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STANION, Corby, Northamptonshire: Archaeomagnetic Dating Report 2002

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Summary

During preparations for the construction of a new barn on farmland at Stanion near Corby in Northamptonshire, tesserae were uncovered suggesting the presence at of a Roman mosaic. Subsequent excavations revealed the remains of a Roman villa, with areas of intact mosaic, suggesting a structure of some pretension. The Archaeometry Branch was requested to provide archaeomagnetic analysis for two fired clay features discovered on the site. The first appeared to be a hearth, composed of fired clay laid on top of a Roman mosaic floor and also overlying a villa wall footing. The second was a linear feature with a slot-shaped depression, partially lined with stones, conjectured to have been a corn drier.

Archaeomagnetic analysis demonstrated that the clay comprising the hearth feature had not been fired in situ and so could not be dated. The second feature, the putative corn drier, appeared to have been badly disturbed since it was last fired with a high degree of scattering in the magnetisation directions of individual samples. It was thus not possible to deduce a reliable date for its last firing but an approximate estimate was obtained by subjectively choosing to accept only those seven samples that had similar TRM directions. The date obtained suggests that it was last heated during the period spanned by the first centuries BC and AD.

Keywords

Archaeomagnetism

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STANION, Corby, Northamptonshire:
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Introduction

During preparations for the construction of a new barn on farmland at Stanion near Corby in Northamptonshire (SP 917 870, Longitude 0.7°W, Latitude 52.5°N), tesserae were uncovered suggesting the presence at of a Roman mosaic. Subsequent excavations by Dr Martin Tingle and the Northamptonshire Archaeological Unit revealed the remains of a Roman villa, with areas of intact mosaic, suggesting a structure of some pretension. The resourcing necessary to properly examine a discovery of this importance was beyond that which could be obtained through developer funded PPG16 arrangements. Hence, English Heritage was asked to assist with finance through its Archaeology Commissions programme and scientific support.

As a result, the project monitor, Helen Keeley, requested that the Archaeometry Branch provide archaeomagnetic analysis for two fired clay features discovered on the site. The first appeared to be a hearth, composed of fired clay laid on top of a Roman mosaic floor and also overlying a villa wall footing. The second was a linear feature with a slot-shaped depression, partially line with stones: this was conjectured to have been a corn drier. Both features were sampled on the 13th May 2002 by the author who also performed the subsequent measurement and analysis.

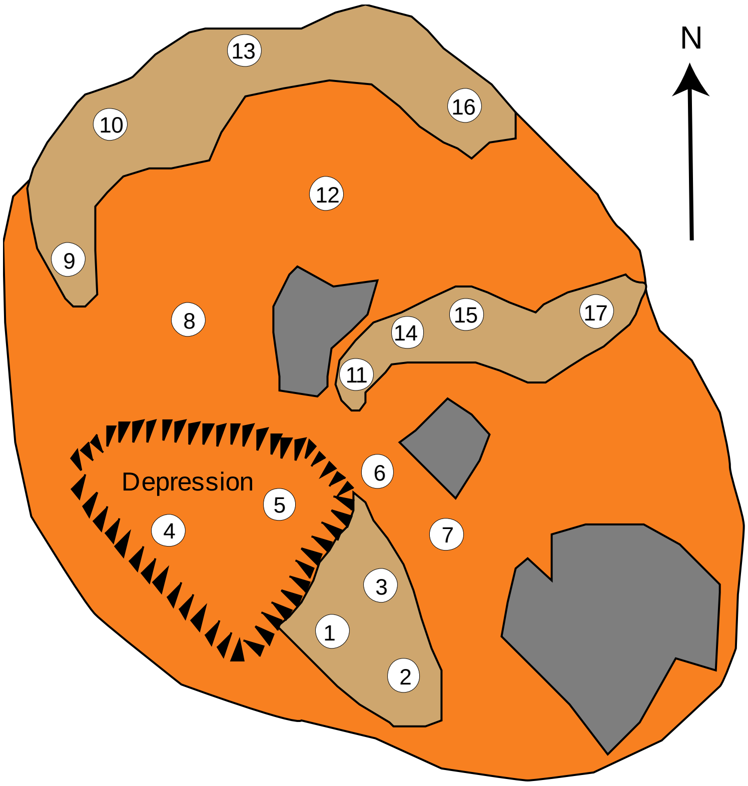

Figure 1; Sketch plan of feature 1STN, the clay hearth, showing the locations of the individual samples. The feature was about a metre in diameter and overlay Roman floor and wall remains from the villa.

Method

The hearth was given the C*f*A archaeomagnetic feature code 1STN and the corn dryer the code 2STN. Samples were collected from both using the disc method (see appendix, section 1a) and orientated to magnetic north using a compass. Subsequently the International Geomagnetic Reference Field (IGRF 2000) was used to establish that magnetic north was 3.3° west of true north at the site on the date when the samples were taken and the sample orientations were corrected accordingly.

Seventeen samples of orange/brown fired clay were collected from feature 1STN (Figure 1). With feature 2STN, 6 samples were taken from a fired stone at the southern end of the apparent flue slot of the feature (Figure 2); 5 more were taken from a black layer of clay and charcoal blocking the northern end of the flue; and a further 7 were taken from an area of orange/red fired clay immediately east of the black layer.

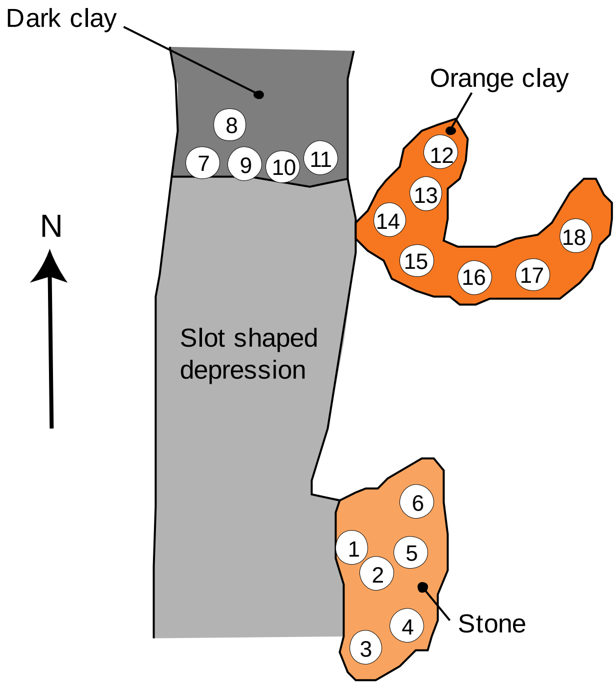

Figure 2; Sketch plan of feature 2STN, the putative corn drier, showing the locations of the individual samples. The feature was about two metres long in the north-south direction.

The natural remanent magnetisation (NRM) measured in archaeomagnetic samples is assumed to be caused by thermoremanent magnetisation (TRM) created at the time when the feature of which they were part 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.

A typical strategy used in archaeomagnetic analysis of a feature is first to measure the NRM field recorded in all the samples. Then a number of representative samples are selected for pilot partial demagnetisation depending upon their material composition and NRM characteristics. Partial demagnetisation involves exposing the sample to an alternating magnetic field of fixed peak strength then measuring the resulting changes in its magnetisation. This procedure is repeated with increasing peak field strengths to build up a complete picture of the coercivity spectrum of the sample. The equipment used for these measurements is described in section 2 of the appendix.

After inspection of the coercivity spectra of the pilot samples, an optimum field strength is selected where it is judged that the maximum amount of secondary magnetisation has been removed, whilst preserving the majority of the primary magnetisation. The remaining samples are then partially demagnetised using this optimum peak alternating field strength. In some cases the set of samples can be partitioned into groups with different material composition or magnetic characteristics. When this occurs several different field strengths may be used, each one judged to be the optimum for a particular group.

A mean TRM direction is calculated from the sample measurements made after partial demagnetisation at their optimum field strength. Some samples may be excluded from this calculation if their TRM directions are so anomalous as to make them statistical outliers from the overall TRM distribution. A “magnetic refraction” correction is often applied to the sample mean TRM direction to compensate for distortion of the earth’s magnetic field due to the geometry of the magnetic fabric of the feature itself. Then the mean is adjusted according to the location of the feature relative to a notional central point in the UK (Meriden), so that it can be compared with UK archaeomagnetic calibration data to produce a date of last firing for the feature. Notes concerning the mean calculation and subsequent calibration can be found in sections 3 and 4 of the appendix.

This measurement and calibration strategy was applied to the analysis of the samples from Stanion. All the samples from both features were taken from horizontal surfaces, so a magnetic refraction correction of 2.4^{o} was added to the inclination of calculated mean TRM directions before calibration.

Results

1STN: The “hearth”

Sample NRM measurements are recorded in Table 1 and Figure 3 depicts the distribution of the sample NRM directions graphically. It is immediately apparent from this figure that the NRM directions are distributed randomly. It was concluded that the burnt material sampled had not been heated *in situ* but had been redeposited after cooling below its blocking temperature. Feature 1STN is thus not datable by archaeomagnetic analysis.

2STN: The “ corn-dryer”

Sample NRM measurements and measurements after partial demagnetisation are recorded in Table 2. Figure 4 depicts the distribution of the sample TRM directions before and after partial demagnetisation. Table 3 records the pilot demagnetisation measurements made on samples 01, 10 and 16 whilst Figures 5-7 illustrate these results graphically.

The maximum stability of the TRM in each pilot sample was estimated using the method of Tarling and Symons (1967). The maximum stability parameters and ranges over which they persist are listed for each sample in Table 4. In this method, any sample with a maximum stability parameter greater than 2 is judged to record a stable TRM direction and a parameter value over 5 suggests extreme stability. The figures in Table 3 indicate that the magnetisations of all the pilot demagnetisation samples are extremely stable. However, the maximum stability of sample 10 (from the black clay layer) occurs at a higher coercivity (5-10mT) than samples 01 and 16 (0-7.5mT and 0-2.5mT respectively).

Based upon these statistics it was decided to partially demagnetise samples 07, 08, 09 and 11, which (in common with sample 10) came from the black layer, in a 7.5mT AF field. The remaining samples from both the stone and the orange/red fired clay were partially demagnetised in a 5mT AF field.

It can be seen from Figure 4b that, even after partial demagnetisation the sample TRM directions are highly scattered with only a few of them forming a central cluster. The low intensities of magnetisation listed in Table 2 suggest that this might be due to the feature only being exposed to relatively low temperatures during heating. This is reinforced by the pilot partial demagnetisation results for samples 01, 10 and 16. In all three cases the magnetisation directions become unstable at higher coercivities (above 20 to 30mT), suggesting that only the lower coercivity, less stable, domains were aligned by the heating event.

Furthermore, both the areas of clay that were sampled were wet and soft to the touch. It is thus highly likely that these surfaces have been disturbed by human or animal activity on the site, since they were last fired.

This high degree of scattering in the TRM directions of the majority of the samples means that it is not possible to deduce a reliable date for the feature. However, it is possible to estimate the approximate date of last firing using a mean TRM direction calculated from only those sample directions that form the cluster in Figure 4b. Such a date must be viewed as an estimate because there are no objective reasons for excluding the other samples from the mean calculation. The mean TRM calculated using only the 7 samples 01-03, 06, 08, 14 and 17 is:

At site: **Dec = -4.5°** **Inc = 68.0°** **α_{95} = 3.1°** **k = 371.0**
At Meriden: **Dec = -4.6°** **Inc = 68.0°**

Figure 7 shows the comparison of the mean TRM vector with the UK archaeomagnetic calibration curve depicted on a Bauer plot. The estimated date for the last firing of the feature deduced from it is:

75 BC to 70 AD at the 63% confidence level.
100 BC to 105 AD at the 95% confidence level.

Conclusions

Archaeomagnetic analysis of the two features from the excavation at Stanion has shown that, whilst both have been exposed to sufficient heat to acquire thermoremanent magnetisation, the directions of magnetisation measured in individual samples are extremely scattered. In the case of feature 1STN, the scattering is so marked that it must be concluded that the fired clay of which it is composed was not fired *in situ* but was redeposited after it had been heated.

Some of the samples from feature 2STN were magnetised in similar directions, although the majority were highly scattered. Demagnetisation measurements suggest that the firing temperature of the feature was probably relatively low but this fact alone would not account for the degree of scattering observed. Disturbance during the time since the feature acquired its TRM is the most likely explanation. It is thus not possible to deduce a reliable date for the last firing of the feature but an approximate estimate can be obtained by subjectively choosing to accept only those seven samples which tend to have similar TRM directions. The date obtained suggests that feature 2STN was last heated during the period spanned by the first centuries BC and AD.

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Date of report: 29/07/2002

Archaeomagnetic Date Summary

Archaeomagnetic ID:	**1STN**
Feature:	**?Hearth overlying Roman mosaic floor**
Location:	**Longitude 0.7^{o}W, Latitude 52.5^{o}N**
Number of Samples (taken/used in mean):	**17/-**
AF Demagnetisation Applied:	**-**
Distortion Correction Applied:	**-**
Declination (at Meriden):	**-**
Inclination (at Meriden):	**-**
Alpha-95:	**-**
k:	**-**
Date range (63% confidence):	**undatable**
Date range (95% confidence):	**undatable**
Independent date estimate:	**probably post 370 AD**

Archaeomagnetic ID:	**2STN**
Feature:	**?Corn drier**
Location:	**Longitude 0.7^{o}W, Latitude 52.5^{o}N**
Number of Samples (taken/used in mean):	**18/7**
AF Demagnetisation Applied:	**5mT/7.5mT**
Distortion Correction Applied:	**+2.4**
Declination (at Meriden):	**-4.5 (-4.6)**
Inclination (at Meriden):	**68.0 (68.0)**
Alpha-95:	**3.1**
k:	**371.0**
Date range (63% confidence):	**75 BC to 70 AD (estimate from only 7 samples)**
Date range (95% confidence):	**100 BC to 105 AD (estimate as above)**
Independent date estimate:	**-**

Sample	NRM Measurements			
	Material	Dec°	Inc°	J(mAm^{-1})
1STN01	Clay	162.0	44.7	653.9
1STN02	Clay	87.8	-21.8	252.8
1STN03	Clay	101.3	-23.8	9.3
1STN04	Clay	152.4	11.6	3.1
1STN05	Clay	169.8	-11.2	11.5
1STN06	Clay	75.8	53.8	3.9
1STN07	Clay	121.4	29.7	2.4
1STN08	Clay	-42.4	-8.8	4.8
1STN09	Clay	74.7	41.1	43.6
1STN10	Clay	-21.5	-44.3	510.2
1STN11	Clay	48.4	9.0	23.4
1STN12	Clay	-99.8	22.0	32.5
1STN13	Clay	-73.4	-44.1	604.4
1STN14	Clay	2.4	68.0	29.9
1STN15	Clay	-62.1	44.0	35.8
1STN16	Clay	172.0	4.2	11.6
1STN17	Clay	-165.7	26.2	77.8

Table 1: NRM measurements of samples for feature 1STN. J = magnitude of magnetisation vector.

Sample	NRM Measurements				After Partial Demagnetisation				
	Material	Dec°	Inc°	J(mAm^{-1})	AF(mT)	Dec°	Inc°	J(mAm^{-1})	R
2STN01	Stone	-5.7	63.0	70.0	5.0	-6.3	63.4	57.7	
2STN02	Stone	7.9	64.6	10.0	5.0	8.1	63.3	8.0	
2STN03	Stone	10.3	67.3	9.6	5.0	-0.8	68.3	9.5	
2STN04	Stone	-40.3	58.4	3.7	5.0	-37.1	34.6	2.5	R
2STN05	Stone	-16.1	71.2	6.9	5.0	-0.6	48.2	3.4	R
2STN06	Stone	11.0	72.9	6.1	5.0	-14.2	67.0	4.0	
2STN07	Clay	36.6	70.7	61.5	7.5	31.8	67.5	28.8	R
2STN08	Clay	-10.5	66.8	1254.6	7.5	-15.5	62.1	843.6	
2STN09	Clay	63.8	12.7	1541.6	7.5	66.3	11.6	1025.7	R
2STN10	Clay	24.7	47.8	560.2	7.5	40.6	51.0	232.2	R
2STN11	Clay	-100.6	63.8	596.6	7.5	-109.2	58.1	352.0	R
2STN12	Clay	-34.8	63.3	141.3	5.0	-29.6	57.4	89.9	R
2STN13	Clay	-0.6	29.1	1222.2	5.0	-2.4	24.0	1146.2	R
2STN14	Clay	6.1	65.9	269.3	5.0	-6.0	68.3	203.3	
2STN15	Clay	13.6	48.2	26.6	5.0	13.1	43.0	19.3	R
2STN16	Clay	17.0	47.1	322.3	5.0	19.8	48.6	271.4	R
2STN17	Clay	-1.7	64.2	684.7	5.0	3.2	65.2	592.7	
2STN18	Clay	27.3	36.4	58.4	5.0	28.6	41.6	55.2	R

Table 2: NRM measurements of samples and measurements after partial AF demagnetisation for feature 2STN. J = magnitude of magnetisation vector; AF = peak alternating field strength of demagnetising field; R = sample rejected from mean calculation.

AF(mT)	2STN01			2STN10			2STN16		
	Dec°	Inc°	J(mAm^{-1})	Dec°	Inc°	J(mAm^{-1})	Dec°	Inc°	J(mAm^{-1})
0.0	-6.2	64.1	69.5	30.1	55.7	554.5	17.8	48.9	329.4
1.0	-5.8	64.0	67.9	33.5	53.7	490.6	17.9	48.9	335.1
2.5	-5.1	64.7	64.0	37.0	52.8	424.3	18.4	48.9	324.5
5.0	-6.3	63.4	57.7	38.9	51.7	334.5	19.8	48.6	271.4
7.5	-5.7	64.0	52.3	40.6	51.0	232.2	22.1	48.0	174.0
10.0	-3.4	62.9	45.5	37.7	50.6	163.2	24.8	49.2	97.4
15.0	-5.0	62.5	34.4	34.4	48.9	83.5	25.9	51.5	40.9
20.0	-1.7	62.1	26.8	27.3	46.9	50.4	20.0	58.1	25.2
30.0	-1.1	61.8	15.3	2.9	38.6	29.8	12.3	50.2	15.6
40.0	11.1	56.3	9.2	-	-	-	-	-	-
50.0	-2.4	49.5	6.0	-	-	-	-	-	-

Table 3: Incremental partial demagnetisation measurements for samples 2STN01, 2STN10 and 2STN16.

Sample	Range min. (mT)	Range max. (mT)	Max. Stability	Dec°	Inc°
2STN01	0.0	7.5	17.1	-5.8	64.0
2STN10	5.0	10.0	6.6	39.1	51.1
2STN16	0.0	2.5	23.7	18.0	48.9

Table 4: Assessment of the range of demagnetisation values over which each sample attained its maximum directional stability for feature 2STN, using the method of Tarling and Symons (1967). The declination and inclination values quoted are for the mean TRM direction for the sample calculated for all demagnetisation measurements in its range of maximum stability.

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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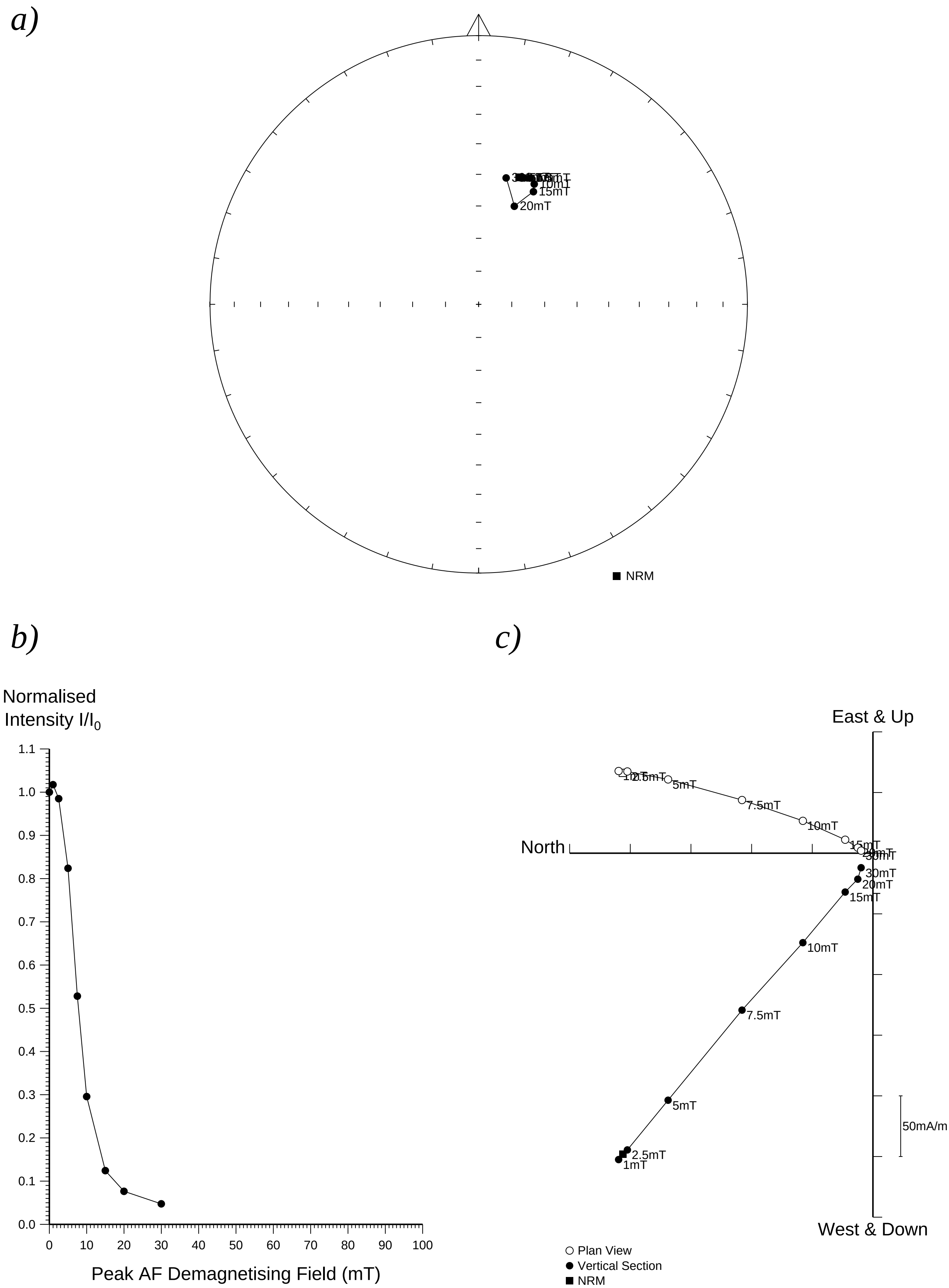

Figure 7: Stepwise AF demagnetisation of sample 2STN16. Diagram a) depicts the variation of the remanent direction as an equal area stereogram (declination increases clockwise, while inclination increases from zero at the equator to 90 degrees at the centre of the projection); b) shows the normalised 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.

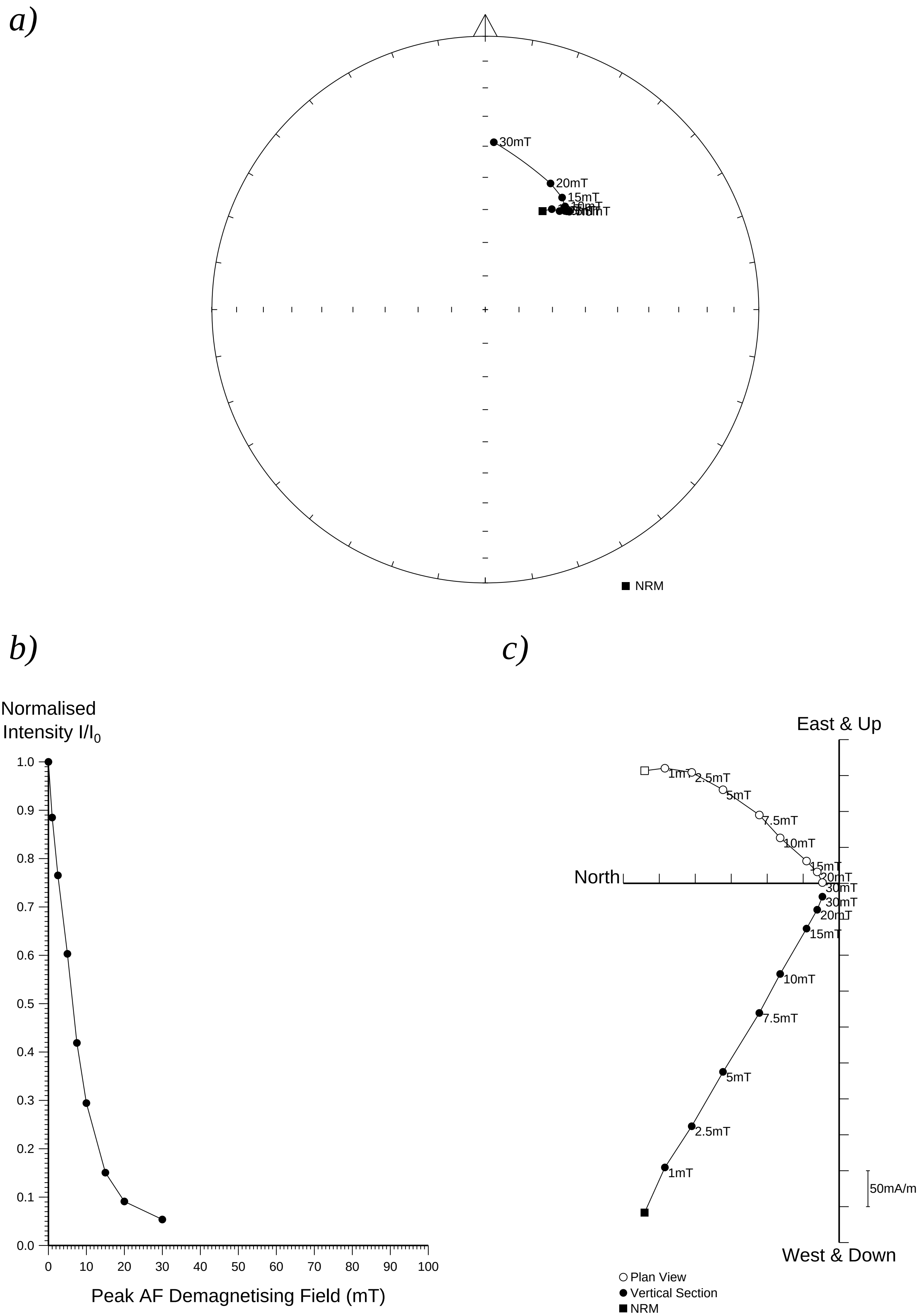

Figure 6: Stepwise AF demagnetisation of sample 2STN10. Diagram a) depicts the variation of the remanent direction as an equal area stereogram (declination increases clockwise, while inclination increases from zero at the equator to 90 degrees at the centre of the projection); b) shows the normalised 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.

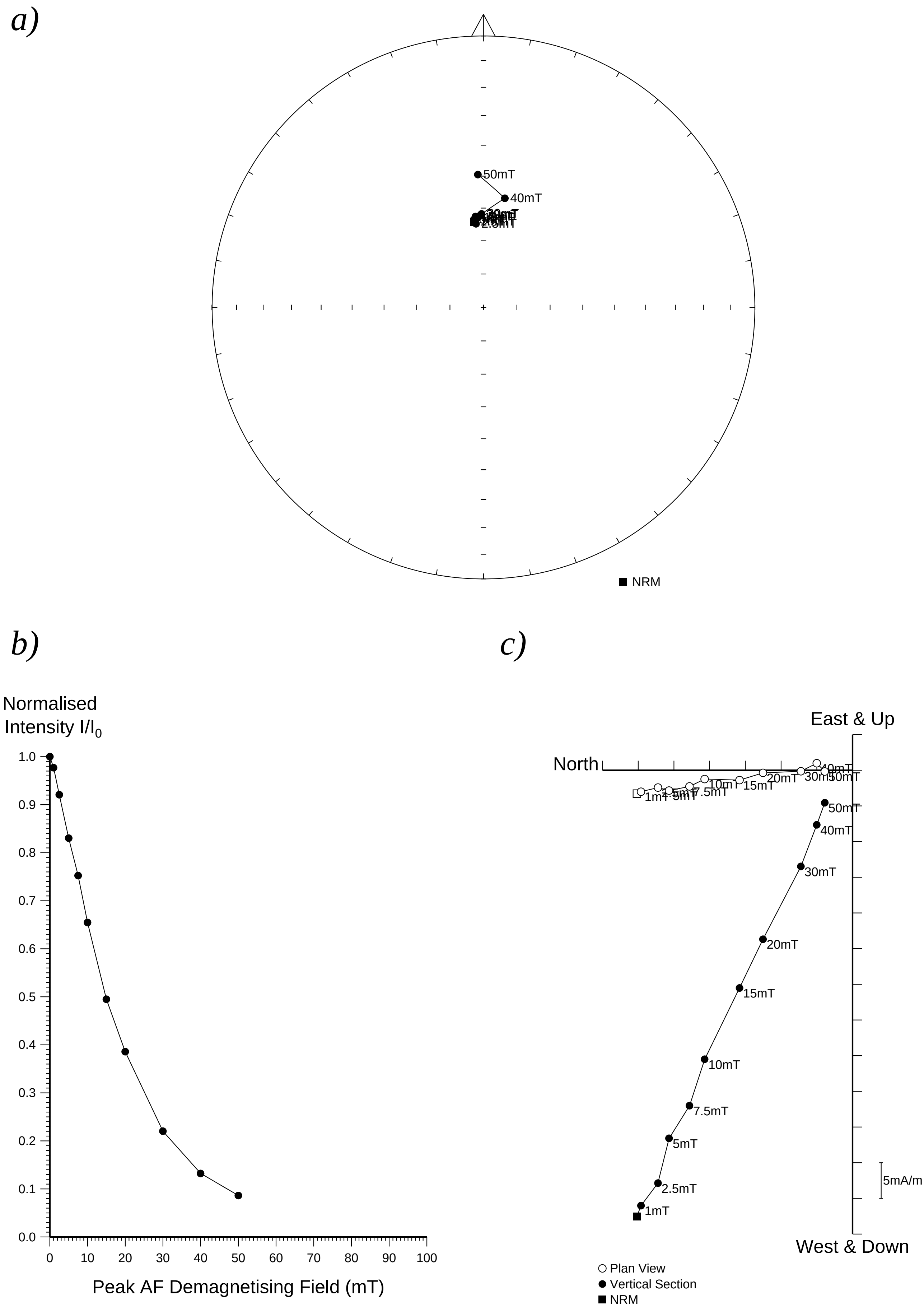

Figure 5: Stepwise AF demagnetisation of sample 2STN01. Diagram a) depicts the variation of the remanent direction as an equal area stereogram (declination increases clockwise, while inclination increases from zero at the equator to 90 degrees at the centre of the projection); b) shows the normalised 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.

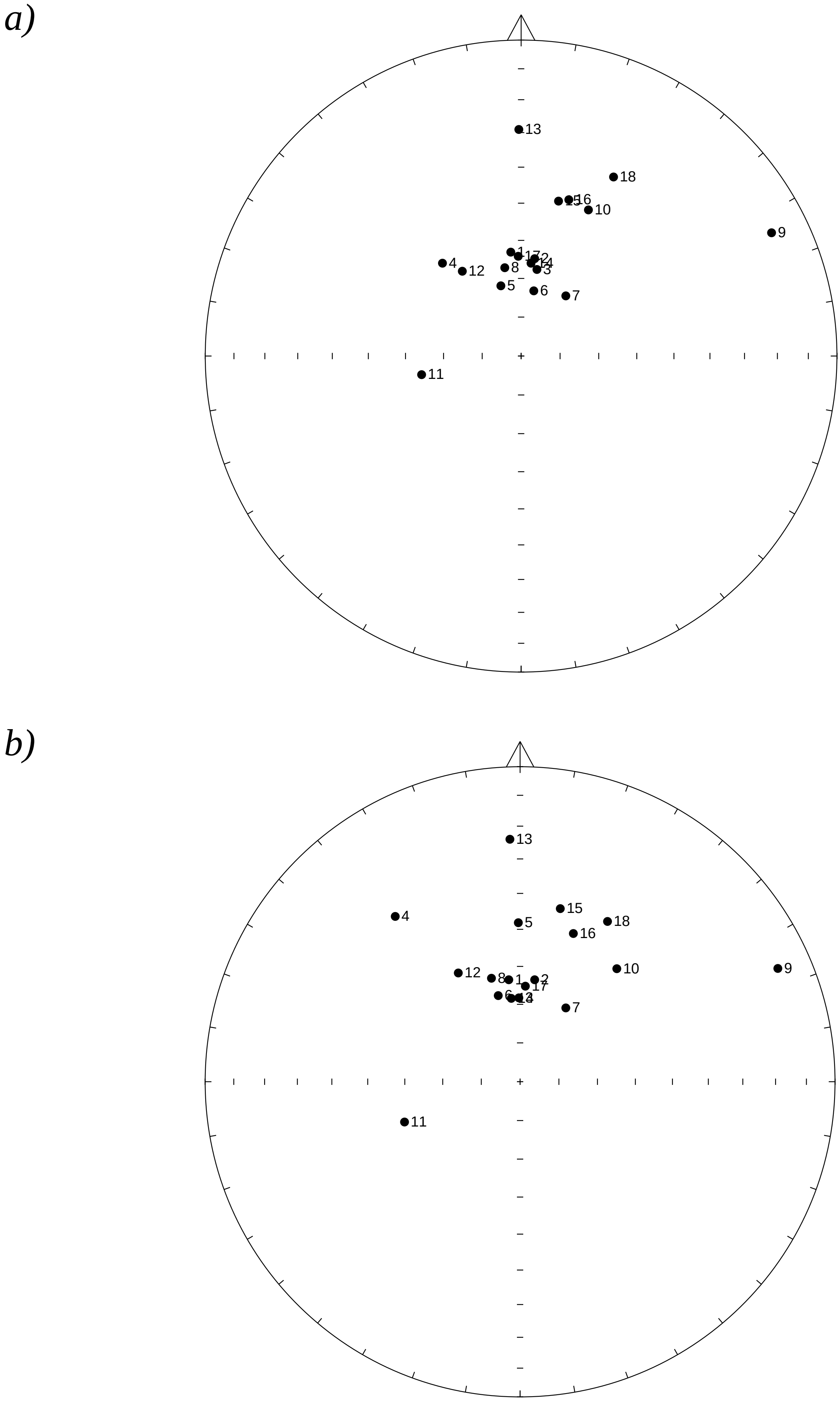

Figure 4: a) Distribution of NRM directions of samples from feature 2STN represented as an equal area stereogram. In this projection declination increases clockwise with zero being at 12 o'clock while inclination increases from zero at the equator to 90 degrees in the centre of the projection. Open circles represent negative inclinations. b) Distribution of thermoremanent directions of magnetisation of the same samples after partial AF demagnetisation to 5mT or 7.5mT.

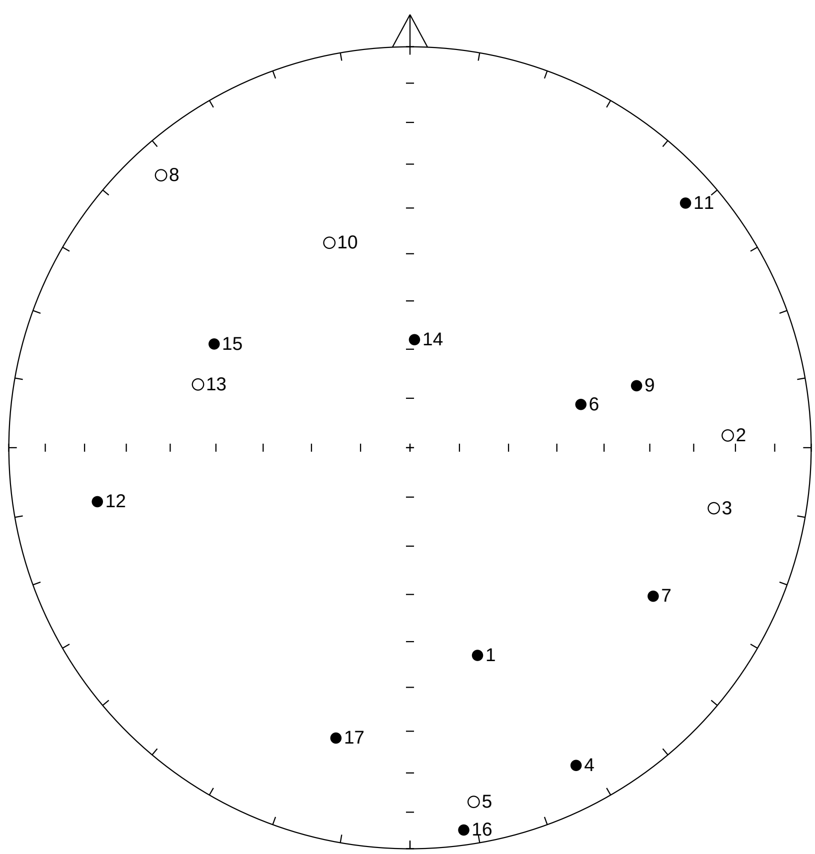

Figure 3: Distribution of NRM directions of samples from feature 1STN represented as an equal area stereogram. In this projection declination increases clockwise with zero being at 12 o'clock while inclination increases from zero at the equator to 90 degrees in the centre of the projection. Open circles represent negative inclinations.

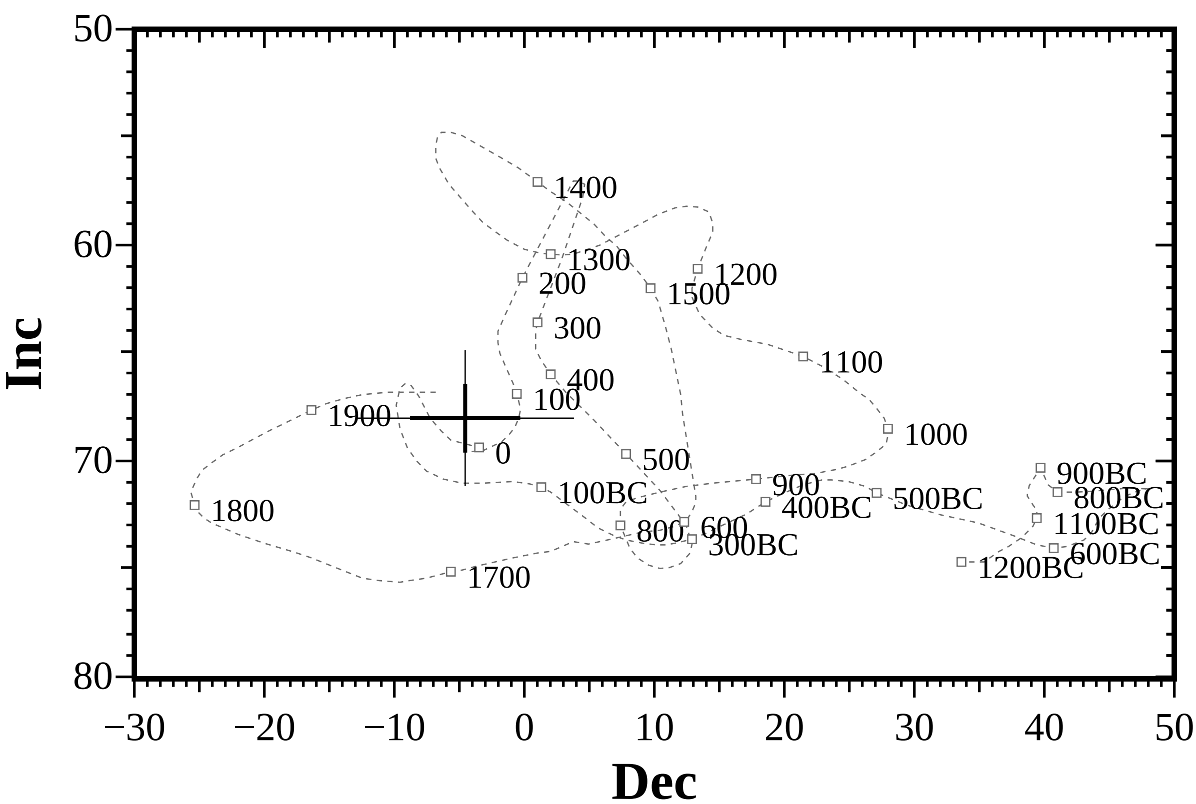

Figure 8: Comparison of the mean thermoremanent vector calculated from samples 01-03, 06, 08, 14 and 17 from feature 2STN after 5mT or 7.5mT partial demagnetisation with the UK master calibration curve. Thick error bar lines represent 63% confidence limits and narrow lines 95% confidence limits.