Danby Lodge Park Centre, Danby, Whitby

A Report on an Archaeological Watching Brief

Site	Danby Lodge National Park Centre, Lodge Lane, Danby, Whitby, YO21 2NB	
Site Code	DL22	
Local Planning	North York Moors National Park	
Location	National Grid Reference	NZ 71736 08261
	Easting and Northing	471736, 508261
	Latitude and Longitude	54.464663, -0.89477956
Planning	NYM/2022/0424	
Development	The installation of a ground source heat pump and the widening of a doorway to a building at the Danby Lodge National Park Centre	
Site Dates	5th – 30th of September and 3rd of October 2022.	
Field Team	Gigi Signorelli Ewan Chipping	
Specialist Contributions	Dr. G. McDonnell (Gerry McDonnell Archaeometals) Dr. J. Carrott (Paleoecology Research Services Ltd.))	
Text and Images	Gigi Signorelli and Donna Signorelli (Text) Gigi Signorelli (Images) Rebecca Scott (Edits)	
Date of Issue	January 2023	
Client	North York Moors National Park	

Summary

The watching brief revealed no evidence of any large scale bloomery within the excavated areas. It is likely that metal working evidence may be located closer to the river Esk and to the woods to the south; both areas were located just outside the monitored area. It was notable that there was no residual metal working waste found across the site. The stratigraphic matrix of the site was incredibly clean, no residual pottery or other domestic waste was observed within the silty sandy alluvial soils. To the south of the site was evidence of a paleochannel and a gravel deposit, both were situated in the exact locations determined during the 2007 geophysical survey.

The earliest archaeological evidence on site was contained within a small, bloomery/burned post hole that revealed a backfill rich in burned oak charcoal and iron smelting tap slag. The tap slag was dated to between 1322-1500. Another cobble filled pit was found within a similar archaeological level to the burned pit/post hole but contained no dating evidence. The tap slag is dated to the period contemporary with Danby Castle and it is likely there was a connection between both sites due to the absence of any other large institution.

A drainage system that had undergone two phases of improvement was observed traversing the site from east to west, as indicated on the 1853 Ordnance Survey Map. A 17th-18th century stone capped drain was later improved with additional 19th century parallel clay field pipes. Further to this, at ground level, directly above the drainage system, a clay lined ditch had been dug to further accommodate the flow of water down from the moors towards the river Esk. This drainage system is likely associated with Danby Lodge.

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Introduction

This report outlines the results of a recent archaeological watching brief carried out during the installation of a ground source heat pump system at the Danby Lodge National Park Centre, Danby, North Yorkshire (Figure 1).

Danby Lodge National Park Centre is situated within the Esk Valley, sited to the east of the village of Danby. The site is centred at NZ71736 – 08261. It is located within the grounds of Danby Lodge and is enclosed by the River Esk to the west and Crow Wood to the east.

A geophysical survey carried out within the grounds suggested the presence of archaeological deposits associated with a bloomery, paleochannel and ridge and furrow (Geo Quest Associates, 2007). Subsequently, an archaeological watching brief was requested during the groundworks to ensure that any hitherto unknown archaeological assets would be fully recorded. One of the aims of the archaeological watching brief was to try and determine the presence and date ranges of these deposits.

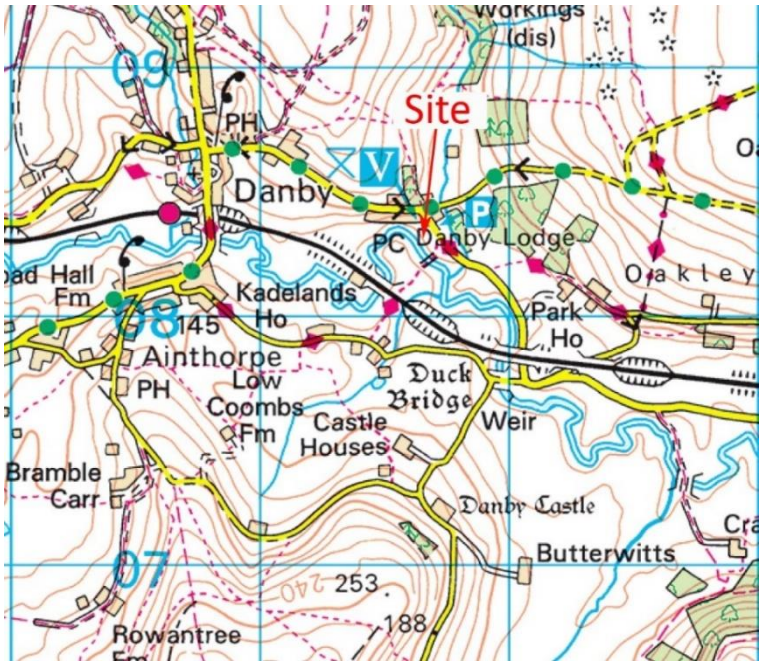

Figure 1: The location of the site is indicated in red.

Associated texts

- Geoquest Associates. (2007); Geophysical Survey on Two Areas at the Moors Centre, Danby, North Yorkshire.
- LS Archaeology. (2022); Archaeological Written Scheme of Investigation, Danby Lodge National Park Centre, Danby.

Planning

Full planning permission (NYM/2022/0424) was granted by the North York Moors National Park Authority for the installation of a ground source heat pump and the widening of a doorway to the Danby Lodge National Park Centre's building.

An archaeological condition was attached to the approved planning permission due to the site's location within an area of known archaeological activity, which also seeks to conserve and enhance the historic assets and cultural heritage of the National Park. **Condition 5:**

No development shall take place at the site until a Written Scheme of Investigation has been submitted to and approved in writing by the Local Planning Authority. The scheme shall include an assessment of significance and research questions – and [if indicated by the Desk Top Study submitted with the application]:

- *the programme and methodology of site investigation and recording.*
- *the programme for post investigation assessment.*
- *the provision to be made for analysis of the site investigation and recording.*
- *the provision to be made for publication and dissemination of the analysis and records of the site investigation.*
- *the provision to be made for archive deposition of the analysis and records of the site investigation.*
- *the nomination of a competent person or persons/organisation to undertake the works set out within the Written Scheme of Investigation.*

Reason:

In order that any remains of archaeological importance can be adequately investigated and recorded before any development takes place on the site and to comply with Strategic Policy I and Policy and Policy ENV10 of the North York Moors Local Plan which seeks to conserve and enhance the historic assets and cultural heritage of the National Park.

Decision Notice Letter dated: 17th August 2022.

Archaeological and Historical Summary

The Danby Lodge Moors Centre is located within the Esk Valley, an area rich in past human activity ranging from the prehistoric period through to the Industrial Revolution and beyond.

The scheduled monument Danby Rigg (1018782) includes the buried and earthwork remains of a predominantly Bronze Age landscape of farming and funerary activity with these higher elevations being preferable for settlement than the wetland river valleys. Nonetheless, river valleys such as the Esk would have supplied a rich hunting and foraging landscape.

During the Early and Middle Ages, when the valleys were under ownership of the de Brus family and later the Latimer's, woodland areas were cleared to create meadows for grazing. Some woodland was retained and later deer parks were created to safeguard the hunting stock from livestock (NYMNP, 2021).

During the 14th century, Lord Latimer instructed the construction of the architecturally pioneering Danby Manor Castle and Court. During the same period, infrastructure was improved with the instalment of Castle Bridge (later Duck Bridge) creating a routeway over the River Esk to the east. Bloomeries were functioning with cinder heaps visible and are likely to date to the late Medieval period. The location of the site close to the River Esk could suggest rural iron production, enhanced by the introduction of waterpower to operate bellows or trip hammers.

Danby Lodge, constructed in 1630, remained in private ownership until 1974 when work commenced to adapt the lodge to the NYMNP National Park Centre (NYMNP, 1976). During the 19th century, the Esk Valley Rail line became operational, supporting the expansion of the Esk Valley mining industry. The line is located to the south of Danby Lodge (Figure 2)

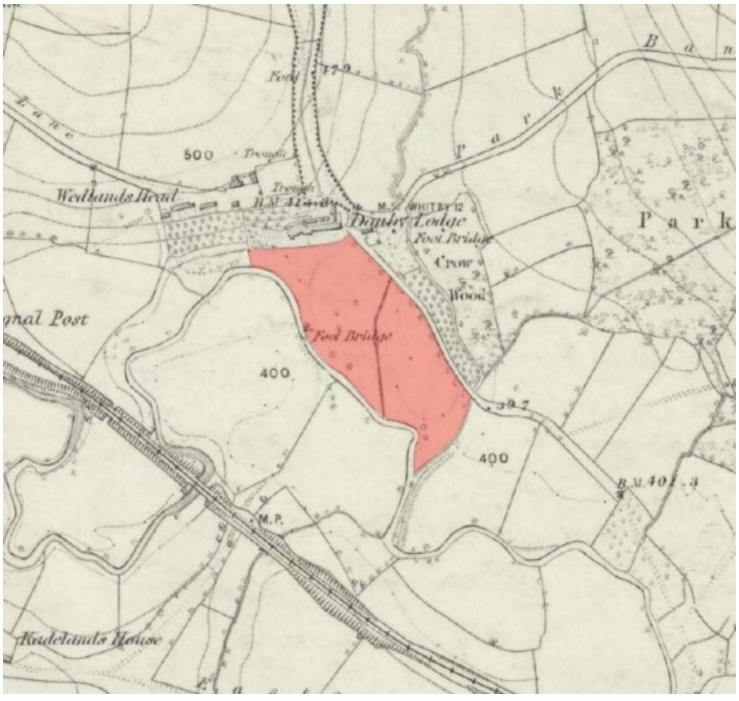

Figure 2: 1853 Ordnance survey map of the site within its immediate locality

Geology and Topography

Located at 870m from the village of Danby (formerly Dale End), the site (NZ 71736 08261) lies at a variable 136m to 124m above sea level. Covering an area of approximately 4889 m²; the majority of the site is currently laid as rough grass and is utilised as an over spill car park for the National Park Centre.

The site is situated within Danby Dale, a broad, relatively straight valley with low steep sides, enclosed by the projecting moorland ridges of Castleton Rigg and Danby Rigg (North York Moors National Park Authority, 2004). The river Esk meanders through this valley with its banks bounding the land containing the Centre.

Description	Geology
1:50 000 scale superficial deposits	Alluvial deposits. Alluvium is a general term for clay, silt, sand and gravel. It is the unconsolidated detrital material deposited by a river, stream or other body of running water as a sorted or semi-sorted sediment in the bed of the stream, its floodplain or delta, or as a cone or fan at the base of a mountain slope. Normally soft to firm consolidated, compressible silty clay but can contain layers of silt, sand, peat and basal gravel. A stronger, desiccated surface zone may be present.
1:50 000 scale bedrock geology description	Saltwick formation and Cloughton formation - sandstone, siltstone and mudstone. Sedimentary bedrock formed between 174.1 and 168.3 million years ago during the Jurassic period.

Geophysical Survey

The 2007 geophysical survey of the land to the southwest of the National Park Centre identified a variety of archaeological and geological features (Figure 3), including a possible buried paleochannel, traces of ridge and furrow field systems and two well-defined clusters of intense magnetic dipoles that may suggest evidence for concentrations of iron slag (Geo Quest Associates, 2007).

Area B was to undergo the greatest damage due intensive trench excavation to house the ground loops for the ground source heat pump. This level of excavation presented the opportunity to investigate the stratigraphic record for evidence of NW SE aligned ridge and furrow, fired material with ferrous litter and alluvial deposits associated with paleochannels.

Features f6 (Paleochannel) and f9 (furnace slag) are deemed to be 90% likely to be present. The furrows (f3) have a 70% chance of being in situ (Table 1). From this data, there is the opportunity to record archaeological deposits dating from the prehistoric through to the Medieval period.

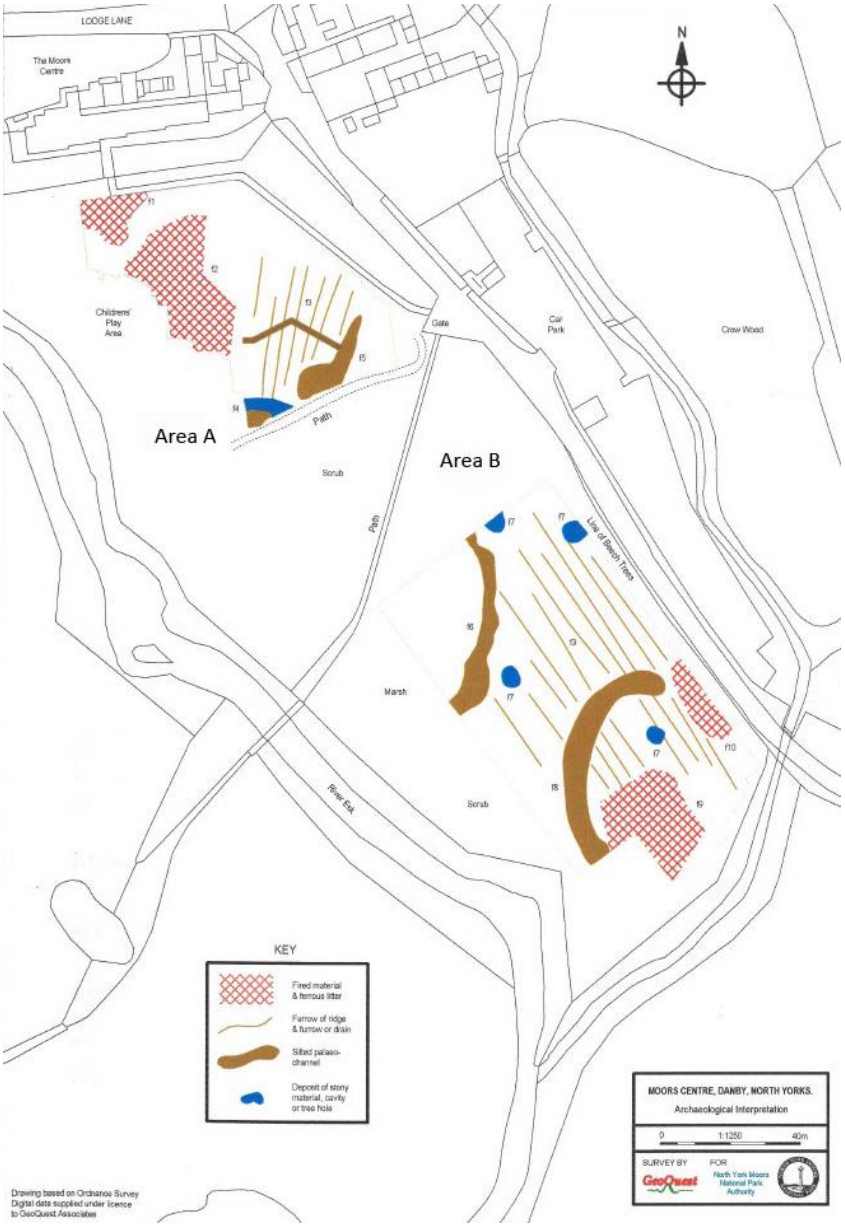

Figure 3: Archaeological interpretation of the 2007 geophysical survey (2007, Geo Quest Associates)

FEATURE	INTERPRETATION	CONFIDENCE LEVEL, %									
		10	20	30	40	50	60	70	80	90	100
f1	Iron litter or slag	■	■	■	■	■	■	■	■	■	
f2	Furnace slag	■	■	■	■	■	■	■	■		
f3	Furrows/ land drains	■	■	■	■	■	■	■			
f4	Palaeochannel	■	■	■	■						
f5	Channel/pit/ditch	■	■	■							
f6	Palaeochannel	■	■	■	■	■	■	■	■	■	
f7	Tree holes/pockets	■	■	■							
f8	Palaeochannel	■	■								
f9	Furnace slag	■	■	■	■	■	■	■	■	■	
f10	Iron litter/slag	■	■								

Table 1: Confidence Limits of the 2007 Geophysical Survey (2007, Geo Quest Associates).

Aims and Objectives

The broad aims of the watching brief are:

- To ensure that the watching brief, post-excavation and archive are carried out and fulfilled in accordance with guidance as stated in CIfA, (2014), *Standard and Guidance for an Archaeological Watching Brief*.

Site-Specific Value:

- What information is contained within the archaeological deposits and how is this data related to the current historical and archaeological narrative of the local area?
- Is there evidence of a paleochannel and, if so, what type of information does it potentially hold; is the potential for data high and, if so, what type of sampling strategy is required?
- Some of the groundworks will take place close to an area identified as a bloomery. What sort of archaeological data is present? Are structural features associated with a bloomery present or does it take the form of finds such as industrial waste and tools?
- The assessment of the industrial waste will reveal important information regarding the types of manufacturing taking place and methods for doing so. Can this information aid with the dating of the site and place its purpose into a wider local context?
- The bloomery is believed to have its origins in the Medieval period. Does the archaeological data concur with this theory or is there evidence that the bloomery predates this period?
- Danby Castle is located one kilometer to the south of the bloomery site and can be reached by crossing Duck Bridge. Can the archaeological deposits encountered impart any connection between the two locations?
- Ridge and furrow is present on the geophysical survey. Can a dating period be assigned to these features either from finds found within a primary or residual context?

Methodology

A mechanical excavator fitted with a toothless ditching bucket was used to excavate the seventeen trenches required for the installation of the ground heat source pump (Figure 4). Originally, all the excavated trenches were to be left open for a short period of time in order to fully record any archaeological remains and the stratigraphy of the site.

However, due to the restricted storage space for the excavated soil, the original plan was altered and a new strategy adopted. This meant that as soon as one trench was opened and the cable pipes laid, it was then backfilled immediately by the soil excavated from the adjacent trench.

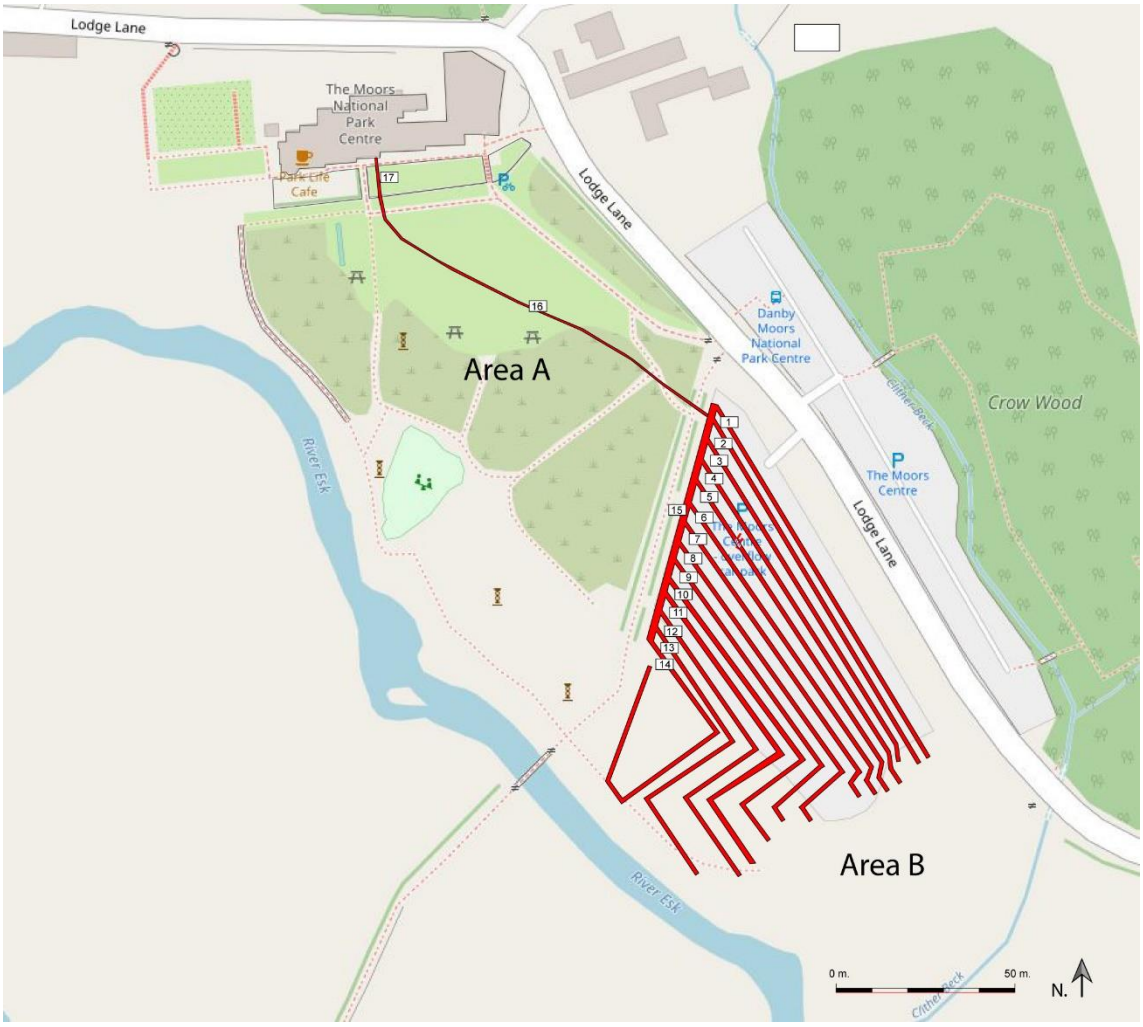

Figure 4: Site plan with the location of the trenches required for the ground source heat pump indicated in red.

To facilitate the recording of findings, the site was divided into two areas, A and B (Figure 4).

Figure 5: Area A, looking north towards Danby Lodge.

The field located to the front of Danby Lodge slopes downwards on a south to south-east direction (Figure 5). Ground to the north is levelled at 130.00m AOD, decreasing to 125.00m AOD to the south. Two trenches, 16 and 17, were excavated in this area, the purpose being to connect the manifold chamber from Area B to Danby Lodge.

Figure 6: Area B, looking north towards Danby Lodge.

A north north-east to south south-west footpath creates a boundary between the two areas, with Area B occupying a large relatively flat field, levelled at 124.00m AOD and formerly being the overflow carpark for the Lodge (Figure 6).

The ground source heat pump system required a total of fifteen trenches to be opened within Area B, with fourteen trenches orientated north-west to south-east, having average dimensions of 100.00m x 1.10m and 1.00m totalling 1400.00m of trench loops. Trenches were spaced evenly apart (2.00m) and were excavated in shallow spits to enable any archaeological features/deposits to be observed and recorded.

Trench 15 was orientated north-east to south-west and was positioned at the northern end of Area B. Its dimensions were 70.00m x 2.00m x 1.20m and was excavated to create the manifold chamber to which all ground loops connect.

Trench recording involved the hand cleaning of sections every 2.00m with the results being noted and photographed.

A standard single context recording system was used to keep a documented record of all contexts encountered and sections drawn onto permatrace to a scale of 1:10, with plans drawn at 1:20 scale.

Digital photographs were taken and a selection of these are reproduced below.

A Leica TS07 Total Station was used for the survey as a GPS system couldn't function due to the lack of a telephone signal.

Post-Excavation Analysis

The watching brief produced 28 contexts and 17 trench interventions (Appendix 1). All records and photographs of said contexts were suitably stored and catalogued, in accordance with the CIfA (2014 d); *Standard and Guidance for the Collection, Documentation, Conservation and Research of Archaeological Materials* and (Watkinson & Neal, 1998).

A small assemblage of slag was found within pit [6] and was sent to Dr. Gerry Mc Donnell for further assessment (Appendix 2).

One judgement based large sample (10-20 litres) suitable for flotation was taken from pit [6] (English Heritage, 2011). Dr. John Carrott of the Palaeoecology Research Services advised upon sampling and assessed its potential (Appendix 3).

Results

The archaeological watching brief involved the monitoring of the excavation of seventeen trenches within two areas (A and B) by a mechanical excavator fitted with a toothless bucket. The archaeological results from each of the seventeen trenches are summarised below.

Two 14th-16th century pits ([**6**] and [**8**]), two 19th century field drains ([**15**] and [**18**]) and a 19th-20th century ditch ([**12**]) were observed during the watching brief being visible in trenches 1, 2, 13 and 14 respectively (Table 2).

The stratigraphic matrix of the site consisted of topsoil overlying three naturally formed geological layers and comprised an alluvial deposit associated with the river Esk flooding activity (**2**) , a paleochannel (**9**) and a gravel deposit (**25**). (Figure 7).

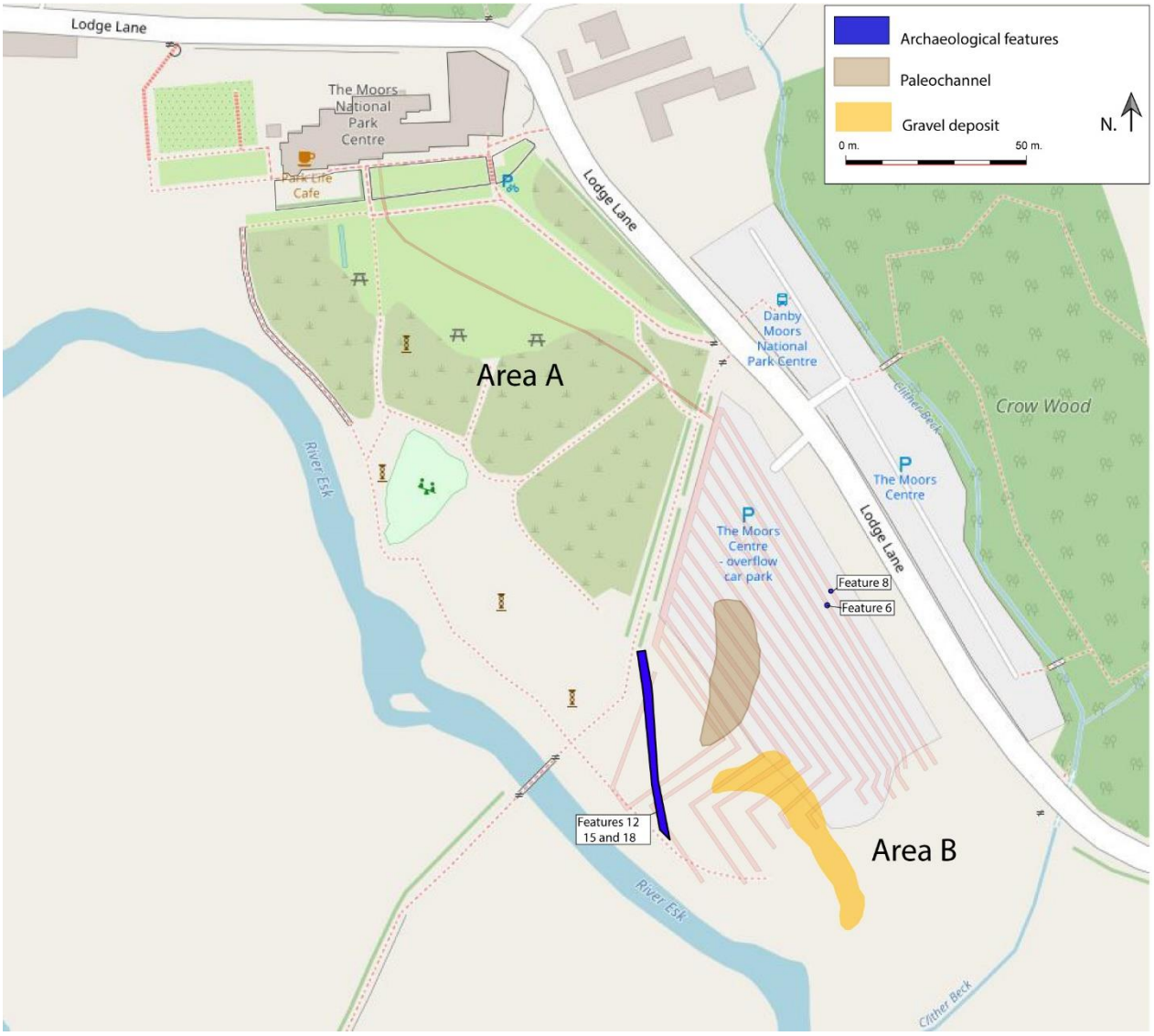

Figure 7: Site plan showing the locations of the archaeological features, paleochannel and gravel deposit.

Table 2: Context Index

Context	Feature	Description	Period
1		Topsoil in Area A	Modern
2		Strong orange, brown, silty sand	Geological Post glacial alluvial
3		Tarmac and associated made ground	Modern
4		Made up ground associated with the construction of the terrace	19th - 20th
5	6	Fill of a small pit [6]	14th-16th century
6	6	Cut of a small charcoal and slag rich pit	14th-16th century
7	8	Cobbles, fill of a pit [8]	Uncertain
8	8	Cut of an oval shape in plan pit	Uncertain
9		Fill of a paleochannel	Geological post-glacial alluvial
10	12	Upper fill of a North-west to South-east ditch [12], present within trenches 13 and 14	19th - 20th
11	12	Very sticky white / light yellowish brown clay. Lining of ditch [12]	19th - 20th
12	12	Cut for a north-west to south-east ditch. Cuts drain [15] and [18]	19th - 20th
13	15	Fill of cut [15] covers the drain clay pipe (14)	Mid to late 19th
14	15	Clay pipe (drain), laid within cut [15]	Mid to late 19th
15	15	Cut for a clay pipe field drain. Runs adjacent to the stone drain [18] and cut by ditch [12]	Mid to late 19th
16	18	Fill of a stone drain [18]	Early 19th
17	18	Square drain stone structure	Early 19th
18	18	Cut for a north-west to south-east capped stone drain	Early 19th
19		Topsoil in Area B	Modern
20		Natural deposit of clay and gravel bands. Similar to context 24	Geological Post glacial alluvial
21		Tarmac layer. Laid on top of (22)	Modern
22		Made-up ground for the tarmac footpath (21)	Modern
23		Cut for an East to West footpath, filled by contexts (21) and (22)	Modern
24		Natural yellowish grey, brown sandy clay deposit. Underneath (2), (19), (25) and (26). Same as (20)	Geological
25		Natural grey, brown sand and gravel deposit, overlays the natural clay (24) under alluvial deposit (26)	Geological
26		Alluvial deposit overlaying the gravel deposit (25)	Geological Post glacial alluvial
27		Terrace retaining wall	19th - 20th
28		Topsoil over the terrace, abutted by tarmac (3) and overlay context (4)	Modern

Trench 1 (29)

Orientated north-west to south-east, trench 1 had the following dimensions: 110.00m x 1.10m x 1.20m. The stratigraphic matrix comprised topsoil (**19**) overlaying the natural orange, brown silty sand (**2**) (Figure 8). A cobble/stone filled pit (**7**), [**8**], was recorded within the limits of the trench.

Figure 8: The natural geology as observed in section in Trench 1.

Pit feature [8]

Located towards the center of Trench 1, buried under topsoil (**19**) and cutting the natural (**2**), this feature was ovate in plan and measured 0.90m in length, 0.45m in width and 0.45m in depth. It was filled by a single deposit (**7**), consisting of a mixed loose yellowish grey silty sand and large cobbles (Figures 9-11).

Figure 9: Pre-excavation photograph of pit [8].

The cobbles were mostly accumulated along the eastern part of the feature, indicating a possible packing function for a potential post, although no evidence of a decomposed post or staining was noticed. No dating material was found within the pit. The nature and date of this pit are uncertain.

Figure 10: North-east facing section of feature [8].

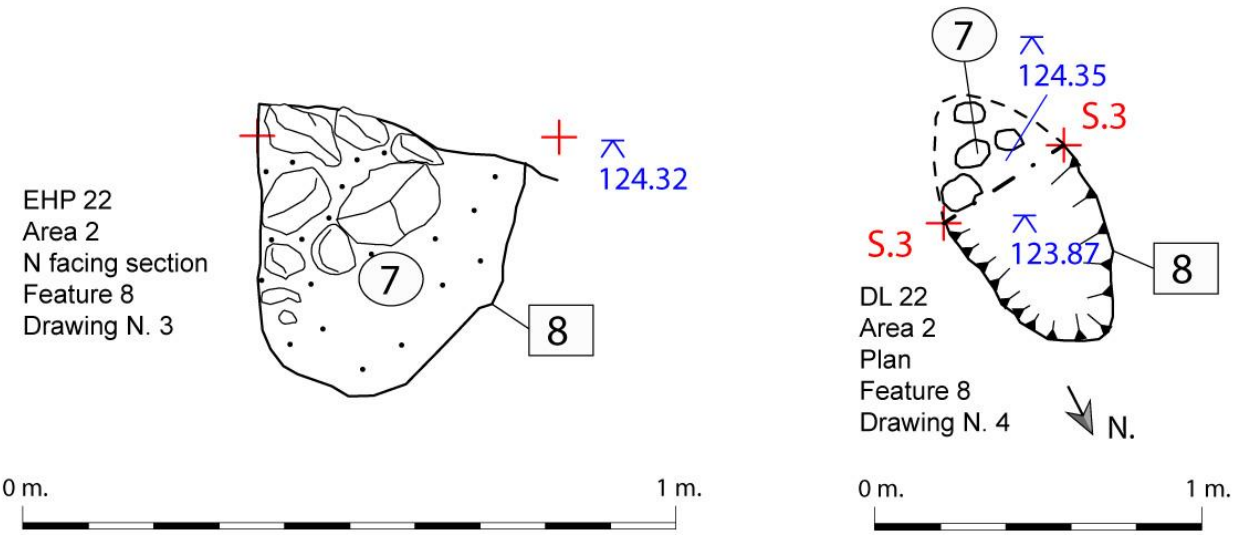

Figure 11: Section and plan drawings of pit [8].

Trench 2 (30)

Orientated north-west to south-east, trench 2 had the following dimensions: 110.00m x 1.10m x 1.20m. This trench was located to the immediate west of Trench 1. The stratigraphic matrix comprised topsoil (**19**) overlaying the natural silty sand (**2**) (Figure 12). One archaeological feature was identified, a small pit [**6**] filled with charcoal and metal slag (**5**).

Figure 12: The natural geology as observed in section in Trench 2.

Pit feature [6]

This pit feature was sealed under topsoil (**19**) and cut into the natural (**2**). It had a rounded shape with vertical edges, measuring 0.43m in length, 0.43m in width and 0.12m in depth (Figures 13-15).

Figure 13: Pre-excavation photograph of pit [6].

The fill (**5**) consisted of a mixed sand containing large and small charcoal blocks and slag. Along the edges and at the base, the natural ground showed evidence of reddening, most likely caused by substantial heat. The content of the fill and the reddening at the base of the feature could suggest the use of this feature as a small bloomery (Carrott, 2022) or may constitute a burned posthole with slag packing (Mc Donnell, 2022).

Figure 14: Feature [6] looking north-east.

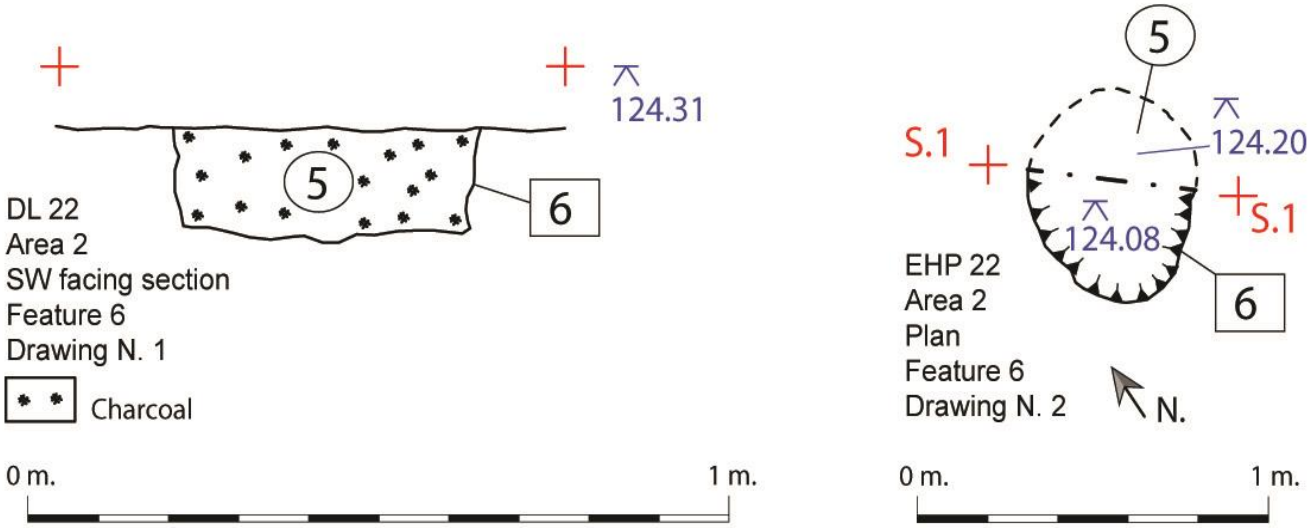

Figure 15: Section and plan drawings of pit feature [6].

Trench 3 (31)

Orientated north-west to south-east, trench 3 had the following dimensions: 105.00m x 1.10m x 1.10m. This trench was located to the immediate west of Trench 2. The stratigraphic matrix comprised topsoil (**1**) with (**19**) overlaying silty sand (**2**) (Figure 16). No archaeology was present.

Figure 16: The natural geology as observed in section in Trench 3.

Trench 4 (32)

Orientated north-west to south-east, trench 4 had the following dimensions: 100.00m x 1.10m x 1.20m. This trench was located to the immediate west of Trench 3. The stratigraphic matrix comprised topsoil (**19**) overlaying silty sand (**2**) (Figure 17). No archaeology was present.

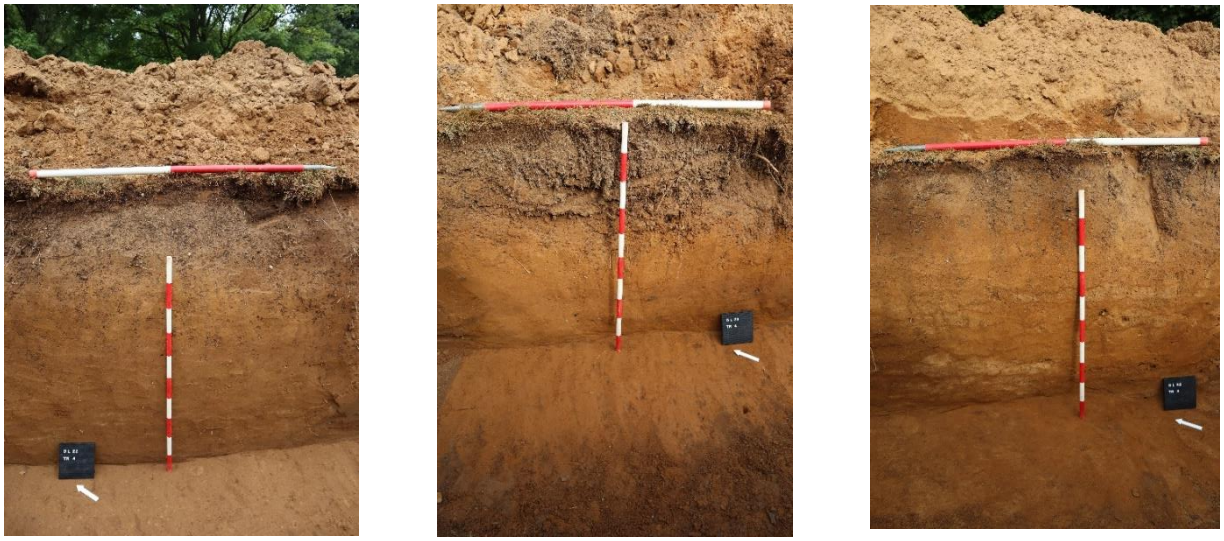

Figure 17: The natural geology as observed in section in Trench 4.

Trench 5 (33)

Orientated north-west to south-east, trench 5 had the following dimensions: 100.00m x 1.10m x 1.20m. This trench was located to the immediate west of Trench 4. The stratigraphic matrix comprised topsoil (**19**) overlaying the silty sand (**2**) (Figure 18). No archaeology was observed within the trench.

Figure 18: The natural geology as observed in section in Trench 5.

Trench 6 (34)

Orientated north-west to south-east, trench 6 had the following dimensions: 100.00m x 1.10m x 1.20m. This trench was located to the immediate west of Trench 5. The stratigraphic matrix comprised topsoil (**19**) overlaying natural silty sand (**2**) (Figure 19). No archaeology was present.

Figure 19: The natural geology as observed in section in Trench 6.

Trench 7 (35)

Orientated north-west to south-east, trench 7 had the following dimensions: 100.00m x 1.10m x 1.20m. This trench was located to the immediate west of Trench 6 following the same layout as the previous trench. The matrix was the same as observed in trenches 3-6 and consisted of topsoil (**19**) overlaying the silty sand (**2**) (Figure 20). No archaeology observed within the trench.

Figure 20: The natural geology as observed in section in Trench 7.

Trench 8 (36)

Orientated north-west to south-east, trench 8 had the following dimensions: 100.00m x 1.10m x 1.20m. This trench was located to the immediate west of Trench 7. The stratigraphic matrix was the same in trenches 8-14 and comprised topsoil (**19**) overlaying silty sand (**2**). Also overlaying the natural (**2**) was the paleochannel (**9**), located at the northern end of the trench with the natural gravel (**25**), located to the south (Figure 21). Archaeological features were not visible within the trench.

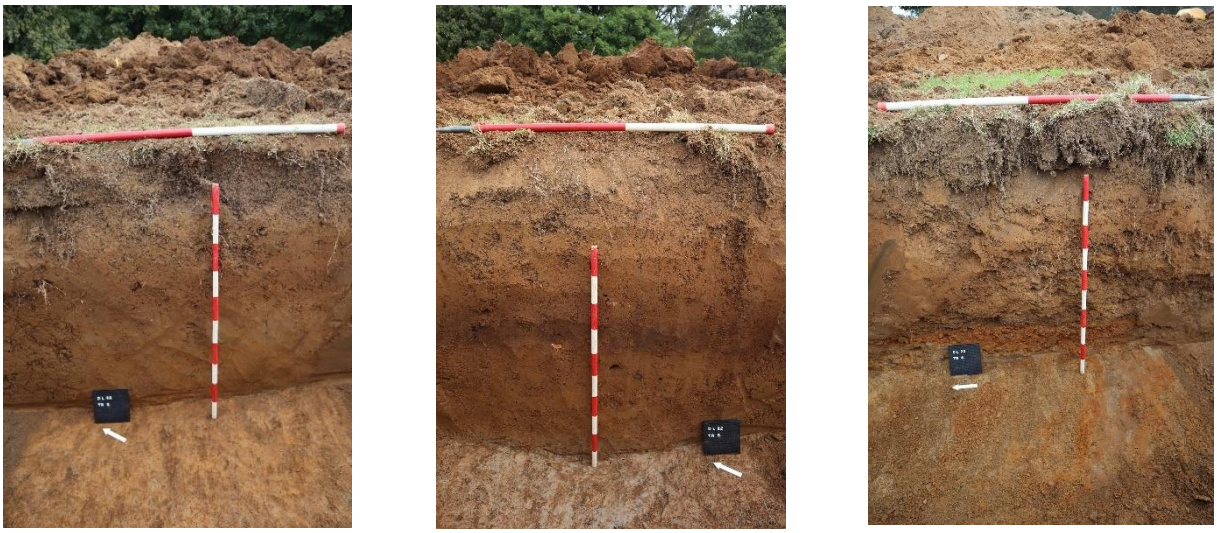

Figure 21: The natural geology and evidence of the paleochannel, as observed in section in Trench 8.

Trench 9 (37)

Orientated north-west to south-east, trench 9 had the following dimensions: 100.00m x 1.10m x 1.20m. This trench was located to the immediate west of Trench 8. The matrix comprised topsoil (**19**) overlaying the natural silty sand (**2**). Also overlaying the natural (**2**) was the paleochannel (**9**) which was situated at the northern end of the trench, whereas the natural gravel (**25**) was located towards the southern part of the trench (Figure 22). No archaeology was present.

Figure 22: The natural geology and evidence of the paleochannel, as observed in section in Trench 9.

Trench 10 (38)

Orientated north-west to south-east, trench 10 had the following dimensions: 100.00m x 1.10m x 1.20m. This trench was located to the immediate west of Trench 9. The matrix comprised topsoil (**19**) overlaying orange, brown silty sand (**2**). Overlaying the natural (**2**) was the paleochannel (**9**) located at the northern end of the trench with the natural gravel (**25**) and alluvial deposit (**26**) located towards the southern part of the trench (Figure 23). No archaeology present within this trench.

Figure 23; The natural geology and evidence of the paleochannel, as observed in section in Trench 10. From left to right looking northeast and southeast.

Trench 11 (39)

Orientated north-west to south-east, trench 11 had the following dimensions: 100.00m x 1.10m x 1.20m. This trench was located to the immediate west of Trench 10. The stratigraphic matrix comprised topsoil (**1**) and (**19**) overlaying the natural silty sand (**2**) and clay (**24**). Overlaying the natural (**2**) and (**24**) was the paleochannel (**9**), situated at the centre of the trench, whereas the natural gravel (**25**) and alluvial deposit (**26**) was located towards the south (Figure 24). No archaeology was observed within this trench.

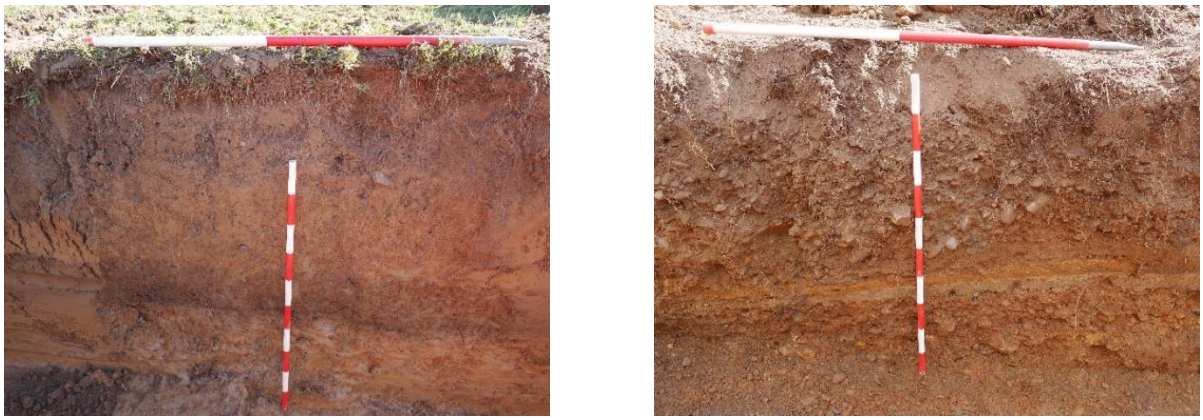

Figure 24: The natural geology and evidence of the paleochannel, as observed in section in Trench 11. From left to right looking northeast and southeast.

Trench 12 (40)

Orientated north-west to south-east, trench 12 had the following dimensions: 100.00m x 1.10m x 1.20m. This trench was located to the immediate west of Trench 11. The stratigraphic matrix comprised topsoil (**19**) overlaying silty sand (**2**) and clay (**24**). Overlaying the natural (**2**) and (**24**) was the paleochannel (**9**) located at the centre of the trench with alluvial deposit (**26**) located towards the southern part of the trench (Figure 25). No archaeology was present.

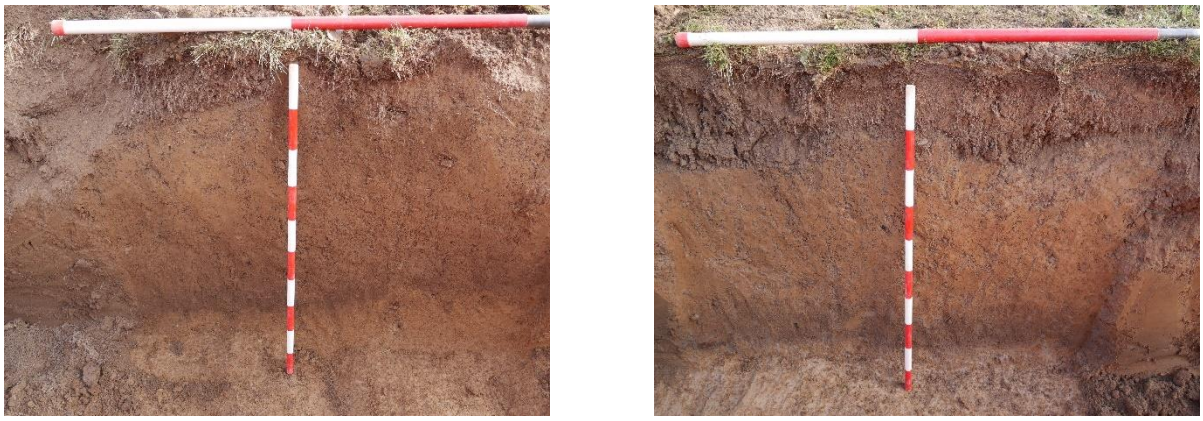

Figure 25: The natural geology and evidence of the paleochannel, as observed in section in Trench 12. From left to right looking northeast.

Trench 13 (41)

Orientated north-west to south-east, trench 13 had the following dimensions: 100.00m x 1.10m x 1.20m. This trench was located to the immediate west of Trench 12. The matrix comprised topsoil (**19**) overlaying the natural silty sand (**2**) and clay (**24**). Overlaying the natural (**2**) and (**24**) was the paleochannel (**9**) located at the centre of the trench with alluvial deposit (**26**) located towards the southern part of the trench. A north-west southeast orientated ditch and two field drains [**12**],]**15**] and [**18**] were present within trenches 13 and 14 Figure 26).

Figure 26: The natural geology and evidence of the paleochannel, as observed in section in Trench 13. From left to right looking northeast.

Trench 14 (42)

Orientated north-west to south-east, trench 14 had the following dimensions: 100.00m x 1.10m x 1.20m. This trench was located to the immediate west of Trench 13. The matrix consisted of topsoil (**19**) overlaying the natural silty sand (**2**) and clay (**24**). Overlaying the natural (**2**) and (**24**) was the paleochannel (**9**) located at the centre of the trench with the alluvial deposit (**26**) located towards the south. A north-west southeast orientated ditch and two field drains [**12**],]**15**] and [**18**] were present within trenches 13 and 14 (Figure 27).

Figure 27: The natural geology and evidence of the paleochannel, as observed in section in Trench 14. From left to right looking northeast.

Linear feature [12]

This linear ditch feature [**12**] was visible at ground level, presenting as a shallow concaved ground depression and extending as a ditch to 0.80m below ground level. It was fully observed within trenches 13 and 14 and was excavated for a combined total length of 4.80m. Orientated north-west to south-east and located towards the western side of Area B, it was identified and recorded from section. It measured 2.10m in width and extended to a depth of 0.80m.

Figure 28: Trench 14, north facing section showing ditch [12] cutting field drains [15] and [18].

Figure 29: Trench 14, plan of drains [15] and [18].

This ditch was filled by two deposits with the upper fill (**10**) consisting of a homogenous strong brown clay silt mixed with small gravel, extending to a depth of 0.60m. Sealed by context (**10**), was a 0.20m thick light yellowish-brown clay (**11**) mixed with small, fragmented sandstone blocks. This context was identified as a possible lining of the ditch, presumably to improve its permeability (Figures 28-29).

Field drain [15]

Running on the same alignment and cut by ditch [**12**], feature [**15**] was identified as a field drain filled by a homogenous dark brown silty clay (**13**) overlaying segmented clay pipes (**14**). Each clay pipe segment measured 0.34m in length and 0.20m in diameter (Figure 29).

Capped drain [18]

Not fully excavated and only recorded in plan, this feature located at the western side of Area B, extending in the same direction as features [12] and [15], was recorded as being a stone-built drain (Figures 29-31).

The drain was constructed from yellow limestone blocks (17) and was as wide as it was deep; 0.40m in width and 0.40m deep. A dark reddish-brown silty clay filled the gaps between the cut [18] and the structure (17). Only the southern part of this feature survived, the upper part truncated by ditch [12] and the northern part removed by drain [15]. This feature was recorded to a depth of 1.1m below ground level. The drain exceeded the depth of the trench and will subsequently be preserved in situ.

Figure 30: Trench 13, capped drain [18].

Figure 31: Trench 13, capped drain [18] and sondage cut to investigate construction methods.

Trench 15 (43)

Orientated north-west to south-east, trench 15 had the following dimensions: 70.00m x 2.00m x 1.30m. This trench was located to the north of Area 2. The stratigraphic matrix comprised topsoil (**1**) overlaying the natural silty sand (**2**) and clay (**24**) (Figure 32). No archaeology was present.

Figure 32: The natural geology as observed in section in Trench 15.

Trench 16 (44)

Orientated north-west to south-east, trench 16 had the following dimensions: 113.00m x 0.60m x 0.60m. This trench was located to the immediate south of the Lodge terrace. The matrix comprised topsoil (**1**) overlaying the natural silty sand (**2**) and clay (**24**). Overlaying the natural (**2**) was the tarmac footpath (**21**) and made ground (**22**) [**23**] (Figure 33). No archaeology was present.

Figure 33: The hardcore stratigraphic matrix in Area A underneath the footpath and natural bands of geology further to the south as observed in Trench 16.

Trench 17 (45)

Orientated north-south, trench 17 had the following dimensions: 12.00m x 0.50m x 0.60m. The stratigraphy consisted of a layer of tarmac (**3**) and associated made ground (**4**) which forms the footpath adjacent to the entrance of the centre (Figure 34).

Figure 34: Trench 17 extended towards the entrance of Danby Lodge with the stratigraphy consisting of disturbed garden soils with shallow layers of hardcore present at the entrance.

Discussion

The broad aims of the evaluation were:

To ensure that the watching brief, post-excavation and archive are carried out and fulfilled in accordance with guidance as stated in CIfA, (2014), *Standard and Guidance for an Archaeological Watching Brief*.

Site-specific value:

What information is contained within the archaeological deposits and how is this data related to the current historical and archaeological narrative of the local area?

The latest feature on site consists of a large clay lined concave ditch cutting a mid-19th to early 20th century clay pipe drain. Both systems overlay and/or run parallel to an earlier post-Medieval capped drain. The alignment and trajectory of this multiple drainage system corresponds to that depicted in the 1853 first edition Ordnance Survey Map (Figure 35).

The location of the site at Danby Lodge on relatively flat pastureland beneath the rising moors to the north, would have required adequate drainage to remain flood free. Quantities of water flow down from the moors via Clither Beck, emptying into the River Esk. It may be the case that additional drains were formed to further dissipate the stream to ensure flood waters did not hamper access to the lane connecting Danby Lodge to Lawns road to the south. It is likely that the earlier 17th-18th century capped drain was installed after the construction of Danby Lodge in 1630. Later during the 19th century, another ceramic pipe field drain was laid parallel to the original capped drain. At this point or later, a ground level ditch was dug and lined with clay, directly above the field drains to further support the movement of water away towards the Esk.

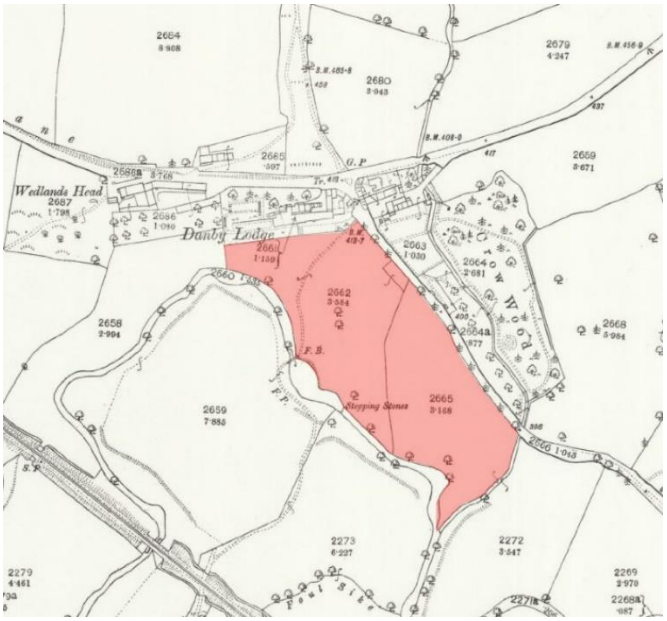

Figure 35: 1853 Ordnance survey map with the line of the drainage systems traversing the center of the site.

Two pits, one dating to an earlier period, were present on site. The cobbled filled pit was found relatively close to another pit that had evidence of burning and contained a good amount of oak charcoal (Carrott, 2022; Appendix 3) and iron smelting tap slag. The assessment of the slag provides a date range from 1322-1500 for the burned pit. The cobble pit contained no dating material but was found at a similar archaeological horizon to the burned pit with both being situated 0.30m-0.35m below ground level. It is possible that this evidence of either a small bloomery or a burned posthole are contemporary with the construction of the 14th century Danby Castle. The time periods correlate and a metal working site would require a funding source as well as a purpose.

Is there evidence of a paleochannel and, if so, what type of information does it potentially hold; is the potential for data high and, if so, what type of sampling strategy is required?

The remains of a paleochannel were observed in trenches 7-14. On inspection, it comprised a single (visible) layer of sterile alluvial silts. It was agreed that this natural geological feature did not offer much potential, therefore it was not sampled. It is however preserved in situ within the areas unaffected by trenching.

Some of the groundworks will take place close to an area identified as a bloomery. What sort of archaeological data is present? Are structural features associated with a bloomery present or does it take the form of finds such as industrial waste and tools?

Unusually, when considering the proximity of a possible bloomery, the only evidence of metal working was a small sample of iron smelting tap slag, contained within the discrete, burned pit. There was no residual waste found across the site. However, the burned post hole, if this interpretation is to be accepted, could be related to an ancillary building such as a charcoal store (Mc Donnell, 2022; Appendix 2).

The assessment of the industrial waste will reveal important information regarding the types of manufacturing taking place and methods for doing so. Can this information aid with the dating of the site and place its purpose into a wider local context?

A small quantity of iron smelting tap slag was found and sent for further assessment. There are limitations to what such a small sample size can yield in terms of the site's metal working function and production. Assessment revealed that the iron smelting tap slag had a very similar mineralogy and chemistry to the sample retrieved from Danby Lodge in 2008, and to those from the Cistercian sites in Bisdale North Yorkshire. The Cistercian sites at Bilsdale were large water-powered furnaces, operating at near maximum efficiency resulting in slags low in iron oxide (Appendix 2: Mc Donnell, 2023).

The bloomery is believed to have its origins in the Medieval period. Does the archaeological data concur with this theory or is there evidence that the bloomery predates this period?

The small quantity of tap slag is dated to the 14th-16th century. There was no evidence of earlier metal working on site.

Danby Castle is located one kilometer to the south of the bloomery site and can be reached by crossing Duck Bridge, formally Castle Bridge. Can the archaeological deposits encountered impart any connection between the two locations?

A working bloomery would require funding to undertake the metal working as well as a purpose for the items it was manufacturing. The only large institution of any wealth and importance within the immediate vicinity of the site is Danby Castle. Due to this and a similar date range, it would appear likely that any metal working at the location of Danby Lodge would have been associated with this Castle.

Ridge and furrow are present on the geophysical survey. Can a dating period be assigned to these features either from finds found within a primary or residual context?

The stratigraphic composition of the site contained no evidence of ridges and furrows. This may be due to the area having undergone systematic landscaping in previous years.

Archive

The archaeological watching brief did not produce a physical archive. A digital copy of this report will be deposited with the North York Moors National Park Historic Environment Records Office. A copy will be uploaded to OASIS for inclusion in the accredited Archaeological Data Service repository. This will ensure the data is archived online and easily accessible for future research. The OASIS report submission, once validated, will be included in the Archaeology Data Service LS Archaeology grey literature records page:

https://archaeologydataservice.ac.uk/archives/view/greylit/browse.cfm?unit=LS%20Archaeology

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Appendix 1: Context Data

Context	Feature	Location	Type	Shape	Profile	Length cm	Width cm	Depth cm	Notes
1		Area A	Topsoil	Flat	Layer	NA	NA	30	Topsoil in Area A. Consist of a strong brown clay silt mixed with 5% of small gravel. Occasional presence of C19th- C20th century pottery. Same as (19).
2		Area B	Natural	Deposit	Layer	NA	NA	80	Strong orange, brown silty sand, located to the East and North-east of the field (Area B), overlaying a clay deposit (24) and the remains of a possible paleochannel (9).
3		Area A	Tarmac	Deposit	Layer	65 Exc.	30	30	Tarmac and associated made ground. The tarmac layer measures 7 cm in depth overlaying a layer of grey fragmented stones and sand, measuring 23cm deep. Identified as part of the footpath adjacent to the Centre.
4		Area A	Made ground	Deposit	Layer	60	360	50	Mixed yellowish brown sandy silty clay. Includes fragmented sandstone blocks with some showing tool marks. Interpreted as the made ground associated with the construction of the terrace. The rubble deposit is most likely to be associated with the construction of Danby Lodge.
5	6	Area B Trench 2	Fill	Oval	U shaped flat base	40	43	12	Fill of a small pit. Consists of a mixture of small and large blocks of charcoal, also contains slags. Thought to be burned in situ, since the soil at the base was red form heat. Possible waste from bloomery.
6	6	Area B Trench 2	Cut	Oval	U shaped flat base	40	43	12	Straight sided cut with a flat base. Identified as a possible bloomery. At the base the ground appeared to have been redden by heat indicating fire activity.

Context	Feature	Location	Type	Shape	Profile	Length cm	Width cm	Depth cm	Notes
7	8	Area B Trench 1	Fill	Oval	U shaped	90	45	45	Loose yellowish grey silty sand, mixed with 40% of large cobbles, mainly accumulated along the eastern side of the feature. Identified as the cobble fill of a pit. (Some cobbles seemed burned).
8	8	Area B Trench 1	Cut	Oval	U shaped	90	45	45	With an oval shape in plan and orientated north to south, this feature had vertical edges and a concave base. Interpreted as a possible pit excavated in order to dispose of the cobbles context (7).
9		Area B	Deposit	Layer	Layer	3700	NA	66	This context consists of a dark brown / black clay silt, layer measuring in average 0.4m in thickness and is approximately 0.7m below the ground surface, sandwiched between natural deposits (2) and (24). It was present in trenches 8, 9, 10, 11, 12 and 13, and identified as the remains of a paleochannel.
10	12	Area B	Fill	Linear	Concave	4800	210	60	This context, located at the western end of the field (Area B). Consists of a thick strong brown clay silt mixed with 5% of small gravel. Very homogenous. Recorded from section and identified as the upper fill of a North-west to South-east ditch, present within trenches 13 and 14.
11	12	Area B	Fill	Linear	Square	4800	210	20	Very sticky white / light yellowish brown clay mixed with small sandstone fragments. Identified and recorded from section, as the lining of ditch [12], most likely functioned as waterproofing in order to make the ditch more efficient on water managing.
12	12	Area B	Cut	Linear	Concave	4800	210	80	Cut for a north-west to south-east ditch, located at the southern end of the field (Area B). Edges cutting at about 45°, with a concave base. Cuts drain [15 and [18]. Seen in trenches 13 and 14.

Context	Feature	Location	Type	Shape	Profile	Length cm	Width cm	Depth cm	Notes
13	15	Area B	Fill	Linear	Layer	4800	50	30	Homogenous, very sticky dark grey clay. Fill of cut [15] covers the drain clay pipe (14).
14	15	Area B	Fill	Linear	Conical	34	20	20	Clay pipe (drain), laid within cut [15]. Each drain segment consists of a conical clay pipe that measures 0.34cm long and 0.20cm in diameter.
15	15	Area B	Cut	Linear	U shaped	4800 exp.	50	30	Linear cut with vertical edges and a concave base. Identified as the cut for a clay pipe field drain. Runs adjacent to the stone drain [18] and was cut by ditch [12].
16	18	Area B	Fill	Linear	Layer	4801 exp.	50	40	Homogenous reddish brown silty clay, mixed with 5% of small gravel. Identified as the fill of a stone drain [18], covering the stone structure (17).
17	18	Area B	Fill	Linear	Layer	4802 exp.	40	40	Square drain stone structure. Consists of large sandstone blocks, each measures in average 40cm long, 20cm wide and 5cm thick. It seems that the drain may have had a cap, however it appeared that some of the upper stones (cap) were dislodged by ditch [12]. No bonding material was present.
18	18	Area B	Cut	linear	U shaped	4803 exp.	50	40	Cut for a north-west to south-east stone drain. Recorded in plan, since it was seen at the base of trenches 13 and 14 were the maximum depth for these trenches was reached at 1.10m. The drains [15] and [18] were not fully excavated and will be preserved in situ.
19		Area B	Topsoil	Deposit	Deposit	NA	NA	30	Topsoil in Area B. Consisted of a strong brown clay silt mixed with 5% of small gravel. Overlaid by pasture grass. Same as (1).
20		Area A	Natural	Deposit	Deposit	1100 exc.	60	30	Natural deposit of clay and gravel bands recorded within the limits of trench 16, in Area A. Similar to context 24.

Context	Feature	Location	Type	Shape	Profile	Length cm	Width cm	Depth cm	Notes
21		Area A	Tarmac	Deposit	Layer	150	60	8	Thin layer of tarmac, laid as part of a second footpath, that runs east - west and is located at the base of the Danby Lodge terrace. Laid on top of (22)
22		Area A	Access Road Trench	Linear	Layer	180	60	50	Made ground for the tarmac footpath (21). Consists of a mixture of small, fragmented sandstone, CBM and gravel and mortar.
23		Area A	Cut	Linear	U shaped flat base	150	60	58	Cut for an East to West footpath, it has vertical edges and a concave base. Filled by contexts (21) and (22).
24		Area B	Natural	Deposit	Layer	NA	NA	90	Natural yellowish grey, brown sandy clay deposit mostly present at the centre and south-west of the field (Area B). This context was seen to be underneath (2), (19), (25) and (26). Same as (20).
25		Area B	Natural	Deposit	Layer	NA	NA	80	Context allocated to a grey, brown sand and gravel deposit located to the South-east of the field (Area B) and forms a bank between the river Esk and the higher ground of Area B. This context overlay the natural clay (24) and is under alluvial deposit (26). Identified as the northern bank of the river Esk.
26		Area B	Natural	Deposit	Layer	NA	NA	80	This is a strong brown sandy silt deposit located to the south of the site overlaying the gravel deposit (25). Only seen in trenches 13 and 14, interpreted as an alluvial deposit associated with the river flooding activity.
27		Area A	Structure	Wall	Linear	NA	60	210	Terrace retaining wall made of large sandstone blocks, measuring in average 0.4m long, 0.3m wide and 0.2m deep.
28		Area A	Topsoil	Layer	Layer	NA	50 exc.	25	Topsoil over the terrace, made of a dark brown sandy silt clay, abutted by tarmac (footpath) (3) and overlay context (4).
29	Trench 1	Area B	Card	Linear	Square	10000	110	100	Trench 1 orientated North-west to South-east, was 110m long, 1.10m wide and 1.20m deep. The ground cover was grass. The

Context	Feature	Location	Type	Shape	Profile	Length cm	Width cm	Depth cm	Notes
									geology consists of topsoil (19) overlaying the natural (2). A rock filled pit (7), [8] was recorded within the limits of the trench.
30	Trench 2	Area B	Card	Linear	Square	10000	110	100	Trench 2 orientated North-west to South-east, was 110m long, 1.10m wide and 1.20m deep. This trench was located to the immediate west of Trench 1. The ground cover was grass. The geology consists of topsoil (19) overlaying the natural (2). One archaeological feature [6] identified, filled with charcoal and metal slags (5).
31	Trench 3	Area B	Card	Linear	Square	10500	110	110	Trench 3 orientated North-west to South-east, was 105m long, 1.10m wide and 1.10m deep. This trench was located to the immediate west of Trench 2. The ground cover was grass. The geology consists of topsoil (1) and (19) overlaying the natural (2). At the bottom end the trench tourn slightly south. No archaeology present.
32	Trench 4	Area B	Card	Linear	Square	10000	110	120	Trench 4 orientated North-west to South-east, was 100m long, 1.10m wide and 1.20m deep. This trench was located to the immediate west of Trench 3. The ground cover was grass. The geology consists of topsoil (19) overlaying the natural (2). Following trench 3, the last 15m of the trench tourn slightly south. No archaeology present.
33	Trench 5	Area B	Card	Linear	Square	10000	110	100	Trench 5 orientated North-west to South-east, was 100m long, 1.10m wide and 1.20m deep. This trench was located to the immediate west of Trench 4. The ground cover was grass. The geology consists of topsoil (19) overlaying the natural (2). Same as trench 4, 15m prior the end the trench tourn slightly south. No archaeology present.

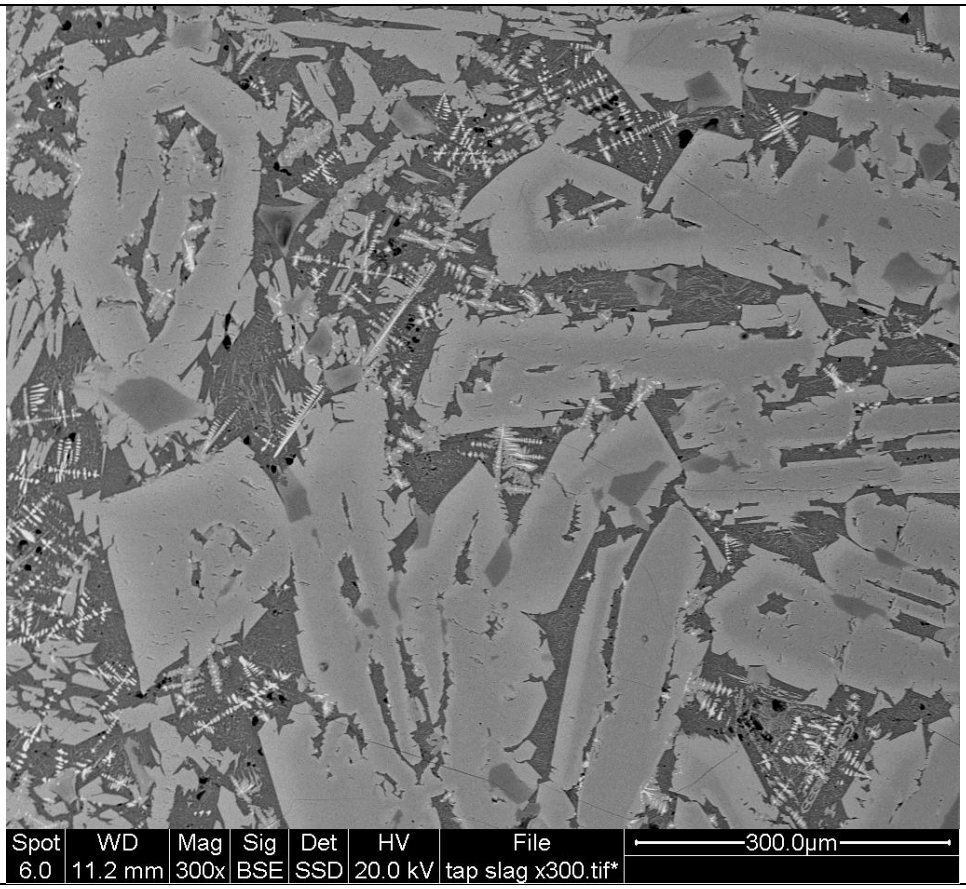
Context	Feature	Location	Type	Shape	Profile	Length cm	Width cm	Depth cm	Notes
34	Trench 6	Area B	Card	Linear	Square	10000	110	120	Trench 6 orientated North-west to South-east, was 100m long, 1.10m wide and 1.20m deep. This trench was located to the immediate west of Trench 5. The ground cover was grass. The geology consists of topsoil (19) overlaying the natural (2). The trench had a dog leg shape in plan. No archaeology present.
35	Trench 7	Area B	Card	Linear	Square	10000	110	110	Trench 7 orientated North-west to South-east, was 100m long, 1.10m wide and 1.20m deep. This trench was located to the immediate west of Trench 6 following the same layout as the previous trench. The ground cover was grass. The geology consists of topsoil (19) overlaying the natural (2). No archaeology present.
36	Trench 8	Area B	Card	Linear	Square	10000	110	120	Trench 8 orientated North-west to South-east, was 100m long, 1.10m wide and 1.20m deep. This trench was located to the immediate west of Trench 7. The ground cover was grass. The geology consists of topsoil (19) overlaying the natural (2), also overlaying the natural (2) was the paleochannel (9) located at the northern end of the trench, and the natural gravel (25) located towards the southern part of the trench. The trench had a dog leg shape in plan. No archaeology present.
37	Trench 9	Area B	Card	Linear	Square	10000	110	120	Trench 9 orientated North-west to South-east, was 100m long, 1.10m wide and 1.20m deep. This trench was located to the immediate west of Trench 8. The ground cover was grass. The geology consists of topsoil (19) overlaying the natural (2), also overlaying the natural (2) was the paleochannel (9) located at the northern end of the trench, and the natural gravel (25) located

Context	Feature	Location	Type	Shape	Profile	Length cm	Width cm	Depth cm	Notes
									towards the southern part of the trench. The trench had a dog leg shape in plan. No archaeology present.
38	Trench 10	Area B	Card	Linear	Square	10000	110	120	Trench 10 orientated North-west to South-east, was 100m long, 1.10m wide and 1.20m deep. This trench was located to the immediate west of Trench 9. The ground cover was grass. The geology consists of topsoil (19) overlaying the natural (2), also overlaying the natural (2) was the paleochannel (9) located at the northern end of the trench, and the natural gravel (25) and alluvial deposit (26) located towards the southern part of the trench. The trench had a dog leg shape in plan. No archaeology present.
39	Trench 11	Area B	Card	Linear	Square	10000	110	120	Trench 11 orientated North-west to South-east, was 100m long, 1.10m wide and 1.20m deep. This trench was located to the immediate west of Trench 10. The ground cover was grass. The geology consists of topsoil (1) and (19) overlaying the natural (2) and clay (24), also overlaying the natural (2) and (24) was the paleochannel (9) located at the centre of the trench, and the natural gravel (25) and alluvial deposit (26) located towards the southern part of the trench. The trench had a dog leg shape in plan where at the bottom 20m end it tourn slightly south. No archaeology present.
40	Trench 12	Area B	Card	Linear	Square	10000	110	120	Trench 12 orientated North-west to South-east, was 100m long, 1.10m wide and 1.20m deep. This trench was located to the immediate west of Trench 11. The ground cover was grass. The geology consists of topsoil (19) overlaying the natural (2) and clay (24), also overlaying the natural (2) and (24) was the paleochannel (9) located at the centre of the trench, and the alluvial deposit (26)

Context	Feature	Location	Type	Shape	Profile	Length cm	Width cm	Depth cm	Notes
									located towards the southern part of the trench. The trench had a Z shape in plan. No archaeology present.
41	Trench 13	Area B	Card	Linear	Square	10000	110	120	Trench 13 orientated North-west to South-east, was 100m long, 1.10m wide and 1.20m deep. This trench was located to the immediate west of Trench 12. The ground cover was grass. The geology consists of topsoil (19) overlaying the natural (2) and clay (24), also overlaying the natural (2) and (24) was the paleochannel (9) located at the centre of the trench, and the alluvial deposit (26) located towards the southern part of the trench. The trench had a Z shape in plan. A ditch and two field drain [12],]15] and 18] North-west to South-east orientated where recorded.
42	Trench 14	Area B	Card	Linear	Square	10000	110	120	Trench 14 orientated North-west to South-east, was 100m long, 1.10m wide and 1.20m deep. This trench was located to the immediate west of Trench 13. The ground cover was grass. The geology consists of topsoil (19) overlaying the natural (2) and clay (24), also overlaying the natural (2) and (24) was the paleochannel (9) located at the centre of the trench, and the alluvial deposit (26) located towards the southern part of the trench. The trench had a **d** shape in plan. A ditch and two field drain [12],]15] and 18] North-west to South-east orientated where recorded.
43	Trench 15	Area B	Card	Linear	Square	7000	200	130	Trench 15 orientated North-east to South-west, was 70m long, 2.00m wide and 1.30m deep. This trench was located to the immediate north end of Area 2, its function was to connect all the individual ground loops of the 14 trenches to the manifold chamber. The ground cover was grass. The geology consists of

Context	Feature	Location	Type	Shape	Profile	Length cm	Width cm	Depth cm	Notes
									topsoil (1) overlaying the natural (2) and clay (24), No archaeology was present.
44	Trench 16	Area B	Card	Linear	Square	11300	60	60	Trench 16 orientated North-west to South-east, was 113 long, 0.60m wide and 0.60m deep. This trench was located to the immediate south of the Lodge terrace, its function was to connect the Centre with the manifold chamber in Area 2. The ground cover was grass. The geology consists of topsoil (1) overlaying the natural (2) and clay (24), also overlaying the natural (2) was the tarmac footpath (21) and made ground (22) cut [23]. No archaeology was present.
45	Trench 17	Area A	Card	Linear	Square	1200	50	60	Trench 17 was excavated in order to connect the main entrance of the Lodge with Trench 15. It measures 12m long , 0.5m wide and in average was excavated to a depth of 0.7m. The geology consisted of a layer of tarmac (3) and associated made ground (4) that forms the footpath adjacent to the entrance of the centre. Further south the geology consisted of a deposit made of a mixed ground deposits of masonry, charcoal, yellowish clay and brown silty clay, this deposit was identified as the make up ground for the terrace.

Appendix 2: Slag Assessment



Assessment of the slags recovered from North Yorkshire Moors National Park Centre, Danby Lodge, Danby, North Yorkshire. Site Code: DL22

Author

Dr. Gerry McDonnell

Tuesday, 1st November 2022

gerry mcdonnell archaeometals

Assessment of the slags recovered from North Yorkshire Moors National Park Centre, Danby Lodge, Danby, North Yorkshire. Site Code: DL22

Introduction

This assessment report describes the material classified as slag recovered from a watching brief at the North Yorkshire Moors National Park Centre, Danby Lodge, Danby, North Yorkshire. The underlying solid geology is the Saltwick Formation and Cloughton Formation, and the southern area is overlain by alluvium. Much of the valley is overlain by Quaternary till and other deposits masking the underlying solid geology. The Dogger Iron Seam outcrops approximately 1km to the southeast of the Lodge beyond Park House. The HER records five slag heaps near the lodge (Anon 2022, p8), and some slag samples had been recovered in 2008 by Graham Lee (National Park Archaeologist) and given to the author as part of a research project on ironworking slag heaps of the North Yorkshire Moors. Hayes (1978) published a list of known slag heaps on the moors and included a record for the Lodge. The slag sample recovered in 2022 is recorded and discussed with reference to the 2008 analysis. The significance of the material is discussed, and recommendations made for further work. The assessment report follows the guidelines issued by Historic England (Dungworth 2015, 13-14).

Slag Classification

The slags were visually examined, and the classification is based solely on morphology. Additional data to improve the interpretation was obtained from a programme of Hand-Held X-Ray Fluorescence (HH-XRF). Details of the method are provided in Appendix 1. The debris associated with metalworking or submitted in the understanding that they are associated with metalworking, can be divided into two broad groups; residues diagnostic of a particular metallurgical process or non-diagnostic residues that may have derived from any pyrotechnological process (McDonnell 2001). The diagnostic ferrous debris can be attributed to a particular ironworking process; these comprise ores and the ironworking slags, i.e., the macro, hand recovered smelting and smithing slags and the micro-residues such as hammerscale and slag fragments recovered from sieving programmes. The second group are the diagnostic non-ferrous metalworking debris, e.g., crucibles and moulds. Thirdly, there are the non-diagnostic slags, which could have been generated by several different processes but show no diagnostic characteristic that can identify the process. In many cases the non-diagnostic residues, e.g., hearth or furnace lining, may be ascribed to a particular process through archaeological association. The residue classifications used in the report are defined below.

Diagnostic Ferrous Slags and Residues

Tap Slag - this smelting slag is characterised by its ropey flowed morphology, indicating a free-flowing slag. The slag is normally black in colour. The upper surface is smooth, sometimes with ripples. Large gas bubbles may be present.

Spongy slag - this smelting slag is characterised by a highly aerated morphology, similar to a crunchy bar with lots of air pockets and a low density. It is dark gunmetal grey in colour.

Non-Diagnostic Residues

Hearth or Furnace Lining - the clay lining of an industrial hearth, furnace or kiln that has a vitrified or slag-attacked face. It is not possible to distinguish between furnace and hearth lining.

Results

A small quantity of slag (910 grams, 22 pieces) was recovered from the fill (Context 5) of a pit that showed evidence of burning. The fragments displayed typical tap slag morphology showing frozen liquid droplets. The slag is typical of small tap slag fragments, indicating that they had moved naturally some distance from their source, by erosion. Larger pieces do not move far, unless deliberately moved by human action. They do not inform on the function of the pit. One sample was analysed by HH-XRF, and the spectrum showed a small manganese peak (Figure 1).

Discussion

The small assemblage of tap slag fragments is typical of slags eroded away from a slag heap. The fragments themselves show typical tap slag morphologies, in particular frozen flowed droplets. These fragments cannot be dated. The slag pieces examined in 2008 were larger and displayed two morphologies, the first was a typical tap slag with a ropey flowed upper surface; the second were described as spongy highly vesicular (gassed) slag. These descriptions are identical to the iron smelting slags excavated from furnace sites in Bilsdale, North Yorkshire belonging to the Cistercian Abbey of Rievaulx (McDonnell 1999). The evidence indicates that these furnaces were water-powered, i.e. the bellows were driven by a water-wheel. They were large, with a footprint of c. 2m across and probably stood 3m high. In 2008 slag samples from Danby Lodge were given to the author by Graham Lee the National Park Archaeologist, but it is unclear where they came from, other than 'Danby Lodge', possibly from the tree planting scheme (Anon 2022, p9 Locations 2 and 5). They were analysed using optical and Scanning Electron Microscope utilising Back Scattered Electron Imaging and the bulk areas and phases were quantitatively analysed using energy dispersive x-ray analysis (full details are provided in Appendix 2).

The analysis showed that the mineral texture of the tap slags (Plate 1) was blocky iron silicate, (light grey) with hercynite (darker grey) segregation and free iron oxide dendrites (white) in a glassy matrix

(dark grey). The spongy slag had very little free iron oxide present, and the silicate phase occurred as laths rather than blocks (Plate 2). This microstructure indicates a very efficient smelting process, with a very liquid slag indicative of high temperatures (1300°C plus) at the moment of tapping the slag from the furnace. These microstructures are similar to those observed in the monastic slags from Bilsdale (source Author). The mean values of the bulk area analyse, and phase analyses are presented in Table 1. The bulk area compositions of both the tap slag and the spongy slag are typical of tapped iron smelting slags and can be compared with a mean value obtained from the author's research in the 1980's (Table 2, after McDonnell 1986). This demonstrates that the Danby lodge slags are richer in silica and lower in iron oxide compared to McDonnell's mean. Other oxides are in broad agreement, but it is worth noting the low manganese oxide levels in the Danby Lodge slag indicating the ore was very low in manganese. The presence of phosphorus pentoxide in the slag also indicates that the ore was phosphoric. The low iron oxide content of the Danby Lodge slags is similar to the levels in the mean Bilsdale data (Table 2), but the Bilsdale slags are lower in silica but richer in magnesia (MgO) and lime (CaO). The table also includes data from two North Yorkshire Moors Iron Age sites, Levisham Moor (Hayes 1983, 51-54,)and Broomfield Farm, Whitby (McDonnell 2022). They are distinguished by higher MnO and lower MgO, Al_2O_3, P_2O_5 K_2O and CaO contents. The mineral texture of the Broomfield Farm slag was also very different, (globular free iron oxide and blocky iron silicate), indicating a slower cooling slag. Note the Levisham Moor slag analysed by McDonnell (1986) was a piece of tap slag associated with the shaft furnace and probably dates to the medieval or Romano-British periods.

Percy (1864, p223, Table VII Number 11) published analyses of Dogger iron ores including three from Grosmont (10km to the east of Danby Lodge). These show a low manganese oxide and phosphorous pentoxide contents in the ore. The manganese would be enhanced in the slag.

The evidence for water-powered medieval iron smelting at Danby Lodge is very strong, but there is some contradictory evidence. Canon Atkinson noted the presence of a large slag heap at the Lodge (Anon 2022, 8), and the geophysics seems to confirm the presence of slag in the area. However the geophysics (Geoquest 2007, Figure 2), cropped the magnetic response at +/- 20 nano-tesla and research has demonstrated that slag heaps generate much stronger responses, and the smelting furnaces can generate readings of the order of 300nT. (Powell et al 2002, Vernon 2004, Vernon et al 2001, Vernon et al 2002). Furthermore the watching brief examined a large area but recovered no slag from the topsoil; the section of strong (slag filled?) ditch like anomaly in Area 2 of the geophysical survey recovered no slag in the section. Also the evidence from Bilsdale (McDonnell 1972 and 1999), shows that the smelting sites comprise a single slag heap, rather than several, as appears at Danby Lodge. The largest site in northern Bilsdale was the Grange (SE 57220 96127), has some similarities to Danby Lodge, (Vernon 2004, 93-94). The area surveyed was circa 80 x 70m , which included a large slag heap and other features, and the data was processed from using a +/- 70nT filter to a +/-1000nT, filter, some anomalies exceeded 1500nT. Slag has commonly been

used as hardcore, so it is probable that the slag heap noted by Atkinson has been mined for hardcore and what remains is the scattered remnants. The Bilsdale iron smelting landscape was Cistercian, and it is not known whether the seigneurial iron smelting landscape was the same.

The pit in which the slag was found was approximately 50cm in diameter and 30cm deep (data taken from a photograph). It appeared to be burnt at its base. Excavation of furnace sites tend to focus on the furnace and its immediate area; however a large smelting site needs a number of ancillary buildings, including ore and charcoal stores. In the later blast furnace period, e.g. Duddon, Cumbria, the largest building on the site is the charcoal store, and it has been proposed that the refectory building at Rievaulx abbey became the charcoal store for the blast furnace built there in 1576. Thus the pit may be a large post hole belonging to one of these buildings.

Conclusion

The slag recovered from the 2022 watching brief is iron smelting tap slag. The analyses of the slags recovered in 2008 shows that they have similar mineralogy and chemistry to those from the Cistercian iron smelting sites in Bilsdale, North Yorkshire. These sites were large water-powered furnaces, operating at near maximum efficiency resulting in slags low in iron oxide. The Bilsdale sites were blown out probably after the English-Scottish war and the Battle of Byland (1322), followed by the establishment of one large ironworks at The Grange that operated until the late 15th Century. The Danby Lodge smelting site is more likely to belong to the later phase 1322-1500.

No further work is required on the assemblage. The Danby Lodge iron smelting landscape should be re-examined in the light of new knowledge concerning the evolution of medieval iron smelting technology.

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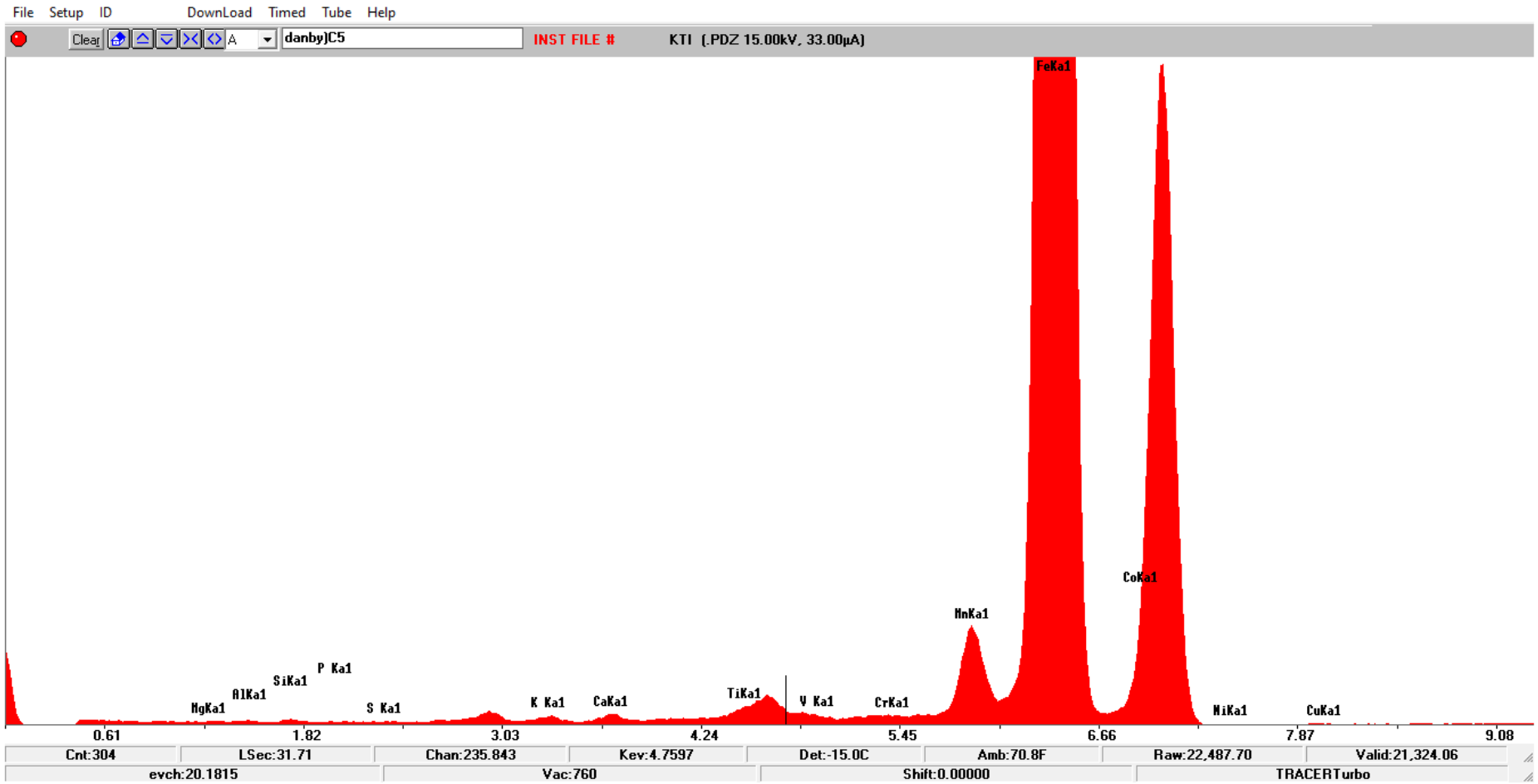

Figure 36 HH-XRF spectrum derived from a tap slag sample from Context 5, showing a minor manganese peak.

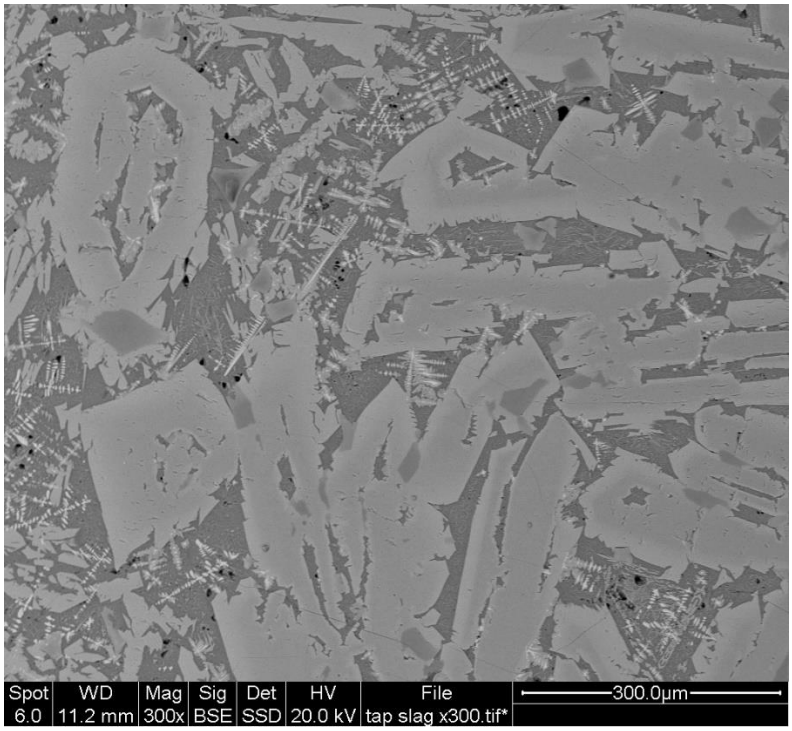

Plate 1SEM BSE image of a tap slag sample from Danby Lodge, showing blocky iron silicate, (light grey) with hercynite (darker grey) segregation and free iron oxide dendrites (white) in a glassy matrix (dark grey)

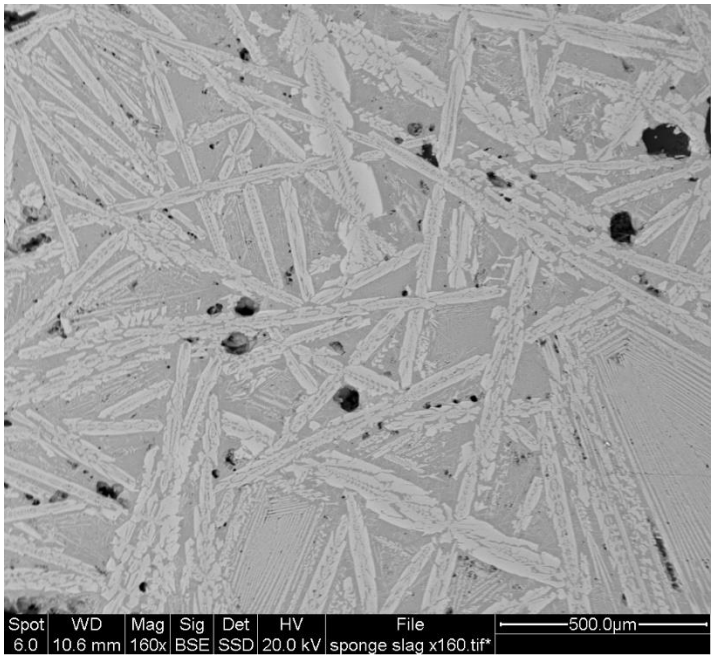

Plate 2 SEM BSE image of the spongy slag, showing no free iron oxide, and the silicate occurring as laths.

	Tap Slag					Spongy Slag			
	Mean Bulk	Silicate	Hercynite	Glass		Mean Bulk	Silicate	Hercynite	Glass
Na_2O	0.5	0.1	0.0	1.4		0.5	0.0	0.0	0.7
MgO	2.6	4.3	1.7	0.0		2.7	9.4	3.5	0.2
Al_2O_3	7.2	0.2	43.4	13.3		9.5	0.0	48.2	13.0
SiO_2	32.6	33.0	0.6	40.0		34.0	33.7	0.8	39.2
P_2O_5	1.0	0.2	0.2	3.0		1.9	0.6	0.2	3.8
S	0.3	0.0	0.0	1.5		0.4	0.2	0.3	1.1
K_2O	1.4	0.1	0.0	4.8		1.7	0.1	0.1	3.4
CaO	3.5	0.7	0.1	11.6		4.7	0.6	0.1	10.8
TiO_2	0.4	0.0	1.3	0.3		0.5	0.5	1.5	1.2
V_2O_5	0.0	0.0	0.4	0.0		0.2	0.0	0.9	0.0
Cr_2O_3	0.0	0.1	0.1	0.0		0.0	0.0	0.2	0.0
MnO	0.5	0.6	0.2	0.1		0.6	0.9	0.5	0.6
FeO	49.4	60.6	51.6	23.4		43.0	54.4	44.1	26.5
CoO	0.4	0.2	0.5	0.4		0.3	0.3	0.1	0.4
NiO	0.1	0.0	0.1	0.1		0.1	0.2	0.2	0.0
CuO	0.1	0.1	0.1	0.0		0.1	0.0	0.0	0.0
BaO	0.1	0.0	0.1	0.1		0.1	0.0	0.0	0.0

Table 3 Bulk are and phase analyses of the tap slag and spongy slags recovered from Danby Lodge in 2008, (weight %).

	Danby Lodge		McDonnell (mean)	Bilsdale (mean)	Levisham Moor			Broomfield Farm, whitby
					Hayes 1983		McDonnell 1986	
	Tap	Spongy			Sample 2	Sample 33		
Na2O	0.5	0.5	0.2	0.7	n.d.	n.d.	0.5	0.3
MgO	2.6	2.7	1.0	4.6	0.9	0.7	0.6	0.2
Al2O3	7.2	9.5	5.5	9.2	5.0	3.1	1.0	4.6
SiO2	32.6	34.0	28.4	28.8	41.0	39.5	22.1	21.8
P2O5	1.0	1.9	1.0	2.3	0.5	0.4	0.4	0.7
S	0.3	0.4	0.1	n.d.	n.d.	n.d.	0.2	0.2
K2O	1.4	1.7	1.5	1.4	n.d.	n.d.	0.5	0.4
CaO	3.5	4.7	5.1	8.0	2.7	2.0	2.8	0.6
TiO2	0.4	0.5	0.4	0.5	0.3	0.3	0.3	0.2
V2O5	0.0	0.2	0.0	n.d.	n.d.	n.d.	n.d.	0.0
Cr2O3	0.0	0.0	0.0	n.d.	n.d.	n.d.	0.2	0.0
MnO	0.5	0.6	3.4	1.2	5.6	5.2	8.9	3.3
FeO	49.4	43.0	53.1	44.4	38.1	47.4	64.3	66.8
CoO	0.4	0.3	0.2	0.3	n.d.	n.d.	0.3	0.3
NiO	0.1	0.1	0.1	0.1	n.d.	n.d.	0.2	0.1

Table 4 Danby Lodge mean bulk area analyses with comparative data. McDonnell Mean - overall mean derived from McDonnell's research (1986); Bilsdale mean- mean value derived from eight medieval smelting sites in Bilsdale (Source Author); Levisham Moor includes slag from an Iron Age ditch (Hayes 1983) and from the (medieval?) furnace site (McDonnell 1986); Broomfield slag from Iron Age site near Whitby (McDonnell 2021).

Appendix 1 HH-XRF Methodology

The instrument used was a Bruker S1 Turbosdr hand-held XRF instrument operating at 15kV. The technique is non-destructive. A beam of x-rays is generated in the instrument and focussed on a fresh fractured surface of the sample, the x-rays interact with the elements present in the sample resulting in the emission of secondary x-rays which are characteristic (in terms of their energy and wavelength) of the elements present in the sample. The energies of the secondary x-rays are measured, and a spectrum generated showing a level of background noise with peaks of the elements present superimposed on the background noise. Slag samples were analysed for 30 live seconds; the spectrum is stored. All elements heavier than magnesium (Mg, Z=12), can be detected.

Appendix 2 Optical and Scanning Electron Microscopy Methodology

A thick section was removed from a slag piece, mounted in resin and ground and polished to a one micron finish. The polished section was examined using a metallurgical reflected light microscope to assess the slag mineralogy. The mounted specimen was carbon coated and then analysed using an FEI Quanta 400 scanning electron microscope, with Oxford Instruments INCA software to using energy dispersive x-ray analysis to determine bulk area and phase analyses. The instrument used a working distance of 11mm and operated at 20kV, with filament at saturation. Back Scattered Electron imaging was utilised to capture images at various magnification of the slag mineral texture. Five area readings for elemental composition were taken at different locations on each of the samples and the different phases (silicate, iron oxide etc) were also analysed.

Early ironworking slags (both smelting and smithing), normally comprise three major phase, free iron oxide and iron silicate in a glassy phase. In some cases additional phases may be present. Some minerals are readily identified during the optical metallographic examination, others are only characterised by elemental x-ray analysis using the Scanning Electron Microscope. These minerals are solid solutions, e.g. although fayalite has a fixed composition of 70% FeO and 30% SiO2, Mn and sometimes Ca may substitute for FeO, and the composition can range from c. 25-40% SiO_2. This means that it is often referred to as the silicate phase. The texture of the mineral is its shape or morphology that it occurs as it crystallises from the molten silicate melt. It must be realised that the polished sample is a two-dimensional picture cut through a three-dimensional structure, i.e. we see the X and Y direction but not the Z direction. Common terms are dendritic which is when the mineral has the form of a Christmas tree, i.e. a trunk with arms. The dendrite may be skeletal, i.e. very fine, or rounded or globular as the trunk and the arms become larger. Another form is lath, long straight minerals, the thinner the lath the faster the slag has cooled. Block is a shorted fatter lath and massive means that the laths have fused together and cannot be resolved. The texture may also be vesicular, i.e. the presence of gas bubbles.

Major Minerals

Fayalite - Formula: $2FeO.SiO_2$. Composition: SiO_2 =29.5%, FeO=70.5%. Texture: lath, blocky or massive. Alternate Names – Silicate Phase

Wüstite – Formula: FeO. Composition 77.8% Fe, 22.2% O. Texture dendritic, globular.

Major Other Phase

Glass – a solid solution of oxides that freezes as a glass and not a crystal, and therefore does not have a fixed formula. It is normally rich in Al_2O_3, SiO_2, P_2O_5, K_2O and CaO.

Minor Minerals

Hercynite – Formula: $2FeO.Al_2O_3$. Composition: Al_2O_3 = 59%, FeO= 41%. Texture: lath or blocky.

Leucite – Formula: $K_2O\ Al_2O_3\ 4SiO_2$. Composition: K_2O=21.6%, Al_2O_3=23.4%, SiO_2=55.0%. Texture: eutectic (a mixture of two or more oxides that have a melting temperature below the other minerals present in the silicate mixture, which on freezing cannot be physically separated).

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Dr Gerry McDonnell
Tuesday, 1st November 2022

Appendix 3: Assessment of biological remains

Palaeoecology Research Services ***PRS* 2022/18**

Assessment of biological remains from a sediment sample recovered during an archaeological watching brief at Danby Lodge National Park Centre, Lodge Lane, Danby, Whitby, North Yorkshire (site code: DL22)

by

John Carrott

Summary

A single 'bulk' sediment sample recovered from the fill of a pit encountered during an archaeological watching brief at Danby Lodge National Park Centre, Lodge Lane, Danby, Whitby, North Yorkshire, was submitted for an assessment of its bioarchaeological potential. The fill of the pit was recorded on site as consisting of "mixed sand, large and small charcoal blocks and slag" and the feature was provisionally interpreted as a bloomery.

Biological remains recovered from the bulk sediment sample and of probable 'ancient' origin (i.e. likely to be contemporary with deposit formation) consisted exclusively of a substantial assemblage (approximately 3 litres) of rectilinear charcoal ranging in size from little more than ash to quite large fragments. All of the charcoal identified was of oak and, subjectively, the assemblage may well consist exclusively of this species. The only other organic remains present were intrusive modern rootlets. The residue fraction was predominantly artefactual in nature consisting largely of slag, with other components restricted to just occasional stones and a trace of modern rootlet. The slag recorded appeared in two forms with larger pieces being rounded and amorphous and exhibiting little magnetic response and the majority of the smaller material being granular and quite strongly magnetic. No invertebrate or vertebrate remains were recovered and there were no interpretatively valuable microfossils present, although the 'squash' subsample did reveal the continued presence of charcoal/ash down to the microscopic level.

Overall, the excavator's on-site interpretation of the pit as a bloomery seems well-founded and is strongly supported by the artefactual remains (slag) and the organic material (oak charcoal – an excellent fuel wood for this purpose as it will burn at high temperatures and with good duration) recovered from the sediment sample.

Although not ideal for the purpose, some of the charcoal recovered could be submitted for radiocarbon dating. Any date could not be taken as precise but, in the absence of any other dating evidence, could provide a broad indication of the time period of the activity and an 'earliest possible' date.

No further study of the biological remains is warranted but the slag recovered may provide further insights into the smelting being undertaken and should be forwarded to an appropriate specialist if further investigation is considered worthwhile.

KEYWORDS: DANBY LODGE NATIONAL PARK CENTRE; LODGE LANE; DANBY; WHITBY; NORTH YORKSHIRE; ASSESSMENT; UNDATED; PLANT REMAINS; CHARRED PLANT REMAINS; CHARCOAL; OAK (*QUERCUS*); SLAG

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Assessment of biological remains from a sediment sample recovered during an archaeological watching brief at Danby Lodge National Park Centre, Lodge Lane, Danby, Whitby, North Yorkshire (site code: DL22)

Introduction

An archaeological watching brief was undertaken by LS Archaeology (LSA) at Danby Lodge National Park Centre, Lodge Lane, Danby, Whitby, North Yorkshire (NGR NZ 71736 08261), in 2022. The works were undertaken to monitor groundworks associated with the installation of a ground source heat pump and the widening of a doorway

A 2007 geophysical survey of the grounds determined the presence of archaeological deposits associated with a paleochannel, bloomeries and ridge and furrow; the exact nature and date of these features is unknown. The current works encountered a pit (in Trench 2) with a fill consisting of "mixed sand, large and small charcoal blocks and slag" provisionally interpreted as a bloomery.

A bulk sediment samples ('GBA'/'BS' *sensu* Dobney *et al*. 1992), from the fill of the pit [6], was submitted to Palaeoecology Research Services Limited, Kingston upon Hull, for an assessment of its bioarchaeological potential.

Methods

The lithology of the sediment sample was recorded, using a standard *pro forma* prior to processed for the recovery of plant and invertebrate macrofossils, broadly following the techniques of Kenward *et al*. (1980), producing a washover and a residue fraction.

No uncharred remains (other than intrusive rootlet) were observed and the washover was dried prior to recording. The residue was essentially mineral in nature and was also dried prior to separation into fractions (using 10, 4 and 1 mm sieves) to facilitate the sorting and recording of its components. Quantities of inorganic and environmental material refer to the larger pieces which have been extracted and reserved; smaller fragments remain in the residue and are not included. The residue fractions (including the less than 1 mm fraction) were scanned for magnetic material.

The processed sample fractions were examined for plant, invertebrate and vertebrate remains, using a low-power binocular microscope (x7 to x 45) where necessary. The components were recorded either as actual counts or via a five-point semi-quantitative scale: 1 – few/rare, up to 3 individuals/items or a trace level component of the whole; 2 – some/present, 4 to 20 items or a minor component; 3 – many/common, 21 to 50 or a significant component; 4 – very many/abundant, 51 to 200 or a major component; and 5 – super-abundant, over 200 items/individuals or a dominant component of the whole. The processed sample fractions were scanned until no new remains were observed and a sense of the abundance of each taxon or component (relative to the processed fraction as a whole) was achieved. The abundance of recovered organic and other remains within the sediment as a whole may be judged by comparing the washover weight/volume and the quantities of remains recovered from the residue with the size of the processed sample.

'Ancient' plant macrofossil remains recovered from the sample were exclusively of charcoal and species identifications were attempted for a small number of fragments which were over 4 mm in at least one linear dimension. The pieces were broken to give clean cross-sectional surfaces and the anatomical structures were examined using a low-power binocular microscope (x7 to x45) and higher magnification where necessary (x100 and x150). Identification was attempted by with reference to published works (principally Hather 2000 and Schoch *et al*. 2004).

No 'ancient' invertebrate or vertebrate remains were recovered from the bulk sediment sample.

A small quantity of sediment (~1 ml) from the sample was examined as a microfossil 'squash' subsample. This was examined using the 'squash' technique of Dainton (1992), originally designed specifically to assess the content of eggs of intestinal parasitic nematodes; however, this method routinely reveals the presence of other microfossils, such as pollen and diatoms, which were also noted if present. The assessment slide was scanned at x150 magnification and at x600 where necessary.

During recording, consideration was given to the suitability of the remains for submission for radiocarbon dating by standard radiometric technique or accelerator mass spectrometry (AMS).

Results

The results of the investigation of the sample are presented below in context number order. Archaeological information, provided by LSA, is given in square brackets. A brief summary of the processing method follows (in round brackets) after the sample number.

Context 5 [fill of pit [6]; undated]
Sample 1/T (10 kg/~10 litres sieved to 300 microns with washover and microfossil 'squash'; no unprocessed sediment remains)

More or less dry, very dark grey-brown to black, unconsolidated (and noticeably un-dense), very ashy, sandy silt/silty sand, with abundant charcoal (there was actually relatively little sediment matrix) and occasional lumps (to 100 mm) of just moist, mid brown, crumbly sandy sily/silty sand. Intrusive rootlets were also abundant.

The large washover (dry weight 838.0 g/~3000 ml) was mostly charcoal (to 59 mm; abundance score 5), with frequent modern rootlets (score 3) and a trace of sand (score 1). All of the charcoal was rectilinear fragments and, of 20 pieces examined more closely (from sizes ranging from the largest down to fragments around 10-12 mm), 17 were positively identified as oak (*Quercus*) and the remaining three as ?oak.

The small residue (dry weight 1002.7 g: >10 mm – 389.9 g; 4-10 mm – 187.6 g; 1-4 mm – 141.8 g; <1 mm – 283.4 g) was mostly rounded amorphous slag (to 63 mm; score 5) which exhibited little magnetic response, and more angular and granular slag (to 10 mm; score 4) which was quite strongly magnetic, with sand (score 3; most of the less than 1 mm fraction), occasional stones (to 23 mm; score 2) and traces of modern rootlet (score 1). Other components of the less than 1 mm residue fraction were a few small pieces of rootlet and a magnetic component (to 1 mm; 17.3 g) which was predominantly fine 'crumbs' of the granular slag material but which also contained occasional ?heat-affected sand grains.

The ‘squash’ subsample was mostly inorganic but with frequent black flecks of microscopic charcoal/ash (score 3). There were occasional fragments of fungal hyphae (score 2) but no interpretatively valuable microfossils were present.

Discussion and statement of potential

Biological remains recovered from the bulk sediment sample from Context 5 (fill of pit [6]) and of probable ‘ancient’ origin (i.e. likely to be contemporary with deposit formation) consisted exclusively of a substantial assemblage (approximately 3 litres) of rectilinear charcoal ranging in size from little more than ash (less than 1mm) to quite large fragments (to 59 mm). All of the charcoal identified was of oak and, subjectively, the assemblage may well consist exclusively of this species. The only other organic remains present were intrusive modern rootlets.

The residue fraction from the processed sample was predominantly artefactual in nature consisting largely of slag, with other components restricted to just occasional stones and a trace of modern rootlet. The slag recorded appeared in two forms with larger pieces being rounded and amorphous and exhibiting little magnetic response and the majority of the smaller material being granular and quite strongly magnetic. The latter form accounted for almost all of the magnetic material recovered from the less than 1 mm fraction of the residue and there was no flake or sphere hammerscale (that might indicate smithing rather than, or as well as, smelting) present.

No invertebrate or vertebrate remains were recovered from the sample and there were no interpretatively valuable microfossils present, although the ‘squash’ subsample did reveal the continued presence of charcoal/ash down to the microscopic level.

There was clearly sufficient charcoal recovered from Context 5 for AMS dating to be attempted and, although, intrusive rootlet was also present and will have affected some degree of bioturbation, the quantity and fragment size of charcoal indicate this to be an integral part of the deposit as a whole. Unfortunately, all of the fragments were of an unknown number of years of wood growth and the ‘old wood’ problem whereby any date returned could be much earlier than the charring event would, therefore, apply (a potential source of particularly large uncertainty in the case of long-lived tree species, such as oak which was the only species level identification from the charcoal assemblage).

Overall, the excavator’s on-site interpretation of pit [6] as a bloomery seems well-founded and is strongly supported by the artefactual remains (slag) and the organic material (oak charcoal – an excellent fuel wood for this purpose as it will burn at high temperatures and with good duration) recovered from the sediment sample.

Recommendations

No further study of the biological remains is warranted.

Although not ideal for the purpose, some of the charcoal recovered could be submitted for radiocarbon dating. Any date could not be taken as precise (as noted above) but, in the absence

of any other dating evidence, could provide a broad indication of the time period of the activity and an 'earliest possible' date.

The slag recovered may provide further insights into the smelting being undertaken in pit [6] and should be forwarded to an appropriate specialist if further investigation is considered worthwhile.

Retention and disposal

The washover fraction should be retained, for the present at least, pending a decision regarding submission of material for radiocarbon dating of the deposit/feature.

The entirety of the residue fraction (this has been retained separated into four fractions but unsorted) will be returned to the excavator to be considered by an appropriate specialist and included within the physical archive for the site if warranted.

Archive

All material is currently stored by Palaeoecology Research Services (Unit 4, National Industrial Estate, Bontoft Avenue, Kingston upon Hull), pending return to the excavator or permission to discard, along with paper and electronic records pertaining to the work described here.

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