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Ancient Monuments Laboratory
Report 83/2000

TYLER HILL, CANTERBURY, KENT, ARCHAEOMAGNETIC DATING REPORT, 2000

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Summary

Excavations for the Time Team television programme at Tyler Hill near Canterbury uncovered the remains of a medieval tile kiln in a remarkably good state of preservation. Archaeomagnetic analysis of the kiln dated its last firing to between 1238 and 1286 (95% confidence level), in broad agreement with the available typological evidence. The archaeomagnetic date was achieved only after the application of an estimated "bedding correction" to compensate for movement of the kiln walls after the structure was abandoned. The accuracy of the date range quoted is therefore dependent upon this correction – which assumes that the tiles in question were originally horizontally disposed.

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TYLER HILL, CANTERBURY, Kent:
Archaeomagnetic Dating Report 2000

Introduction

During archaeological investigations carried out by the Time Team in Canterbury for their live television programme over the August 2000 bank holiday weekend, a medieval tile kiln was discovered on Tyler Hill, overlooking the city (TR 146 602, Latitude 51.3°N, Longitude 1.1°E). The kiln was constructed of stacked tiles mortared together with fired clay. The English Heritage Centre for Archaeology (EH CfA) was requested to sample the feature for archaeomagnetic dating and this request was supported by the regional Inspector of Ancient Monuments, Peter Kendall. Sampling was carried out on the 28th and 29th of August 2000 by the author and subsequent measurement and evaluation was performed by the author and Louise Martin of the EH CfA. The Time Team investigations were carried out in conjunction with the Canterbury Archaeological Trust (CAT site code TH00) for whom this report was prepared.

Method

Samples were collected using the disc method (see appendix, section 1a) and samples TH01-23 were orientated to true north using a gyro-theodolite. The additional samples TH24-32 were orientated using a magnetic compass, the variation between magnetic and true north having been established by the gyro-theodolite.

Samples TH01-07 came from an arch inside the kiln and samples TH08-14 came from what appeared to be a floor layer on top of the line of arches. Samples TH15-23 came from the north wall of the kiln and samples TH24-32 from the west wall. In all areas samples of both tile and fired clay were taken, the composition of each sample being indicated in Table 1.

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 are listed in Table 1 and the distribution of their directions is depicted in Figure 1. Most of the samples are quite strongly magnetised and their directions form a distinct group. The exceptions are samples TH08-14 from what appeared to be a floor laid on top of the kiln arches. These appear to be weakly magnetised and have highly anomalous NRM directions. It was concluded that these samples were unlikely to have been in the same position in the kiln when it was last fired and they were excluded from further analysis.

The NRM of the samples is assumed to be caused by thermoremanent magnetisation (TRM) at the time that the feature was last fired. However, a secondary component acquired in later geomagnetic fields can also be present, caused by diagenesis or partial reheating. Additionally, the primary TRM may be overprinted by a viscous component, depending on the grain size distribution within the magnetic material. These secondary components are usually of lower stability than the primary TRM and can thus be removed by partial demagnetisation of the samples.

In the case of tile samples, it is also possible that a TRM is retained relating to the time when the tile itself was manufactured. If the tile was subjected to a very high temperature during its manufacture then all its magnetic domains, even those with high coercivities, would be realigned. However, when it was later incorporated into the kiln wall, it is possible that it was not exposed to such a high temperature. Thus, only the lower coercivity domains would realign with the new field direction. In this case the total magnetisation of the tile would consist of two components, one, relating to the time it was manufactured, preserved in the high coercivity domains, the other, relating to the last firing of the kiln, preserved in the lower coercivity domains.

Hence three samples, TH01 (clay), TH06 (tile) and TH28 (tile), were demagnetised incrementally to a peak alternating field of 100mT and the changes in their remanence recorded to identify the components of their magnetisation. The measurements are tabulated in Table 2 and depicted graphically in Figures 2-4. The magnetisation in all three samples appears stable, with no secondary component apparent at higher coercivities in the two tile samples. However, a small component of viscous remanence has been detected at low coercivities in sample TH01 and TH06 and it persists up to the 5mT in sample TH28.

It was thus decided to partially demagnetise the remaining samples in a 10mT AF field to remove this viscous component[1]. The distribution of sample TRMs after this treatment is depicted in Figure 5a; the measured values are listed in Table 1.

It can be seen in Figure 5a, that the sample TRM directions form two distinct clusters which relate to the parts of the kiln structure they derived from. Figure 5b plots the mean TRM directions of the samples from the arch, north wall and west wall calculated separately, along with their α_{95} confidence limits (note 3c). In this figure the samples from the arch and north wall may be seen to be statistically indistinguishable. However, the samples from the west wall, although having a statistically precise mean, all have anomalously low inclination directions.

Whilst some shape dependent distortion of the TRM direction can be caused by so called "magnetic refraction" effects (note 3b), it generally accounts for deviations of only 2-3°. Inspection of the kiln and the samples taken from it suggests that the more likely explanation is slumping of the structure since it was last fired. Samples from the west wall appeared to be particularly badly affected and it was thus decided to exclude these from further analysis. The mean TRM direction of the remaining 16 samples, TH01-07 and TH15-23, was calculated (see note 3) to be:

[1] It should be noted that sample TH17 was used as a fourth pilot sample. However, owing to computer problems, its incremental partial demagnetisation values were not recorded, so the TRM after the final 100mT demagnetisation step has been used.

At site:	**Dec = 5.0°**	**Inc = 53.4°**	α_{95} **= 1.9°**	**k = 387.6**
At Meriden:	**Dec = 4.1°**	**Inc = 54.4°**		

This mean is depicted in relation to the UK archaeomagnetic dating curve in Figure 6a. In this figure it is apparent that the mean direction does not coincide closely with any portion of the UK archaeomagnetic dating calibration curve. Despite exclusion of samples from the west wall, this mismatch is likely to be due to the slumping of the structure previously noted. Thus a bedding correction (Tarling 1983, p83) was estimated by assuming that the tile samples from the north wall were stacked horizontally when the kiln was last used and that their deviation from this orientation has occurred since the kiln was abandoned. This bedding correction (strike = 61.9°, dip = 5.5°) was applied to all the samples and the mean TRM direction was recalculated:

At site:	**Dec = 9.7°**	**Inc = 57.9°**	α_{95} **= 1.9°**	**k = 387.6**
At Meriden:	**Dec = 9.0°**	**Inc = 58.7°**		

This mean is depicted in Figure 6b and it can be seen that it coincides with the segment of the calibration curve for the 13th Century AD, giving date ranges of:

1247 to 1276 cal AD at the 63% confidence level.
1238 to 1286 cal AD at the 95% confidence level.

Conclusions

Archaeomagnetic analysis of the samples from Tyler Hill has established that the kiln excavated there was last fired in the 13th Century AD. This date is in good agreement with the analysis of pottery from the site, none of which appeared to date from later than this period. It should be noted that the structure has clearly slumped since the feature was last fired. To derive the archaeomagnetic date, it was necessary to assume that the tiles forming its north wall were originally stacked horizontally, resettlement to their present orientation being entirely caused by slumping since the kiln was abandoned. Any deviation from this assumption or error in estimating the bedding angle will introduce a systematic error into the calculated mean TRM. This error would affect the accuracy (but not the precision) of the date range making it up to 20 years earlier or later than that quoted.

Finally, samples TH08-15 from what appeared to be a floor laid on top of the kiln arches, seem not to have been heated whilst in their present orientations. This would tend to suggest that the apparent floor is, in fact, an aggregation of material that has collapsed into the kiln since it was abandoned.

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Date of report: 8/12/2000

Archaeomagnetic Date Summary

Site:	**Tyler Hill, Canterbury**
Location:	**Longitude 1.1E, Latitude 51.3N**
Number of Samples (taken/used in mean):	**32/16**
AF Demagnetisation Applied:	**10mT**
Distortion Correction Applied:	**None**
Bedding Correction Applied:	**Strike = 61.9°, Dip = 5.5°**
Mean Declination at Site:	**9.7°**
Mean Inclination at Site:	**57.9°**
Mean Declination at Meriden:	**9.0°**
Mean Inclination at Meriden:	**58.7°**
Alpha-95:	**1.9°**
k:	**387.6**
Date range (63% confidence):	**1247 to 1276 cal AD**
Date range (95% confidence):	**1238 to 1286 cal AD**

	NRM Measurements				After partial demagnetisation		
Sample	Material	Dec°	Inc°	J (mA/m)	AF (mT)	Dec°	Inc°	J (mA/m)
TH01	Clay	4.7	49.2	4402.8	10	4.3	48.6	3709.0
TH02	Tile	3.4	51.9	4197.8	10	3.6	51.8	3539.2
TH03	Tile	-1.5	55.5	11081.3	10	-1.9	55.2	9543.3
TH04	Clay	3.2	48.9	1138.2	10	0.6	48.2	907.1
TH05	Tile	4.8	53.9	11312.1	10	2.7	54.1	8987.7
TH06	Tile	0.8	57.3	12822.0	10	2.0	57.2	11242.2
TH07	Tile	6.9	47.8	4986.8	10	6.1	47.9	4572.6
TH08	Clay	-4.3	72.2	62.3	-	-	-	-
TH09	Clay	-155.1	25.9	123.6	-	-	-	-
TH10	Tile	-159.1	27.0	58.1	-	-	-	-
TH11	Tile	-171.2	28.4	69.1	-	-	-	-
TH12	Tile	176.4	32.0	60.0	-	-	-	-
TH13	Tile	171.5	32.2	52.1	-	-	-	-
TH14	Clay	51.0	4.4	187.8	-	-	-	-
TH15	Tile	5.0	54.1	4091.9	10	4.9	54.2	3319.1
TH16	Tile	5.6	55.7	5764.0	10	4.8	55.2	4686.3
TH17	Clay	6.9	55.9	4089.6	100	1.8	53.1	534.5
TH18	Clay	7.4	54.6	3450.1	10	4.7	54.5	2508.6
TH19	Clay	7.1	57.9	2560.2	10	5.8	57.2	1840.3
TH20	Clay	4.9	59.2	2132.1	10	3.2	58.6	1687.4
TH21	Tile	12.7	52.6	29441.7	10	9.7	52.2	24604.1
TH22	Tile	12.1	54.5	36503.3	10	12.2	54.8	29923.4
TH23	Tile	16.9	51.2	31374.1	10	14.8	50.9	26448.2
TH24	Both	6.0	42.5	5208.1	10	5.7	41.0	3968.4
TH25	Tile	7.5	42.7	604.4	10	6.5	40.5	391.4
TH26	Tile	14.0	44.3	2248.8	10	13.2	43.2	1829.6
TH27	Clay	6.2	41.3	2529.8	10	6.0	39.4	1175.1
TH28	Tile	13.0	39.4	2246.8	10	12.6	37.7	1745.8
TH29	Tile	8.6	41.7	748.7	10	8.5	41.0	496.7
TH30	Tile	7.0	43.2	257.2	10	7.3	41.8	182.9
TH31	Tile	8.2	43.3	271.2	10	9.8	40.9	199.3
TH32	Tile	8.0	43.2	95.0	10	10.5	41.5	61.2

Table 1: NRM measurements and measurements after partial demagnetisation for all samples. J = magnitude of magnetisation vector; AF = peak alternating field strength of applied demagnetising field.

	TH01			TH06			TH28		
AF(mT)	Dec°	Inc°	J(mA/m)	Dec°	Inc°	J(mA/m)	Dec°	Inc°	J(mA/m)
0.0	5.6	49.0	4389.1	1.9	57.7	12939.5	13.4	39.5	2249.1
2.5	5.3	49.0	4347.7	0.2	57.1	12860.7	12.0	38.8	2190.5
5.0	5.0	48.9	4198.6	2.1	57.2	12527.5	11.6	37.8	2118.3
10.0	4.3	48.6	3709.0	2.0	57.2	11242.2	12.6	37.7	1745.8
15.0	4.9	48.4	3050.3	2.0	57.1	9411.7	12.0	37.2	1404.9
20.0	4.7	48.3	2619.2	1.7	57.1	8091.5	12.3	36.9	1166.9
30.0	4.6	48.0	2073.2	1.3	56.8	6456.0	11.2	36.3	909.7
50.0	4.4	48.1	1533.5	1.8	56.8	4841.9	12.1	36.3	685.1
100.0	2.7	46.3	1067.4	1.9	57.1	3269.8	12.3	37.0	531.5

Table 2: Incremental partial demagnetisation measurements for samples TH01, TH06 and TH28.

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 applied, where appropriate, to measured inclinations, in keeping with the practise of Clark, Tarling and Noel (1988).

c) 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 α_{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.

d) For the purposes of comparison with standardised UK calibration data, 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).

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 63% and 95% confidence levels. 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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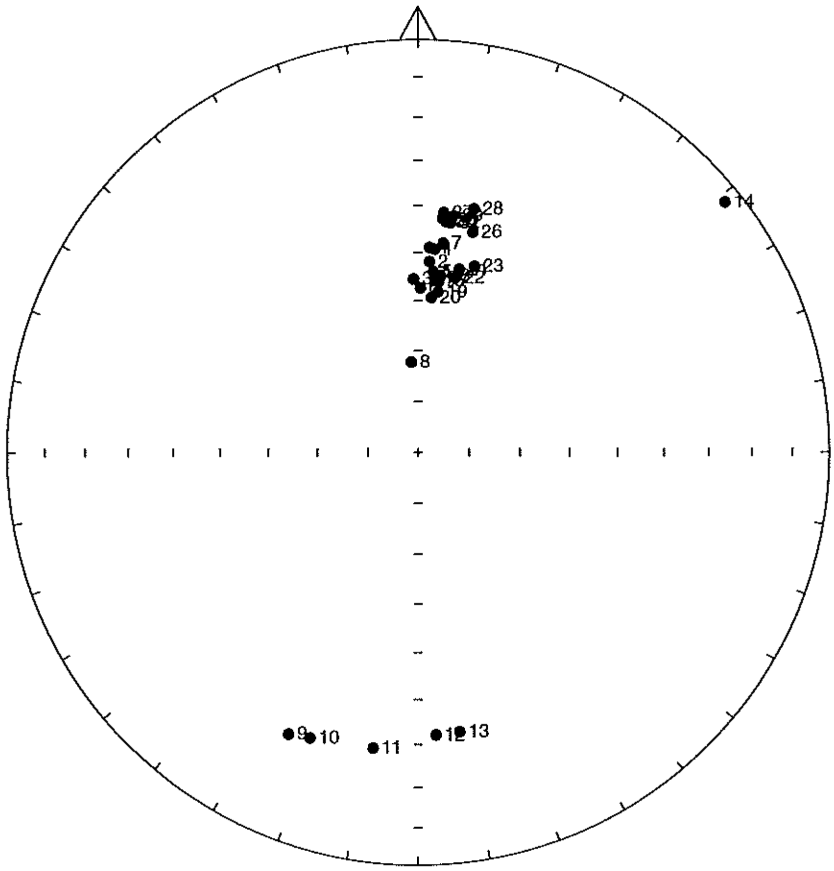


Figure 1: Distribution of NRM directions represented as an equal area stereogram. In this projection declination increases clockwise with zero being at 12 o'clock while inclination increases from zero at the equator to 90 degrees in the centre of the projection.

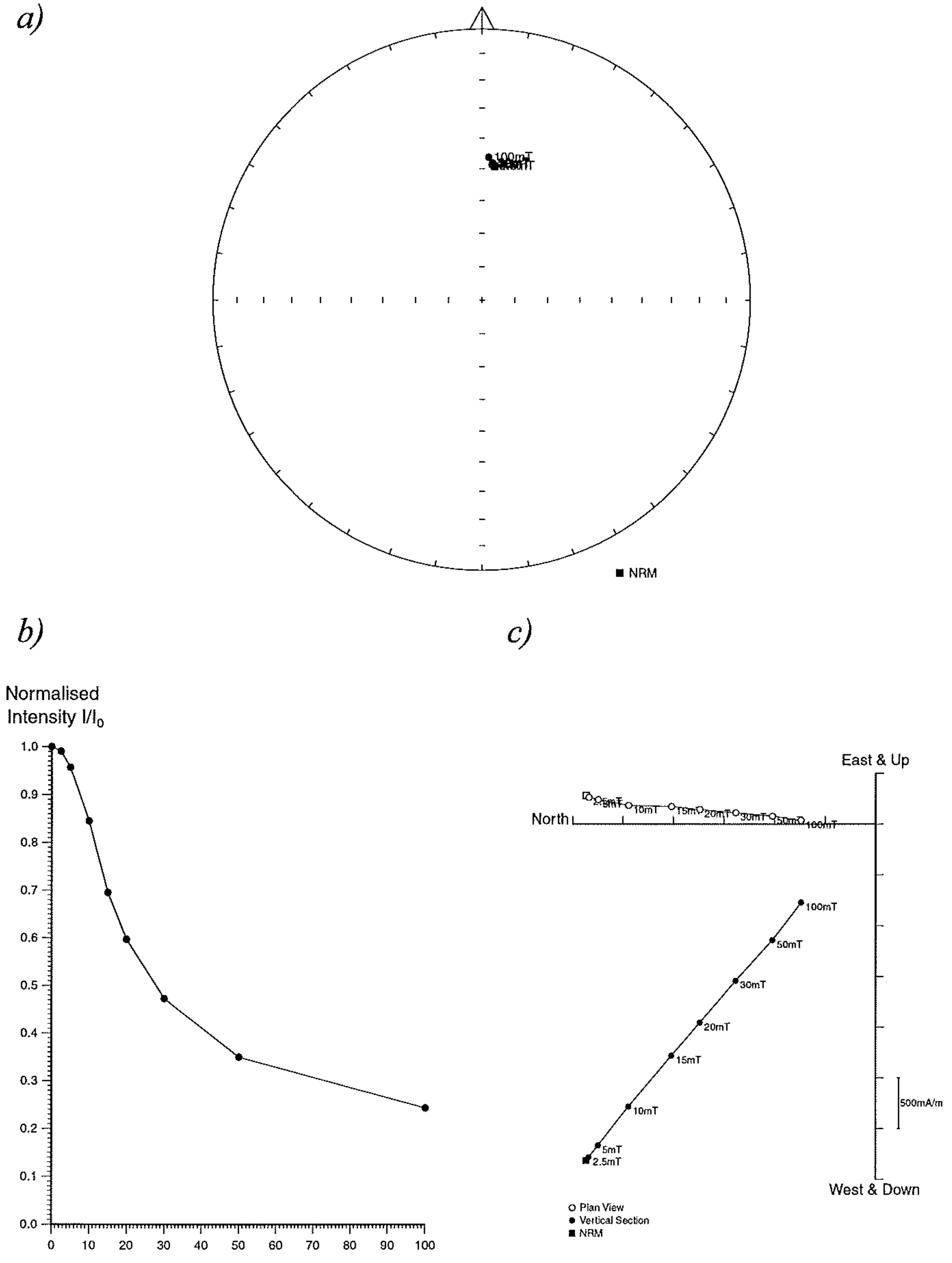
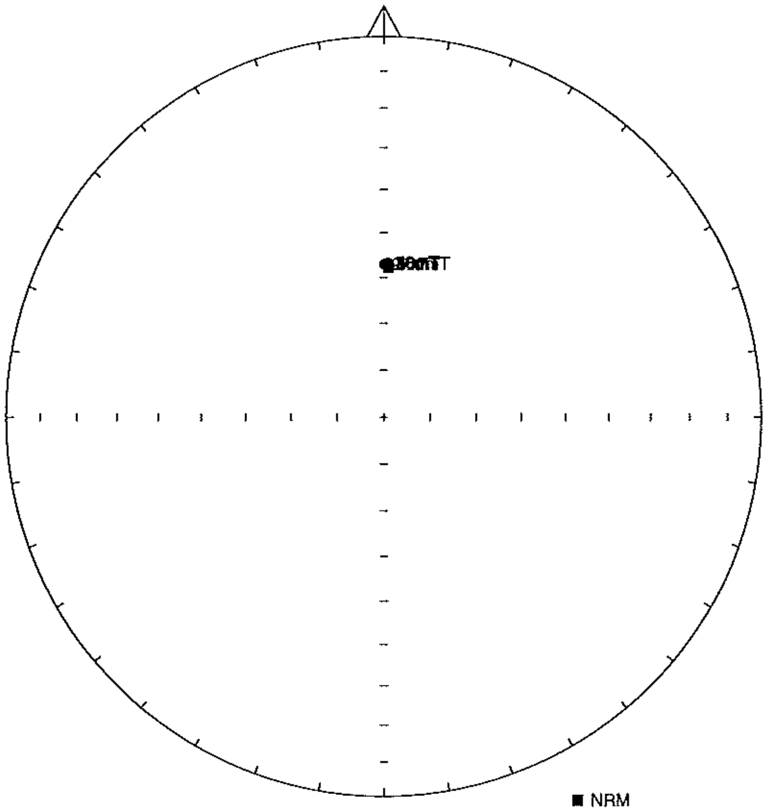
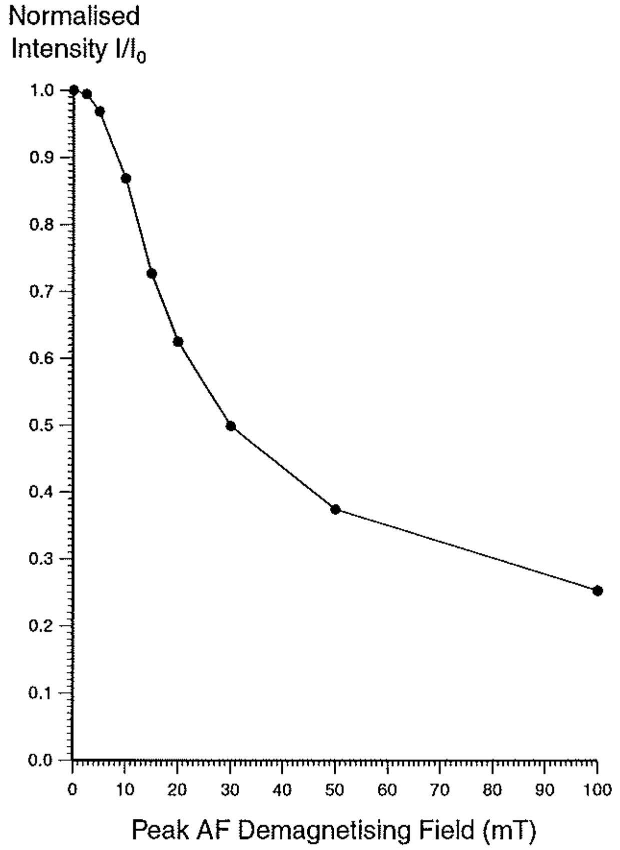


Figure 2: Stepwise AF demagnetisation of sample TH01. Diagram a) depicts the variation of the remanent direction as an equal area stereogram (declination increases clockwise, while inclination increases from zero at the equator to 90 degrees at the centre of the projection); b) shows the normalised change in remanence intensity as a function of the demagnetising field; c) shows the changes in both direction and intensity as a vector endpoint projection.

a)



b)



c)

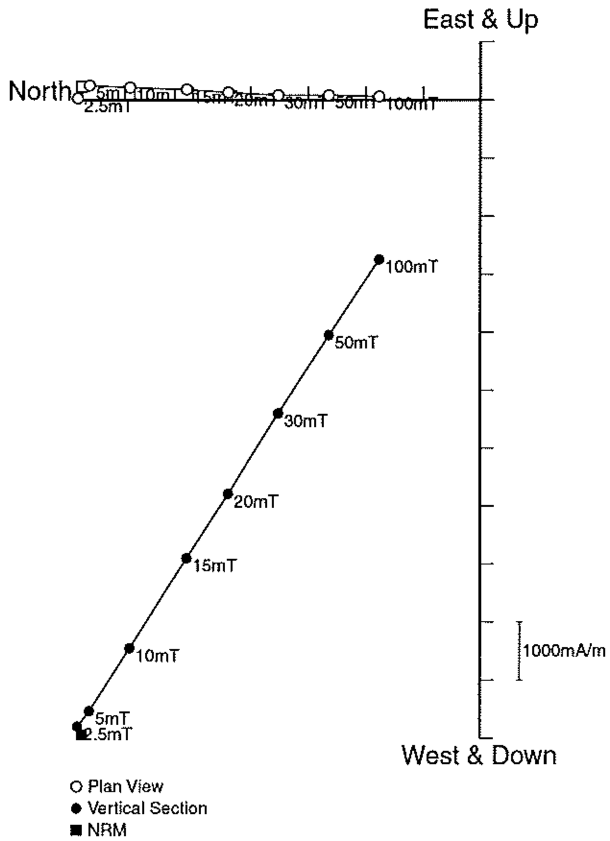


Figure 3: Stepwise AF demagnetisation of sample TH06. Diagram a) depicts the variation of the remanent direction as an equal area stereogram (declination increases clockwise, while inclination increases from zero at the equator to 90 degrees at the centre of the projection); b) shows the normalised change in remanence intensity as a function of the demagnetising field; c) shows the changes in both direction and intensity as a vector endpoint projection.

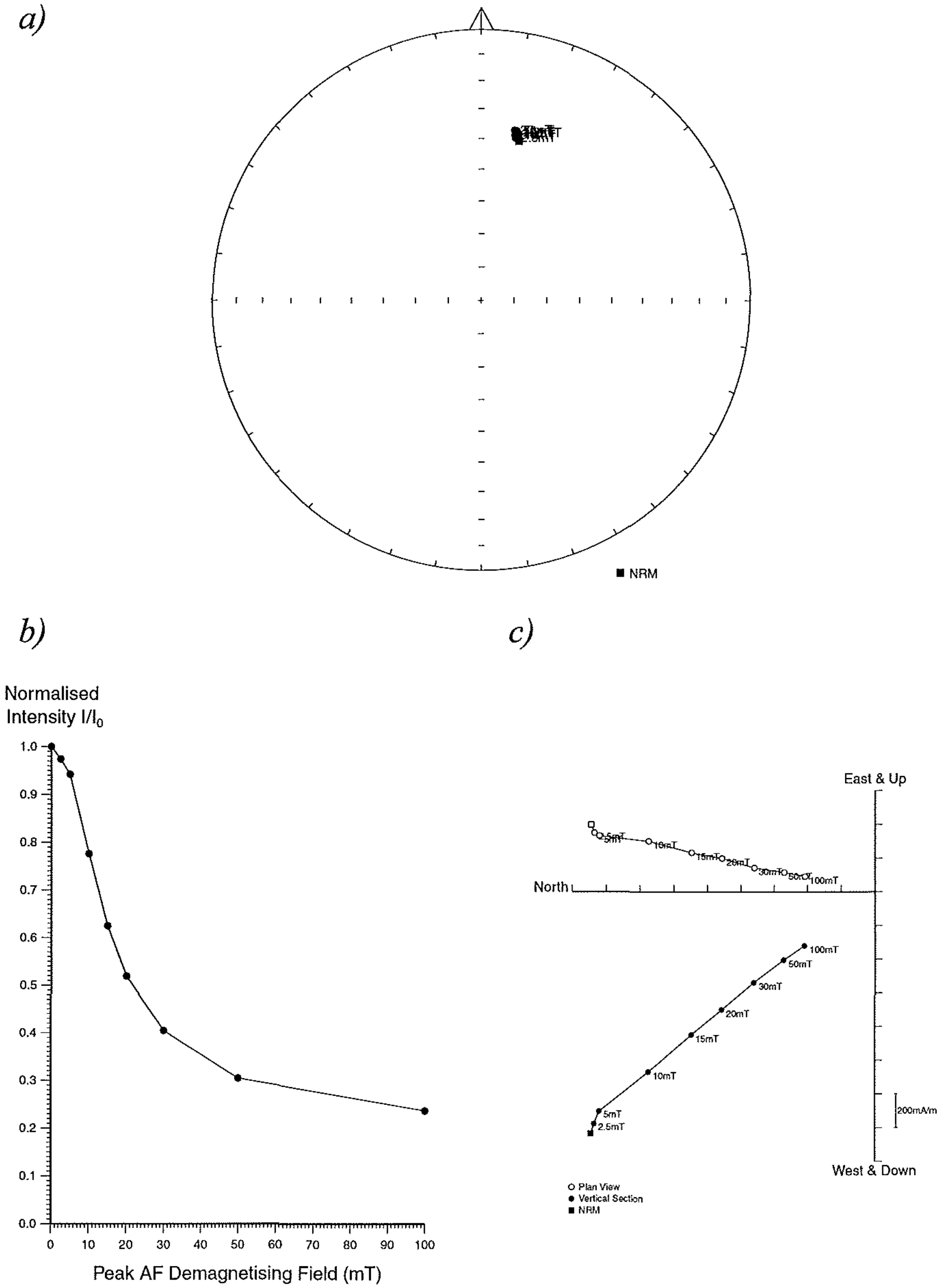


Figure 4: Stepwise AF demagnetisation of sample TH28. Diagram a) depicts the variation of the remanent direction as an equal area stereogram (declination increases clockwise, while inclination increases from zero at the equator to 90 degrees at the centre of the projection); b) shows the normalised change in remanence intensity as a function of the demagnetising field; c) shows the changes in both direction and intensity as a vector endpoint projection.

a)

b)

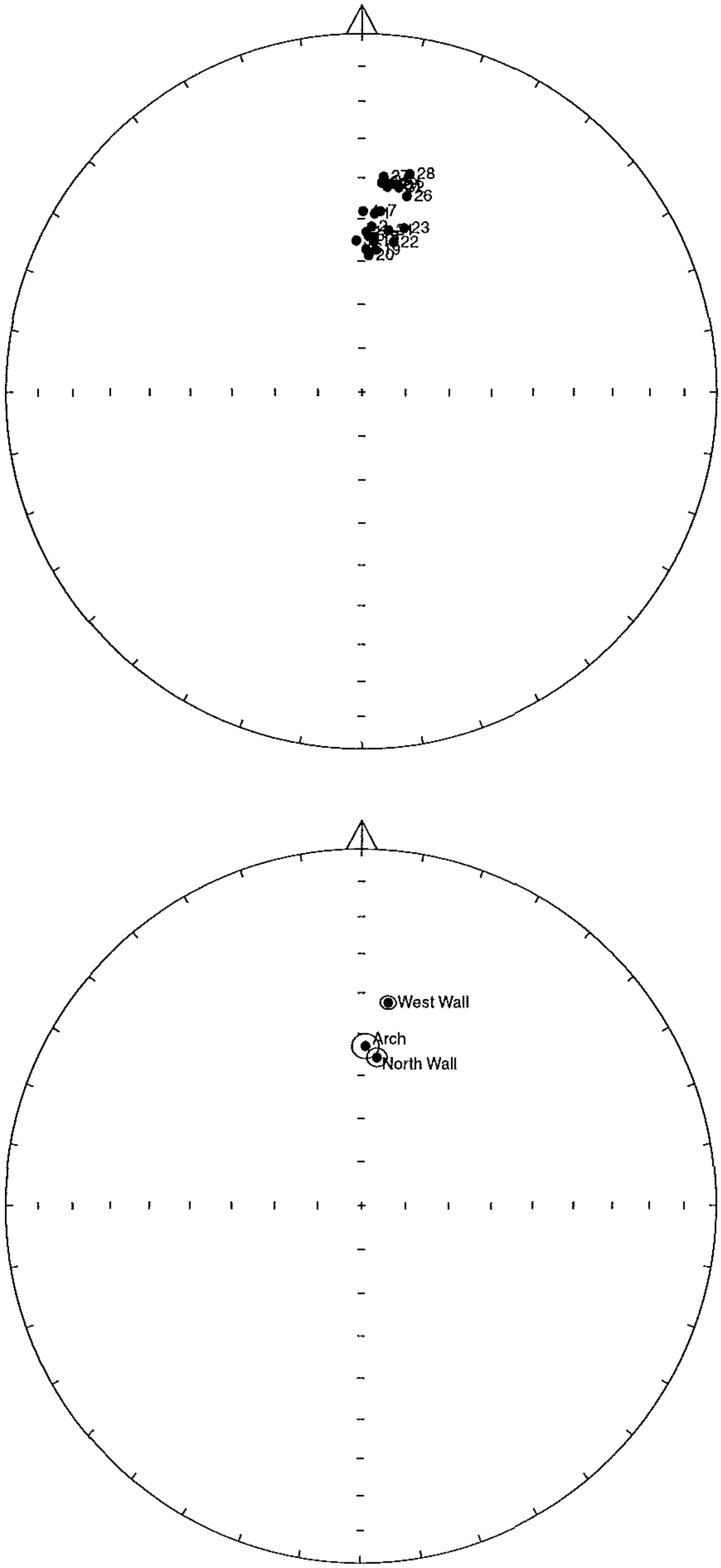
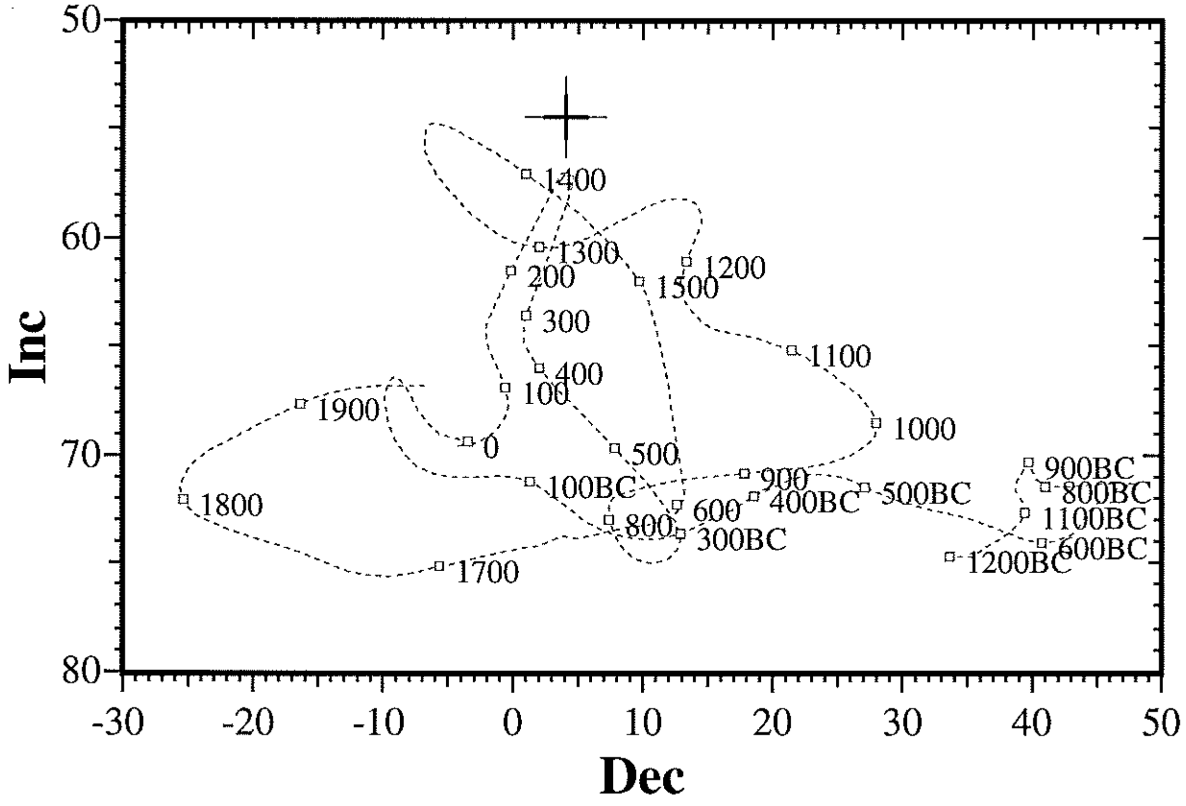


Figure 5: a) Distribution of thermoremanent directions of magnetisation of samples after partial AF demagnetisation to 10mT, represented as an equal area stereogram. b) Mean TRM directions of samples from the Arch, North and West walls of the kiln depicted with ellipses representing the projection of the α_{95} cone of confidence parameter for each.

a)



b)

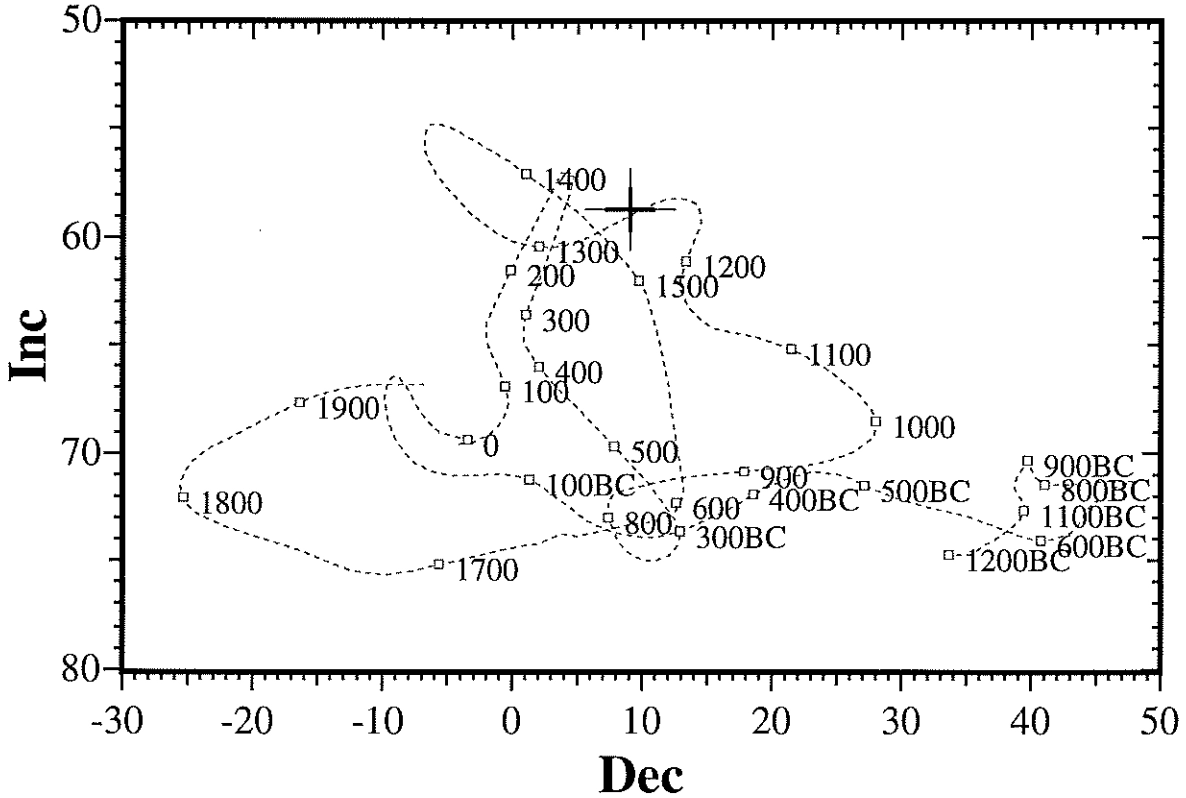


Figure 6: Comparison of the mean thermoremanent vector of samples TH01-07 and TH15-23 after 10mT partial AF demagnetisation with the UK master calibration curve. a) Meriden corrected mean TRM direction without bedding correction. b) The same mean direction with a bedding correction of strike = 61.9, dip = 5.5 applied before Meriden correction. In both graphs, thick error bar lines represent 63% confidence limits and narrow lines 95% confidence limits.