Centre for Archaeology Report 84/2001

Glyn, Llanbedrgoch, Anglesey: Archaeomagnetic Dating Report 2001

Paul Linford & Peter Rauxloh

ISSN 1473-9224

The Centre for Archaeology Reports Series incorporates the former Ancient Monuments Laboratory Report Series. Copies of Ancient Monuments Laboratory Reports will continue to be available from the Centre for Archaeology (see back of cover for details).

Centre for Archaeology Report 84/2001

Glyn, Llanbedrgoch, Anglesey: Archaeomagnetic Dating Report 2001

Paul Linford[1] & Peter Rauxloh[2]

Summary

During excavations by Dr Mark Redknap of the National Museums and Galleries of Wales at Glyn, Llanbedrgoch on Anglesey, a burnt feature was discovered which consisted of a concentration of limestone blocks set in a matrix of apparently heated clay. The blocks were arranged in a roughly circular form with a diameter of about one metre and it was postulated that they formed the lining of an oven of early-medieval date. The feature was sampled for archaeomagnetic analysis by Peter Rauxloh of the Museum of London Archaeology Service, to determine the date of its last firing. Unfortunately, it had not been heated to a sufficient temperature to consistently magnetise either the limestone blocks or the clay matrix and so an archaeomagnetic date could not be achieved.

Keywords

Archaeomagnetism

Authors' addresses
[1]English Heritage, Centre for Archaeology, Fort Cumberland, Fort Cumberland Road, Eastney, Portsmouth, PO4 9LD. [2]Museum of London Archaeology Service, Mortimer Wheeler House, Eagle Wharf Road, London, N1 7ED

GLYN, LLANBEDRGOCH, ANGLESEY:
Archaeomagnetic Dating Report 2001

Introduction

During excavations by Dr Mark Redknap of the National Museums and Galleries of Wales at Glyn, Llanbedrgoch on Anglesey (SH 519 810, Longitude 4.2°W, Latitude 53.3°N), a burnt feature was discovered which consisted of a concentration of limestone blocks of between 15cm and 40cm across. These were arranged in a roughly circular form with a diameter of about one metre and lay within an area of fired clay (see Figure 1). It was postulated that the stones formed the lining of an oven of early medieval date with the clay comprising the lining matrix into which the stones were set. It is therefore possible that the clay in the lining of the feature may not have been exposed directly to the heat.

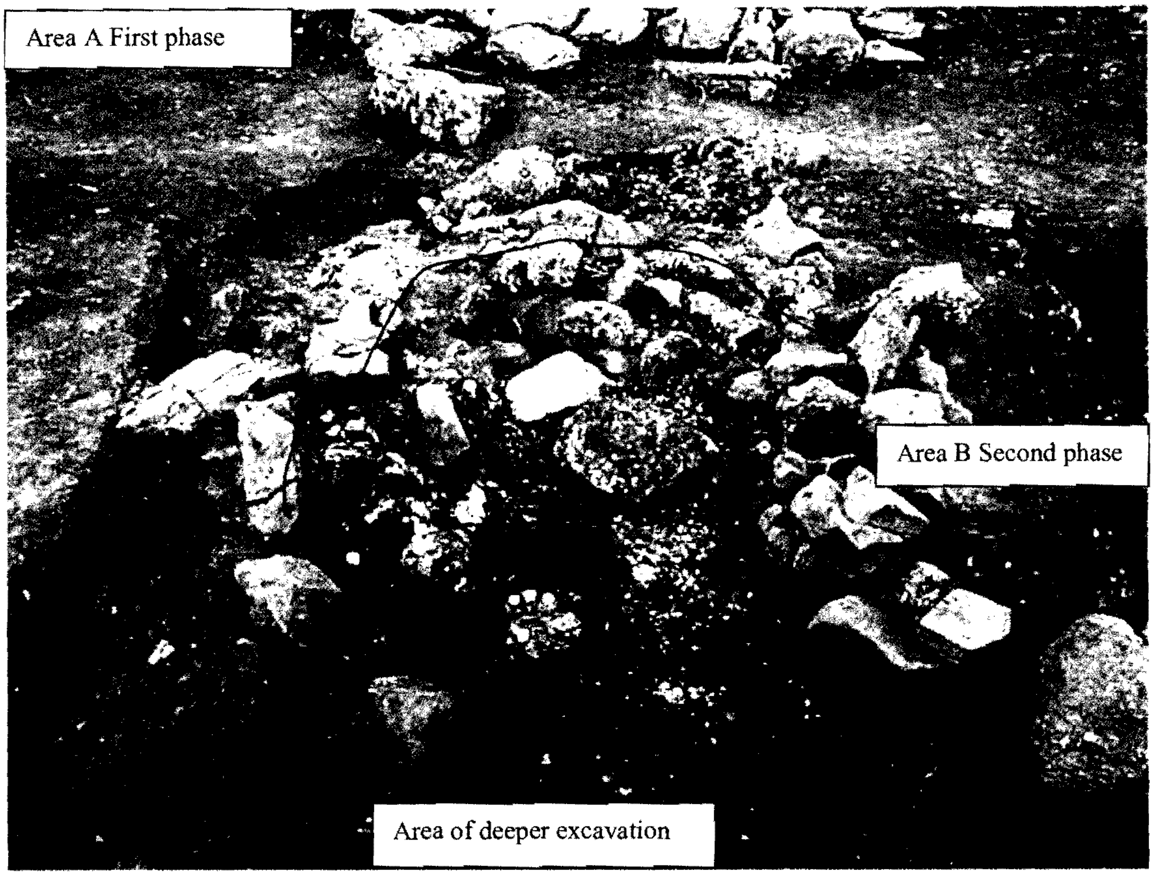
The feature was sampled for archaeomagnetic analysis by the Peter Rauxloh of the Museum of London Archaeology Service on the 23rd of August 2001 and given the feature code GL01. Measurement and evaluation was performed by Paul Linford of the English Heritage Centre for Archaeology.

Method

Samples were collected using the disc method (see appendix, section 1a) and orientated to true north using a gyro-theodolite. In all, twenty samples were taken from the feature, both from the limestone blocks and from the interstitial clay matrix. Additionally, two samples, 01 and 03, were of an ochre coloured conglomerate/sandstone composed of variously sized (0.05 – 5mm) quartz grains. The limestone blocks showed only slight evidence of reddening caused by heating, whilst the clay samples were of a variable colour from light beige to a deeper red. Approximate sample locations are indicated in the sketch plan in Figure 1 and the material composition of each sample is listed in Table 1.

It is believed that there were two major stages of use of the feature, the first being the widest circle of stones with a subsequent phase commencing with the creation of smaller lining within the first. The second phase of use shows clear evidence of successive depositional events since a number of charcoal lenses were observable in a section cut through the feature's centre. The sampling strategy took this phasing into account, with samples 01-10 being placed in the area of the first phase (context 912a) and 11-20 in the area of the second (context 912b).

The excavation from which this section was observable was extended downwards both to see if the bottom of the feature could be identified and in an attempt to find better fired clay than the relatively malleable material on the surface. A firm well-fired base to the feature was located and samples 16-19 were taken from it. It is possible that this base represents the original floor and is thus contemporary with the first phase of the oven. It is also possible that the relatively soft clay lying above this base was infill, since it was very mixed with numerous charcoal flecks, small stones and fragments of burnt rock within it.



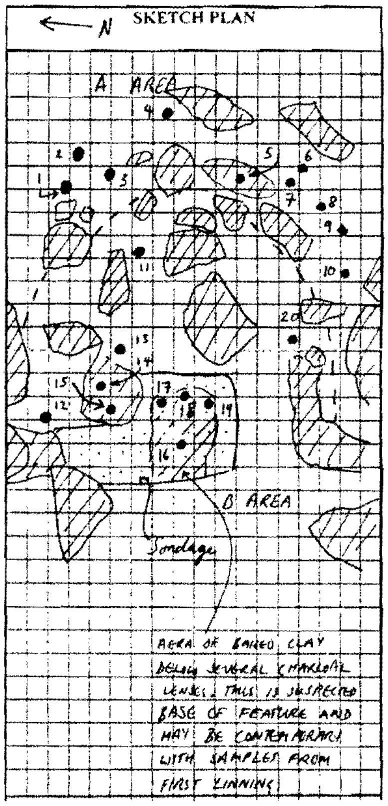


Figure 1: Photograph of the oven feature viewed from the west with annotations indicating the postulated phasing (above); and sketch plan showing the approximate sample locations (left).

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 for analysing a set archaeomagnetic samples from a fired archaeological feature is to first measure their NRM magnetisation. These NRM measurements are then inspected and one or more samples are selected for pilot partial demagnetisation. Pilot demagnetisation of a sample involves exposing it to an alternating magnetic field of fixed peak strength and measuring the resulting changes in its magnetisation. The procedure is repeated with increasing peak field strengths to build up a complete picture of the coercivity spectrum of the pilot sample. From these pilot partial demagnetisation results an optimum peak field strength is selected to be applied to the remaining samples. This optimum field strength is selected to remove as much of the secondary magnetisation as possible whilst leaving the primary magnetisation intact. The equipment used for these measurements is described in section 2 of the appendix.

A mean TRM direction is then calculated from the partially demagnetised sample measurements. 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 Llanbedrgoch. As all the samples were taken from floor contexts, a magnetic refraction correction of 2.4^{o} was added to the inclinations of the mean TRM direction before calibration.

Results

NRM measurements and measurements of the samples after partial demagnetisation are recorded in Table 1. Figure 2 depicts the distribution of the sample TRM directions before and after partial demagnetisation. Tables 2 and 3 record the pilot demagnetisation measurements made on samples 01, 07, 10, 16 and 17. Figures 3-5 graphically illustrate these results for the measurements made on samples 01, 07 and 16 respectively.

Samples 01 and 03 had extremely low intensities of magnetisation and pilot demagnetisation of sample 01 indicates that it contains no stable magnetisation. For this reason the two conglomerate/sandstone samples were excluded from further analysis.

Partial demagnetisation of sample 07 suggests that the clay samples do record a magnetisation acquired when the feature was last fired but that it is primarily held in low coercivity domains. This implies that, as conjectured, the clay has not been exposed to particularly high temperatures. Unfortunately, low coercivity domains are subject to viscous realignment in later geomagnetic fields and there is evidence from Figure 4 that this has occurred in the case of sample 07. As a result the remaining clay samples were demagnetised in a 2.5mT AF field. This value was chosen to demagnetise those lowest coercivity domains most likely to have been subject to viscous realignment, whilst preserving as much of the weak sample magnetisation as possible.

Figure 2a shows that limestone samples 13-15, 18 and 19 have anomalous negative inclinations of magnetisation. These were extremely small samples, as the sampling discs had only adhered to a very thin, friable, layer on the surface of the stones. This layer broke away when attempting to cut the stone samples to a size that would fit into the magnetometer. It was thus decided that these samples should be excluded from further analysis.

Partial demagnetisation of sample 16 (Figure 5), indicates that the magnetisation in this sample is stable. Some slight viscous realignment is apparent in domains with coercivities below 5mT. Therefore the remaining limestone samples, 02, 05 and 17, were partially demagnetised in a 5mT AF field. However, it should be noted from Figure 2b that the magnetisation directions of samples 02 and 05 change significantly after this partial demagnetisation, suggesting that their magnetisations were not stable.

It is clear from Figure 2b that even after partial demagnetisation the distribution of sample TRMs are still widely scattered. Thus it is unfortunately not possible to calculate a mean TRM of sufficient precision to be able to infer a date for the last firing of the feature.

Conclusions

Archaeomagnetic study of heated clay and limestone samples from contexts 912a and 912b from Glyn, Llanbedgoch on Anglesey indicates that whilst the feature was heated sufficiently for some magnetisation of its fabric to occur, no direction of magnetisation could be isolated that was consistent between samples. In the case of the clay samples this is likely to be because, as conjectured on site, the clay matrix was not exposed to sufficiently high temperatures for stable, high coercivity, domains to unblock. What magnetisation has been acquired has largely been overprinted by viscous realignment since the feature was last heated.

With the limestone samples the situation is more complex. Whilst difficulties with sample preparation reduced the number of samples that could be reliably examined, it can be seen that samples 16 and 17 exhibited stable magnetisations but samples 02 and 05 did not. This suggests that the temperatures experienced in different parts of the feature were extremely variable. Furthermore, the magnetisation directions of the stable samples, 16 and 17, are significantly different. This might imply that some localised disturbance to the feature has also occurred since it was last fired. A second possibility is that the stones that these samples were drawn from have been reused after earlier incorporation into a structure that attained a higher temperature.

Thus it has unfortunately not been possible to infer an archaeomagnetic date for the last firing of the feature.

P. Linford
Archaeometry Branch,
Centre for Archaeology, English Heritage

P. Rauxloh
Museum of London Archaeology Service

Date of report: 03/11/2001

Archaeomagnetic Date Summary

Archaeomagnetic ID:	**GL01**
Feature:	**Glyn, Llanbedrgoch, Anglesey, contexts 912a/b**
Location:	**Longitude 4.2°W, Latitude 53.3°N**
Number of Samples (taken/used in mean):	**20/-**
AF Demagnetisation Applied:	**2.5/5mT**
Distortion Correction Applied:	-
Declination (at Meriden):	-
Inclination (at Meriden):	-
Alpha-95:	-
k:	-
Date range (63% confidence):	**undatable**
Date range (95% confidence):	**undatable**

		NRM Measurements			After Partial Demagnetisation			
Sample	Material	Dec°	Inc°	J (mAm^{-1})	AF (mT)	Dec°	Inc°	J (mAm^{-1})
01	Cong'ate	-59.9	8.2	6.1	-	-	-	-
02	L'stone	-66.7	41.2	2.1	5.0	66.1	-12.5	1.2
03	Cong'ate	-124.1	-6.5	4.8	-	-	-	-
04	Clay	25.7	75.2	499.4	2.5	37.7	76.4	426.3
05	L'stone	-45.5	74.5	4.8	5.0	92.2	68.0	2.9
06	Clay	-160.0	82.9	254.2	2.5	-178.0	80.0	224.7
07	Clay	-32.6	64.3	116.8	2.5	-24.1	61.0	87.0
08	Clay	-53.1	31.1	1.3	2.5	83.3	-25.5	1.3
09	Clay	79.9	49.7	44.8	2.5	91.8	44.4	39.4
10	Clay	-6.5	81.8	160.6	2.5	23.2	80.7	118.6
11	Clay	33.2	65.8	7.3	2.5	63.9	42.0	4.2
12	Clay	36.7	82.9	431.8	2.5	42.4	82.5	349.3
13	L'stone	-61.7	-21.9	0.8	-	-	-	-
14	L'stone	-86.5	-43.5	1.8	-	-	-	-
15	L'stone	-92.5	-41.5	2.2	-	-	-	-
16	L'stone	-38.4	77.5	104.9	5.0	-38.9	76.6	85.1
17	L'stone	21.2	67.6	284.8	5.0	21.4	68.2	247.5
18	L'stone	-88.4	-21.2	3.0	-	-	-	-
19	L'stone	-90.5	-35.3	2.7	-	-	-	-
20	Clay	-51.6	30.7	454.1	2.5	-51.9	19.4	419.2

Table 1: NRM measurements and measurements of the samples after partial AF demagnetisation for feature GL01. J = magnitude of magnetisation vector; AF = peak alternating field strength of demagnetising field; R = sample rejected from mean calculation. Cong'ate = Conglomerate/sandstone, L'stone = Limestone.

	01			07			10		
AF (mT)	Dec°	Inc°	J (mAm^{-1})	Dec°	Inc°	J (mAm^{-1})	Dec°	Inc°	J (mAm^{-1})
0.0	-66.8	6.7	5.9	-33.5	66.1	115.5	-10.9	80.6	154.1
2.5	-41.2	37.2	4.4	-24.1	61.0	87.0	23.2	80.7	118.6
5.0	-23.3	48.5	4.3	-19.0	57.3	60.4	42.4	79.0	87.5
10.0	-13.7	50.9	3.6	-15.5	54.2	31.2	44.4	73.6	41.5
15.0	-22.2	48.2	2.5	-25.8	53.4	17.6	34.7	69.6	19.6
20.0	-26.7	46.0	1.8	-39.2	48.0	12.6	13.4	68.0	13.9
30.0	-33.6	49.2	1.7	-34.8	31.3	8.3	11.3	51.0	8.5
50.0	-57.7	35.2	1.0	-	-	-	-	-	-

Table 2: Incremental partial demagnetisation measurements for samples 01, 07 and 10 from feature GL01.

	16			17		
AF(mT)	Dec°	Inc°	J(mAm⁻¹)	Dec°	Inc°	J(mAm⁻¹)
0.0	-42.2	76.8	103.9	21.8	67.8	283.2
2.5	-39.7	77.1	97.2	21.9	68.0	273.3
5.0	-38.9	76.6	85.1	21.4	68.2	247.5
10.0	-40.7	76.5	52.5	20.9	68.3	169.0
15.0	-41.7	75.6	37.1	17.9	68.9	106.5
20.0	-37.8	76.5	27.8	18.6	68.8	77.4
30.0	-43.1	75.0	18.9	21.8	68.1	48.5
50.0	-41.5	76.1	11.2	9.4	69.1	29.0

Table 3: Incremental partial demagnetisation measurements for samples 16 and 17 from feature GL01.

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).

References

Aitken, M. J. 1990. *Science-based Dating in Archaeology*. London: Longman.

Aitken, M. J. and H. N. Hawley 1971. Archaeomagnetism: evidence for magnetic refraction in kiln structures. *Archaeometry* **13**, 83-85.

As, J. A. 1967. The a.c. demagnetisation technique, in *Methods in Palaeomagnetism*, D. W. Collinson, K. M. Creer and S. K. Runcorn (eds). Amsterdam: Elsevier.

Clark, A. J., D. H. Tarling and M. Noel 1988. Developments in Archaeomagnetic Dating in Britain. *J. Arch. Sci.* **15**, 645-667.

Creer, K. M. 1959. A.C. demagnetisation of unstable Triassic Keuper Marls from S. W. England. *Geophys. J. R. Astr. Soc.* **2**, 261-275.

Fisher, R. A. 1953. Dispersion on a sphere. *Proc. R. Soc. London A* **217**, 295-305.

Molyneux, L., R. Thompson, F. Oldfield and M. E. McCallan 1972. Rapid measurement of the remanent magnetisation of long cores of sediment. *Nature* **237**, 42-43.

Mook, W. G. 1986. Recommendations/Resolutions Adopted by the Twelfth International Radiocarbon Conference. *Radiocarbon* **28**, M. Stuiver and S. Kra (eds), 799.

Tarling, D. H. 1983. *Palaeomagnetism*. London: Chapman and Hall.

Thompson, R. and F. Oldfield 1986. *Environmental Magnetism*. London: Allen and Unwin.

Turner, G. M. and R. Thompson 1982. Detransformation of the British geomagnetic secular variation record for Holocene times. *Geophys. J. R. Astr. Soc.* **70**, 789-792.

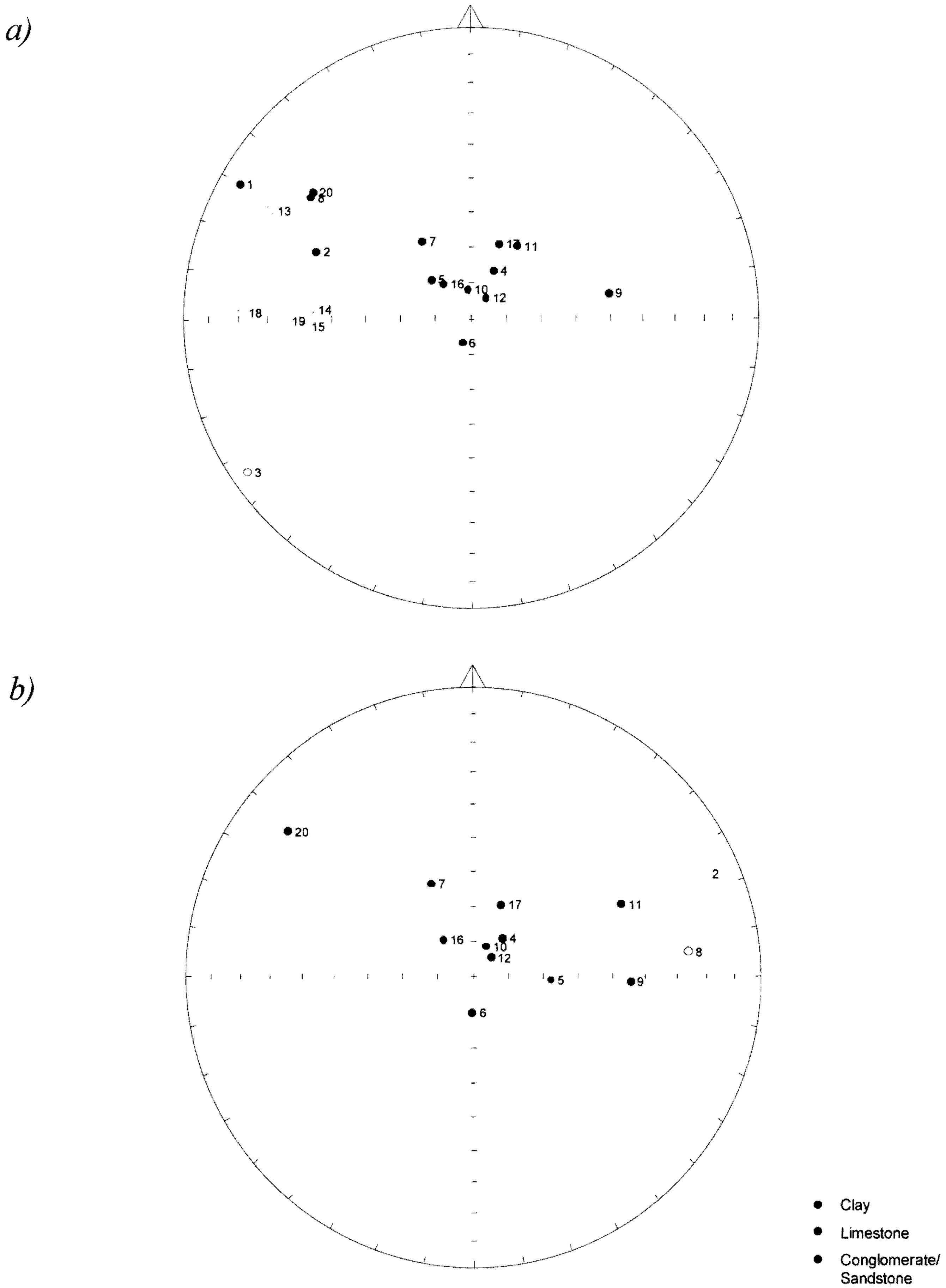


Figure 2: a) Distribution of NRM directions of samples from feature GL01 represented as an equal area stereogram. In this projection declination increases clockwise with zero being at 12 o'clock while inclination increases from zero at the equator to 90 degrees in the centre of the projection. Open circles represent negative inclinations. b) Distribution of thermoremanent directions of magnetisation of the same samples after partial AF demagnetisation to either 2.5 or 5mT. Colour coding shows sample composition.

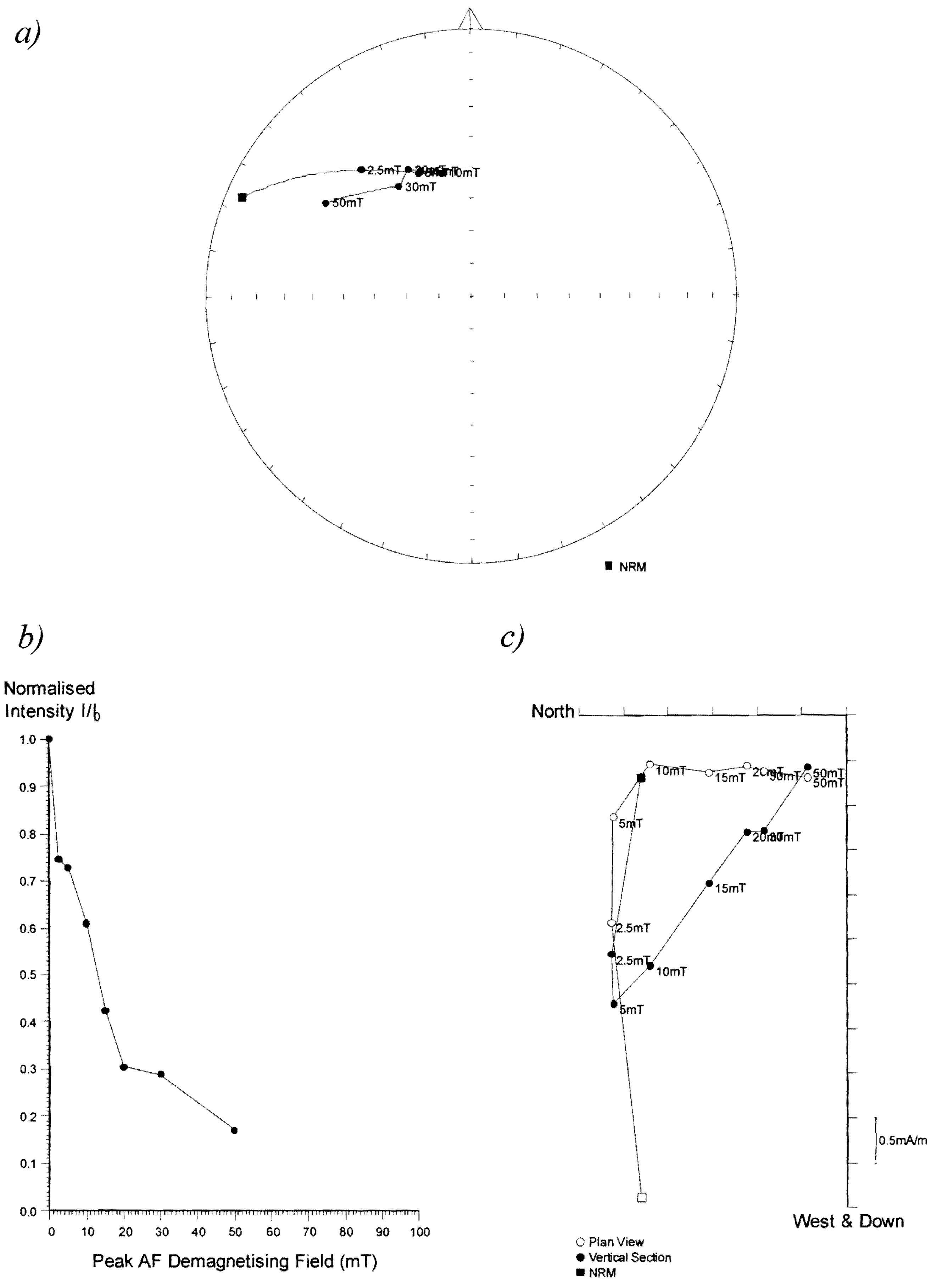
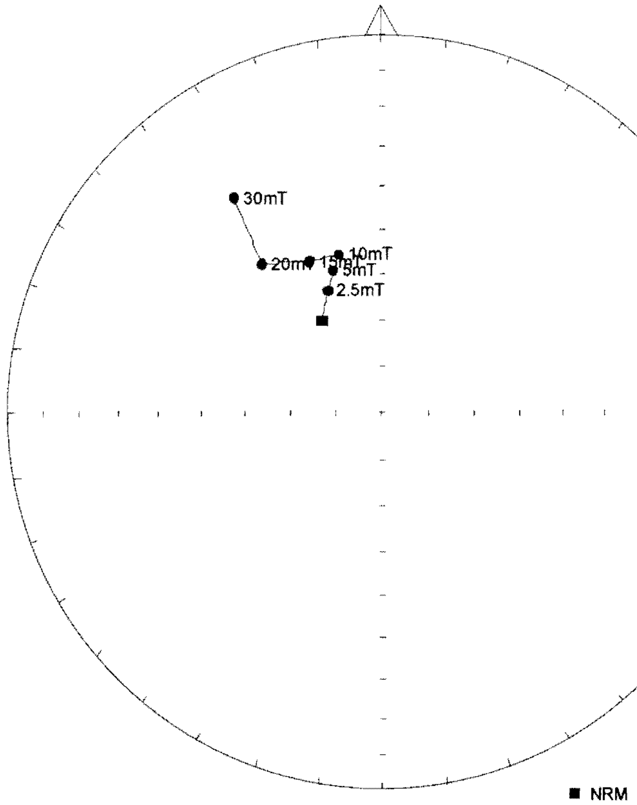
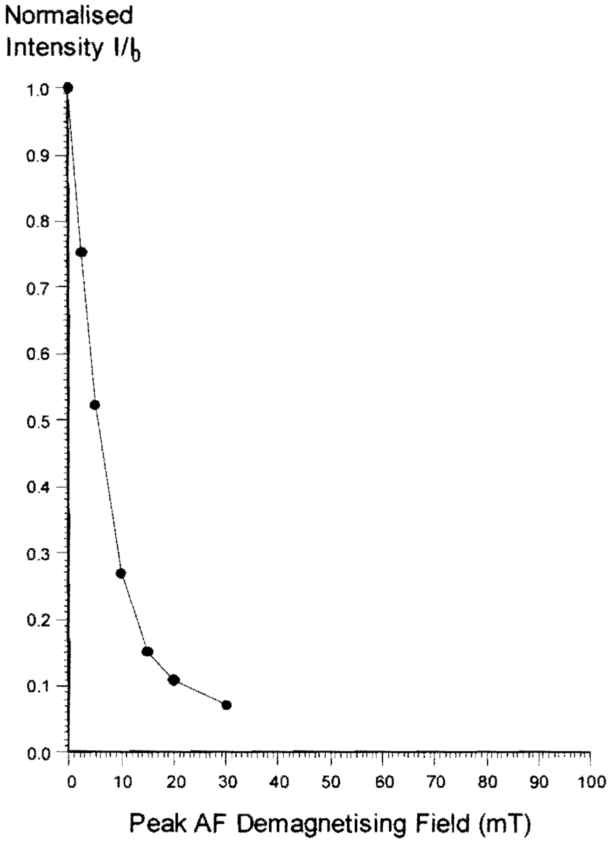


Figure 3: Stepwise AF demagnetisation of sample 01. Diagram a) depicts the variation of the remanent direction as an equal area stereogram (declination increases clockwise, while inclination increases from zero at the equator to 90 degrees at the centre of the projection); b) shows the normalised change 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)

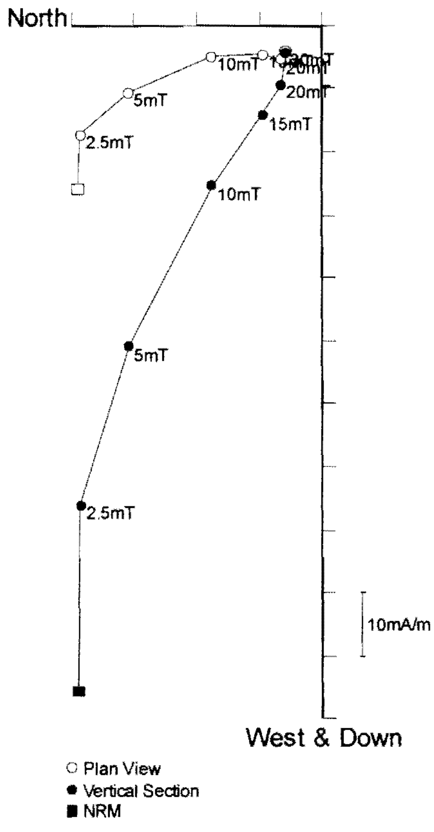


Figure 4: Stepwise AF demagnetisation of sample 07. Diagram a) depicts the variation of the remanent direction as an equal area stereogram (declination increases clockwise, while inclination increases from zero at the equator to 90 degrees at the centre of the projection); b) shows the normalised change in remanence intensity as a function of the demagnetising field; c) shows the changes in both direction and intensity as a vector endpoint projection.

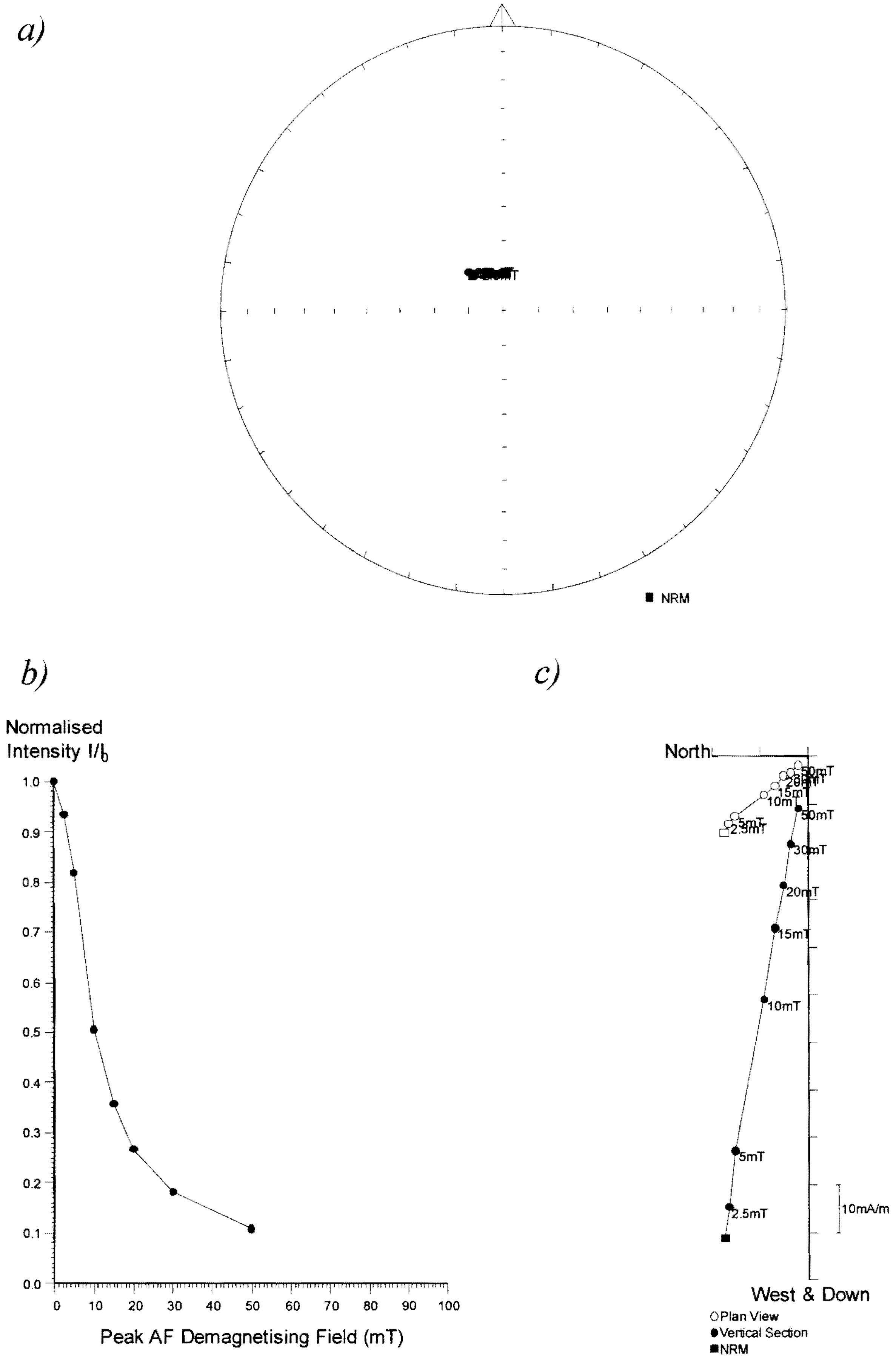


Figure 5: Stepwise AF demagnetisation of sample 16. Diagram a) depicts the variation of the remanent direction as an equal area stereogram (declination increases clockwise, while inclination increases from zero at the equator to 90 degrees at the centre of the projection); b) shows the normalised change in remanence intensity as a function of the demagnetising field; c) shows the changes in both direction and intensity as a vector endpoint projection.