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Report 38/96

ARCHAEOMAGNETIC ANALYSIS OF SAMPLES FROM A KILN AT WOOTON QUARR, ISLE OF WIGHT

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Summary

An archaeomagnetic study has been carried out of a kiln excavated at Wooton Quarr on the Isle of Wight. The samples were found to contain a thermoremanent magnetisation providing a high quality record of the ancient geomagnetic field. Comparison of the mean archaeomagnetic vector in the kiln with the UK Master Curve indicates that the feature was last in use at some time during the period 1400-1425 AD.

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ARCHAEOMAGNETIC ANALYSIS OF SAMPLES FROM A KILN AT WOOTON QUARR, ISLE OF WIGHT

RESEARCH CARRIED OUT IN COLLABORATION WITH

ANCIENT MONUMENTS LABORATORY
ENGLISH HERITAGE

By

GeoQuest Associates

INTRODUCTION

This report describes an archaeomagnetic study of oriented samples obtained from a Medieval kiln at Wooton Quarr on the Isle of Wight. The research was carried out on behalf of the Ancient Monuments Laboratory, English Heritage, with the aim of determinining the time of last firing.

SAMPLE PREPARATION

Archaeomagnetic sampling was carried out by Paul Linford and Neil Linford on 16th December 1993 using the button method described in Appendix A. The collection initially comprised 10 specimens of tile and 10 specimens of fired clay and these were delivered to GeoQuest Associates on 29th March 1996.

The specimens were first consolidated by impregnation with a dilute solution of PVA in acetone. Each sample was then cut with a water cooled diamond saw until the button retained a volume which fitted the standard 25x25mm specimen holder inside the archaeomagnetic magnetometer. After drying at room temperature, a further protective coating of PVA was applied to the samples.

MEASUREMENT

The natural remanent magnetisation (NRM) of all the samples was measured in a Molspin fluxgate spinner magnetometer (Molyneux, 1971) with a minimum sensitivity of around $5x10^{-9}Am^2$. Remanence directions were corrected for field orientation in accordance with data supplied by the Ancient Monuments Laboratory. The resulting vectors are plotted on the stereogram of Figure 1 and are 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 characteristics was demagnetised incrementally, up to a peak alternating field of 35mT and the changes in remanence recorded in order to identify the components of archaeomagnetism and their stability (Figure 2).

From a study of the pilot sample behaviour, an alternating field of 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 in Figure 3.

RESULTS AND DISCUSSION

General

Intensities of natural remanent magnetisation in the kiln were generally very intense but variable, with measured magnetic moments ranging from 73 $mAm^{-1}x10^{-3}$ (sample of tile) to 7710 $mAm^{-1}x10^{-3}$ (sample of clay) in a typical 1ml specimen. This inhomogeneity probably reflects variation in the efficiency of the thermoremanent magnetisation and uneven concentration of the ferrimagnetic remanence-carrying mineral in the construction materials.

Analysis

Samples from the kiln have produced a very tight cluster of initial archaeomagnetic vectors (Figure 1) providing good evidence for consistent heating and remagnetisation during use, with negligible disturbance during burial. No evidence was found for a magnetic 'refraction' of the vectors in the kiln structure. The pilot sample demagnetisation tests indicate a very good stability of the remanence and the archaeomagnetic vectors retain their excellent grouping after partial demagnetisation in a field of 5mT (Figures 2 & 3).

Absolute Dating

A standard correction was used to convert the mean archaeomagnetic vector to Meriden, the reference locality for the British Master Curve (Noel & Batt, 1990). Figure 4 then compares the new vector and its associated error envelope to the Master Curve segment 600AD-2000AD.

The mean archaeomagnetic vector makes a closest approach to the archaeomagnetic curve during the medieval period. A date range has been estimated by considering the extent of overlap between the vector circular standard error and the Master Curve. The following date range is thus inferred:

1400-1425 AD

CONCLUSIONS

The results of this research can be summarised as follows:

1 An archaeomagnetic study has been carried out of a kiln excavated at Wooton Quarr on the Isle of Wight. The samples were found to contain a thermoremanent magnetisation providing a high quality record of the ancient geomagnetic field.

2 Comparison of the mean archaeomagnetic vector in the kiln with the UK Master Curve indicates that the feature wase last in use at some time during the period 1400-1425 AD.

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.

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TABLE 1

ARCHAEOMAGNETIC RESULTS FROM WOOTON QUARR

Sample	LITH	J	D	I	A.F.	D	I
QA1	T	SAMPLE DISINTEGRATED					
QA2	T	1169	358.7	56.9	5	357.6	56.1
QA3	T	SAMPLE DISINTEGRATED					
QA4	T	2781	7.5	64.7	5	5.8	64.1
QA5	C	470	10.6	57.4	5	10.8	57.3
QA6	T	2378	7.5	52.6	5	6.8	52.1
QA7	T	2130	359.5	53.6	5	359.2	53.8
QA8	C	SAMPLE DISINTEGRATED					
QA9	T	838	357.2	55.3	5	357.6	55.1
QA10	T	1298	359.4	53.7	5	1.1	53.4
QA11	C	949	2.6	56.4	5	1.9	56.0
QA12	T	2037	0.2	54.4	5	359.4	54.4
QA13	C	1081	2.1	55.5	5	2.0	55.6
QA14	T	73	1.9	63.2	5	2.7	63.5
QA15	C	192	354.7	60.4	5	354.5	58.5
QA16	C	1508	1.2	59.3	5	0.2	60.2
QA17	C	1363	3.2	57.6	5	2.1	57.9
QA18	C	1977	7.0	59.4	5	5.9	58.6
QA19	C	2989	10.2	60.3	5	10.3	60.4
QA20	C	7710	4.3	63.5	5	4.7	64.1
Mean of Feature			2.7	58.0		2.5	57.8
			alpha95=1.9	k=344.1		alpha95=1.9	k=343.6
						c.s.e.=1.1	
AT MERIDEN						**2.5**	**59.4**

NOTES: LITH=Lithology, 'T'=tile, 'C'=fired clay. D=declination, I=inclination, J=intensity of measured magnetic moment 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. 'Sample disintegrated' refers to specimens which either fragmented during the cutting process or those from which the button became detached.

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.

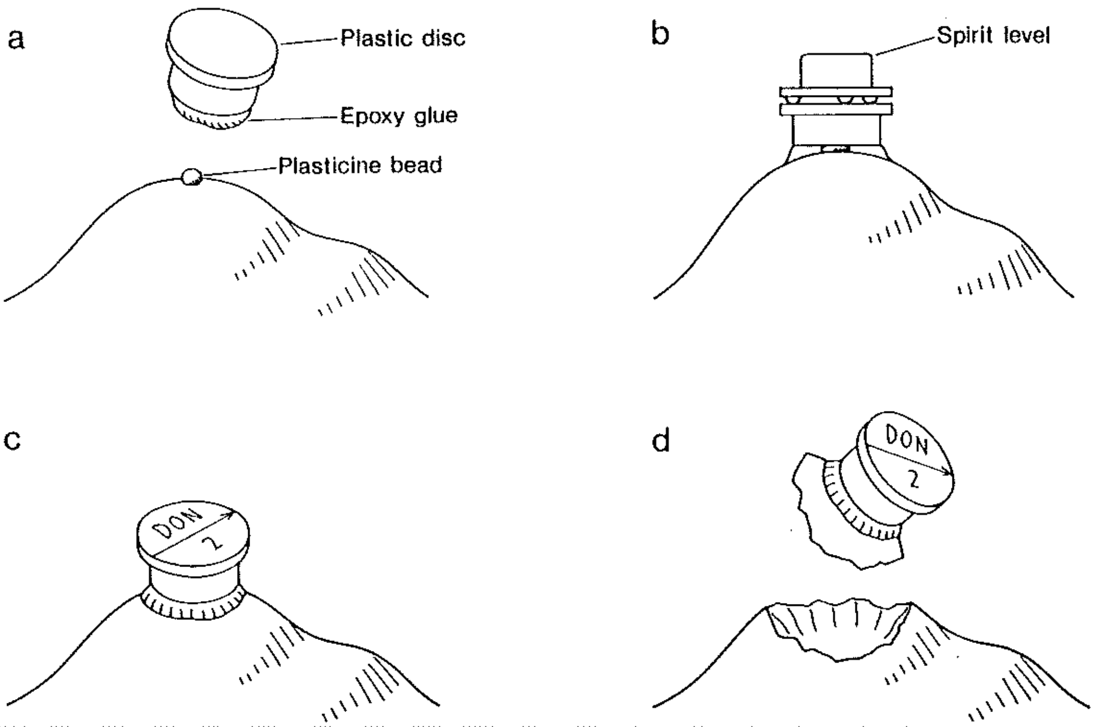

a
Plastic disc
Epoxy glue
Plasticine bead
b
Spirit level
c
DON
2
d
DON
2

FIGURE 1

Directions of natural remanent magnetisation in samples in the kiln 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.

WOOTON

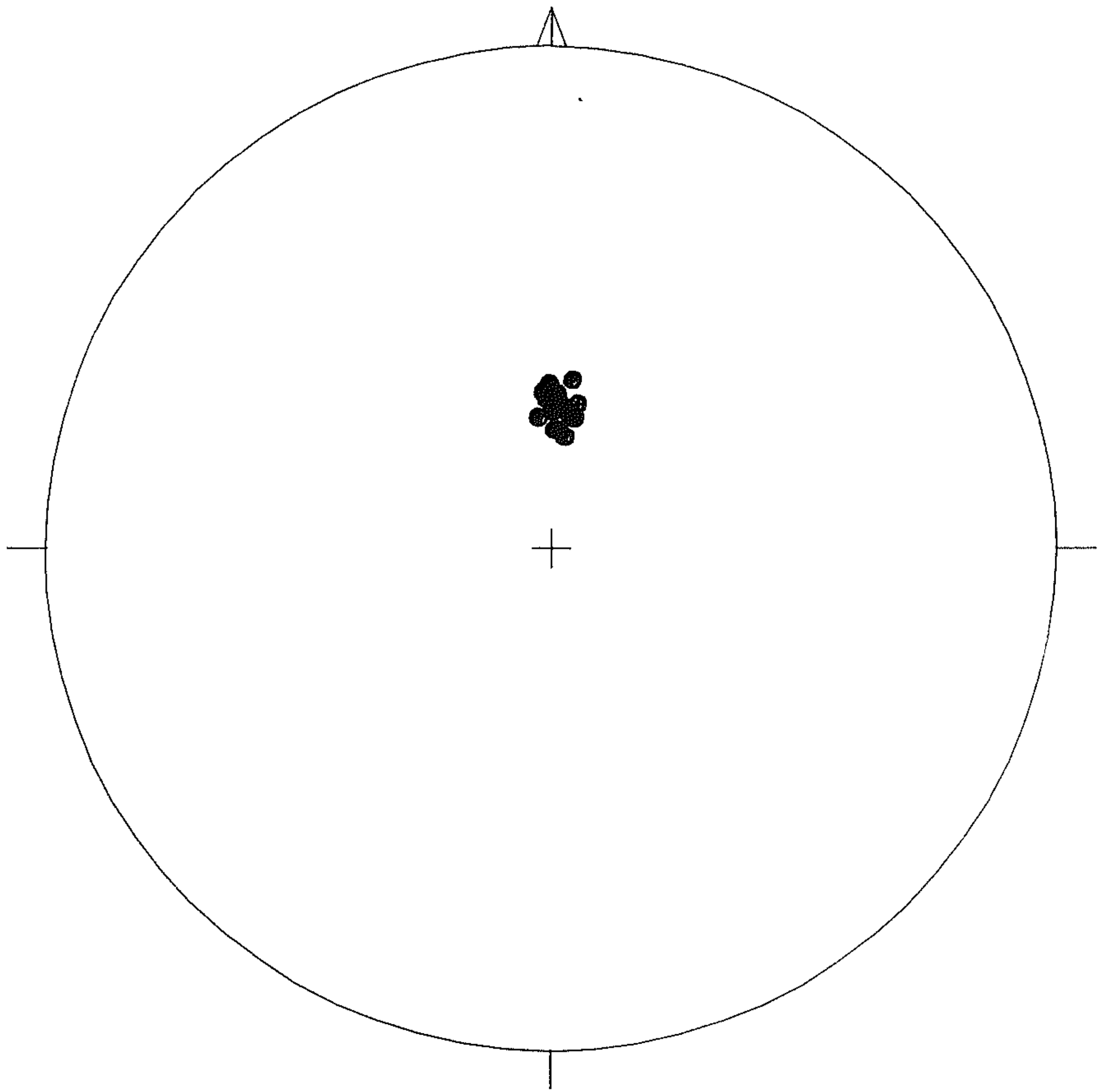
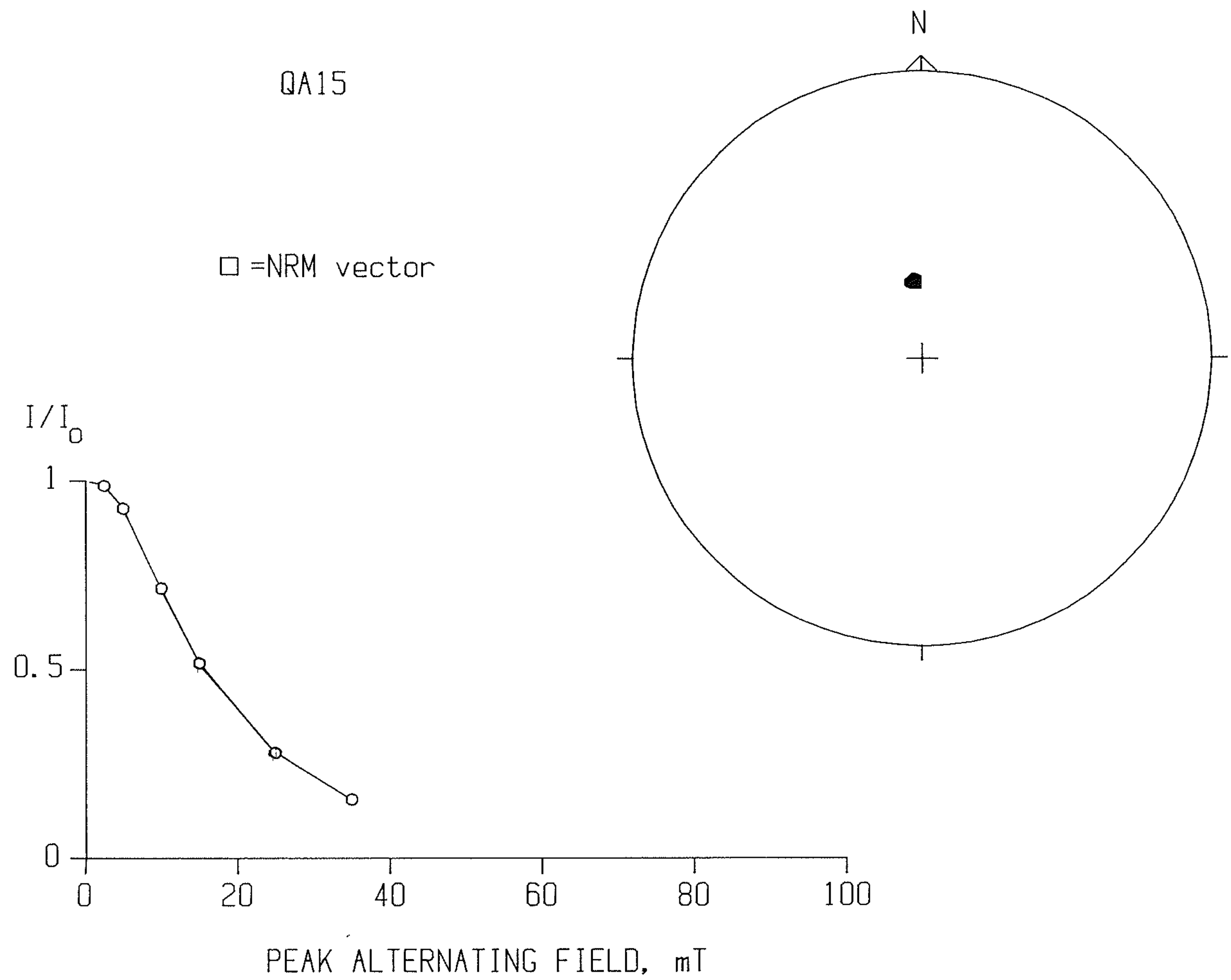


FIGURE 2

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


QA15
□ =NRM vector
N
I/I0
1
0.5
0
0
20
40
60
80
100
PEAK ALTERNATING FIELD, mT

QA15

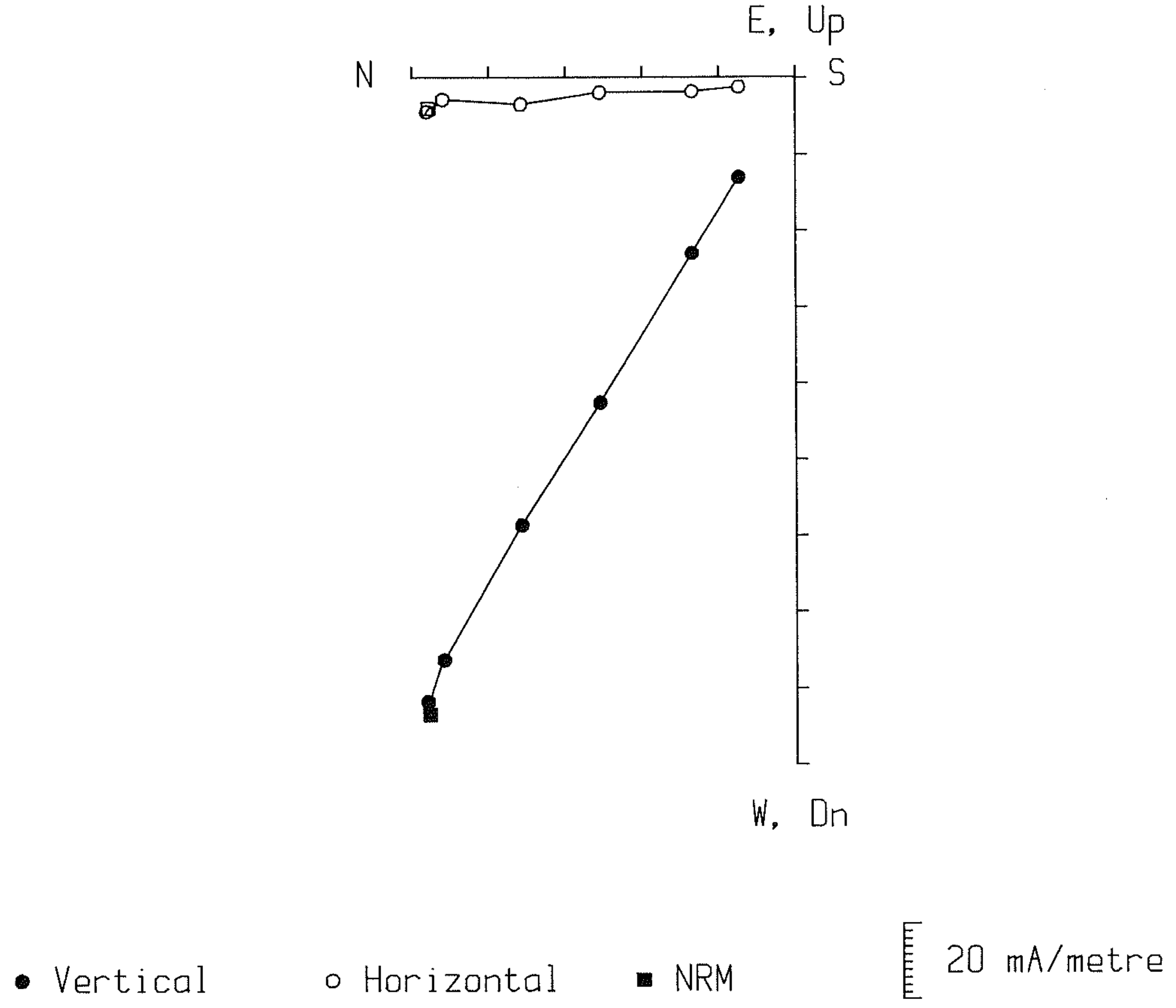


FIGURE 3

Directions of remanent magnetisation in samples from the kiln after partial demagnetisation in an alternating field of 5mT

WOOTON, 5mT

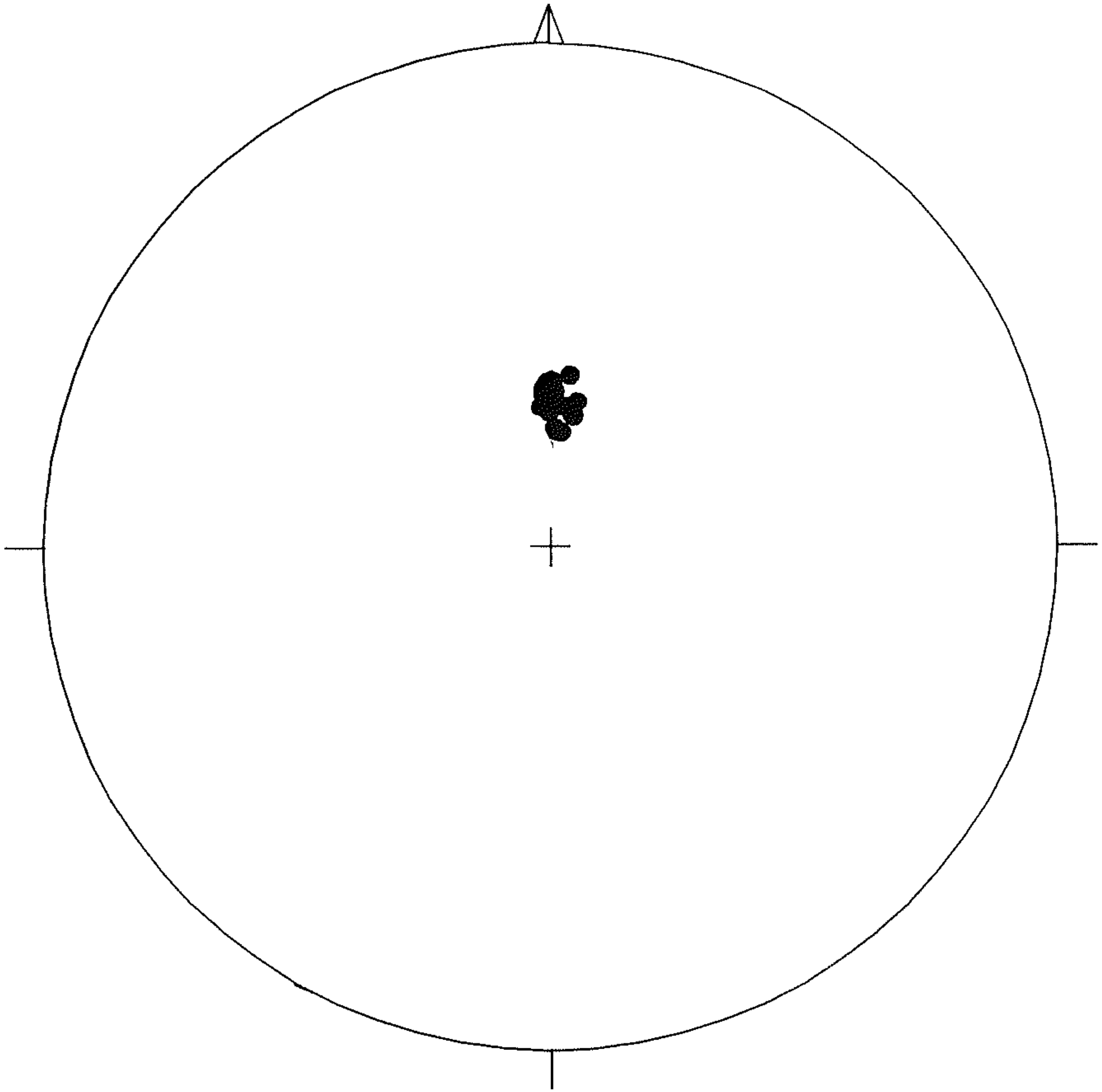
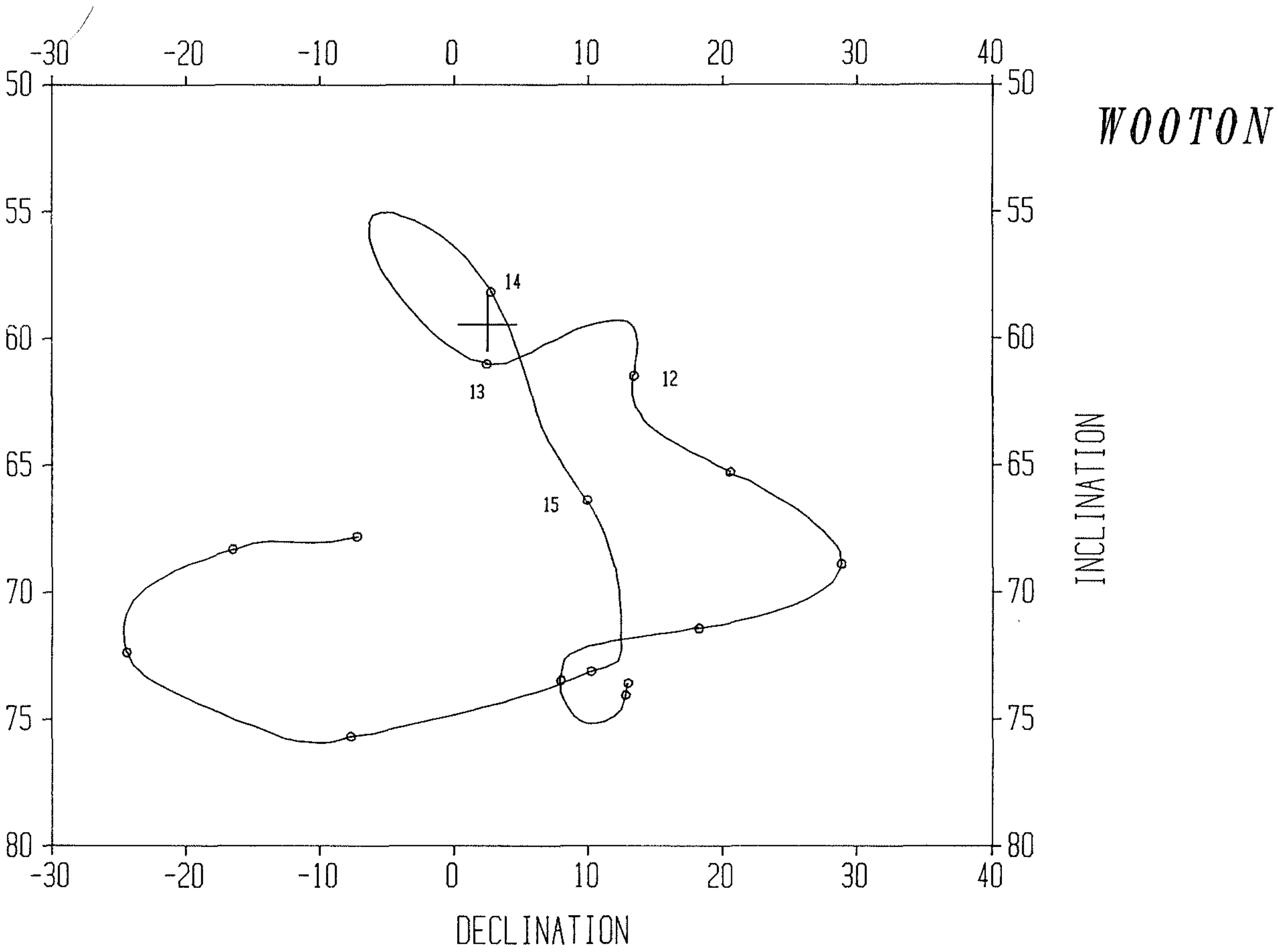


FIGURE 4

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


WOOTON
DECLINATION
INCLINATION
-30
-20
-10
0
10
20
30
40
50
55
60
65
70
75
80
12
13
14
15