
Plate 1. Context 6003. Facing East.

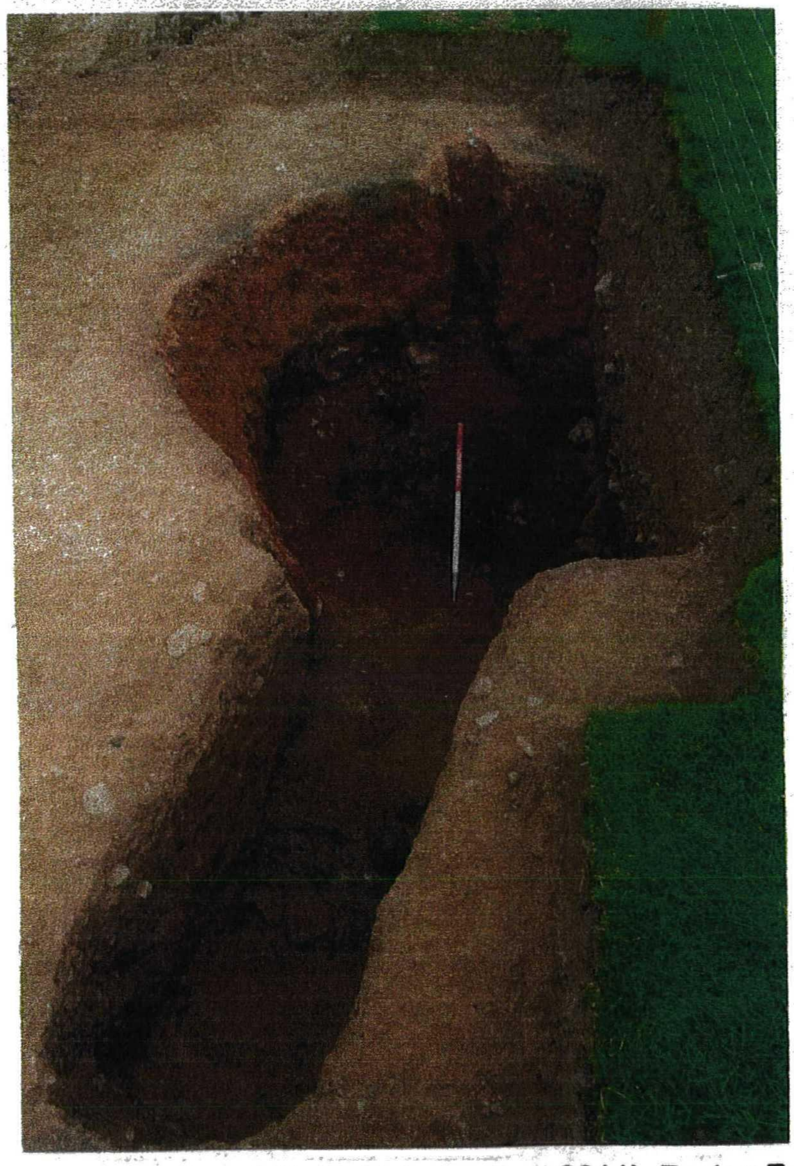
Plate 2. Kiln (context 6010) and Stoke Hole (context 6011). Facing East.

Plate 3. North Facing Section. Facing South.

Plate 4. Contexts 6006 and 6008. Facing East.

APPENDIX 1

Context Listing

Context Number	Description
6001	Deposit: Turf and Topsoil, sandy silt, 10YR5/4
6002	Deposit: Subsoil, silty sand, 10YR6/4
6003	Deposit: clay silty sand, 10YR4/4
6004	Deposit: sandy silt, 10YR5/4
6005	Deposit: sandy silt, 10YR4/4
6006	Deposit: silty clay, 10YR5/4
6007	Deposit: clay silt & sand, 10YR4/4
6008	Deposit: silty clay, 10YR5/3
6009	Deposit: fired clay natural, 2.5YR5/8 to 5YR5/8
6010	Cut: Lime Kiln Bowl and Flue
6011	Cut: Stoke Hole

APPENDIX 2

Finds Catalogue

Context	Description	Date
6001	1 body sherd, Staffordshire Type Slipware	18th century
6002	1 body sherd, Manganese Mottled ware	18th century
	1 body sherd, Staffordshire Slipware	
	2 Ferrous Nails	
	1 Ferrous Buckle Plate	
	1 Ferrous Object	
6003	1 base sherd, Manganese Mottled ware Tankard	18th century
	1 base sherd, Humber ware	
	1 bowl fragment, Clay Tobacco Pipe	
	1 fragment, bottle glass	
	1 fragment Copper Alloy Strip	
	2 fragments, Animal Bone	
6004	1 body sherd, Cistercian ware	16th century
6005	1 fragment, Animal Bone	

APPENDIX 3

Archive Listing

1. Plan: Kiln Fill 6003. Scale 1:20.
2. Plan: Kiln Fill 6004. Scale 1:20.
3. Plan: Kiln Fill 6005. Scale 1:20.

4. Plan: Kiln Fill 6006. Scale 1:20.
5. Plan: Kiln Fill 6007. Scale 1:20.
6. Plan: Kiln Fill 6008. Scale 1:20.
7. Plan: Kiln Fill 6009 and Cuts 6010 and 6011. Scale 1:20.
8. North Facing Section. Scale 1:10.
9. Profile: Kiln and Stoke Hole Cuts 6010 and 6011. Scale 1:20.

APPENDIX 4

Photographic Listing

Colour and Monochrome Prints

1. Kiln Fill 6003. Facing East.
2. Kiln Fill 6003. Facing East.
3. Kiln Fill 6006 and Stoke Hole Fill 6008. Facing East.
4. Kiln Fill 6006 and Stoke Hole Fill 6008. Facing East.
5. Kiln under Excavation. Facing West.
6. North Facing Section. Facing South.
7. Kiln Cut 6010 and Stoke Hole Cut 6011, Facing East.
8. Kiln Cut 6010 and Stoke Hole Cut 6011, Facing East.
9. Kiln Cut 6010 and Stoke Hole Cut 6011, Facing West.

APPENDIX 5

Archaeomagnetic Study (Geoquest Associates)

INTRODUCTION

Excavations have recently been carried out by MAP Archaeological Consultancy at Marfield Quarry, Masham, with the aim or preserving, by record, archaeological features within a proposed quarry extension. Topsoil stripping revealed a substantial lime kiln (circa 2.0m x 1.8m x 1.5m deep) that had been excavated into the gravel subsoil and lined with clay.

Archaeomagnetic samples were obtained from the kiln wall (Context 6009) on 23rd July 1999 with the aim of establishing the time when the furnace was last in use. The principles of the dating technique that were employed in this study are outlined in Appendix A.

SAMPLING

The kiln had been constructed as a deep hole excavated into the friable gravel subsoil and the walls then lined with a 2-5cm layer of silty clay. This material had been converted by firing into a hard red surface, and the zone of thermal alteration could be seen (as a colour change) to extend behind the kiln wall a further 10-15cm. After a careful cleaning and examination of the kiln wall surface it was decided to cut a ledge into the clay lining, about

10cm below the lip, and collect archaeomagnetic samples from this position. This procedure would ensure that the samples were obtained in area with minimal disturbance by ploughing, rootlets and burrowing.

Oriented samples were 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, orientation arrows were marked using a sun compass, along with a specimen code.

The specimens were slowly dried over several days and then consolidated by impregnation with a dilute solution of PVA in acetone. Each specimen was cut with a diamond saw until the button retained a volume which fitted the standard 25x25mm specimen holder inside the archaeomagnetic magnetometer.

MEASUREMENT

The natural remanent magnetisation (NRM) of all samples were measured in a Molspin fluxgate spinner magnetometer (Molyneux, 1971) with a minimum sensitivity of around $5x10^{-9}Am^2$. Remanence directions were corrected for sun compass orientations using data contained in the Nautical Almanac tables: these results are listed in Table 1 and presented on the stereogram of Figure 1.

Generally, the NRM 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 (MAR2) was demagnetised incrementally, up to a peak alternating field of 3OmT 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 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 stereogram of Figure 3.

RESULTS

The fired clay was found to contain an intense natural remanent magnetisation indicating that the material has a significant content of iron oxides. The NRM has clearly been polarised by the Earth's magnetic field with a mean direction that is both steeper and more westward than the present day direction (Figure 1, Table 1). The excellent grouping of archaeomagnetic vectors from the sample set provides good evidence that the clay of the kiln wall has been fired to temperatures exceeding 580°C which is the blocking temperature of titanomagnetite.

A study of Figure 2 shows that stepwise demagnetisation of pilot sample MAR2 induced only minor changes in remanence direction consistent with the removal of small components of secondary magnetisation acquired since firing. A field of 2.5mT was therefore chosen for the partial demagnetisation of the remaining specimens which would suffice to remove residual secondary (eg. viscous) components of magnetisation. This process induced negligible change in the vector grouping, confirming the stability of the samples' remanent magnetisation (Figure 3).

The mean archaeomagnetic vector for the sample set has been computed Table 1 and then corrected to Meriden, the reference location for the UK Master Curve. Comparison of the adjusted vector with the Master Curve in Figure 4 suggests that the last firing of the kiln took place during the period:

1760 A.D. - 1790 A.D.

CONCLUSIONS

The results of this research can be summarised as follows:

1. Fifteen oriented archaeomagnetic samples have been obtained from the inner clay lining of a substantial kiln recently excavated at Marfield Quarry extension, near Masham. The specimens were found to be strongly magnetised in a direction consistent with the recent historic Earth's magnetic field. It is therefore clear that heating of the kiln wall must have risen to above the blocking temperature of titanomagnetite (580°C).

2. Demagnetisation tests showed that the archaeomagnetism within the fired clay is highly stable and hence the results can be relied upon to provide an accurate record of the Earth's magnetic field direction.

3. Comparison of the mean archaeomagnetic vector in the kiln wall with the UK Master Curve suggests that the last firing took place during the period 1760 A.D. to 1790 A.D.

REFERENCES

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

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TABLE 1
ARCHAEOMAGNETIC RESULTS FROM A KILN AT MARFIELD QUARRY EXTENSION, MASHAM, NORTH YORKSHIRE

Sample	LITH	J	D	I	A.F.	D	I
MAR1	FCL	62.4	321.3	78.6	2.5	321.2	78.3
MAR2	FCL	147.3	337.0	75.2	2.5	336.2	74.9
MAR3	FCL	150.1	332.9	73.2	2.5	329.5	73.8
MAR4	FCL	267.1	323.5	75.5	2.5	322.4	77.0
MAR5	FCL	213.7	337.2	81.1	2.5	337.4	82.0
MAR6	FCL	239.1	320.7	73.8	2.5	319.3	73.8
MAR7	FCL	70.4	343.1	76.1	2.5	341.5	76.4
MAR8	FCL	107.7	344.6	74.2	2.5	344.1	74.4
MAR9	FCL	94.9	334.8	71.2	2.5	334.2	72.6
MAR10	FCL	75.5	325.9	75.4	2.5	322.5	75.0
MAR11	FCL	135.9	337.5	72.6	2.5	339.7	73.5
MAR12	FCL	186.5	340.7	73.0	2.5	341.6	73.6
MAR13	FCL	138.2	335.3	74.5	2.5	336.9	74.1
MAR14	FCL	45.4	340.3	70.9	2.5	339.2	71.7
MAR15	FCL	24.9	342.6	73.1	2.5	343.6	72.9
Mean of samples			**334.9**	**74.7**		**334.3**	**75.1**
At Meriden						**335.7**	**74.1**

K=558.0 cse=0.9 alpha 95=1.60°

NOTES: LITH = Lithology, FCL fired clay. D = declination, I = inclination, J = intensity in units of $mAm^{-1}x10^{-2}$. A.F. = peak alternating demagnetising field in milliTesla. K = precision parameter, cse = circular standard error, alpha95 = semi-angle of the 95 % cone of confidence.

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.