ARCHAEOMAGNETIC ANALYSIS OF TWO BURNT FEATURES AT MARFIELD, NORTH YORKS.

A PROGRAMME OF RESEARCH CARRIED OUT ON BEHALF OF

MAP ARCHAEOLOGICAL CONSULTANCY LTD

By

GeoQuest Associates

INTRODUCTION

This report describes the archaeomagnetic analysis and dating of material from two burnt features at Marfield, near Masham, North Yorkshire, in an area where an extension is planned to an existing gravel quarry (Site code MAR6/96). The features were detected as strong magnetic anomalies in a fluxgate magnetometer survey and then excavated and recorded by the MAP Archaeological Consultancy during August and September 1996.

The features selected for archaeomagnetic study were as follows:

Context 4006: A circular depression, approximately 1.5m in diameter, formed of redenned, burnt clayey soil. The base of the feature was found to contain several large blocks of limestone and it is conjectured that the remains once formed part of a post-medieval lime kiln.

Context 4005: This comprised a 1.8m diameter sub-circular hollow feature with a patchy rim of redenned, burnt soil. The floor was found to contain randomly distributed cobbles of limestone, some of which were burnt. In the absence of significant finds and related structures, the age and function of this feature was unclear.

The aim of this study was to obtain oriented samples in order to attempt archaeomagnetic dating for the times of last firing. The archaeomagnetic sampling was carried out on 5th and 18th September, 1996 under the direction of Mark Stephens, Project Director for MAP Archaeological Consultancy Ltd. The principles of the archaeomagnetic dating technique are described in Appendix **A**.

SAMPLING

Archaeomagnetic sampling was carried out during the final stages of excavation when both contexts had been cleaned and fully recorded. Since little *in situ* fired material was present in the floor of either context it was decided that samples would only be recovered from the the fired rims and sides of each depression.

All surfaces were first brushed clear of loose material and oriented samples then recovered using the *button method* devised by Clark, Tarling & Noel (1988). This technique employs a 25mm, flanged plastic disc to act as a field orientation reference, sample label and specimen holder inside the laboratory magnetometer. Buttons were glued in position using a fast setting epoxy resin (Devcon Rapid) with their surfaces set horizontal with a spirit level. Small beads of plasticene beneath the buttons held them steady while the resin cured. Finally, geomagnetic orientation arrows were marked using a Nautech fluxgate compass, along with a specimen code. The set of orientation arrows were finally checked for parallelism to test for errors due to the bulk magnetisation within each feature; no significant flux distortion was detected.

The specimens were slowly dried over several days and then consolidated by impregnation with a dilute solution of PVA in acetone. Finally, the samples were cut with a diamond saw until each button retained a volume which fitted the standard 25x25mm specimen holder inside the archaeomagnetic magnetometer. Further consolidation with PVA solution was then carried after the specimens had dried after cutting.

MEASUREMENT

The natural remanent magnetisation (NRM) of the samples was measured in a Molspin fluxgate spinner magnetometer (Molyneux, 1971) with a minimum sensitivity of around $5 \times 10^{-9} Am^2$. Remanence directions were corrected for the local geomagnetic variation using data published by the British Geological Survey and the vectors plotted on the stereograms of Figures 1 and 2, and listed in Table 1.

Generally, the NRM of an archaeological material will comprise a primary magnetisation, (in this case presumed to be of thermal origin), together with secondary components acquired in later geomagnetic fields due to diagenesis or partial reheating. Usually, a weak viscous magnetisation is also present, reflecting a tendency for the remanence to adjust to the recent field. If the secondary components are of relatively low stability, then removal by partial demagnetisation will leave the primary remanence of archaeological interest. A pilot specimen with typical NRM and lithological characteristics (MAR11) was demagnetised incrementally, up to a peak alternating field of 30mT and the changes in remanence recorded in order to identify the components of archaeomagnetism and their stability (Figure 3).

From a study of the pilot sample behaviour, an alternating field of 2.5mT was chosen which would provide for the optimum removal of secondary components of magnetisation in the remaining samples. After partial demagnetisation in this field, sample remanences were remeasured and the results are shown on the stereograms of Figures 4 and 5.

RESULTS AND DISCUSSION

General

Intensities of natural remanent magnetisation in the burnt soils were found to be rather variable, with measured magnetic moments ranging from 7.8 to 6254.0 $mAm^{-1} \times 10^{-3}$ in a typical 1ml specimen, reflecting variation in the efficiency of the thermoremanent magnetisation and uneven concentration of the ferrimagnetic remanence-carrying mineral in the fired soil around each depression.

Context 4006

The NRM vectors from this feature are tightly grouped with no outliers, defining a mean direction which is clearly geomagnetically controlled. Demagnetisation tests on pilot sample MAR11 show that the remanence is soft (ie. easily demagnetised) but contains a stable, single component of magnetisation.

Partial demagnetisation in a field of 2.5mT produced a negligible change in the vector directions, confirming the absence of negligible secondary, post-firing magnetisation (Figure 4).

Context 4005

The NRM vectors form a loose cluster, which is again geomagnetically controlled. Thus, despite the relatively poor state of preservation of the fired material in this feature, it is clear that the burnt soil has retained a good quality record of the ancient Earth's magnetic field (Figure 5).

Absolute Dating

A standard correction was used to convert the mean archaeomagnetic vectors in both contexts to Meriden, the reference locality for the British Master Curve (Noel & Batt, 1990). Figure 6 then compares the new vectors and their associated error envelopes to the Master Curve segment 600AD-2000AD: it can be seen that the mean vectors make their closest approaches to the curve in the post medieval period (assuming that context 4005 is younger than 800AD).

Once a slight correction is made to the mean vector from context 4006 to account for magnetic refraction (dotted lines in Figure 5) the following date ranges for the last firing can be inferred:

Context 4006: 1680-1730 AD
Context 4005: 1585-1650 AD

CONCLUSIONS

The results of this research can be summarised as follows:

1 An archaeomagnetic study has been carried out of two fired features recently excavated by MAP Archaeological Consultants at Marfield Quarry near Masham in North Yorkshire. Both contexts were found to contain remanent magnetisations of good fidelity, providing evidence for firing in the ancient geomagnetic field.

2 Comparison of the mean archaeomagnetic vectors with the UK Master Curve indicates that both features were fired during the post-medieval period.

REFERENCES

Clark, A.J., Tarling, D.H. & Noel, M., 1988. Developments in archaeomagnetic dating in Britain, *Archaeometry*, **15**, 645-667.

Molyneux, L., 1971. A complete result magnetometer for measuring the remanent magnetisation of rocks, *Geophys. J. R. astr. Soc.*, **24**, 429-433.

Noel, M. & Batt, C.M., 1990. A method for correcting geographically separated remanence directions for the purpose of archaeomagnetic dating, *Geophys. J. R. astr. Soc.*, **102**, 753-756.

Credits
Sampling, analysis & report: M.J. Noel PhD, FRAS
Date: 12/10/96

TABLE 1
ARCHAEOMAGNETIC RESULTS FROM MARFIELD, MASHAM, N. YORKS.

Sample	LITH	J	D	I	A.F.	D	I
Context 4006							
MAR1	FCL	122.7	19.2	73.8	2.5	18.4	69.6
MAR2	FCL	483.3	10.6	77.1	2.5	13.3	76.4
MAR3	FCL	392.0	346.7	73.1	2.5	343.3	72.8
MAR4	FCL	1429.2	338.3	72.4	2.5	337.7	72.2
MAR5	FCL	386.3	348.5	74.0	2.5	346.2	74.2
MAR6	FCL	749.6	342.4	71.9	2.5	341.8	71.9
MAR7	FCL	494.3	343.0	75.1	2.5	347.3	75.7
MAR8	FCL	1597.1	344.9	72.8	2.5	342.6	72.6
MAR9	FCL	673.2	334.0	71.4	2.5	333.8	71.2
MAR10	FCL	721.3	335.2	74.5	2.5	334.2	74.3
MAR11	FCL	938.0	346.2	76.3	2.5	347.4	76.4
MAR12	FCL	592.8	354.8	77.2	2.5	352.2	77.5
MAR13	FCL	300.0	9.1	78.7	2.5	7.9	78.8
MAR14	FCL	427.4	9.3	73.7	2.5	8.9	72.8
Mean of Feature						350.6	74.5
					alpha95=2.4	c.s.e.=1.3	k=275.4
AT MERIDEN						**351.1**	**73.4**
Context 4005							
MAR20	FCL	110.4	34.9	65.1	2.5	33.6	63.9
MAR21	FCL	82.8	332.1	79.2	2.5	331.2	79.2
MAR22	FCL	11.3	1.9	71.3	2.5	350.7	72.7
MAR23	FCL	127.2	24.8	72.8	2.5	21.0	74.0
MAR24	FCL	350.0	359.3	80.3	2.5	359.1	80.0
MAR25	FCL	6254.0	7.5	70.8	2.5	6.4	71.0
MAR26	FCL	18.5	5.7	71.4	2.5	11.1	70.3
MAR27	FCL	27.0	13.0	77.5	2.5	26.3	74.7
MAR28	FCL	16.8	21.1	79.0	2.5	13.4	71.6
MAR29	FCL	25.6	36.3	73.3	2.5	32.7	73.1
MAR30	FCL	7.8	334.2	78.0	2.5	355.6	79.2
Mean of Feature						11.1	75.2
					alpha95=3.7	c.s.e.=2.0	k=140.4
AT MERIDEN						**10.4**	**74.1**

NOTES: LITH = Lithology, 'FCL' = fired clay. D = declination, I = inclination, J = intensity in units of $mAm^{-1}x10^{-3}$. A.F. = peak alternating demagnetising field in milliTesla. alpha95 is the semi-angle of the 95% cone of confidence, c.s.e. is the circular standard error and k is the precision parameter.

FIGURE 1

Directions of natural remanent magnetisation in samples from Context 4006 shown on an equal area stereogram. In this representation, declination increases clockwise while inclination increases from zero at the equator to 90 degrees at the centre of the projection.

CONTEXT 4006, NRM

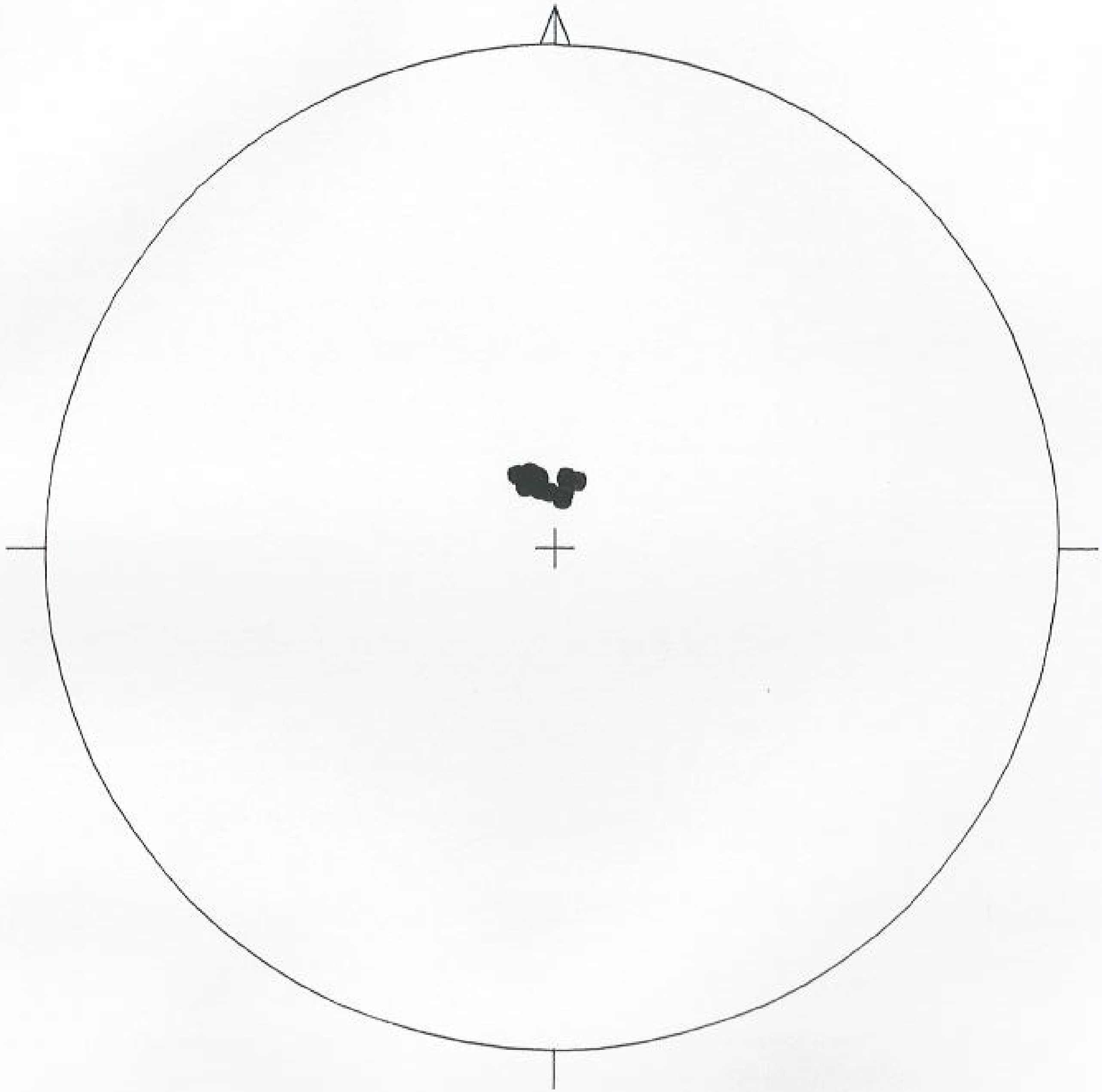


FIGURE 2

Directions of natural remanent magnetisation in samples from Context 4005 shown on an equal area stereogram. In this representation, declination increases clockwise while inclination increases from zero at the equator to 90 degrees at the centre of the projection.

CONTEXT 4005, NRM

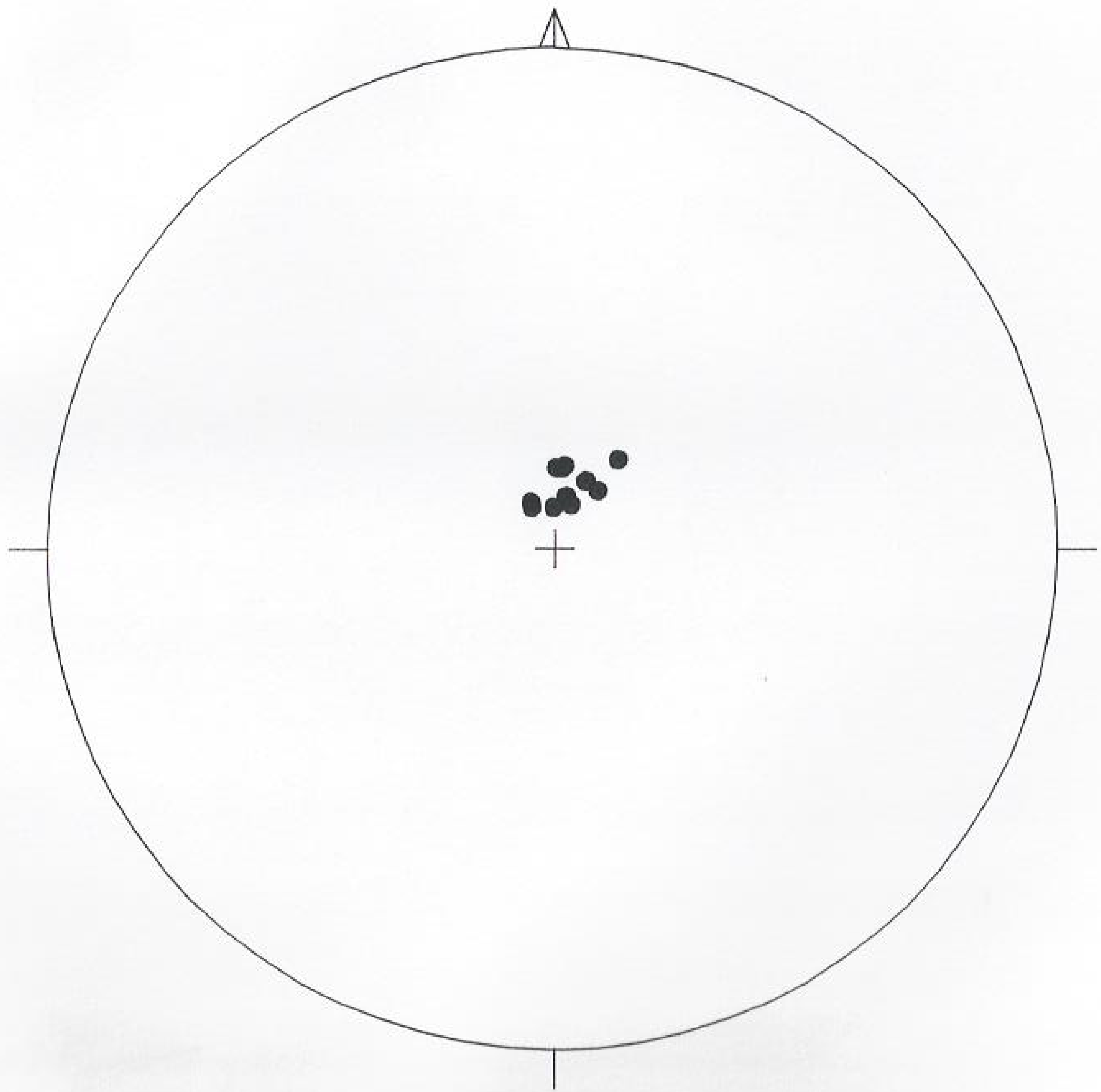
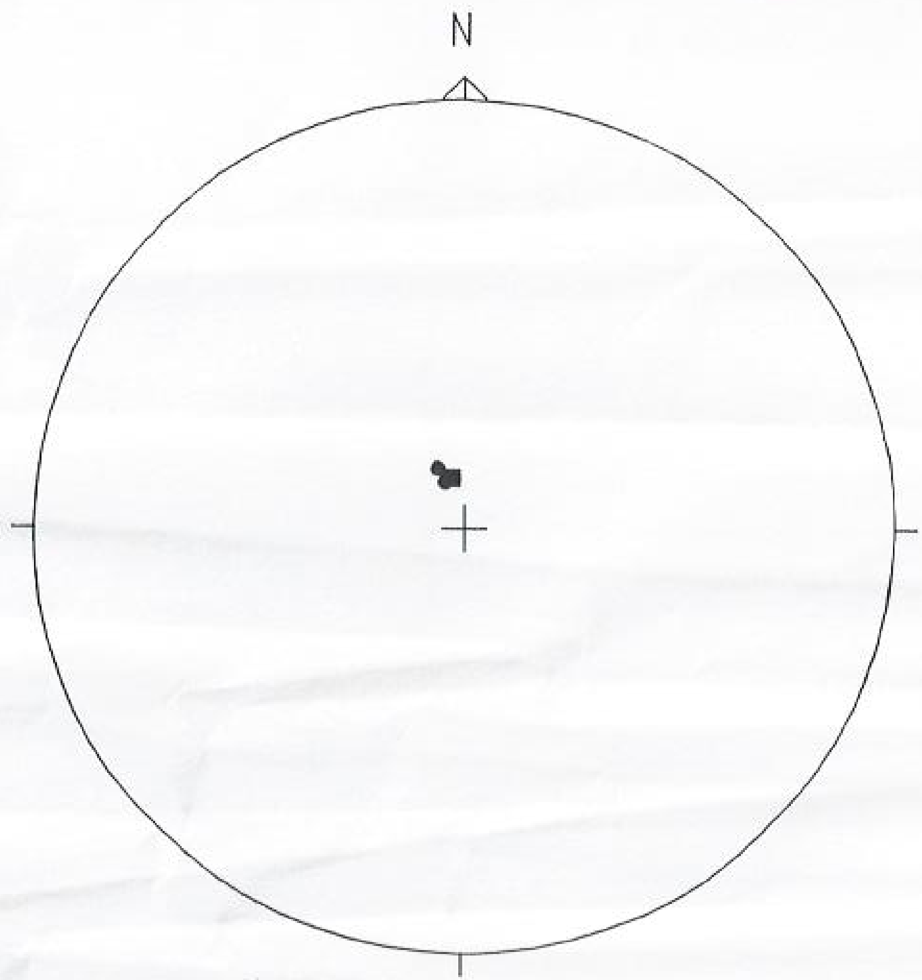


FIGURE 3

Changes in the direction and intensity of remanent magnetisation in test sample MAR11 during stepwise demagnetisation by alternating magnetic fields.

MAR11

□ =NRM vector



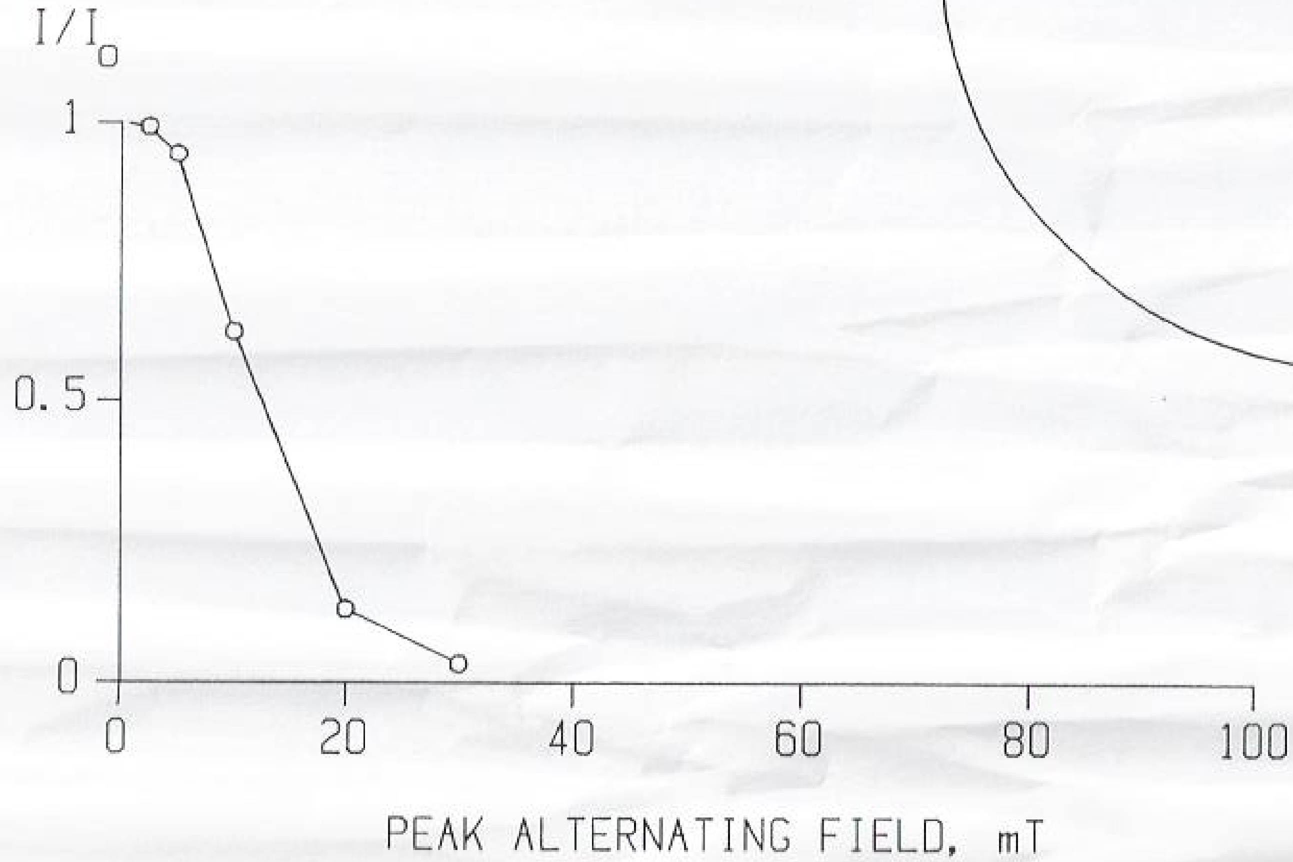


FIGURE 4

Directions of remanent magnetisation in samples from Context 4006 after partial demagnetisation in an alternating field of 2.5mT

CONTEXT 4006, 2.5mT

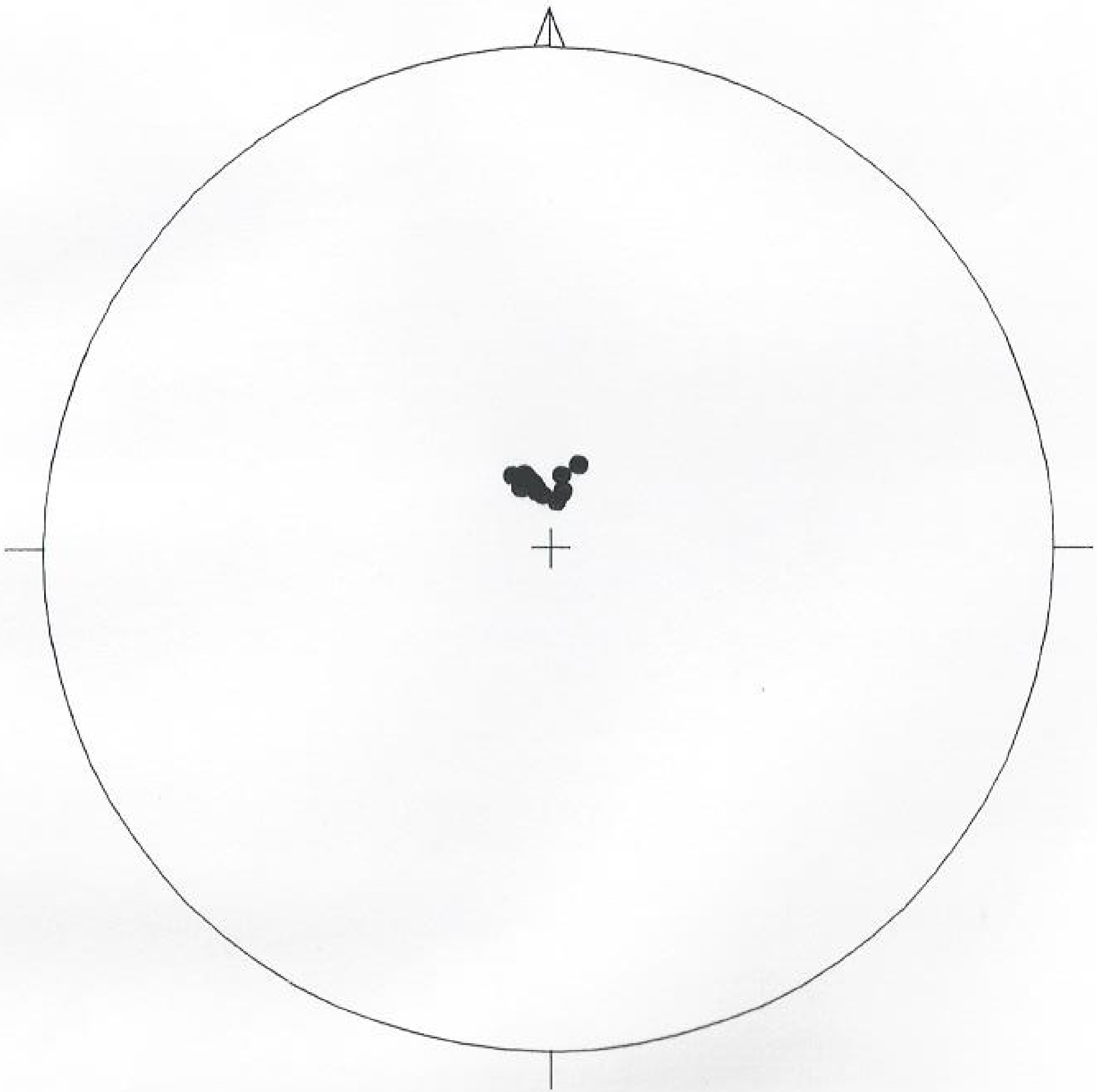


FIGURE 5

Directions of remanent magnetisation in samples from Context 4005 after partial demagnetisation in an alternating field of 2.5mT

CONTEXT 4005, 2.5mT

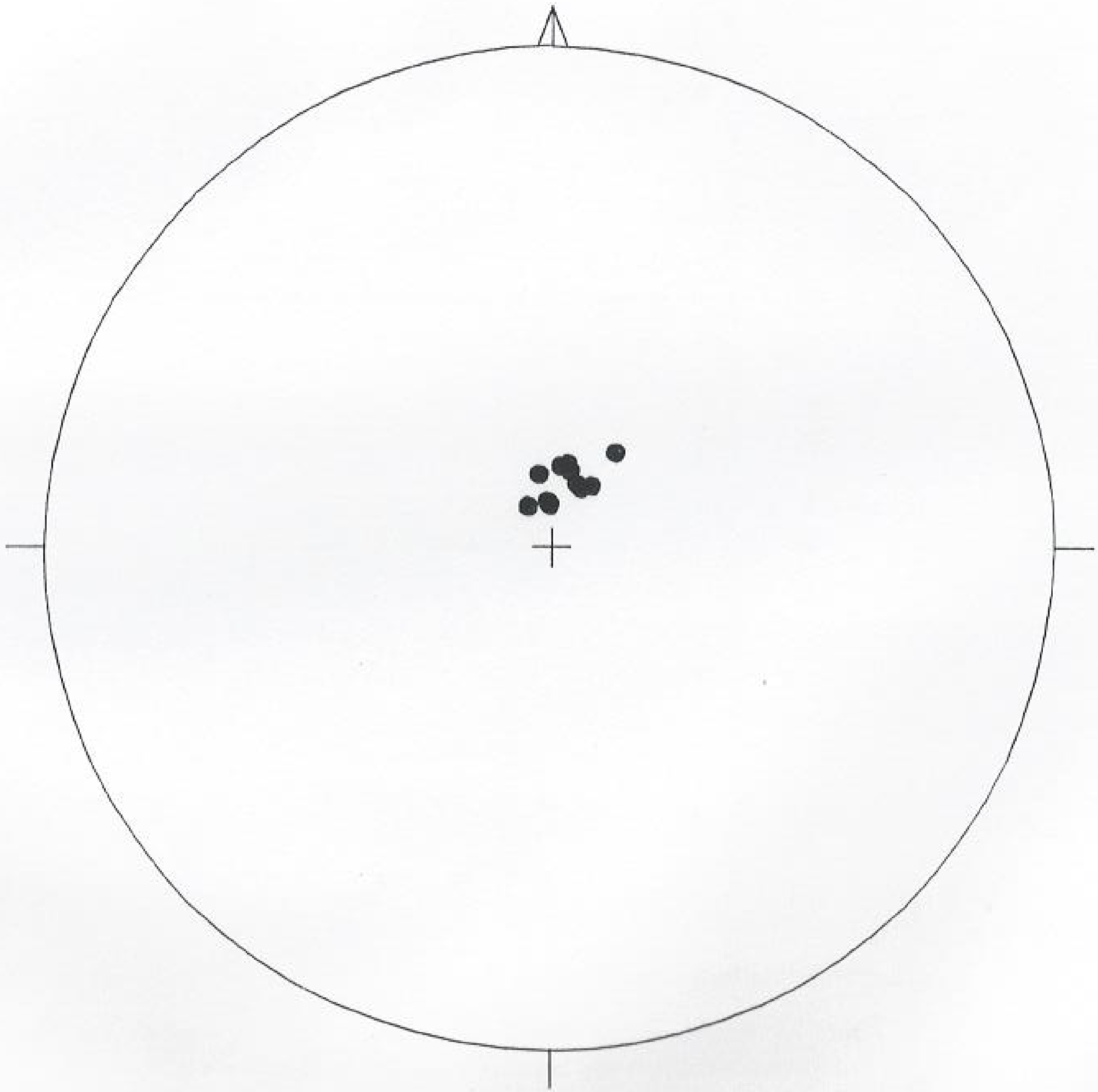
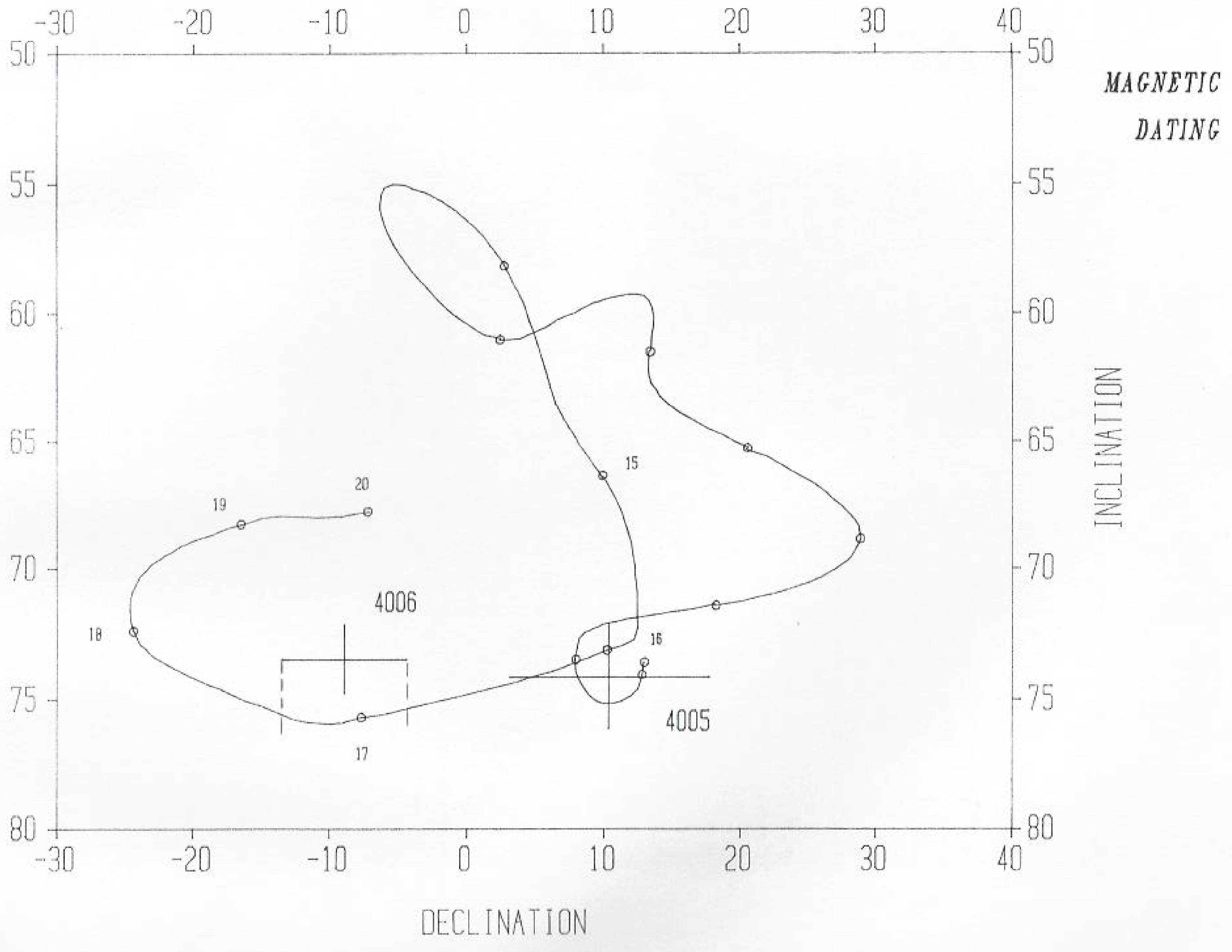


FIGURE 6

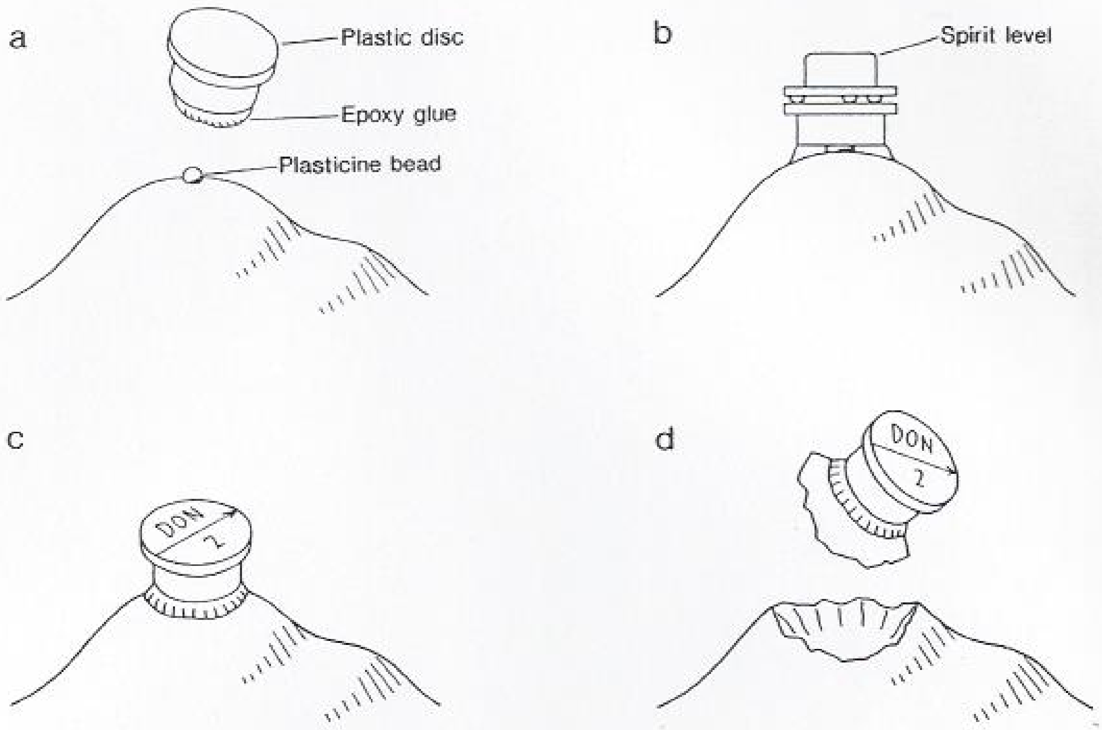
Comparison between the mean archaeomagnetic vectors in Contexts 4005 and 4006, corrected to Meriden, with the UK Master Curve. Numbers refer to the time in centuries.


MAGNETIC
DATING
INCLINATION
DECLINATION
4006
4005
15
16
17
18
19
20
-30
-20
-10
0
10
20
30
40
50
55
60
65
70
75
80

APPENDIX A
Principles of Magnetic Dating

Magnetic dating is based on comparing the remanent magnetisation in an archaeological structure with a calibrated reference curve for the geomagnetic secular variation. Two distinct methods have evolved. The *intensity* technique relies on obtaining estimates of the past strength of the Earth's magnetic field while *directional* magnetic dating uses archaeomagnetic measurements to derive the orientation of the geomagnetic vector in antiquity. Intensity dating can only be applied to fired materials which have acquired a thermoremanent magnetisation upon cooling from high temperatures (>600°C) while the directional method enables the age of a broader range of archaeological materials to be determined. For example, sediments and soils may have acquired a dateable 'detrital remanence' if magnetic grains had been aligned by the ambient field during deposition. The growth of magnetic minerals during diagenesis or as a result of manufacturing processes can also give rise to a magnetisation which may enable materials such as iron-rich mortars, for example, to be dated. However hearths, kilns and other fired structures are the most common features selected for magnetic dating primarily because their thermoremanence is generally strong, stable and sufficiently homogeneous that the ancient field can be determined with sufficient precision from a small set of specimens. An analysis of dated archaeomagnetic directions, largely from fired structures, together with lake sediment and observatory records has enabled a master curve for the UK region to be synthesised for the period 2000 B.C. to the present (Clark, Tarling & Noel, 1988).

For directional magnetic dating it is essential to obtain specimens of undisturbed archaeological material whose orientation with respect to a geographic coordinate frame is known. A number of sampling strategies have evolved, enabling specimens to be recovered from a range of archaeological materials with orientations being recorded relative to topographic features, the direction of the sun, magnetic or geographic north. For this feature the miniaturised 'button method', illustrated overleaf, was employed. Modern archaeomagnetic magnetometers are sufficiently sensitive that only small volumes of material (~1ml) are required for an accurate remanence measurement. This has the advantage of reducing the impact of sampling on archaeological features - of particular significance if they are scheduled for conservation and display.


a
Plastic disc
Epoxy glue
Plasticine bead
b
Spirit level
c
DON
2
d
DON
2