ARCHAEOLOGICAL SERVICES WYAS

Skipton Castle Car Park
Skipton
North Yorkshire

Archaeological Evaluation

December 2010

Report No. 2152

CLIENT

Mr Sebastian Fattorini

Skipton Castle Car Park
Skipton
North Yorkshire

Archaeological Evaluation

Summary

This report details the results of the archaeological evaluation undertaken at Nearer Storam, Skipton Castle, to advise on the archaeological potential of the site prior to the proposed construction of a new car park. The evaluation, via trial trenching, sought to evaluate anomalies identified by geophysical survey, earthworks and an apparently 'blank' (control) area.

At the northern end of the site a trench targeting a sub-circular magnetic anomaly revealed part of a large feature which showed evidence of having undergone intense burning. The presence of wood charcoal and a lime deposit suggests that this feature forms part of a substantial lime kiln; the geophysical survey suggests there may be flues to the eastern and western sides. Although the wood charcoal was not suitable for radiocarbon dating, an archaeomagnetic date was acquired indicating a late 12th to early 13th century date for the final firing of the kiln. This period covers the time during which the gatehouse was re-built in stone (1192-1195) and the major re-building of the castle in stone from about 1227.

The trench sampling across the route of a post-medieval tramway revealed that it ran within a wide, deep cutting now backfilled with compacted limestone fragments.

An area of high resistance at the southern end of the site appears to have been due to a spread of rubble which may be collapse from a nearby structure. However, no in situ structure was identified within the trial trench.

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Report Information

Client:	Mr Sebastian Fattorini
Address:	Skipton Castle, Skipton, North Yorkshire, BD23 1AW
Report Type:	Archaeological Evaluation
Location:	Skipton
County:	North Yorkshire
Grid Reference:	SD 9932 5214 (centred)
Period(s) of activity represented:	Medieval to Post-medieval
Report Number:	2152
Project Number:	3635
Site Code:	SKC10
Date of fieldwork:	September 2010
Date of report:	December 2010
Project Management:	Louise Martin BSc
Fieldwork supervisor:	Phil Weston BSc
Report:	Louise Martin
Illustrations:	Louise Martin
Photography:	Phil Weston and Louise Martin
Specialists:	Dr Chris Cumberpatch (Pottery)
	Dr Diane Alldritt (Wood)
	Dr Mark Hounslow (Archaeomagnetic Dating)
	Sam Harris (Archaeomagnetic Dating)

Produced by: Archaeological Services WYAS, PO Box 30,
Nepshaw Lane South, Morley, Leeds LS27 0UG
Telephone: 0113 383 7500
Email: admin@aswyas.com

Authorisation for distribution: ---

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Acknowledgements

Archaeological Services WYAS would like to extend their thanks to Mr Sebastian Fattorini, administrator of Skipton Castle and David Robinson (Skipton Castle; Grounds) for their assistance during the excavations. Thanks are also extended to Lynn Northrop and Peter Harrison of Wales, Wales and Rawson Architects who assisted in developing the scheme of archaeological investigations. Pre-application advice was sought from Lucie Hawkins of the North Yorkshire County Council Historic Environment Record.

1 Introduction

Archaeological Services WYAS (ASWYAS) was commissioned by Mr Sebastian Fattorini, administrator of Skipton Castle, to undertake an archaeological evaluation of *Nearer Storam* field to the north-east of Skipton Castle. The evaluation comprised the excavation of four trial trenches which was undertaken as part of an archaeological condition attached to planning approval for the creation of a new car park. The evaluation followed the methodologies outlined in the Written Scheme for Archaeological Investigation (Appendix 3) produced by ASWYAS and approved by Craven District Authority Planning Office.

Site location and topography

The site is located just to the north of Skipton town centre to the immediate north-east of Skipton Castle (SD 9932 5214; see Fig. 1) and comprises an irregular parcel of land known as *Nearer Storam*, contained within the estate of Skipton Castle. It is bounded to the north by Bailey Cottage, to the east by the estate wall and The Bailey, to the south by the estate wall and the west by low estate fencing and a track (see Fig. 2) and covers an area of 9925m^2. The site is gently undulating, sloping from the highest point in the extreme north-eastern corner (142m above Ordnance Datum) to both the west (136m aOD) and to the south where the lowest point is approximately 133m aOD.

Soils, geology and land-use

The geology is recorded as Palaeozoic drift and Mesozoic sandstone and shale, whilst the soils are mapped as slowly permeable seasonally waterlogged fine loamy soils of the Brickfield 2 (713f) association (GBS 2010). At the time of the investigations the site was under permanent pasture.

2 Archaeological and Historical Background

An archaeological desk-based assessment recently undertaken of the proposed development site and its surroundings (Grassam and Martin 2009) revealed potential for the survival of sub-surface archaeological remains dating from the medieval period through to the post-medieval period. Of particular interest is the Haw Bank tramway, which was used to transport limestone from Haw Bank Quarry, north of the town, to the terminus of Thanet's Canal, situated to the immediate south-east of the development site. Historic mapping revealed that an earlier route of this tramway (which operated between 1794 and 1836) traversed the development site on a north-west to south-east alignment. A site visit revealed that linear earthworks were visible on the same alignment, with those towards the south-east of the site being more prominent. This is presumably where the cutting for the tramway was much deeper, providing an incline for the trucks running southwards towards the tunnel and the canal terminus beyond. The earthwork became less clear towards the northern end of the site and it is possible that the tramway merely lay in a shallow cutting at this point. It is of interest that the eastern end of the northern boundary wall may be a later addition, possibly locating the former entranceway for the tramway.

Given its proximity to Skipton Castle, potential exists for the site to contain evidence of activities and/or land use, by the castles estate, during the medieval period. The desk-based assessment also presented the possibility of evidence and artefacts being recovered from the site relating to the Civil War Parliamentarian attack on the castle in the 17th century.

A recently completed geophysical (magnetometer and earth resistance) survey undertaken in support of the planning application submitted by Skipton Castle Ltd., helped to define the line of the former Haw Bank tramway and identified further areas of archaeological potential including an area of high resistance possibly indicative of a range of out-buildings and an unusual sub-circular, 'ring-like', anomaly of unknown origin identified to the north of the field (GSB 2010).

3 Aims and Objectives

The aims and objectives of the proposed archaeological investigation were:

- to formulate a better understanding of the significance, potential and character of the heritage assets identified by the desk-based assessment and geophysical survey, by means of limited trial trenching;
- to investigate the location, extent, date, character, condition, significance and quality of any Heritage Assets likely to be threatened by the proposed development, by means of limited trial trenching;
- to establish the impact of the proposed car park, and associated groundworks, on any Heritage Assets contained within the development site, by means of limited trial trenching;
- to produce a report detailing the results of the trial trenching, setting any Heritage Assets exposed in a regional and national framework and;
- to advise if further mitigation is required to ensure any heritage assets are either preserved *in situ* or adequately recorded prior to the development of the site, in accordance with PPS5.

4 Methodology

Trial Trenching

In accordance with the Written Scheme of Investigation (ASWYAS 2010; Appendix 1) four trial trenches were excavated. Three targeted potential archaeological features as identified by the desk-based assessment and geophysical survey with one as a control in an apparently 'blank' part of the site. All investigations were undertaken in accordance with recognised professional standards and ASWYAS methodologies (ASWYAS 2005).

The trench measurements and rationale are shown in Table 1 (see below) and their locations are shown on Figure 2. It was necessary to move Trench 3, 3m to the north of its original intended location, due to the overhanging branches of a nearby tree. The trenches total $100m^2$, approximately 1% of the proposed development area.

Trench	**Rationale**	**Size**	**Area**
1	Evaluate the cause of an area of high resistance identified by geophysical survey and interpreted as a possible range of buildings.	15m by 2m	$30m^2$
2	To investigate and characterise the form of the Haw Bank tramway revealed as an earthwork.	10m by 2m	$20m^2$
3	'Control' trench located to test an apparently 'blank' part of the site.	10m by 2m	$20m^2$
4	Evaluate the cause of a sub-circular magnetic anomaly and to characterise the form and function of the feature causing the anomaly.	15m by 2m	$30m^2$

Table 1: Trench rationale

Survey

The trench locations and reference objects were set out using a Trimble 600 Series Theodolite TST using data supplied by Geophysical Surveys of Bradford to ensure that the trenches targeted the geophysical anomalies identified. Levels were calculated from the Ordnance Survey bench mark situated on The Bailey wall (137.28m aOD) to the east of the site. A temporary bench mark was established within the curtilage of the site against the eastern wall.

Fieldwork

The trenches were excavated using a JCB 3CX mechanical excavator fitted with a toothless ditching bucket. Topsoil and/or subsoil were removed by mechanical means under constant archaeological supervision. Machining was halted at the first identifiable archaeological horizon or natural, with all subsequent investigation undertaken by hand.

A full written, drawn and photographic record was made of all archaeological features in accordance with ASWYAS methods and the WSI (ASWYAS 2005 and 2010). *Pro-forma* recording sheets were completed for all trenches.

Environmental samples were collected from both the lime rich deposit and wood exposed from the feature indentified in Trench 4. In addition, samples were taken for archaeomagnetic dating by Dr Mark Hounslow and Sam Harris from the Centre for Environmental Magnetism and Palaeomagnetism (CEMP), University of Lancaster.

5 Results

Topsoil was consistently recorded as a very dark brown silty sandy loam, whilst the subsoil comprised a mid to dark orange brown silty clay. The natural deposits comprised a mid-orange brown clay glacial drift that was a distinctly lighter shade than the subsoil.

Trench 1 (Fig. 3; Plates 1 and 2)

Located towards the southern end of the site, this trench was positioned to evaluate an area of very high and very low resistance that was interpreted as possibly indicative of a range of outbuildings (GSB 2010).

The topsoil was removed (deposit 100; 0.25m in depth) to reveal a layer of sub-angular, platy, limestone fragments (deposit 103 – Plate 2). This rubble deposit, in which some lime mortar was observed, was confined to the very eastern extent of the trench at 134.64m aOD. Excavation revealed that the rubble lay directly above the subsoil (deposit 101) with no evidence of an in situ structure being identified. The subsoil (101) was 0.27m in depth and overlay the natural drift deposits (102). No other archaeological features were identified in this trench. The rubble deposit may be the cause of the high resistance readings. No artefacts were recovered to assist with dating.

Trench 2 (Fig. 3; Plates 3 and 4)

This trench was positioned to investigate a former tramway originally identified from documentary sources whose route is still clearly marked by the presence of a linear earthwork. The geophysical survey also provided clear evidence of the route of the tramway.

The construction cut for tramway was exposed beneath topsoil (200; 0.25m in depth) and subsoil (201; 0.27m in depth) at the western end of the trench rather than in the centre as was expected (at 135.48m aOD). Although the full width of the construction cut was not exposed, excavation revealed a gradual, sloping, U-shaped profile (203), greater than 4.85m in width and at least 0.85m in depth cutting the natural drift geology (202; see Fig. 3, S. 2). The concave sides of the feature were filled with a compacted deposit of dark limestone fragments (204) in which a modern ceramic land drain had been placed. This was sealed by a mid-orange-brown silty clay (deposit 205) which may have accumulated during landscaping.

Trench 3 (Plate 5)

Situated in an apparently 'blank' part of the site, as defined by the geophysical survey, this trench was excavated as a control.

Removal of topsoil (300, 0.2m in depth) and subsoil (301; up to 0.65m in depth) revealed the natural drift geology (302, observed at 135.6m aOD). As anticipated, no archaeological features were present in this trench.

Trench 4 (Fig. 3; Plates 6-12 inclusive)

Trench 4 was positioned at the northern end of the site to investigate the sub-circular magnetic anomaly identified by the geophysical survey.

Removal of 0.2m of topsoil (deposit 400) and up to 0.5m of sub-soil revealed the glacial drift natural (deposit 408) into which a large circular feature had been cut. The natural sloped from 137.80m aOD at the eastern end of the trench to 137.21m aOD at the western end.

Measuring at least 10.5m in diameter, three test slots were excavated through this feature revealing it to have a U-shaped, gradually sloping, flat-based profile (Fig. 3, S. 5 and 6; Plates 6 to 10). The sides and base of the feature had been tinged red from the effects of heating and the remains of fuel, in the form of large charcoal fragments (407; Plate 9), were identified against the eastern and western sides of the feature. The charcoal was sent for analysis and has been identified as deriving from oak (Alldritt, see Section 7). The charcoal was sealed by a light grey/white, lime-rich deposit (406; Plate 11) which was present in all the sections excavated through the feature. At the eastern end of the trench a red orange-silty clay (403) was observed, above deposit 406. This either represents a further episode of use (firing) or more probably an eroded material deposited after the feature went out of use. A single sherd of abraded pottery, of possible medieval date, was retrieved from this deposit. A compacted mid-yellow brown sandy clay (405) containing abundant small limestone fragments represents deliberate backfilling of the feature following abandonment. The upper fill (409) was only observed in the centre and western areas of the feature and comprised a mid-orange brown homogenous silty clay, not dissimilar to the subsoil. This probably reflects natural silting of the feature.

The continuation of this feature is suggested in the extreme north-eastern corner of the trench where there was further evidence of burning which probably corresponds to the linear 'arm' that was identified in the geophysical survey. It is interesting to note that the western ‘arm’, over which the trench was placed to target, was not identified during the investigations.

Archaeomagnetic dating of the material sampled from the burnt walls of the feature indicates that the most probable date of the last heating is 1157AD, with an approximate 95% confidence interval on this date of between 1087AD and 1227AD. The small sherd of abraded pottery, recovered from the infilling of this feature, is possibly medieval in date, thereby providing some corroboration of the archaeomagnetic results.

6 Artefact Record

Pottery by Dr Chris Cumberpatch

Introduction

The small pottery assemblage from *Nearer Storam* field was examined by the author on September 26th 2010. The assemblage consisted of five sherds of pottery of medieval and early modern to recent date. The details are summarised in the catalogue below.

Catalogue

Trench 4 Deposit 400

One rim sherd from an Edged ware plate (8 grams); wavy edge with prominent moulding blue paint and a wavy edge; c.1813 – c.1834.

One flaked body sherd (1 gram) with part of a transfer printed Chinese landscape surviving externally; possibly transfer printed Pearlware (c.1780 – c.1840).

Trench 4 Deposit 401

One small, square-sectioned bowl rim (7 grams) in a quartz sand tempered reduced ware with buff external margins, probably a Brandsby type ware (mid-13th to mid-14th century).

One abraded body sherd (3 grams) in a reduced quartz tempered fabric with pale green flakey and possibly splashed glaze externally; on the basis of the glaze the sherd could be as early as the 12th century but the condition is too poor for a definite date to be assigned and it could be later, 13th to early 14th century.

Trench 4 Deposit 403

One heavily abraded body sherd (1 gram) in an unidentified soft orange sandy fabric, most probably of medieval date.

Discussion

The assemblage is too small and fragmentary for any definite conclusions to be drawn. The condition of all the sherds was poor, from the abraded medieval sherds from contexts 401 and

403 to the flaked and discoloured sherds from context 400. Given this no further work is recommended on this assemblage unless further work is undertaken on the site in which case it should be incorporated into any larger assemblage resulting from such work. The pottery should be deposited in the appropriate local museum where it will be available for examination in the future.

7 Environmental Record

Wood Charcoal by Diane Alldritt

Introduction

Five samples consisting of wood charcoal, were examined for short-lived wood types suitable for radiocarbon dating. The samples originated from the lining of a possible lime kiln, deposit (407), with the wood possibly being used as fuel in the production of lime mortar (Martin pers. comm.).

Methodology

Samples were received as unprocessed 'spot samples' and consisted of large fragments of carbonised wood. All fragments were scanned under low powered microscopy, with the T.S. (Transverse Section) being examined for potential short-lived wood types. Up to ten fragments (where possible) from each sample were then selected for further analysis. These pieces were examined using a high powered Vickers M10 metallurgical microscope at magnifications up to x200. Unfortunately, no fragments suitable for radiocarbon dating were recovered. All fully identified species were measured, weighed and bagged separately by type, apart from Sample 3 (407) where the fragments were too heavy for the scales.

The reference photographs of Schweingruber (1990) were consulted for charcoal identification. Plant nomenclature utilised in the text follows Stace (1997) for all vascular plants.

	C14 Sample	2	3	4	5	6
SKC10	**Context**	407	407	407	407	407
	Other Details	TPA	TPA	TPC	TPC	TPB
Charcoal	**Common Name**					
Quercus	Oak	10 (168.46g)	4 (>100g)	10 (92.91g)	10 (64.12g)	10 (93.90g)

Table 2. Results of wood charcoal identification

Discussion

The charcoal samples from possible lime kiln fill (407) produced large fragments of wood charcoal measuring from 70mm by 55m for the largest fragment to 25mm by 20mm and

20mm by 15mm for some of the smaller pieces. All fragments were identified as Quercus (oak) and therefore cannot be used for obtaining accurate radiocarbon dates. Interestingly, every sample produced pieces in the range of 40mm by 40mm and 30mm by 40mm, which may suggest a degree of consistency in the sizes of wood selected for fuel (or manufactured into charcoal prior to use as fuel).

Each sample was found to contain pieces with a light green/blue sticky clay-like staining when the fragments were dissected, suggesting possible penetration from the chemical by-products of heated limestone or other material whilst the charcoal was *in-situ*.

Conclusion

The samples retrieved from the site produced large fragments of wood charcoal which were uniformly identified as oak throughout each sample. It is possible this material had a fuel purpose, either as ready-made charcoal or wood, and could have acted as a lining to a pit used for lime manufacture or other processes. Oak burns at a high temperature for long periods, and particularly in its charcoal form, would have provided a long lasting heat for use in industrial-type activities.

8 Dating

Archaeomagnetic Dating by Sam Harris and Mark Hounslow

The full report, including sample collection methodology, tables and figures is presented in Appendix 4.

Summary

The circular heated feature observed within Trench 4 (402) was dated using archaeomagnetic techniques. Thirteen samples of burnt clay were collected from the floor and sides of the feature. Eight of them provided useful archaeomagnetic directions. The mean direction (variation corrected) is declination = 15.7°, inclination = 62.5° ($\alpha 95$ = 2.4°, N = 8, K = 547.8). This produces a direction (corrected to Meriden) of declination = 15.4°, inclination = 61.3° ($\alpha 95$ = 2.4°). This mean direction, when used with the Bayesian-based program RenDate (v.4.0.0.1) of Lanos et al. (2005) and the United Kingdom master curve data of Zananiri et al. (2007) suggest that the best estimate of the last heating of the feature was AD1138, with a 95% confidence interval of AD1048 to AD1228.

This data was also evaluated with respect to the older master curve of Clarke et al (1988), which involved correcting for magnetic shallowing. This produced a direction (corrected to Meriden) of declination = 15.4°, inclination = 62.2° ($\alpha 95$ = 2.4°), suggesting the date of the last heating of the feature to be AD1175, (95% confidence interval of AD1150 to 1200).

Both these master curves have limitations with regard to confidence intervals and data quality, and a realistic, combined date of most probable last heating is AD1157, with an approximate 95% confidence interval on this date of AD1087 to AD1227.

9 Discussion and Conclusions

The trial trench investigations have confirmed the presence of archaeological features and deposits in *Nearer Storam* field which are likely to be impacted by the proposed car park development.

Of greatest interest and potential significance is the identification of a large sub-circular feature, initially identified as a magnetic anomaly, in Trench 4 in the north-western corner of the site. This feature has been archaeomagnetically dated to between the mid-12th to early 13th century. The form and location of this feature suggests that it is a substantial oven or kiln and the nature of deposit 406, at the base of the feature, suggests that it was most probably used for the production of lime.

Lime kilns are industrial structures used for the burning of limestone in which calcium carbonate is heated to temperatures of 1000°C to produce quicklime. The resulting product can be mixed with water and sand to produce mortar for use in the construction of stone buildings. Quicklime is also known to have been used in agriculture, being spread on fields in order to help neutralise soil acidity and break down heavy clay soils (English Heritage 1989).

Generally lime kilns are circular in shape, although square and rectangular examples are also known. They comprise a central circular firing pit, with associated flues, which would have served to control the ventilation as well as a means of removing the quicklime (English Heritage 1989). Although no definitive evidence for the presence of flues was revealed during the excavations the magnetic data clearly shows two linear 'arms' extending from the eastern and western sides of the 'kiln' anomaly. It is considered likely that these locate the flues from the large circular firing pit identified at Skipton.

No evidence of a stone/brick lining was seen in the Skipton structure and it appears to be of a simple and crude form. Whether this indicates that is was a single use feature, or more likely representative of its date (medieval kilns were less sophisticated than later post-medieval examples; English Heritage 1989) is unclear at this time. In such a structure, the limestone would be placed into a hollow cut into the ground and packed with wood (oak, in the case of the Skipton example). The feature would have then been covered with turf and left to slowly burn (Crossley 1990). Such a superstructure would have left no above ground archaeological remains.

The size of this feature is intriguing, with most examples of lime kilns possessing firing pits of between 1.2m and 5m in diameter; from the geophysical data it can be postulated that the Skipton example is *c.*10.5m. This would have produced a large quantity of lime in a single firing and together with the date indicates that it could have functioned to supply lime for the construction of the first stone castle at Skipton. The location of the feature, within the castle grounds but at a far enough distance away to prevent the toxic fumes affecting the castle residents, lends credence to such a theory.

Skipton's first castle was a earth and timber 'motte and bailey' established by Robert de Romilly in around the late 11th or early 12th century (Spence 2002). By the late 12th century, William de Forz I began the modification of the castle into a stone stronghold, defending the most vulnerable part of the castle with the construction of a gatehouse. The gatehouse is purported to be the earliest element of Skipton Castle which was converted to stone and was probably constructed between 1192 and 1195 (Spence 2002). Although the best estimates for the final firing of the 'kiln' have produced slightly earlier dates than the construction of the gatehouse, the 95% range spans the period when the de Forz family were modifying the castle in earnest. The latter date of the archaeomagnetic range also falls within William de Forz II rebuilding of the castle in c.1227. This scheme saw the construction of a near-palatial residence, protected by towers and curtain walls (Spence 2002).

In Trench 2 the excavations have defined the form of the Haw Quarry tramway revealing it to have run in a relatively deep, wide, cutting which has been subsequently filled with limestone. No evidence of tracks were identified in the excavated section, which appears to have been deliberately backfilled.

At the southern end of the site in Trench 1 no evidence of any structures was found. However, the trench only slightly extended into the area of high resistance (which had been interpreted as potentially being due to the presence of former buildings) and a rubble spread, possibly from the collapse of a wall or structure, was found to correlate with the high resistance readings. The possibility therefore remains that there may be structures further to the south or east of the trench.

No archaeological features or deposits were present in Trench 3 confirming the 'negative' results of the geophysical survey in this part of the site.

10. Recommendations

The evaluation has established that archaeological features are highly likely to be adversely affected by the proposed car park development, in particular during any site preparation or topsoil stripping that may be undertaken. Discussions with the architect who has examined the proposed ground levels in relation to the known levels of the archaeological horizons has confirmed that archaeological remains are likely to be impacted by the groundworks, particularly in the area around the 'kiln'. To mitigate against any damage to the known and potentially unknown archaeological remains, a further scheme of archaeological investigation is proposed.

Watching Brief

It is advisable that a watching brief is undertaken during the topsoil strip in order to ensure that any known and unknown archaeological remains that are exposed are investigated and recorded prior to their destruction by the development.

In addition to damage caused during ground reduction, archaeological remains can also be impacted upon through rutting from mechanical excavators, compaction by heavy bearing loads and the insertion of new drainage/services. These should be considered against the proposed construction plans.

If archaeological remains are exposed during the topsoil strip but will not be impacted upon by the development, preservation *in situ* is recommended. In such a scenario the archaeology should be recorded in plan (photographs and drawings) and covered with a geotextile such as Terram and sand for protection prior to backfilling.

'Kiln'

Only a small sample of the large circular anomaly identified by the geophysical survey has been investigated as part of this evaluation but this has confirmed it to be a structure where burning took place *in situ*, most probably a lime kiln. It would be advisable to establish the complete form of this structure, in particular given the archaeomagnetic date which indicates it may have been associated with the construction of the first stone castle at Skipton. The date of this feature and its likely association with Skipton Castle, make it of both local and regional significance. It is therefore recommended that further investigation of the feature is undertaken before it is disturbed by the creation of the car park. Even if the construction levels do not impact upon the feature it is advised that the area around the feature is stripped under archaeological supervision to expose the feature in its entirety in plan. This will enable the form of the feature to be established before reburial and preservation *in situ* (covered by terram geotextile and sand). Should the construction levels necessitate ground reduction below the level of the kiln (137.8m at the east and 137.21 at the west; north and south unknown) a scheme of archaeological excavation would be necessary. Given the environmental potential of the wood charcoal contained within the 'kiln', consideration should be given to any drainage proposals that may alter the water equilibrium within the feature which in turn might affect organic preservation. Any further exposure or disturbance to the feature would also probably render it useless for any further archaeomagnetic dating.

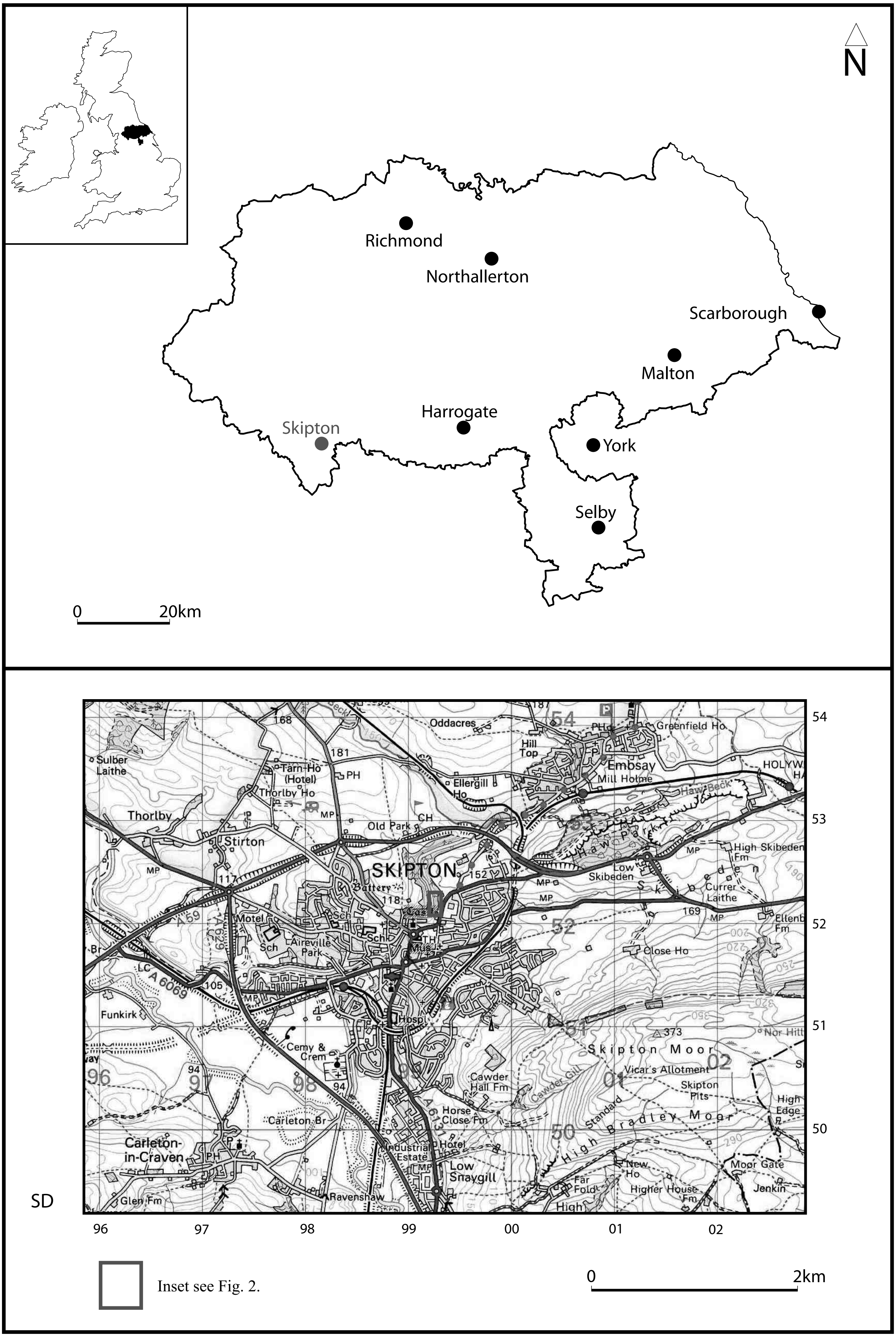

Fig. 1. Site location

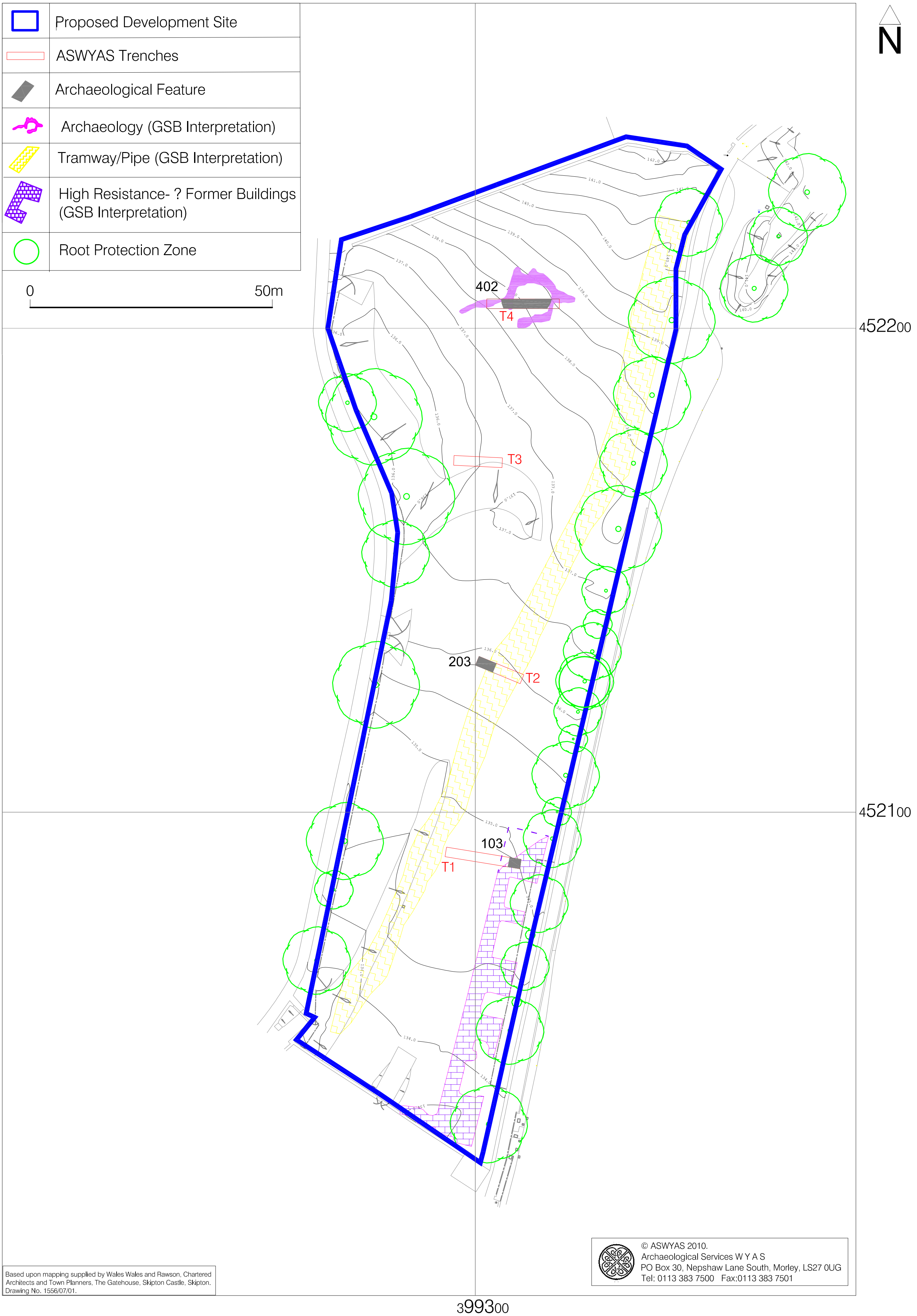

Fig. 2. Site location showing geophysical anomalies and trial trenches (1:1000 @ A4)

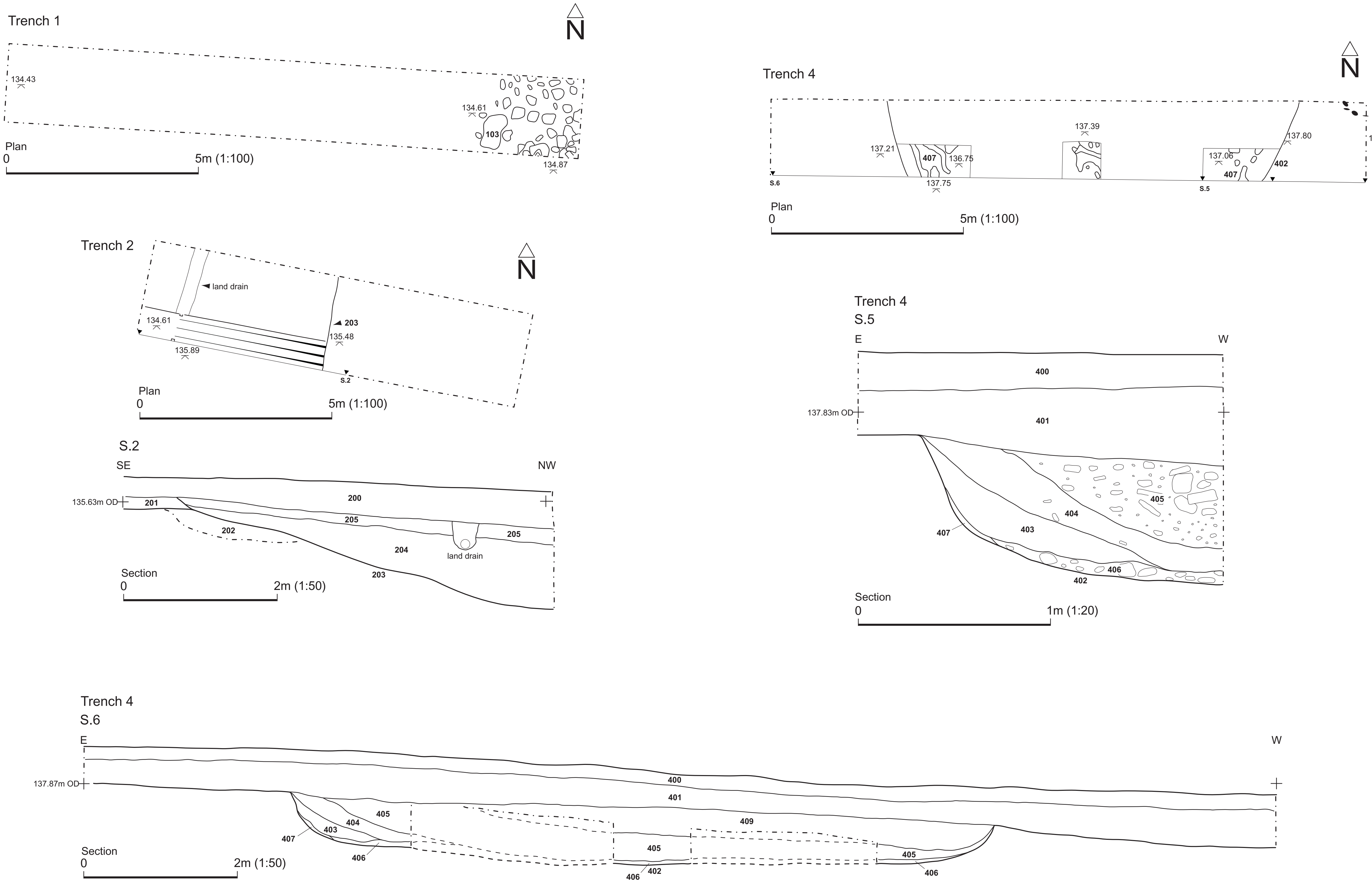

Fig. 3. Trench plans and sections

Plate 1. Trench 1: General view of trench, looking west

Plate 2. Trench 1: Deposit 103, looking east

Plate 3. Trench 2: General view of trench, looking east

Plate 4. Trench 2. Section through tramway 203, looking south

Plate 5. Trench 3: General view of trench, looking west

Plate 6. Trench 4: Pre-excavation shot of the trench, looking east

Plate 7. Trench 4 : Pre-excavation shot of feature 402 showing burnt edge, looking north

Plate 8. Trench 4: Eastern slot through feature 402, looking south

Plate 9. Trench 4: Eastern slot through feature 402 showing burnt edges and wood charcoal, looking east

Plate 10. Trench 4: Western slot through feature 402, looking south

Plate 11. Trench 4. Central slot through feature 402 showing lime rich deposit 406, looking south

Plate 12: Trench 4. Shot showing excavated sections through feature 402, looking west

Plate 13. Trench 4: Preparation of area for sample collection, looking south

Plate 14. Trench 4: Preparation of flat plaster surface, looking south-east

Plate 15. Trench 4: Establishing the horizontal reference direction, looking south-east

Plate 16. Trench 4: Establishing the horizontal reference direction, looking north-east

Plate 17. Trench 4: Removal of monolith, looking south-east

Plate 18. Trench 4: Removal of monolith, looking east

Appendix 1: Inventory of primary archive

File/Box No	Description	Quantity
File no.1	Trench Record sheets	4
	Context registers	4
	Context cards	23
	Drawing register	1
	Permatrace sheets	2
	Photo register sheets	3
	Level sheets	3
	B&W negative strips	1
	Colour transparencies	1
	CD with digital images	1

Appendix 2: Concordance of contexts

Context	Trench	Description	Artefacts and environmental samples
100	1	Topsoil	
101	1	Subsoil	
102	1	Natural	
103	1	Limestone layer of stone	
200	2	Topsoil	
201	2	Subsoil	
202	2	Natural	
203	2	Construction cut of tramway	
204	2	Basal fill of 203	
205	2	Upper fill of 203	
300	3	Topsoil	
301	3	Subsoil	
302	3	Natural	
400	4	Topsoil	Pottery (2)
401	4	Subsoil	Pottery (2)
402	4	Cut of sub-circular feature	
403	4	Red baked fill of 402	Pottery (1)
404	4	Grey brown silty clay fill of 404	
405	4	Yellow brown backfill of 402	
406	4	Light grey white lime rich fill of 402	GBA ◇1
407	4	Timbers (burnt/charcoal) within 402	GBA ◇2,3,4,5,6
408	4	Natural	
409	4	Upper fill of 402	

Appendix 3: Written Scheme of Investigation

Skipton Castle Car Park

Skipton

North Yorkshire

Written Scheme of Investigation for a Programme of Archaeological Evaluation by Trial Trenching

Introduction

This Written Scheme of Investigation (WSI) has been produced as part of an archaeological condition attached to planning approval for the creation of a new car park at Skipton Castle. It has been produced by Archaeological Services WYAS (ASWYAS) at the request of Mr Sebastian Fattorini, Skipton Castle. Pre-application advise was sought from Lucie Hawkins of North Yorkshire County Council Historic Environment Team, in preparation of a previous scheme of archaeological investigation. In formulating this WSI, consideration has been paid to the root protection areas around the extant trees and to the development proposals. This document supersedes the WSI for archaeological works previously submitted to Craven District Council for approval.

Site Location

The proposed development site is located within Skipton town centre to the immediate north-east of Skipton Castle (SD 9932 5214; Figs 1 and 2). It comprises an irregular parcel of land known as Nearer Storam field, contained within the estate of Skipton Castle. It is bounded to the north by Bailey Cottage, to the east by the estate wall and The Bailey, to the south by the estate wall and the west by low estate fencing and a track (Fig. 2). The site totals 9925m^2 and is currently under pasture.

Archaeological Background

An archaeological desk-based assessment has recently been undertaken by Archaeological Services WYAS (ASWYAS) of the proposed development site and its surroundings. This report details known archaeological sites, find spots and any previous interventions (Grassam and Martin 2009). The study revealed potential for the survival of sub-surface archaeological remains dating from the medieval period through to the post-medieval period. Of particular interest is the Haw Bank tramway, which was used to transport limestone from the Haw Bank quarry at the north of the town to the terminus of Thanet's Canal, situated to the immediate south-east of the development site. Historic mapping revealed that an earlier route of this tramway (which operated between 1794 and 1836) is known to have traversed the development site on a north-west to south-east alignment (Fig. 3). A site visit revealed that linear earthworks are visible on the same alignment, with those towards the south-east of the site being more prominent. This is presumably where the cutting for the tramway was much deeper, providing an incline for the trucks running southwards towards an extant tunnel and the canal terminus beyond. The earthwork becomes less clear towards the northern end of the site and it is possible that the tramway merely lay in a shallow cutting at this point. It is of interest that the eastern end of the northern boundary wall may be a later addition, possibly depicting the former entranceway for the tramway.

Given its proximity to Skipton Castle, there is also potential for the development site to contain evidence of land use, by the castle estate, during the medieval period. The desk-based assessment also presented the possibility of evidence and artefacts being recovered from the site, relating to the Civil War Parliamentarian attack on the castle in the 17th century.

A geophysical survey (magnetometer and resistance) has recently been undertaken by GSB Prospection Ltd. in support of the planning application submitted by Skipton Castle Ltd. The survey helped to define the line of the former Haw Bank tramway and identified further areas of archaeological potential. To the south-east of the site a range of out-buildings is suggested by the data, with an unusual 'ring-like' anomaly identified in the north of the field (GSB 2010)

Aims and Objectives

The aims and objectives of the proposed archaeological investigation are:

- to formulate a better understanding of the significance, potential and character of the heritage assets identified by the desk-based assessment and geophysical survey, by means of limited trial trenching;
- to investigate the location, extent, date, character, condition, significance and quality of any Heritage assets likely to be threatened by the proposed development, by means of limited trial trenching;

- to establish the impact of the proposed car park, and associated groundworks, on any Heritage Assets contained within the development site, by means of limited trial trenching;
- to produce a report detailing the results of the trial trenching, setting any Heritage Assets exposed in a regional and national framework and;
- to advise if further mitigation is required to ensure any heritage assets are either preserved *in situ* or adequately recorded prior to the development of the site, in accordance with PPS5.

Methodology

Trial Trenching

It is proposed that four trial trenches are to be excavated, three targeting known potential archaeological features and one 'control' trench. The trench measurements and rationale is shown in Table 1 and their locations are shown on Fig. 2. The trenches total $100m^2$, approximately 1% of the available area.

Trench	**Rationale**	**Size**	**Area**
1	Targeting 'ring-like' geophysical anomaly to characterise form and function.	15m by 2m	$30m^2$
2	'Control' trench. Located to test 'blank area' and determine if geophysical trends continue to the south.	10m by 2m	$20m^2$
3	To characterise the form of the tramway, indicated by geophysical anomalies.	10m by 2m	$20m^2$
4	Targeting possible building range identified by geophysical survey, to characterise form and function. To test 'blank area'.	15m by 2m	$30m^2$

Table 1: Trench rationale

A further 50m^2 of trenching should be set aside as a contingency should the results of the investigations require further clarification, to meet the aims and objectives outlined in this document (e.g. a feature extents beyond the limit of the trench). This contingency would only be used following consultation with planning officer and the client.

The trenches will be laid out using a 5800 VRS dGPS. All topsoil and/or modern deposits will be removed by mechanical means under archaeological supervision using a mechanical excavator equipped with a toothless ditching bucket. Machining will stop at the first identifiable archaeological horizon or natural, whichever is the shallower. Thereafter all further investigation will be manual.

All identified archaeological features will be accurately recorded in plan at scales of either 1:20 or 1:50 as appropriate. Feature sections will be drawn at scales of either 1:10 or 1:20. All plans and sections will include spot heights related to Ordnance Datum in metres. Tie-in information will be undertaken during the course of the evaluation and will be fixed in relation to nearby permanent structures and roads, and to the National Grid.

Unless otherwise determined, all linear features will be subject to a manual sampling regime of 10% of their length within the designated area of investigation, or a minimum of a 1m sample section if the feature is less than 10m long. No section will be less than 1m in length. W here possible one section will be located and excavated adjacent to a trench edge and particular attention will be paid to terminal-ends, corners and intersections. Discrete features, such as pits, post-holes, kilns, hearths and graves, to be subject to a 50% manual excavation in the first instance. Built structures, such as walls, will be examined and sampled to a degree whereby their extent, nature, form, date, function and relationship to other features and deposits can be established. With consultation, some features may require full excavation.

A full written, drawn and photographic record will be made of all material revealed during the course of the excavation. Context recording will be by ASWYAS standard method. All contexts, and any small finds and samples from them, will be given unique numbers. Bulk finds will be collected by context. Significant small finds will be recorded 3-dimensionally. Colour digital and monochrome negative photographs will be taken at a minimum format of 35mm. All artefacts recovered will be recorded and removed from the site for appropriate storage in controlled environments. All artefacts recovered will be retained, cleaned, labelled and stored as detailed in the guidelines laid out in the IFA Guidelines for Finds Work. Conservation, if required, will be undertaken by approved conservators. UKIC guidelines will also apply. All finds of gold and silver and associated objects shall be reported to HM Coroner according to the procedures relating to the Treasure Act 1996, after discussion with the client and Craven District Council’s planning officer or their representative.

Routine soil sampling (bulk samples for artefact recovery, land snails, bones and charred plant remains) will be undertaken. Where appropriate and practicable, soil samples of up to 30-40 litres will be taken from excavated contexts, and larger samples will be taken of any rich carbonised deposits. Particular attention will be paid to the sampling of primary ditch fills, large discrete features (e.g. refuse pits), structural and occupational evidence, and any surviving buried soils. Provision will be made for the recovery of samples suitable for scientific dating (e.g. radiocarbon/AMS, dendrochronological and archaeomagnetic dating).

In the event of human remains being discovered they will be left in situ, and covered and protected. At this evaluation stage, removal of human remains is not anticipated. Should their removal be unavoidable, it will only take place in compliance with the Burial Act 1857 and with an exhumation licence obtained form the Ministry of Justice (MoJ).

Analysis and Reporting

The site archive will contain all the data collected during the archaeological investigations, including records, finds and environmental samples. It will be quantified, ordered, indexed and internally consistent. Adequate resources will be provided during fieldwork to ensure that all records are checked and internally consistent. Archive consolidation will be undertaken immediately following the conclusion of fieldwork:

- ·the site record will be checked, cross-referenced and indexed as necessary;
- all retained finds will be cleaned, conserved and packaged in accordance with the requirements of the recipient museum;
- all retained finds will be assessed and recorded using pro forma recording sheets, by suitably qualified and experienced staff. Initial artefact dating will be integrated within the site matrix;
- all retained (bulk) environmental samples will be processed by suitably experienced and qualified staff and recorded using pro forma recording sheets.
- Upon completion of the investigations, the artefacts, ecofacts and stratigraphic information shall be assessed as to their potential and significance for further analysis. A report will be prepared within an agreed timetable following the completion of onsite archaeological investigations and will include the following:
- a non-technical summary of the results of the work;
- a summary of the project's background;
- the site location, supported by an overall plan of the site and accurate location of all trenches;

- an account of the method;
- the results of the archaeological investigations, including phasing and interpretation of the site sequence and spot-dating of artefacts, if recovered
- specialist analysis of any artefacts or environmental material recovered during the investigations;
- a summary of the contents of the project archive and its location;
- an assessment of the archaeological significance of any archaeological features, deposits, artefacts and/or ecofacts identified, with an interpretation of the results in relation to other sites in the vicinity.

Copies of the report (including digital copies) will be supplied to the client, the planning officer and the County Historic Environment Record. Upon completion of the work ASWYAS will make the results accessible to the wider research community by submitting digital data online to OASIS (http://ads.ahds.ac.uk/project/oasis/). It is possible that the excavation findings will warrant wider publication. This shall be effected either through one of ASWYAS's in-house series of publications or through publication with an appropriate archaeological journal.

Archiving and Museum Deposition

Provision will be made for the deposition of the archive, artefacts and environmental material, subject to the permission of the relevant landowner (and if no further archaeological work is to be initiated), in the appropriate recipient museum, in this instance Craven Museum, Skipton. The museum will be advised of the timetable of the proposed investigation prior to excavation commencing. The archive will be prepared in accordance with industry standards.

Copyright, Confidentiality and Publicity Copyright in the documentation prepared by the archaeological contractor and specialist sub-contractors should be the subject of additional licences in favour of the repository accepting the archive and the Historic Environment Record (HER) to use such documentation for their statutory educational and museum service functions, and to provide copies to non-commercial third parties as an incidental to such functions. Under the Environmental Information Regulations 2005 (EIR), information submitted to the HER becomes publicly accessible, except where disclosure might lead to environmental damage, and reports cannot be embargoed as 'confidential' or 'commercially sensitive'. Unless the client wishes to state otherwise, the copyright of any written, graphic or photographic record and reports will rest with the originating body (ASWYAS).

Health and Safety

ASWYAS has its own Health and Safety policy which has been compiled using national guidelines such as FAME. These guidelines conform to all relevant Health and Safety legislation. In addition each project undergoes a 'Risk Assessment' which sets project specific Health and Safety requirements to which all members of staff are made aware of prior to on-site work commencing. Health and safety will take priority over archaeological matters.

Insurance

ASWYAS is covered by the insurance and indemnities of the City of Wakefield Metropolitan District Council. Insurance has been effected with: Zurich Municipal Insurance, P.O. Box 568, 6th Floor, 1 East Parade, Leeds, LS21 2UA (policy number QLA-03R896-0013). Any further enquiries should be directed to: Wakefield MDC Risk and Insurance, Room 67, County Hall, Bond Street, Wakefield, WF1 2QW.

Monitoring

The project will be monitored by the Craven District planning officer to whom written documentation will be sent before the start of the work confirming:

- the date of commencement,
- the names of all finds and archaeological science specialists likely to be used in the evaluation, and
- notification to the proposed archive repository of the nature of the works and opportunity to monitor the works.

Where appropriate, the advice of the Regional Advisor for Archaeological Science (Yorkshire and the Humber Region) at English Heritage will be called upon.

Resources and Programming

Project personnel:

Field specialists:

Project Management:	Louise Martin
Project Officer:	TBA

Surveyor:	Mitchell Pollington / Louise Martin

Environmental and post-excavation specialists:

Prehistoric pottery specialists:	Blaise Vyner
	Terry Manby
Roman pottery specialist:	Ruth Leary
	Peter Didsbury
Medieval pottery specialist:	Chris Cumberpatch
Flint specialist:	Ian P Brooks
Small finds specialist:	Hilary Cool
	Gail Hama
Conservator:	Karen Barker
Clay pipe	Peter Hammond
	Susie White
Environmental specialists:	Diane Alldritt (plant remains)
	John Carrott (land snails, insects)
Faunal analyst:	Jane Richardson
Human bone specialist:	Malin Holst

It is anticipated that the fieldwork might take up to two weeks with up to two archaeologists on-site. The time-scale for the production of a full report is dependant on the complexity of any archaeological remains found and specialist availability to examine any artefacts/ecofacts recovered from the site. The client will be made known of any unavoidable delays as soon as they are identified. If necessary, and with approval, alternative specialists may be sought. It may be necessary to produce an interim report, prior to the submission of the full report to assist in the development programme.

Appendix 4: Archaeomagnetic dating report

1. Sample Collection and Preparation

Thirteen samples were extracted on the 15th October 2010 for the purpose of archaeomagnetic dating, from the excavations at the *Nearer Storam* field (Latitude: 53.964°N, Longitude: 2.015°W). Seven orientated samples were collected from the eastern end of Trench 4, with six orientated samples collected from the western end (Fig. A1). All the samples were heated and reddened boulder clay and from the cut 401 (Plates 13 to 18).

For convenience the samples were labelled with a simple code "SC" (for Skipton Castle). Samples SC1, SC2, SC6, SC7, SC12, and SC13 were removed from the western end with SC 12 and 13 extracted from beneath SC 1 and 2 (Fig. A). Samples SC3, SC4, SC5, SC8, SC9, SC10, and SC11 were removed from the western end with SC 10 and 11 extracted from underneath SC 4 and 5 (Fig. A1). Samples SC6 to SC9 were from the floor of the heated feature, below the layer of burnt limestone, and the others were from the side walls of the feature.

All samples were orientated by using a flat plaster surface moulded onto the upper part of the burnt clay. Onto this plaster surface a horizontal reference direction was determined with respect to magnetic north (using a magnetic compass). A check was taken across the feature that no significant magnetic field deviation was produced by the feature. The dip direction of the reference surface on the plaster was determined to an accuracy of 1o.

In the laboratory sodium silicate solution progressively was applied to the sides of the dried monoliths, in order to consolidate them for cutting into individual specimens. Specimens cut from each sample were divided into a 'layer A' (nearest the heating) and 'layer B' (further away from the heated surface). A number of 2.2 by 2.2 by 2.2 cm cubic specimens were cut from each sample in the laboratory using a diamond saw. Between four and seven of the best preserved and intact specimens from each sample were used in the full laboratory analysis.

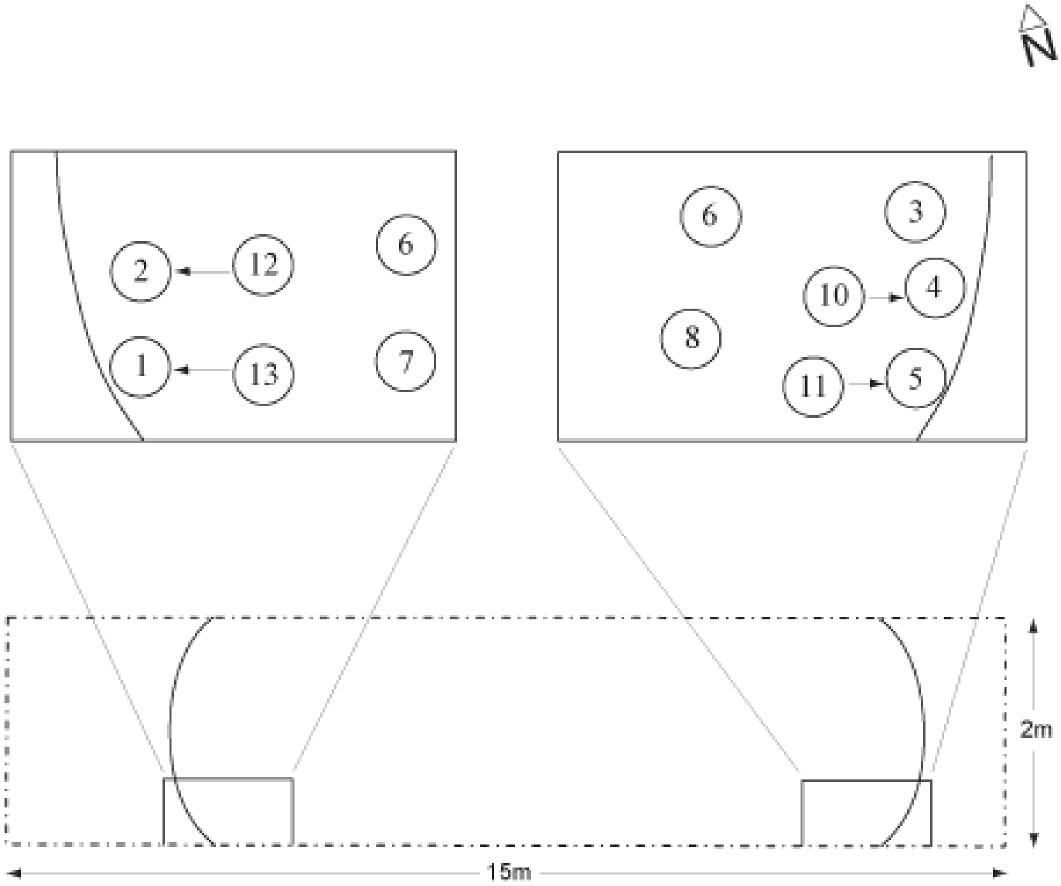

Fig A1: Schematic diagram showing the locations of samples (code SC) removed from the lime kiln feature, labelled as samples 1 – 13. Arrows indicate the samples were beneath those shown (not to scale).

2**. Archaeomagnetic Procedures and Results**

2.1 Natural Magnetisation Remanent and Magnetic Susceptibility

The direction and strength of natural remanent magnetization (NRM) of all the cut specimens was measured at the CEMP, Lancaster University, using a Minispin spinner magnetometer (Table A1). The low-field magnetic susceptibility (kLF) was measured using a Bartington MS2 susceptibility meter (Table A1). Further details about the methodology and background are in Appendix B and in Linford (2004).

The NRM intensity varied over 3 orders of magnitude, with samples SC2, SC6 and SC9 having the lowest intensity and SC10, SC11 and SC12 having the largest. The magnetic susceptibilities approximately mirror the NRM intensity values. The Koenigsberger factor (QNRM) is the ratio between the NRM and the induced magnetisation in a 0.05mT field (i.e. the approximate intensity of the earth's magnetic field, Appendix B, see below). Values larger than 1 indicate that the net in situ magnetisation is dominated by a permanent remanence. This is normally taken to mean a thermoremanence induced by heating of the samples. All samples have an average QNRM larger then one and so have been significantly heated in the past (the individual specimen values are in Appendix A, see below).

Sample	Ns	NRM intensity (mA/m)	kLF, (x10-6 SI)	QNRM
SC1	7	102	1984	1.3
SC2	6	85	1791	1.5
SC3	6	607	7250	2.0
SC4	4	960	6481	3.4
SC5	5	1199	6109	4.5
SC6	6	30	413	1.8
SC7	6	107	1102	2.5
SC8	5	193	2086	2.6
SC9	4	83	894	2.3
SC10	5	2166	7922	5.9
SC11	5	5281	17022	7.4
SC12	4	1645	7825	3.3
SC13	5	105	1513	2.1

Table A1. Average volume-specific magnetic parameters for the samples from the feature, Skipton Castle. Ns = number of specimens used in determining the mean.

The specimen NRM directions were quite varied in both inclination and declination with typical ranges from 51.2° to 78.4° for the inclination and 350.1° to 55.1° for the declination. As can be seen from Figure A2 there are some directional outliers, which are not included in this typical range. This initial analysis suggested that further specimens from SC1, SC2, and SC12 might show large directional scatter, so these samples were excluded from further analysis. The excessive scatter for these samples may be due to some post-heating disturbance.

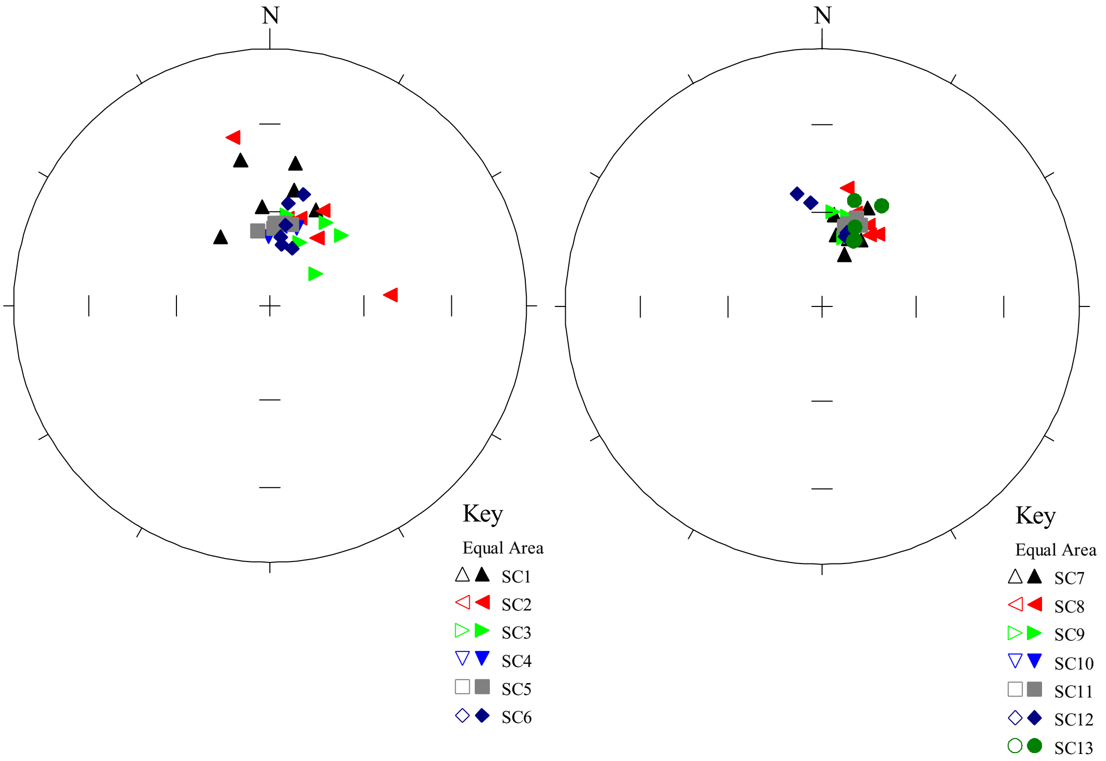

Fig. A2. Stereographic projections of the specimens' NRM directions (uncorrected for magnetic deviation), with specimen data from each sample colour and symbol-coded.

2.2 *Pilot demagnetisation of initial specimens*

One initial specimen per sample was progressively demagnetised with alternating magnetic fields (AF) in seven to eight steps from 5 to 50 mT, using a Molspin AF demagnetizer (see Appendix B for details). The NRM of most specimens contained only very minor viscous overprints which were removed using demagnetisation fields up to 5 – 10 mT (Fig 3). These minor overprints are probably laboratory viscous magnetisations.

Demagnetisation of the specimens in demagnetising fields up to or larger then 10 mT in most cases, revealed a single stable component- i.e. the Characteristic Remanent Magnetisation (ChRM) which is seen on the Zijderveld diagram as a straight line segment mostly intersecting the origin of the Zijderveld plot (Fig. A3). Between 3% and 9% of the NRM intensity was left after demagnetisation at 50 mT, hence magnetite is the dominant carrier of the thermo-remanence.

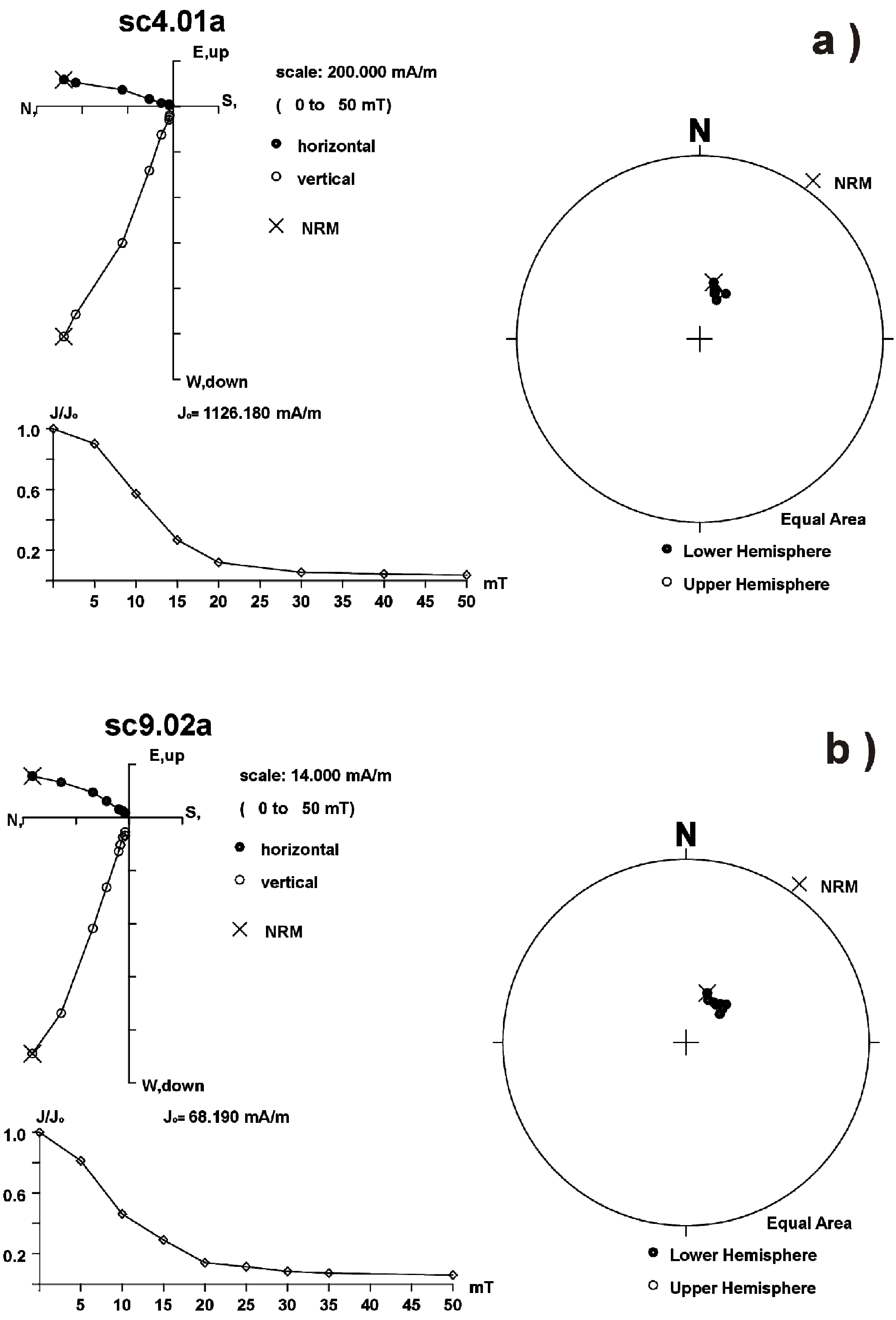

Fig. A3. Typical demagnetisation characteristics of specimens from Skipton Castle samples. (a) SC4 showing linear trajectory ChRM from 10mT and (b) SC9 showing linear trajectory ChRM also from 10 mT.

2.3 Demagnetisation of the remaining specimens

Forty-one more specimens from samples: SC3, SC4, SC5, SC6, SC7, SC8, SC9, SC10, SC11, SC13 were AF demagnetised using four magnetic field steps between 12 mT and 30 mT. The ChRM direction (Fig. A4) of each of these specimens was calculated using principal component analysis as implemented in the LINEFIND program (Kent et al. 1983). All the specimen ChRM directions are listed in Appendix A.

Generally the ChRM directions from most specimens are tightly clustered, however specimens from both samples SC3 and SC8 were more highly scattered (Fig. A4), so the specimen data for these samples was not used for the further analysis.

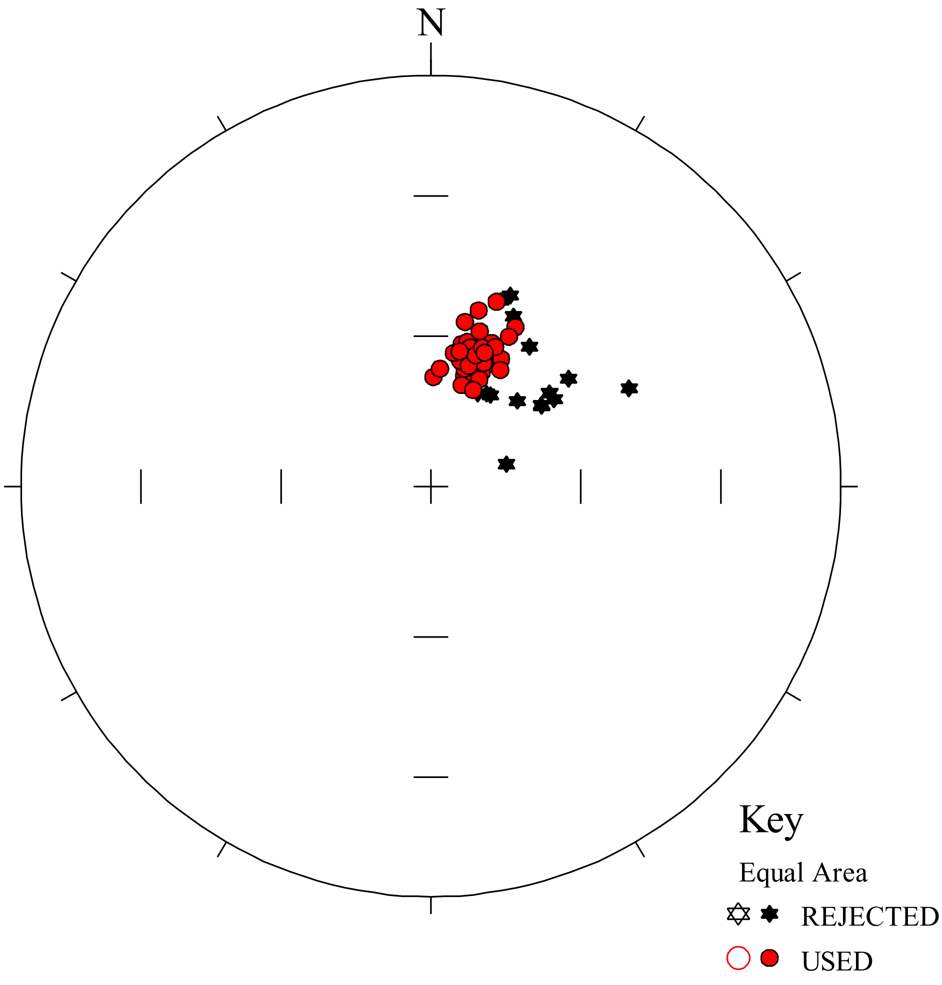

Fig. A4. Stereographic projection of all specimen ChRM directions. A total of 51 specimens is shown, with 35 being accepted for archaeomagnetic dating. Those from samples SC3 and SC8 (marked as star) were rejected from further analysis.

3. Archaeomagnetic Directions

There are two archaeomagnetic master curves widely in use for dating heated features, the first using the hand-drawn curves of Clarke et al. (1988), which attempted to correct the data for artefacts and data quality, and the more recent compilation of Zananiri et al. (2007) which included all data irrespective of quality. An assessment of dating based on these two methods will be given.

3.1 Using the UK master curve of Clarke et al. (1988)

The extracted ChRM components produced relatively tightly-clustered sample-mean directions with little variation in the declination or inclination (Table A2).

Sample	Ns	D (o)	I (o)	α95 (o)
SC4	3	7.4	67.0	5.0
SC5	5	15.9	62.2	2.4
SC6	5	16.5	64.5	5.3
SC7	6	23.6	61.0	4.6
SC9	3	17.5	66.8	5.9
SC10	5	18.6	62.9	1.8
SC11	5	20.7	60.7	2.7
SC13	3	24.2	61.1	15.1

Table A2. Mean declination (D), inclination (I) directions (not corrected for magnetic variation) and intra-sample scatter shown by the Fisher confidence cone angle α95 (rejected specimens and samples no shown). This data includes magnetic shallowing corrections as outlined in the methodology of Clarke et al. (1988), in which 2.4° is added to the inclination of the samples (i.e. SC6, SC7, SC9) that came from the floor of the feature. Ns= number of specimens.

Using the sample means and Fisher statistics an overall sample-based mean archaeomagnetic direction obtained was, D = 18.4°, I = 63.4° (α95 = 2.4, K = 551.8, N = 8). This mean archaeomagnetic direction was corrected for the magnetic field variation of the site, which is 2.7°, using the international geomagnetic reference field model (NASA, 2010). This gave a variation-corrected direction of:

D = 15.7°, I = 63.4°, α95 = 2.4°.

3.2 *Using the data of Zananiri et al. (2007)*

Using this calibration dataset the ChRM directions do not need to be corrected for magnetic shallowing, giving those values in Table A3.

Sample	Ns	D	I	α95
SC4	3	7.4	67.0	5.0
SC5	5	15.9	62.2	2.4
SC6	5	16.5	62.1	5.3
SC7	6	23.6	58.6	4.6
SC9	3	17.5	64.4	5.9
SC10	5	18.6	62.9	1.8
SC11	5	20.7	60.7	2.7
SC13	3	24.2	61.1	15.1

Table A3. Mean directions and sample scatter shown by Fisher α95. This does not include rejected specimens and samples (also does not include the correction added to the inclination for magnetic shallowing on floor samples).

Using the sample means and Fisher statistics gives an overall sample-based mean archaeomagnetic direction of: D = 18.4°, I = 62.5° (α95 = 2.4, K = 547.8, N = 8). When corrected for the magnetic field variation at the site the final archaeomagnetic direction was:

D = 15.7°, I = 62.5°, α95 = 2.4°.

4. Archaeomagnetic dating

4.1 Archaeomagnetic dating using UK master curve of Clarke et al. (1988)

The mean direction result needs to be converted via the pole method of Noel and Batt (1990) in order to compare them to the calibration curve. This corrects the direction to the site of Meriden at latitude 52.436°N and longitude 1.647°W.

Converted to Meriden direction: D = 15.4°, I = 62.2°, $\alpha 95$ = 2.4°

When plotted on the Clark et al. (1988) master curve, the mean direction of the feature gives a best estimated age of last heating to be AD 1175, with a 95% confidence interval of about AD 1150 – 1200. (Fig. A5)

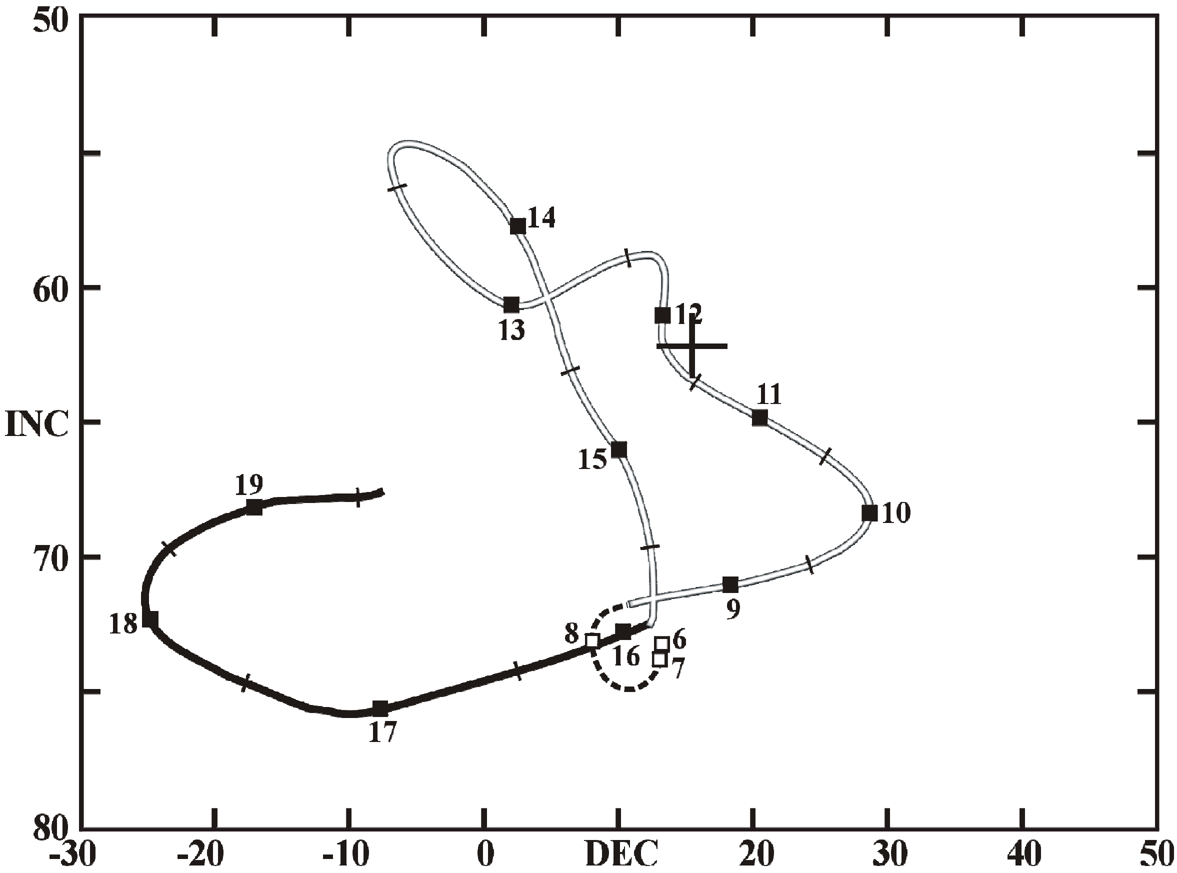

Fig. A5. Comparison between the UK master curve for AD 600 – 1975 of Clarke et al. (1988) and the converted to Meriden sample-based mean ChRM direction, with its error (i.e. the cross) based on the Fisher 95% confidence cone.

4.2 Archaeomagnetic dating using Zananiri et al. (2007)

The direction was converted to Meriden, giving:

Converted to Meriden direction: D = 15.4°, I = 61.3°, α95 = 2.4°

To generate a date, we use the master curve data of Zananiri et al. (2007) in combination with the Bayesian dating program RenDate version 4.0.0.1 (Lanos et al. 2005).

The date generated by combining the declination and inclination probabilities using the Rendate program gives a best estimated date of last heating of AD1138, with a 95% confidence interval on this of AD 1048 – 1228 (Fig. A6).

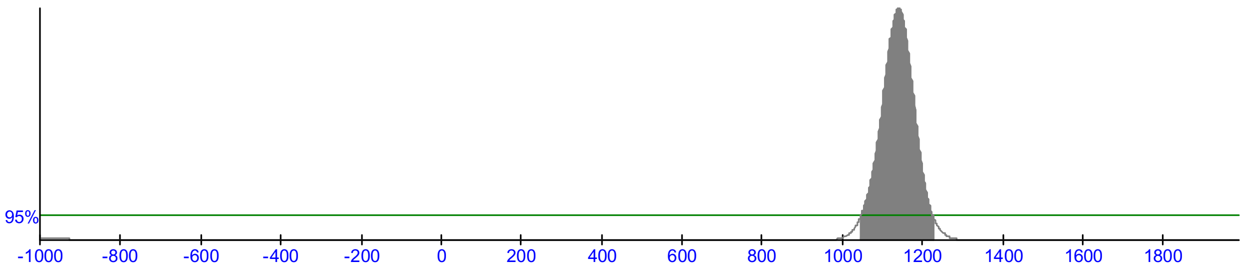

Fig. A6. The combined declination, inclination probability curve from RenDate version 4.0.0.1, with the timescale (>0 == AD) on the x-axis and the probability density on the y-axis. The grey interval includes 95% of the probability values.

5. Conclusion

The archaeomagnetic date from these two methods suggests a most probable last heating between AD1138 and AD1175 (the mean is AD1157). The archaeomagnetic date obtained is significant as it probably links the lime making feature in with the replacement of the timber castle with a stone structure in AD1192 – 1195 (Louise Martin pers comm.). The historical AD1192-1195 date clearly is within the ~±25 year confidence interval of the master curve of Clark et al. (1988), and the ~±100 year confidence interval of the Bayesian methodology.

The UK master curve of Clarke et al. (1988) whilst widely used, however does not take into account the inaccuracies of the hand-drawn curve itself and so the actual 95% confidence interval uncertainties in this date are probably larger than ±25 years. In contrast the Bayesian-based calibration curve has no filtering for data quality, so tends to generate a larger 95% confidence interval. Realistically an approximate 95% confidence interval on the mean date of AD1157 is ±70 years, i.e. AD1087- AD1227.

The summary is shown below using the English Heritage guidelines on archaeomagnetic dating. The Rendate date is given, since this is the more conservative of the two dates, and could be used to better refine the date later (using Bayesian statistics), if radiocarbon dates become available.

Archaeomagnetic ID:	**SC, Skipton Castle**
Feature:	**10.5 metre diameter burnt clay Cut Number 402. Trench 4.**
Location:	**Longitude 357.985°E, Latitude 53.964°N**
Number of Samples (taken/used in mean)/specimens:	**(13/8)/35**
AF Demagnetisation Applied:	**12 - 30mT, ChRM line fit**
Distortion Correction Applied:	**0°**
Declination (at Meriden):	**15.4°**
Inclination (at Meriden):	**61.3°**
Alpha-95:	**2.4°**
K:	**547.8**
Date range (63% confidence):	**1103 AD to 1179 AD**
Date range (95% confidence):	**1048 AD to 1228 AD**
Archaeological date range:	***Medieval***

Appendix A

Volume-specific NRM intensity, magnetic susceptibility (χ_{LF} **),** Koenigsberger ratio (Q_{NRM}) and ChRM directional results.. D=declination (**not variation corrected**), I=inclination. Range is the demagnetisation steps over which the ChRM principle component line was obtained. ChRM directions not accepted for the analysis are shown in bold**.**

Specimen	M, mA/m	K_{LF}, (x10^{-6} SI)	Q_{NRM}	ChRM - D	ChRM - I	Range	a95
sc3.01a	380.5	5722.2	1.9	**30.9**	**68.5**	5 - 20mT	2.4
sc3.02a	464.4	5211.1	2.5	**53.7**	**62.7**	> 12mT	1.6
sc3.04a	156.7	3822.2	1.1	**54.1**	**62.7**	> 30mT	2
sc3.05a	964.0	9988.9	1.3	**54.7**	**59.9**	> 12mT	2
sc3.02b	1008.4	9422.2	3.0	**45.3**	**65.9**	> 12mT	3.2
sc3.03b	801.6	9333.3	2.4	**53.7**	**62.7**	> 12mT	1.6
sc4.01a	1126.2	8166.7	3.9	16.8	67.2	10 - 30mT	2.2
sc4.02a	1527.8	9055.6	4.7	1.2	68.4	> 12mT	0.7

Specimen	M, mA/m	K_{LF}, (x10^{-6} SI)	Q_{NRM}	ChRM - D	ChRM - I	Range	a95
sc4.03a	351.3	4155.6	2.4	4.4	66.7	12 - 23mT	4.3
sc4.04a	452.1	4544.4	2.8	**26.9**	**69.4**	> 12mT	2
Mean	1001.8	7125.9	3.6				
STDEV	598.1	2610.5	1.2				
sc5.02a	347.7	3966.7	2.4	16.1	65.8	10 - 25mT	1.4
sc5.03a	421.3	4666.7	2.5	17.4	61.4	> 12mT	1.6
sc5.04a	949.8	5877.8	4.5	12.3	61.1	> 12mT	1.2
sc5.05a	1630.9	7277.8	6.3	20.0	62.1	> 12mT	1.4
sc5.06a	2045.2	8755.6	6.5	14.1	60.4	> 12mT	0.9
Mean	1079.0	6108.9	4.5				
STDEV	745.3	1942.5	2.0				
sc6.04a	15.6	377.8	1.5	17.5	57.6	10 - 30mT	3.6
sc6.05a	16.7	300.0	1.6	17.1	69.1	> 12mT	1
sc6.06a	24.3	411.1	1.6	**25.9**	**52.0**	> 12mT	0.7
sc6.07a	24.3	288.9	2.4	11.7	56.5	> 12mT	0.4
sc6.08a	43.1	511.1	2.4	13.3	64.5	> 12mT	0.6
sc6.10a	33.4	588.9	1.6	23.7	62.7	> 12mT	2
Mean	26.6	413.3	1.9				
STDEV	11.6	132.3	0.4				
sc7.01a	94.3	811.1	3.2	18.5	61.0	10 - 20mT	2.3
sc7.02a	106.4	1255.6	2.4	24.0	65.2	> 12mT	0.5
sc7.03a	107.4	1066.7	2.8	28.9	61.1	> 12mT	0.8
sc7.04a	158.0	2044.4	2.2	28.1	54.0	> 30mT	2.4
sc7.05a	41.5	622.2	1.9	27.6	56.3	> 23mT	0.9
sc7.06a	70.4	811.1	2.4	15.2	53.5	> 12mT	2

Specimen	M, mA/m	K_{LF}, (x10^{-6} SI)	Q_{NRM}	ChRM - D	ChRM - I	Range	a95
Mean	96.3	1101.9	2.5				
STDEV	39.2	512.3	0.5				
sc8.04a	84.4	1922.2	2.3	**20.6**	**50.1**	10 - 35mT	1.8
sc8.05a	168.0	1577.8	3.0	**35.2**	**55.8**	> 12mT	2
sc8.06a	222.2	2122.2	2.9	**52.0**	**55.0**	> 12mT	2.8
sc8.08a	149.2	2722.2	1.5	**63.7**	**45.2**	18 - 30mT	1.1
sc8.09a	339.2	2800.0	3.4	**51.9**	**59.9**	> 12mT	1.2
sc9.02a	68.2	988.9	1.9	**33.1**	**68.4**	10 - 25mT	2.2
sc9.04a	54.1	711.1	2.1	9.8	63.2	> 12mT	1.6
sc9.05a	94.2	1011.1	2.6	24.6	66.8	> 12mT	1.2
sc9.06a	83.1	866.7	2.7	19.0	62.9	> 12mT	1
Mean	77.1	863.0	2.5				
STDEV	20.7	150.0	0.3				
sc10.01a	4877.0	13777.8	9.9	17.6	62.3	15 - 25mT	2.3
sc10.02a	2497.7	10844.4	6.4	23.4	63.4	> 12mT	1
sc10.04a	640.8	4966.7	3.6	17.5	65.0	12 - 23mT	2.3
sc10.05a	644.4	4966.7	3.6	15.9	61.3	> 12mT	4
sc10.06a	1084.2	5055.6	6.0	18.9	62.5	> 12mT	0.8
Mean	1948.8	7922.2	5.9				
STDEV	1805.2	4138.7	2.6				
sc11.01a	3818.9	11988.9	8.9	12.1	62.6	10 - 35mT	1.3
sc11.02a	7580.6	26477.8	8.0	23.1	59.0	> 12mT	0.8
sc11.04a	1970.9	9844.4	5.6	20.4	60.6	> 12mT	0.8
sc11.04b	8315.2	25777.8	9.0	24.9	59.4	> 12mT	0.8

Specimen	M, mA/m	K_{LF}, (x10^{-6} SI)	Q_{NRM}	ChRM - D	ChRM - I	Range	a95
sc11.05b	2086.2	11022.2	5.3	22.1	61.4	> 12mT	0.8
Mean	4754.4	17022.2	7.4				
STDEV	3017.0	8350.5	1.8				
sc13.01a	101.1	2622.2	1.1	19.6	50.7	10 - 35mT	1.3
sc13.04a	127.5	1288.9	2.8	30.9	63.1	> 12mT	2
sc13.01b	87.4	1066.7	2.3	**73.7**	**74.4**	> 12mT	2
sc13.02b	39.2	377.8	2.9	23.9	69.2	> 30mT	3.2
sc13.06b	116.5	2211.1	1.5	**22.6**	**48.3**	> 12mT	2.3
Mean	89.3	1429.6	2.2				
STDEV	45.3	1128.8	1.0				

Appendix B

Background to archaeomagnetism and archaeomagnetic techniques

The Earth's magnetic field

The magnetic field of the Earth is generated within the core due to a magnetodynamo effect. The form of this magnetic field at the Earth's surface is such that it can be ascribed to a two component system. The first, the dipole component is the main component of the magnetic field. This can be equated to a bar magnet with a fixed north and south pole, which are effectively located over the Geographic North and South Pole respectively. The inclination (see section B.5) of this dipole field is systematically related to the latitude of observation by Tan (I) = 2Tan (I= inclination, = latitude). This relationship is such that near the present day North Pole the magnetic field is steeply dipping downwards, and near the equator the field is shallowly dipping and directed northwards.

The second element of the magnetic field, which is most important for archaeomagnetic studies, is the non-dipole component. This is a subsidiary magnetic field which can be described by a complex set of Fourier harmonics. This non-dipole field varies in intensity and direction through time (the change is called **secular variation**) and gives rise to the current displacement of the magnetic pole into the region of Arctic Canada. If the magnetic field direction is fossilized in archaeological contexts, (like during short heating events in hearths, ovens and kilns) the recorded direction will match the direction of this secular field.

Types of magnetic minerals

There are several types of minerals that can act as recorders of the magnetic field (Table AB.1). Each of these minerals can retain a remanent magnetisation. Magnetite and its magnetically similar titanomagnetite group minerals (e.g. Fe_3O_4 to Fe_2TiO_4 solid solution) are often the most important, because these are strongly magnetic and abundant and are very common in all kinds of archaeological materials.

Within each mineral group, a number of factors influence the magnetic properties of these minerals. These various properties can be useful in: a) distinguishing which mineral is carrying the remanent magnetisation, and b) allow the separation and isolation, during demagnetisation, of the recorded magnetic field information carried by different minerals.

Temperature: Each magnetic mineral has a specific upper temperature above which it can no longer retain its remanent magnetisation. This temperature is its **Curie temperature**, and can be diagnostic of the mineral carrying the remanence.

Grain size: The size of the magnetic particle is a fundamental control on its magnetic behaviour. This is primarily expressed through the grain's **coercivity**, which can be thought of as the degree of difficulty with which the direction of the intrinsic remanent magnetisation can be reset without physically rotating the grain. Generally within any mineral group, the larger the grain size the smaller the coercivity (i.e. more easily reset). Unfortunately, grain-size - coercivity relationships are not quite as simple as this, and it's often best to talk about **multi-domain** (largest grains) and **single domain** grains (mostly smallest grains), when describing magnetic grain behaviour. Single domain grains are the most resistant to resetting, and carry the most important archaeomagnetic information, so it is the magnetic field direction recorded by these grains that demagnetisation is trying to isolate.

In addition to differences in grain size controlling coercivity, different minerals can have markedly different coercivity. For example, magnetite and magnetic sulphides (e.g. greigite) have a relatively low coercivity, compared to haematite whose coercivity is approximately one order of magnitude larger than magnetite of the same grain size.

Mineral Group	Composition	Typical origin	Magnetic characteristic	Curie temperature
Magnetite	Fe_3O_4	Detrital/soil/heating-generated	low coercivity	580 °C
Haematite	Fe_2O_3	Detrital/ weathering	high coercivity	710 °C
Greigite	Fe_3S_4	Anoxic ditch fills, and features	moderate coercivity	~320 °C
Goethite	αFeOOH	Weathering	Very high coercivity	~120 °C

Table AB.1. The main groups of magnetic minerals that are significant in carrying remanent magnetisation and some of their properties.

Introduction to demagnetisation procedures

The remanent magnetisation of any specimen, once it has been collected and first measured is called the Natural Remanent Magnetisation (NRM). This NRM may be composed of several components, namely the **Characteristic Remanent Magnetisation** component **(ChRM),** acquired at (or close to) the time of last heating (or deposition for a sediment), and any later **overprints** which may have been acquired after this time. It is the purpose of demagnetisation to remove these overprints, so the ChRM direction can be defined.

There are various methods of demagnetising rocks the two most commonly used are alternating field (AF) methods and thermal methods. These are summarised in Table AB.2 and outlined below.

Alternating Field (AF) Demagnetisation: The sample is randomly tumbled in an alternating magnetic field, which is slowly reduced in intensity from a peak value to zero (the sample and alternating field are inside a magnetic shield which reduces the ambient Earth's magnetic field to near zero). This procedure randomises the magnetic moments of grains with coercivities up to the value of the applied field. Progressively larger peak fields are applied to remove magnetic components due to grains with larger coercivities. Typically, AF magnetic fields in increments of 5 or 10 mT are used. Between each demagnetisation step, the remanent magnetisation of the sample is measured, which allows analysis of the behaviour of the NRM as it is slowly stripped away.

Thermal Demagnetisation: Samples are heated to a specific temperature and then allowed to cool to room-temperature in a zero magnetic field. Heating a sample in this way randomises the magnetisation of specific types of magnetic grains. The grains which are randomised at this temperature are those whose '**blocking temperature**' is less than this temperature. Thermal demagnetisation is thought to be particularly effective in isolating magnetisation due to thermo-viscous or thermo-remanent causes (e.g. caused by heating in a fire/hearth etc). It is also the only way to demagnetise remanence carried by haematite or goethite, because routine AF demagnetisation equipment cannot achieve large enough magnetic fields to exceed these minerals coercivity of remanence.

Method	**Equipment Used**	**Procedure**	**Minerals effective on**	**Treatment Range**
Alternating Field Demagnetisation (AF)	Alternating magnetic field applied to specimen in zero direct field	AF ramped to peak field, and slowly reduced	Magnetites, Magnetic sulphides	0 to 100 mT peak AF fields
Thermal Demagnetisation	Specimen oven inside a zero magnetic field	Specimen heated to peak temperature for ~20 minutes, and cooled in zero magnetic field	Magnetite, Haematite, Magnetic sulphides, Goethite	50- 720 ^{o}C

Table AB.2. Main types of demagnetisation methods and their characteristics.

Demagnetisation data presentation

Demagnetisation data for specimens is displayed in three ways, using diagrams like Figure A3. Graphs in these demagnetisation figures are composed of: a) Zijderveld diagram, b) Stereographic projection and c) a J/J_0 plot (intensity decay plot). These graphs display the specimen demagnetisation data rotated into the in situ (field) orientation.

a) The Zijderveld diagram presents both the directional and magnitude information of the remanence vector as it is demagnetised. In these diagrams, the distance from the origin (crossing point of axes) corresponds to the magnitude of the remanence vector. Equal intensity scale between axis ticks are used on each of the 4 axes, and are shown on the diagram in mA/m. As a result of demagnetisation, the NRM vector generally plots furthest from the origin, and the last demagnetisation step nearest the origin.

The remanence vector directional information, which is 3-dimensional, is reduced to the 2-dimensions of the paper, by projecting the position of the vector onto 2 orthogonal planes, a horizontal one and a vertical one (indicated on diagram with filled and open symbols). An axis common to both projection planes is shared in the diagram (e.g. E, up; W, down in Fig. 3a). The vertical projection planes are either East-West or North-South oriented, depending upon which projection is suitably oriented for displaying the maximum spread in data points. The vertical plane in Figure 3a is aligned N-S.

The most important point to appreciate is that the removal of a single component of magnetisation results in straight lines (one for each projection) on the Zijderveld diagram connecting demagnetisation steps. Specimens which have curved segments on Zijderveld diagrams do so because the coercivity spectra (or blocking temperature spectra) of the ChRM and other magnetisations overlap (see section B.5).

b) Stereographic Projection: The direction of the remanence vector is plotted on an equal area stereographic projection which displays only the directional information, with negative inclination (i.e. anomalous in archaeomagnetic context) plotted as open circles and positive inclinations (potentially of archaeomagnetic significance) with filled circles. The horizontal projection plane of the Zijderveld diagram is comparable to the stereographic projection.

c) J/J_0 plot: This displays the remanence intensity decay with either AF demagnetisation field, or temperature. The intensity is normalised to the initial NRM intensity (i.e. NRM intensity =1.0), and the NRM intensity (J_o) in mA/m (10^{-3} A/m) is shown just above the diagram. The intensity will generally decay the larger the demagnetisation value used, the shape of this decay can be diagnostic of the stability of the remanence.

Glossary of archaeomagnetic terms

α95 (Alpha 95): This is a measure of angular dispersion (in degrees), commonly used in directional statistics, which is derived from Fisher Statistics. It is the angular radius of a cone about the mean direction, in which the true population mean is found. There is 95% probability that the population mean lies within this range, about the mean direction (i.e. 5 chances in a 100 that the true mean direction lays outside confidence cone).

Blocking Temperature: This is the transition temperature between when a grain is super paramagnetic and single domain. In essence, for each magnetic particle there is a specific temperature, (below the Curie temperature) above which it can no longer retain its remanent magnetisation- i.e. it’s blocking temperature. The blocking temperature is strongly grain-size dependent, with very small single domain particles having lower blocking temperatures than slightly larger single domain grains.

Coercivity (or coercive force): The ease with which the remanent magnetisation of a grain or specimen can be reset into a new direction (i.e. magnetised, or demagnetised in this direction) by an applied magnetic field. This is measured in terms of the magnetic field (in MilliTesla, mT) required to do this. The coercivity of a mineral is strongly related to its grain size, such that smaller grains (above the super paramagnetic size threshold) need a larger magnetic field than bigger grains in order to 'demagnetise' them.

Coercivity Spectra: A specimen remanent magnetic properties are due to a mineral (perhaps 2 or more minerals), of various grain sizes. Consequently, the magnetic field (coercive force) required to 'demagnetise' these various sized magnetic particles will also vary over a range of values. This can be quantified by the Median Destructive field- that coercivity at which 50% of the NRM has been destroyed.

ChRM (Characteristic Remanent Magnetisation): This term is used to describe what is believed to be a specimen's remanent magnetisation produced when the material was formed or last heated. The ChRM is generally (but not always) interpreted to be the last component (i.e. linear segment going through origin of the Zijderveld plot) recoverable from the demagnetisation data.

Declination: The angle between north and the horizontal projection of the magnetisation vector. i.e. 0^o == North directed; 180^o == South directed; 90^o == East Directed; 270^o == West directed. In specimens from unoriented core material the declination is measured from the sample fiducial direction.

Ferrimagnetic/ Ferromagnetic: Minerals which can acquire a permanent magnetisation, which can be retained in the absence of an applied magnetic field (e.g. magnetite). There are a number of sub-groups of magnetic behaviour within this broad grouping. These minerals generally have a large magnetic susceptibility compared to paramagnetic and diamagnetic materials. Common examples are titanomagnetites, haematite (canted antiferromagnetic), pyrrhotite/greigite (ferrimagnetic).

Fisher Statistics: The commonly used statistical method of averaging 3-dimensional vectors (Butler, 1992); the 3-D equivalent of the 1-dimensional normal statistics.

Inclination: The angle between horizontal and the magnetisation vector, such that a down-wards directed vector has positive inclination and an upwards directed vector has negative inclination.

Induced Magnetisation (See magnetisation and magnetic susceptibility).

Koenigsberger factor (Q_{NRM}): The ratio of the induced (determine from the magnetic susceptibility) and remanent magnetisation (determined from the NRM intensity). Values larger than 1 indicate the net magnetisation is more than 50% dominated by the remanence. Materials that have been significantly heated often have large values of Q_{NRM}, hence it's often used as an indication of the nature and 'stability' of the remanent magnetisation.

Magnetic Susceptibility: When a material is exposed to a magnetic field (H) it acquires an induced magnetisation, J_i, such that $J_i = \chi H$, where χ is the magnetic susceptibility. All materials posses a magnetic susceptibility, including diamagnetic, paramagnetic and ferrimagnetic materials, but because ferrimagnetic materials (e.g. magnetite) have magnetic susceptibility several orders of magnitude larger than paramagnetic materials, it is common to think of magnetic susceptibility as a measure of the 'concentration of magnetic materials'. Volume specific magnetic susceptibility has no units in SI (i.e. J_i and H have same units), but when expressed on a mass specific basis its units are $m^3\ Kg^{-1}$.

Magnetisation: The magnetisation of a material is the net magnetic moment per unit volume. There are two types of magnetisation, induced and remanent magnetisation. The induced magnetisation is associated with the magnetic susceptibility, and is ONLY found and measured when materials are in a weak magnetic field. Remanent magnetisation is a 'permanent magnetisation' and is that which enables rocks to record the direction of magnetic fields at their time of formation.

Median Destructive Field (see coercivity spectra).

Multidomain: (see single domain).

NRM (Natural Remanent Magnetisation): The remanent magnetisation of a rock, as it is first measured, prior to laboratory treatment. This may be composed of one of more magnetisation components, perhaps acquired in different times and under different processes.

Paramagnetic: Minerals that acquire an induced magnetisation in the direction of an applied magnetic field are paramagnetic. These also have a positive magnetic susceptibility, generally related to the Fe and Mn-content of the phase. When the magnetic field is removed, they retain NO remanent magnetisation. Common examples of these are Fe or Mn-bearing silicates and carbonates.

pTR: When material is heated, and subsequently cooled in a magnetic field below the Curie temperature of the magnetic minerals responsible for remanence, the material will acquire a partial thermoremanent magnetisation, in the direction of the magnetic field. This is due to the fact that minerals, due to their varying grain size (and other factors), have a range of blocking temperatures.

Remanent Magnetisation: The magnetisation of a specimen which is permanent, and can be likened to that of a bar magnet, having a north and a south pole (i.e. has vector properties). The remanent magnetisation vector is expressed in terms of declination, inclination and magnitude. When this magnitude is expressed on a volume specific basis its units are A/m (or mA/m == 10^{-3} A/m), but on a mass specific basis (to allow for changes in density) its units are $Am^2\ Kg^{-1}$ (magnetic moment per Kg).

Single Domain: In ferromagnetic particles, as a result of the energy-charge configuration, individual magnetic particles may be internally sub-divided into domains. These domains each have different directional alignment of the magnetisation, and contribute to the overall magnetisation of the whole grain. When the particles are small (<~0.1μm for spherical magnetite) these particles consist of only 1 domain, and are called single domain grains. When magnetite particles are larger than 10μm they consist of lots of domains. This type of particle is called a multidomain grain. Single domain and multidomain grains of a specific mineral each have characteristic magnetic properties. Unfortunately, natural magnetic particles also come in different shapes, and are intergrown or subdivided by other (perhaps non-magnetic) sub-regions, so that 'magnetic grain size' (i.e. single domain or multidomain behaviour) may not correspond to the physical size of a magnetic grain. For example, a magnetite particle of say 30μm may be sub-divided internally so that this single grain may posses a single domain and a multidomain behaviour, or perhaps only single domain behaviour.

Susceptibility (see magnetic susceptibility).

Super paramagnetic: Particles which display ferromagnetic/ferrimagnetic behaviour can also be super paramagnetic when these grains are very small. This means that they can retain a remanent magnetisation, but only for a very short period of time. The time over which this retention occurs is grain size dependent (super paramagnetic magnetite grains are <~0.02μm), perhaps from 10^{-10}s to a convenient value of 100s considered by Butler (1992). Such super paramagnetic grains loose the retained remanence due to thermal agitation of the atoms. In many ways such grains are similar to paramagnetic grains, and do not carry a palaeomagnetic remanence.

Thermo- Remanent Magnetisation (TRM): That magnetisation acquired when the grain cools through its Curie temperature.

VRM (Viscous Remanent Magnetisation): Remanent magnetisation which is acquired by magnetic grains when exposed to a weak magnetic field over a period of time. This may 'overprint' the original magnetisation of the material acquired at the time of formation. The magnitude of VRM acquisition can be described by S.log (t), where S= the viscosity coefficient and t is time. S is related to the grain volume, whether it is a multidomain or single domain grain and the temperature (Butler, 1992). Generally multidomain grains acquire VRM much faster than single domain grains.

Zijderveld diagram: A standard method of displaying the remanent magnetisation of a specimen as it is progressively demagnetised (also called vector end point, vector component, or orthogonal projection diagrams). The use of Zijderveld diagrams in interpreting the demagnetisation behaviour of specimens is important for reliable studies. This is because, such diagrams allow the user to evaluate when a magnetic component is being removed, and if it may overlap with another magnetic component in the specimen.

Bibliography

ASWYAS 2005, 'Archaeological Recording Manual' unpubl.

ASWYAS 2010, 'Skipton Castle Car Park: Written Scheme of Investigation' unpubl.

Butler, R.F., 1992, *Palaeomagnetism, magnetic domains to geological terrains*

Clark, A.J., Tarling, D.H., Noel, M., 1988. 'Developments in archaeomagnetic dating in Britain', J. Archaeol. Sci. 15 (6): 645-667.

Crossley, D.,1990, *Post Medieval Archaeology in Britain*

English Heritage 1989, 'Monument Class Description: Lime Kilns', http://www.eng-h.gov.uk/mpp/mcd/lime.htm

GSB Prospection Ltd. 2010, 'Geophysical Survey of Nearer Storam Field, Skipton Castle', GSB Survey No. 2010/43. unpubl.

Grassam, A. and Martin, L., 2009, 'Skipton castle Car Park: Archaeological Desk Based Assessment' ASWYAS Rep. 2010 unpubl.

Kent, J.T., Briden, J.C., Mardia, K.V., 1983, 'Linear and planar structure in ordered mulivariate data as applied to progressive demagnetisation of palaeomagnetic remanence.' Geophysical Journal Royal Astronomical Society 81, 75-87.

Lanos, P., Le Goff, M., Kovacheva, M., Snepp, E., 2005, 'Hierarchical modelling of archaeomagnetic data and curve estimation by moving average technique.' Geophys. J. Int. 160, 440–476

Linford, P. 2004. 'Archaeomagnetic dating'. Physics Education, 39(2), 145-154. (http://www.meteo.be/CPG/aarch.net/linford.pdf)

NASA, 2010. IGRF Geomagnetic Field Model.
http://nssdc.gsfc.nasa.gov/space/model/models/igrf.html [01/11/2010]

Noel, M., Batt, C.M., 1990. 'A method for correcting geographically separated remanence directions for the purpose of archaeomagnetic dating', Geophys. J. Int., 102, 753-756.

Schweingruber, F. H. 1990 *Anatomy of European Woods*

Stace, C.,1997, *New Flora of the British Isles*

Spence, R.T., 2002, *Skipton Castle and its Builders*

Zananiri, I., Batt, C.M., Lanos, Ph., Tarling, D.H., Linford, P., 2007. 'Archaeomagnetic secular variation in the UK during the past 4000 years and its application to archaeomagnetic dating' Journal of Archaeological Sciences. 160 (2), 97-107.