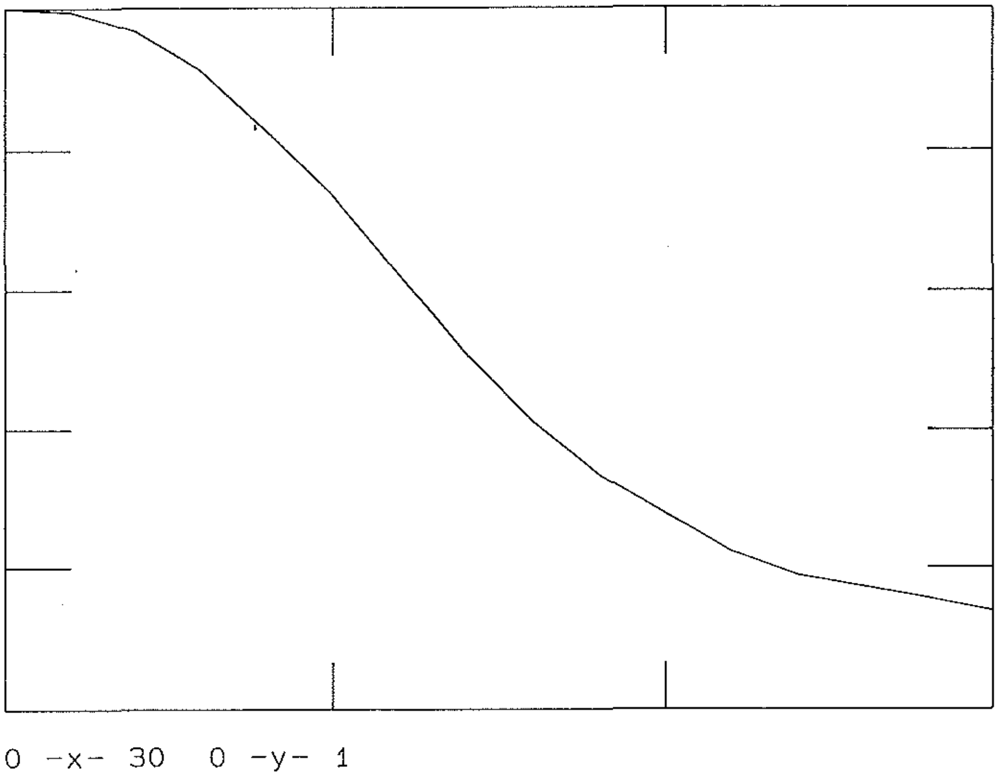

Figure 3; Variation of remanence intensity (y axis), M/M_o, with increasing partial demagnetisation in mT (x axis), for sample 1PR10.

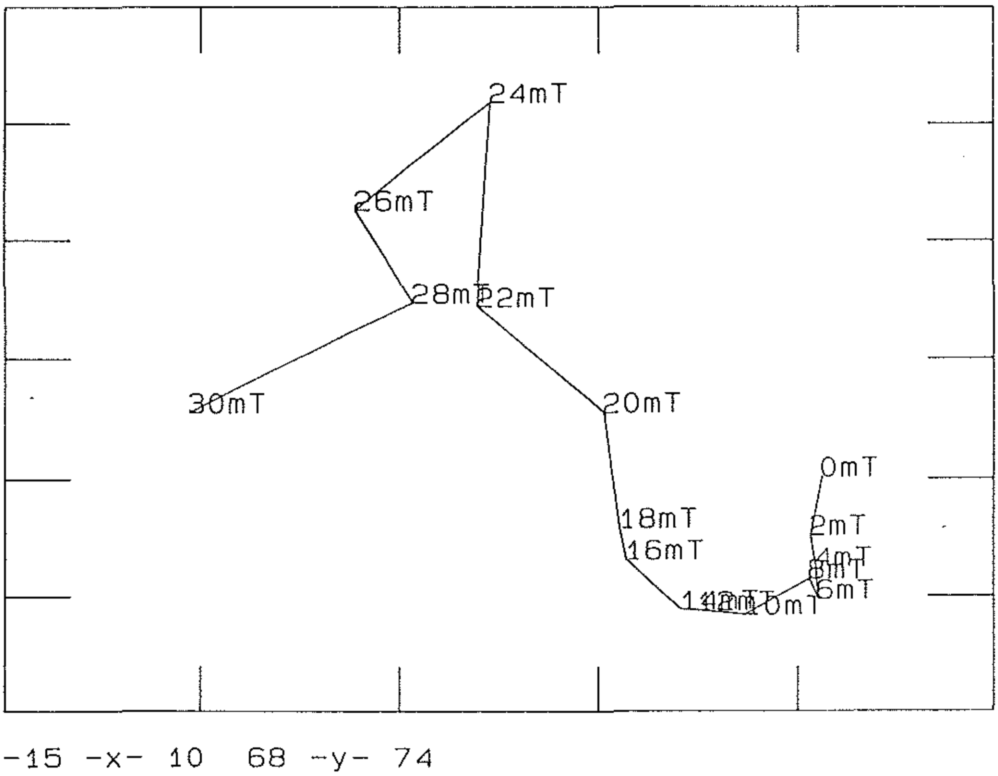

Figure 4; Variation of Dec (x axis) and Inc (y axis) with increasing partial demagnetisation for sample 1PR10.

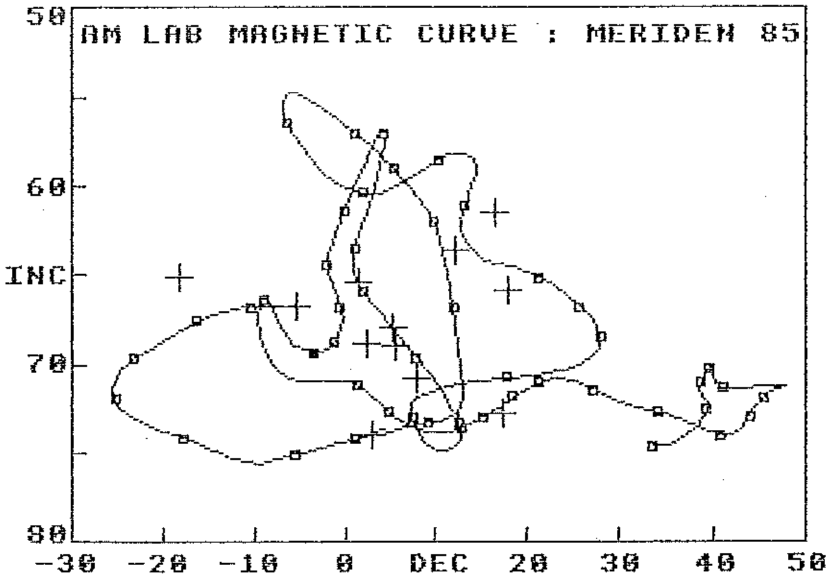

Figure 5; Distribution of partially demagnetised results for feature 1PR.

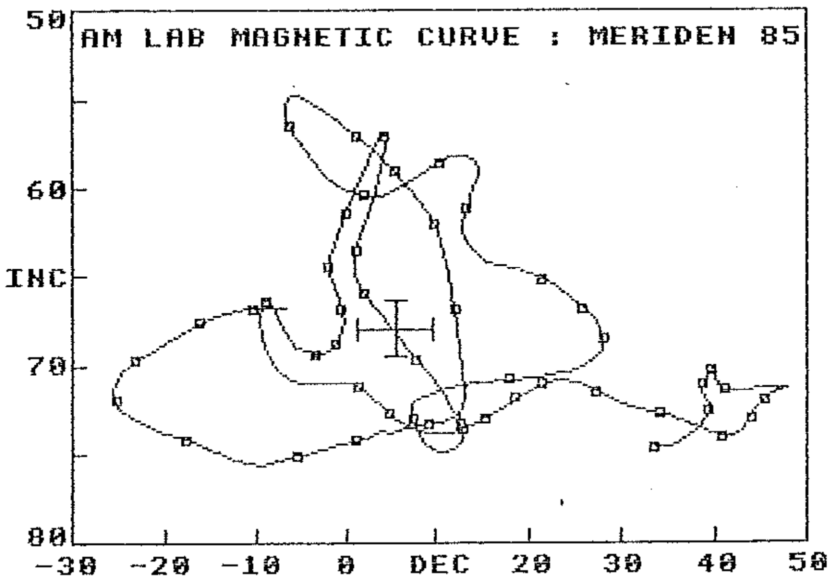

Figure 6; Mean of partially demagnetised results with 68% confidence limits for feature 1PR.

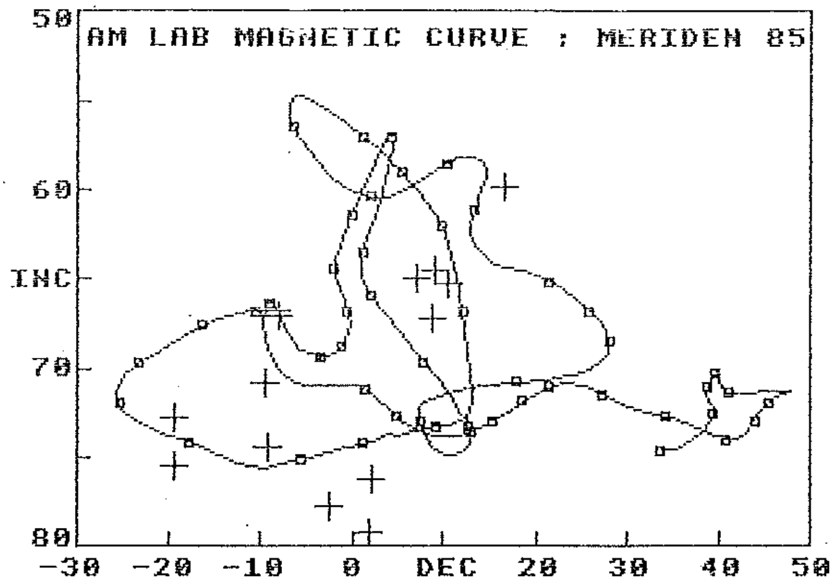

Figure 7; Distribution of NRM results for feature 2PR.

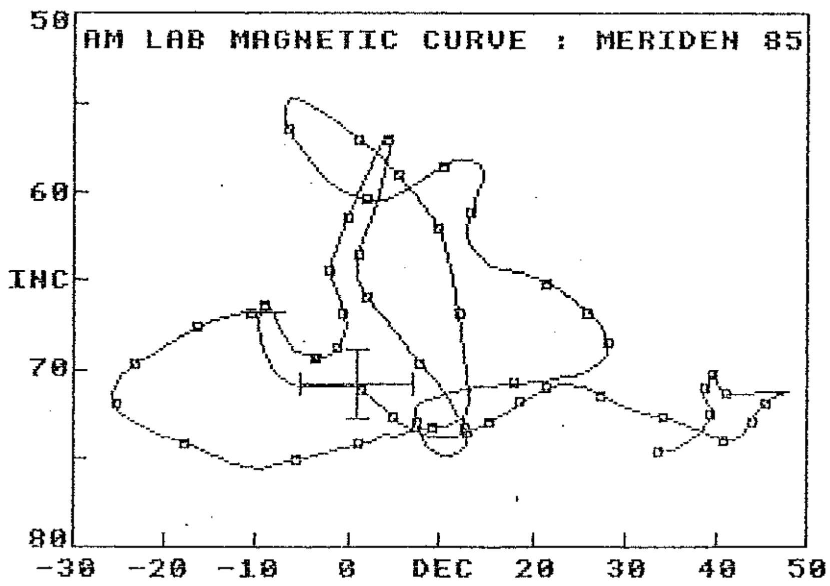

Figure 8; Mean of NRM results with 68% confidence limits for feature 2PR.

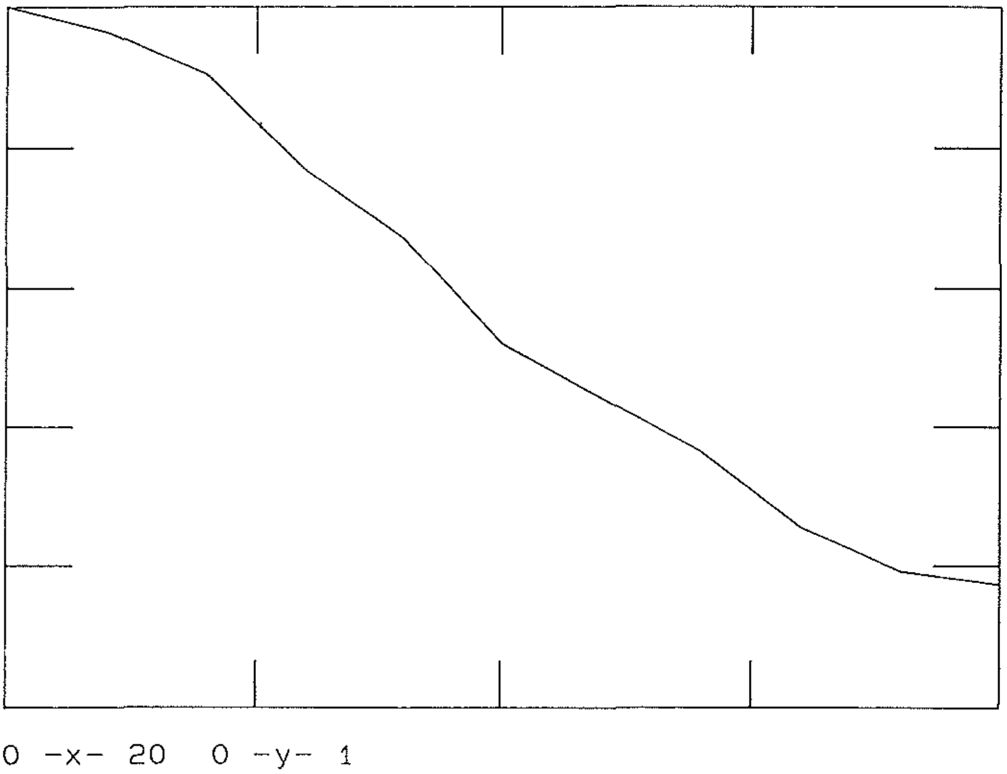

Figure 9; Variation of remanence intensity (y axis), M/M_o, with increasing partial demagnetisation in mT (x axis), for sample 2PR13.

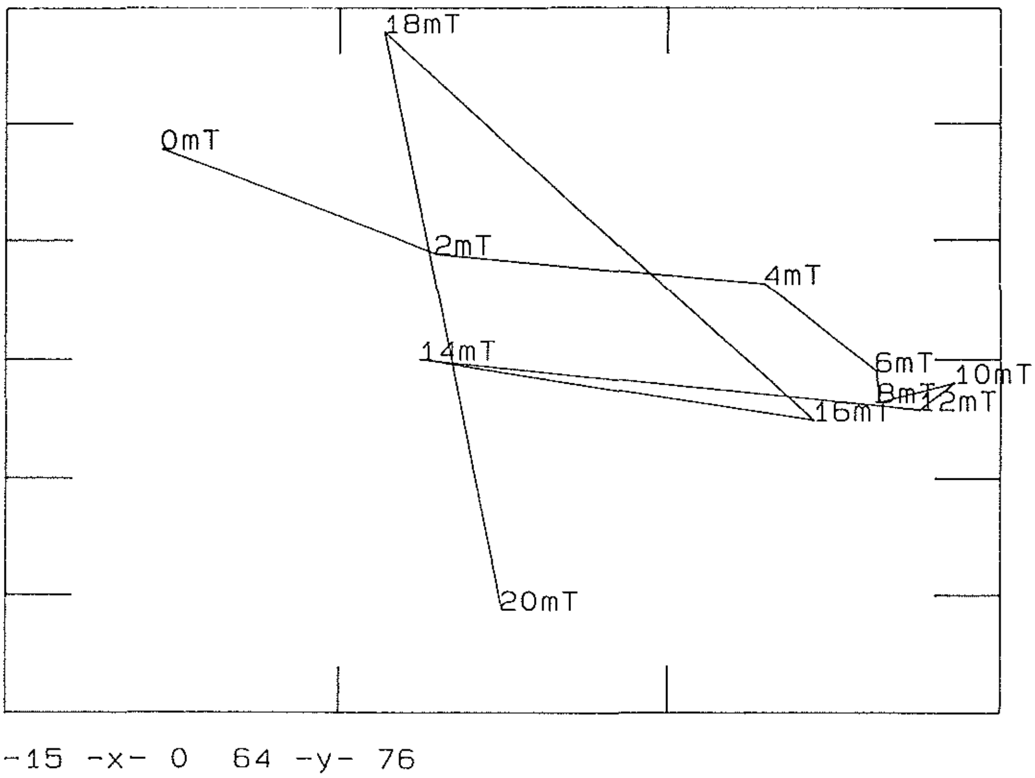

Figure 10; Variation of Dec (x axis) and Inc (y axis) with increasing partial demagnetisation for sample 2PR13.

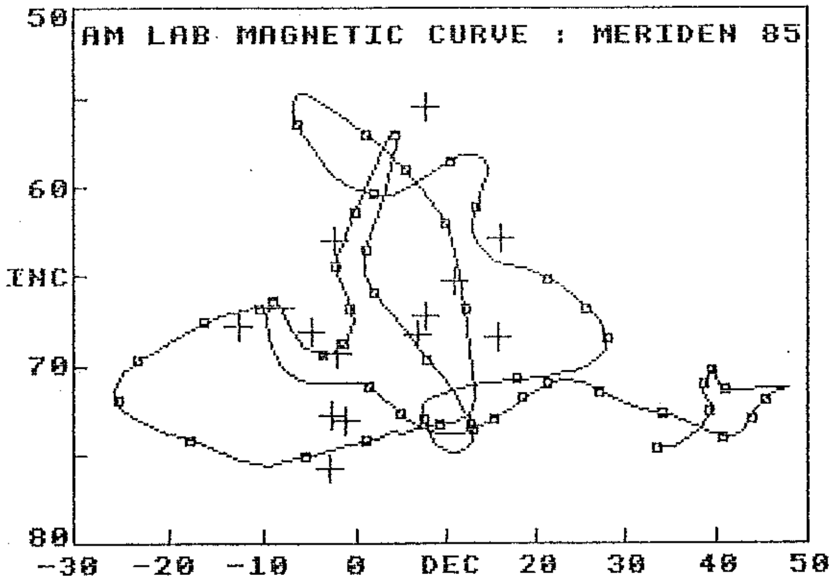

Figure 11; Distribution of partially demagnetised results for feature 2PR.

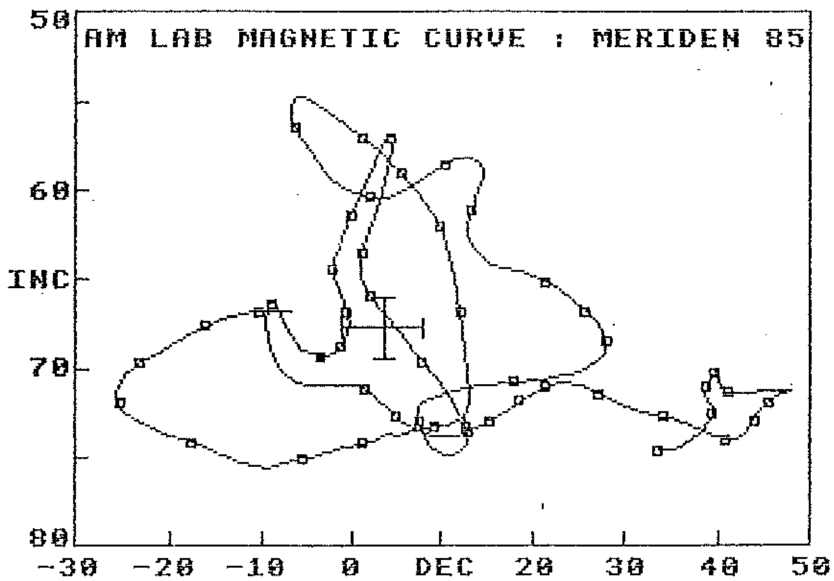

Figure 12; Mean of partially demagnetised results with 68% confidence limits for feature 2PR.

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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