A Roman enclosed settlement with evidence for early medieval Iron smelting at Staveley Lane, Eckington

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A ROMAN ENCLOSED SETTLEMENT WITH EVIDENCE FOR EARLY MEDIEVAL IRON SMELTING AT STAVELEY LANE, ECKINGTON - Figure and Table lists

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A ROMAN ENCLOSED SETTLEMENT WITH EVIDENCE FOR EARLY MEDIEVAL IRON SMELTING AT STAVELEY LANE, ECKINGTON

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SUMMARY

Excavation by Oxford Archaeology in advance of residential development in Eckington investigated part of a rural settlement dating from the Roman period, situated within a large curvilinear enclosure ditch. The settlement was occupied from the late Iron Age or early Roman period until *c* AD 200, but had been substantially affected by ploughing during the medieval and modern periods and few internal features survived. The enclosure was subsequently used for an episode of iron smelting, which was dated by radiocarbon to the mid-7th-8th century. This represents an extremely rare discovery, since a recent survey identified only eight smelting sites in the entire country that date from the early and middle Anglo-Saxon period.

INTRODUCTION

Oxford Archaeology undertook an evaluation and excavation at Staveley Lane, Eckington, in advance of a residential development. The site was located immediately west of Staveley Lane, at the southern edge of the village (NGR SK 4292 7874; Fig. 1). The development area was a *c* 4ha field, bounded to the north and west by allotments and by agricultural fields to the south. Prior to the excavation, the land was under arable cultivation. The site lies on a north-facing slope that reaches a height of *c* 110m aOD in the centre. The River Rother is located *c* 1.25km west of the site and flows northward to join the River Don.

The underlying geology comprises Pennine Middle Coal Measures, a sedimentary sandstone formation. There are no superficial geological deposits at the site, though alluvial gravels and sand occur to the east in the vicinity of the Rother.

Archaeological background

There is no definite evidence for prehistoric activity within Eckington or the wider area. A single find of a Roman coin is reported 0.5km to the north-west of the site and a NE-SW aligned linear feature to the south recorded on aerial photographs has been interpreted as a Roman road. A cropmark of a curvilinear enclosure had been previously identified at the site. A similar enclosure with evidence for *in situ* iron smelting/working had been excavated at Sherwood Lodge, Bolsover and was securely dated to the Roman period (Jones 1995).

A geophysical survey of the site undertaken in 2013 by GSB Prospection (Gater 2013) recorded the part of the enclosure ditch that lay within the site, as well as several irregular linear features that were interpreted as medieval furrows. The northern part of the enclosure extended beyond the site boundary. An evaluation of the site was undertaken by Oxford Archaeology North in August 2013, comprising 18 trenches (OA 2013). Three trenches dug across the enclosure ditch revealed it to be a curvilinear feature containing evidence for ironworking. Trenches in other areas of the field exposed only modern ditches, several of which correlated with features shown on the 18th-century enclosure map. Based on the results of the evaluation, it was decided that an open area excavation should be targeted on the enclosure.

Excavation methodology

The excavation encompassed an area of 0.42ha, comprising the part of the enclosure that lay within the site boundary plus an additional zone of 10-15m beyond the extent of the ditch. The site was stripped using a mechanical excavator fitted with a toothless ditching bucket, under the supervision of an archaeologist. Stripping continued until the first archaeological horizon was exposed. At this point, the site was cleaned and excavation continued by hand. The machine-excavated topsoil and subsoil layers were kept separate and the spoil heaps were scanned with a metal-detector to ensure maximum finds retrieval.

The main enclosure ditch (131) was excavated by hand in ten sections, including two that were dug during the evaluation phase, amounting to a total of *c* 10% of the length of the feature. In addition to the hand-excavated sections, five machine-excavated slots, measuring 5-7m long, were excavated through the ditch to enhance finds recovery (Fig. 2).

THE LATE IRON AGE/EARLY ROMAN SETTLEMENT

The excavation exposed the southern half of the curvilinear enclosure ditch (131), the northern half of which extended into the neighbouring allotments. The ditch bounded a sub-circular area which measured *c* 70m across, east to west. It had an entrance located on its south-western side. Internal features were predominantly located in the western half of the exposed area of the enclosure, though it is possible that features present in the eastern half had been truncated. Excavated features included the remains of several pits and small postholes, gullies/ditches, and an un-urned cremation burial.

Gully 24

Gully 24 was the only feature that certainly pre-dated the construction of the enclosure, since it was cut by the enclosure ditch (131) and only a short section survived between the terminal of the enclosure's entrance (Fig. 2). It was a curving feature that was 0.4m wide and 0.11m deep and limited excavation yielded no artefactual material. The gully petered out to the north-east.

Enclosure ditch 131

The ditch (Fig. 3) was 0.86-1.06m deep, although its base was not reached in several interventions due to flooding by groundwater. The width of the ditch was more varied, measuring 1.3m at its narrowest point, on the eastern side of the enclosure and 2.9m at its widest point, on the western side. It was predominantly V-shaped, but along the southern side of the enclosure it had a more stepped profile that may indicate the presence of recuts. No clear evidence of a recut was seen, however, apart from the western side of the entrance (below). The ditch contained multiple fills, representing several episodes of silting. The basal fill was invariably a thin band of silt lining the side of the ditch nearest to the inside of the enclosure. This may suggest that the material had eroded from a bank adjacent to this side of the ditch. Excavation of this deposit during the evaluation stage of the investigation (21, Fig. 3, section 6) resulted in the recovery of fragments of charred hazelnut shell, one of which was radiocarbon dated to 50 cal BC-cal AD 80. During the excavation stage, an assemblage of 20 pottery sherds was recovered that dated to AD 70-200. Above the primary silt, the middle fills comprised a dark grey clay that produced seven sherds of grog-tempered ware dating to 50 BC-AD 100 (Table 7). The upper fills comprised stony, brown-orange sandy silt that contained a handful of sherds dated to AD 70-300.

The enclosure entrance

The entrance to the enclosure was defined by a pair of opposed ditch terminals located in the south-western part of the boundary. They cut gully 24 and flanked a causeway 1.65m wide. The western terminal appeared to have undergone several episodes of recutting (Fig. 2 and Fig. 4, section 6). The earliest phase of the ditch on this side was represented by terminal 21, a wide, flat-based ditch that may have been as much as *c* 2.5m wide, although both its sides were truncated. This ditch did not align well with the eastern terminal, however, appearing to be somewhat set back from it. It is possible that this side of the entrance was in-turned relative to the opposite side, or alternatively that ditch 21 was an earlier feature and not part of the enclosure ditch. The north-eastern side of terminal 21 was cut by terminal 41, which measured *c* 1m across. The final phase of the terminal was ditch 17, which aligned more closely with the opposite terminal. It had a flat base and measured just over 1m across. The sequence of terminals was cut by a shallow feature (43) that may have been another ditch or, perhaps more likely, a pit. The feature could not be defined clearly in plan but in section it had a flat base and measured more than 2m across. It contained a single fill of dark grey humic clay and sat almost completely on top of ditch 21.

Only one phase of ditch was noted at the eastern terminal. Here, the ditch had a concave profile and measured *c* 0.7m deep. It contained three fills, mostly of brownish sandy clay with numerous stones.

A group of four shallow features (4, 8, 15, 26) were situated outside the entrance, on its western side. They each measured *c* 0.1m deep, with slightly concave bases, and may be the remains of truncated postholes, perhaps defining fence-lines designed to control movement entering or exiting the enclosure.

Internal features

Pits and postholes

Most of the features were situated within the western half of the enclosure, with only a few isolated features in the eastern part. Three pits (50, 86 and 89) were particularly large. Pit 50 was sub-circular in plan, measuring 3.3m x 2.8m and *c* 0.8m deep with quite steep sides. The middle fill (64) contained pieces of ironstone and the upper fill (65) contained several pottery sherds that were dated broadly to the Roman period. Pit 51 was cut into the eastern side of pit 50. It had steep, straight sides and a relatively flat base with a depth of 0.75m. It measured 1.2m across, though it was largely contained within the fills of pit 50. Pit 89 was sub-oval, while pit 86 was more irregular in shape. Pit 89 was almost 0.5m deep and contained two fills that comprised largely of ironstone rubble, with a small number of sherds of Derbyshire ware that dated to AD 150–300. Pit 86 was a shallow hollow only 0.1m deep and contained a smaller quantity of ironstone.

A group of three pits (84, 99 and 101) were located a few metres from the western side of the enclosure ditch. Pit 84 was cut by pit 99 on its southern side. Both were sub-circular in plan, with undulating profiles and similar depths of *c* 0.4m. Pit 84 was the larger of the two, measuring at least 1.5m in diameter. They were filled with quantities of unworked stone, though no artefacts were found. Pit 101 lay just to the south of these two features, although the relationship between them could not be established. Pit 101 had an irregular shape in plan and was cut deeper on its northern side, though it was slightly shallower than pits 84 and 99. It also contained unworked stone.

Pits 56 and 58 lay toward the centre of the excavated part of the enclosure. Pit 56 was relatively wide (0.8m) and shallow, measuring 0.8m wide and 0.1m deep. Pit 58 had a pronounced concave profile and measured 0.6m wide and 0.2m deep. Neither feature produced any finds.

Gullies and ditches

Two intersecting gullies (132 and 133) were located in the western part of the enclosure. The earlier of the two was curving gully 132, which measured *c* 12m from a terminal at its eastern end to its western end, which was truncated by ditch 133. Ditch 133 was *c* 0.2m deep and *c* 0.6m wide. The eastern terminal contained several sherds from a sandy reduced ware dish/bowl and a bead-rimmed dish, both dated to the 2nd century AD or later. The ditch had a shallow, concave profile and rapidly narrowed from west to east, reducing in width from 1.1m to 0.5m. This tapering did not necessarily indicate the presence of a terminal and may have been due to truncation. The feature could not be traced to the west, where its fill was indistinguishable from the surrounding natural. It contained sherds of Roman sandy reduced ware.

Cremation burial 82

A small pit in the western half of the enclosure contained a relatively high quantity of charcoal and a few fragments of cremated human bone (105). The pit was sub-oval in plan and survived to a depth of only 0.03m, suggesting that it had been substantially truncated by ploughing.

EARLY MEDIEVAL IRON SMELTING

An episode of early medieval iron smelting was represented by at least one furnace base (52), a pit (37) and deposits of slag and charcoal in the upper part of the enclosure ditch that were dated by radiocarbon to the mid 7th-8th century. The activity appears to have been restricted to the interior of the Roman enclosure and was located in two discrete areas, situated on the western side of the enclosure and within its south-eastern quadrant.

The most significant feature in the western part of the enclosure was furnace 52 (Figs 5 and 6). It was a small pit-like feature measuring 0.3m in diameter and 0.26m deep. One side of the feature was reddened, indicating that it had been exposed to high temperatures. The furnace contained almost 5kg of iron-smelting residues, mostly consisting of furnace-bottom slag. A sample of charred wheat grain from the fill (53) was radiocarbon dated to cal AD 660-860 (Table 7). A small quantity of furnace-bottom slag (*c*. 0.5kg) was recovered from the uppermost fill of the enclosure ditch on the western side of the enclosure.

The evidence for iron processing in the south-eastern part of the enclosure came from pit 37 and the adjacent part of the enclosure ditch. The pit was located immediately adjacent to the enclosure ditch and was sub-oval in plan and relatively shallow, measuring 1.6m across and 0.3m deep (Fig. 5). It had concave sides with a flat base and contained three fills. The lowest fill (71) consisted mainly of charcoal with a small amount of burnt stone that was spread across most of the base of the feature. This fill also contained several sherds of late Iron Age/early Roman grog-tempered ware. Overlying this was a silty clay deposit (100) containing over 10kg of iron-smelting residues, most of which was furnace-bottom slag, and numerous burnt stones. The upper fill (38) was similar to the middle fill and contained a further 5.5kg of furnace-bottom slag. A sample of hazel charcoal from the upper fill was radiocarbon dated to cal AD 650-770 (Table 7). During the evaluation stage of the investigation, excavation of part of the enclosure ditch adjacent to the pit resulted in the recovery of over 28.5kg of iron slag from the upper fill (12, Fig. 3 section 10). This material from the ditch largely consisted of an incomplete furnace bottom with a sub-conical base, large wood moulds and gravel adhering to the sides. A further intervention located 8m further west produced 6.6kg of furnace-bottom slag, 1.2kg of lining slag and 1.4kg of iron from the upper fill (123), the iron mostly consisting of a corroded mass that was dumped along with the slags. A sample of birch charcoal from this fill produced a radiocarbon date of cal AD 650-770 (Table 7). No slag was present in the interventions to the west and east of these locations, indicating that the ironworking waste represented a localised deposit. Pit 92, which was also situated within the south-eastern part of the enclosure, measured 0.42-0.52 across and 0.21m deep and had been backfilled with 1.7kg of slag. It may have been a furnace base similar to 52, although this was not certain since the surrounding natural was not heat-discoloured. It was not sampled for radiocarbon dating but is likely to form part of the same phase of smelting as the dated features. Pit 91, which was very similar but contained no slag, was situated next to it and may have been of the same date.

A small quantity of burnt stones that was recovered from the upper fill (14) of the eastern terminal of ditch 131 may also have derived from early medieval ironworking activity.

OTHER FEATURES

Pit 6, located 15m north of the enclosure entrance, and pit 72, which lay close to the southern edge of the excavation area, produced no finds and it is uncertain whether they were archaeological in origin. Pit 72 was notably irregular in shape and had a shallow profile with an undulating base, perhaps indicative of a natural feature.

POTTERY

By Edward Biddulph

Some 127 sherds of pottery, weighing 1185g, were recovered from the excavation (Tables 1 and 2). The earliest pottery, dating to the late Iron Age or early Roman period, was grog-tempered (fabric E80). Ditch 131 contained a medium-mouthed cordoned jar (CD) in a grog-and-shell-tempered fabric. Oxidised body sherds with zig-zag and other scored decoration were collected from pit 37. Body sherds in a reduced sand-tempered fabric with clay pellets and elongated voids (R90) were also recovered from ditch 131. The fabric is similar in description to fabric GTA10, which was identified at Ockbrook and found in early Roman deposits there (Leary 2001, 99). The date may equally apply to fabric R90, although a dish or bowl in this fabric, collected from gully 132, was found with a middle Roman bead-rimmed dish (JA) in a sandy reduced fabric (R20), and it is possible that both occurrences of R90 date to the 2nd century or later. Small quantities of Derbyshire ware (R211) were recorded in pits 86 and 89. The ware dates predominantly to the mid/late 2nd and 3rd centuries (*cf.* Leary 2003). Pit 89 also contained a lid-seated jar (CJ) made in a gritty oxidised fabric (O20) that was a little finer than R211, though still as hard-fired. This may be a variant of the standard Derbyshire ware. Other notable pottery included two curving-sided bowls (HC) with a short, curved flange in a hard sandy fabric (R20) from ditch 131 and pit 89. A fragment from a black-burnished ware jar (B11) dating to the mid-2nd century or later was also recovered.

Overall, the assemblage spans the 1st to 3rd centuries. A mean sherd weight (weight divided by sherd count) of 9g suggests that the assemblage is highly fragmented and has undergone multiple episodes of redeposition. However, the bead-rimmed dish in gully 132 was substantially complete and may not have been deposited far from where the vessel was used and originally discarded.

ARCHAEOMETALLURGICAL RESIDUES

By Tim Young

This is a summary of the archaeometallurgical analysis, the full text of which is available online at http://www.geoarch.co.uk/reports/2017-24 Ironworking residues from Eckington revised.pdf. The assemblage was visually inspected as part of an assessment. A programme of analysis was developed from the assessment, with the aims of characterising the somewhat unusual slags, provenancing the ore source and generating a mass balance description of the process. Six samples were selected for further laboratory analysis (Table 4). These were chosen to represent the variety of material present in the overall assemblage, drawn from just a small number of contexts to increase the likelihood of a direct relationship between the raw materials involved in their production. Smelting slags were sampled from two deposits representative of the two styles of smelting identified in the assessment: the fill of the basal pit of furnace 52 (context 53) and a fill of enclosure ditch 131 in the south-eastern quadrant of the enclosure (context 12). A sample of furnace ceramic was taken from the same ditch, from context 123. All five slag samples and the technical ceramic were submitted for bulk elemental analysis. Two of the samples of slag were prepared for microstructural/microanalytical investigation on the analytical scanning electron microscope (ASEM).

In addition to the archaeological materials, two samples of claystone ironstones sampled in the Duckmanton Railway Cutting Nature Reserve were also submitted for bulk elemental analysis to assist with the provenancing studies.

The residues

The assemblage

The assemblage comprised approximately 62kg of residues, almost all firmly indicative of iron smelting in a non-slag tapping bloomery furnace of the slagpit type. One piece of slag was ambiguous and might possibly have been a smithing slag. There was one small fragment of a post-medieval blast furnace slag from ditch 17.

The iron smelting residues (Table 3) were dominated by slags that had flowed into, and cooled within, the basal pit of a furnace (57kg). The assemblage also included some ceramic materials from the furnaces (1.9kg) and a 1.4kg corroded piece of impure bloom.

Distribution of the residues

Almost all the bloomery iron smelting residue (Table 3) assemblage derived from a small area in the south-east of the enclosure:

- 28.6kg from the enclosure ditch in evaluation trench 10
- 9.2kg from enclosure ditch intervention 8m to the west
- 15.8kg from pit 37 just inside the enclosure ditch between those two sections.

Thus, a total of 53.6kg out of the total 62.1kg (i.e. almost 90%) derives from a very small part of the south-eastern section of the enclosure. The hand-dug sections across the enclosure ditch immediately west and east of this area showed no archaeometallurgical residues. This area also produced the single block of fuel ash slag that shows resemblance to the 'Iron Age grey slags' (Cowgill 2000, 2008; Cowgill *et al*. 2007; Swiss and McDonnell 2001). A ditch section further to the west only produced a single, slightly worn looking, slag piece (0.5kg).

An important assemblage from pit 52 is interpreted as being probably *in situ* in the basal pit of a 'slagpit' furnace – a variety of non-slag tapping furnace with a pit below the base of the shaft. This yielded 49 pieces of slag weighing 4.9kg (but the pit was only half-sectioned). The pit, originally interpreted as a posthole, had vertical fire-reddened sides, and was 0.3m in diameter and 0.3m deep. The slags indicated the use of a very slightly different technology to the large collection of material from the south-eastern part of the enclosure.

Pit 69 was of similar size to pit 52 but lacked direct evidence for burning. It produced a small assemblage (1.9kg) of residues, including flow slags, furnace ceramic, furnace bottom fragments and corroded iron. This too may be a furnace, but certainly acquired a fill of iron smelting waste. Unfortunately, the small size of the debris from its fill precludes determination of the nature of the pit-packing employed.

Description of iron-smelting residues

General

The non-slag-tapping furnaces used in Britain during the Iron Age, and subsequently to a lesser extent in the Roman and early medieval periods, employed a combustible pit packing in the base of the furnace. Above this level, the shaft of the furnace would receive the iron ore and charcoal fuel. The air blast was usually supplied by bellows through a blowhole (or sometimes blowholes) close to the base of the shaft. As the gravity-driven reaction proceeded in the shaft, the iron accumulated as a solid bloom in the top of the pit, with the waste material forming a liquid slag that descended into the pit. The combustion of the pit packing created space both for the descending slag and the growing bloom. The slag mass that formed below the level of the bloom is commonly known as a ‘furnace bottom’.

In the case of the Eckington material, there were two distinct types of material that fall into the general category of ‘furnace bottom’. The first of these, comprising the material from the south-eastern quadrant of the enclosure, shows a basal layer with amalgamated dense flow slag prills that have solidified around a pit packing of wood. Although of dense, well-formed slag, the prills are often more vesicular than is typical. The wood was in the form of both split wood and roundwood, up to 70mm wide and 200mm long. The base of this layer commonly showed distinct vertical slag prills and it was unclear whether the prills had solidified within the packing or actually reached a hard base. In contrast, the pit sides tended usually to show non-wetted lobate slag contacts, although a few specimens did show interaction of the slag with the pit wall, leading to large cobbles being embedded with the slag. The basal layer, with its dense slags, is abruptly overlain by a much more open-textured layer, with the slag formed by an open network of crystals. This texture, dubbed ‘coralline’ by Thomas (2000), has been observed in the gap between the bloom and the blowing wall in experimental smelts, but in this case, it appears to run below the bloom as well. The moulds of the wood packing may pass through the granular layer and are truncated at the upper surface of the slag, where there is a thin layer of more rusty appearance and chaotic texture. These slag blocks show a variable profile, but at least in some cases the upper surface of the block is inclined towards the centre of the pit. The blocks may be up to 100mm thick in the centre and as much as 240mm on the steep contacts with the pit wall.

The second variety, including the material from furnace 52, is formed throughout of vesicular but coherent, dense slag. The slag cake is formed by amalgamated prills, as in the first variety, but throughout the whole cake thickness. The upper surface of the cake shows flow lobes, somewhat similar to those of a tapslag but without the reddening. The cakes contain a few very large wood moulds, some of which pass steeply through the thickness of the cake. The wood moulds do not indicate closely packed wood, however. The sides of the cakes show fine moulds from cereal stems or grass and these are occasionally visible on fragments of the upper surface. Impressions of cereals frequently lie on the surface of the slag sheets, which appear to have formed on the sides of the pit.

Furnace 52, and to lesser extent pit 69, also produced a good assemblage of fine flow slag prills.

Less clearly diagnostic, but resembling furnace bottom slags from other sites, are a variety of examples of thick, charcoal-rich slags, often with a prilly texture. Slags with fine amalgamated prills around charcoal are commonly encountered in furnace bottoms, often in the slag of the distal part or below the bloom.

As well as the furnace bottom material, the collection included a significant quantity (1.9kg) of furnace ceramic, with varying degrees of vitrification and failure. Many of these show a higher degree of failure than is typical, with very few pieces showing a simple vitrified stable ceramic surface. Much of the ceramic was strongly bloated. The simplest textures were reduced-fired ceramics with multiple layers of vitrification, suggesting either repair or flow/sloughing of ceramic down-wall.

A single piece of slag (480g; from 100) showed a texture rich in very fine charcoal, overlying a more massive slag layer, which contained tubular vesicles arising of its base. Homogeneous slag with tubular vesicles is commonly seen in the lower part of smithing hearth cakes, but is also sometimes seen on furnace bottoms. In this piece, the size of the original cake is not known, and an interpretation as part of the base of a furnace bottom is preferred.

Comparative claystone ironstones

Two claystone ironstones were sampled: EKN7 from the centre of the Pinder Park Ironstone, and EKN8 from a thin sideritic ironstone 0.25m above the Chavery Coal. The ironstones were sampled in the Duckmanton Railway Cutting Nature Reserve, a locality 8.5km south of the site (Anon. 1980). The section in the Duckmanton cutting includes the Vanderbeckei Marine Band, the boundary between the Lower and Middle Coal Measures, which crops out at the site of the enclosure at Eckington. The marine band rests directly on the Joan Coal and a short distance below is the Chavery

Coal; between the two lie the sampled ironstones. At Eckington, they would crop out immediately west of the enclosure (BGS 1963).

The sample from the Pinder Park Ironstone (EKN7) proved to be highly calcareous, so a poor match for the extremely low-calcium slags. The sample from above the Chavery Coal (EKN8) was a much better match. Even this contained too much calcium and magnesium to be a good fit with a potential source, but the REE profile is very similar to those of the slags. The silica and alumina are also a little too high to be a fit with a potential source, which must have been a little richer in iron to have been able to generate the analysed slags.

Interpretation

Interpretation of the furnaces

The evidence for the type of furnace is both direct, from the furnace, and indirect, from the form of the slag. In both cases, the pit is suggested to be approximately 300mm in diameter. There is no evidence for a furnace arch, which, if present, must have been above ground level. At this small diameter, the furnaces are likely to have been simple, approximately cylindrical, shafts, perhaps resembling the only very slightly smaller examples described and reconstructed by Crew (1987; 1989; 1991; 1998; 2009). Non-tapping furnaces were ubiquitous in the Iron Age, but were largely replaced during the Roman period by a variety of slag-tapping furnaces, with a similar range of morphology from narrow cylindrical furnaces to large domed types, all with some provision for at least part of the slag produced during a smelt to be tapped from the furnace. Non-tapping furnaces re-emerged in some areas during the early medieval period, before being replaced by slag-tapping technology again in around the tenth century.

In most British examples of the 'slag-pit' furnaces, the basal pit carried a pit-packing of split or roundwood. A smaller number show a pit packing of grass/cereal stems. Such occurrences of cereal packed (or partially cereal packed) pits include examples from the Iron Age (Folly Court, Wokingham: Young in prep.), the Roman period (Leda Cottages: Paynter 2007, fig. 4) and the early medieval period (Clearwell Quarry: Paynter 2002; Yorkley: Young 2015; Churchills Farm Hemyock: Young 2016a). The Eckington material shows evidence for the use of wood pit-packing in the material from the south-eastern corner of the enclosure, but of a mixed packing (probably dominated by cereals/grass) in the material from furnace 52.

The size of the furnace(s) represented by the residues from the south-eastern part of the enclosure is not known with any certainty. The slag blocks mostly appear to suggest formation in a slag pit with a central flat floor of *c* 200mm diameter, inclined sides, and an overall pit diameter of *c* 500mm. Some pieces hinted at a somewhat steeper side, so it is possible that furnace pits varied in profile or perhaps that the furnaces were not symmetrical. There was no certain furnace recognised in this area, although pit 92 was of an appropriate size.

The present material is therefore very unusual in both being an example of iron smelting from the early medieval period within the region and, in the case of pit/furnace 52, being a variety of non-tapping furnace employing cereal/grass packing alongside some wood rather than the more common simple wood packing. The closest early medieval parallels for the use of a cereal packing are two sites in the Forest of Dean (Yorkley and Clearwell Quarry) that have produced radiocarbon dates of the 8th-9th centuries (Young 2015; Paynter 2002) and a site at Hemyock, Devon, that gave radiocarbon dates of the late 9th to early 10th centuries (Young 2016a).

Summary

The evidence for the technology of smelting at Eckington is very incomplete. It appears likely that the local ironstone resources were smelted in a small slagpit furnace, with either a wood pit packing or a mixed wood and cereals packing. The analysis was not capable of determining whether there was any distinct functional difference between these approaches.

Overall, the smelting appears to have had a low yield, but a much more comprehensive suite of analyses would be needed to determine the precise figures with any degree of certainty.

The determination of the ore employed suggests that it had a very similar composition to some of the local claystone ironstones, which would have outcropped very close to the site. The extremely low calcium and magnesium contents of the slag suggest that the ore was similarly depleted in these elements, which is unusual for claystone ironstones, although it is possible that weathered ore might have been selectively employed. The weathering would make the ore easier to prepare and some of the impurities would have been leached out.

Both the ore resource (Carboniferous claystone ironstone) and the technology (non-slag tapping with, at least partly, the use of cereals as packing) are unusual for the early medieval period.

FLINT

By Michael Donnelly

A single flint knife was recovered from the enclosure ditch. The piece is a well-made tool with slightly concave ventral backing/blunting down its left edge, regular invasive dorsal retouch along its convex right edge as well as less regular partially invasive retouch on the ventral surface of the right side continuing along its proximal edge.

HUMAN REMAINS

By Helen Webb

A single deposit of cremated human bone (105) was recovered, from pit 82. The deposit was very small, with a total weight of 6.1g. The largest fragment was just 10mm in length. Most of the bone (80%) was white in colour. The non-white bone comprised 15% grey and 5% black fragments. The bone represented a single adult or adolescent individual, based on the size and morphology of the single identifiable fragment within the deposit - the distal end of a hand phalanx. No lesions of pathology were observed.

Whilst low bone weights are a common finding in archaeological cremation deposits, the overall interpretation of deposit 105 is hampered by the fact that it was heavily truncated; it is impossible to estimate the amount of bone that may have been lost. The bone fragments were predominantly white in colour, which is indicative of full oxidation and a temperature of over 600ºC (McKinley 2004, 11). The presence of non-white bone fragments is not unusual, given the date of the remains. A large minority of black, blue and grey fragments are frequently noted in Roman cremation burials and it has been suggested that full oxidation of the bone may not have been considered necessary (McKinley 2000, 39).

CHARRED PLANT REMAINS AND CHARCOAL

By Julia Meen

Charred Plant Remains

Fifteen bulk samples were taken. The samples were processed for the recovery of charred plant remains, charcoal and small artefacts using a modified Siraf style flotation machine. Flots were collected onto 250µm meshes whilst heavy residues were sieved to 500µm. Preliminary examination of the flots showed that charred plant remains were generally sparse, with cereal grain often poorly preserved and weed seeds present only in low quantity. The two flots with greatest potential to provide information regarding the nature of activity at the site were selected for full analysis of charred plant remains, both of which came from enclosure ditch 131 (Table 5). The charred remains in each flot were fully sorted and identified using a Leica EZ4D binocular microscope and identifications were made with reference to published guides (eg Jacomet 2006; Cappers *et al*. 2006) and to the modern reference collection held at OA South. Nomenclature follows Stace 2010.

The lower fill (20) was dated on the basis of associated pottery to the Roman period, while the upper fill (123) produced a radiocarbon date of cal AD 650-770 (SUERC 75181), presumably relating to a dump of material into the partially silted up ditch in the later stages of its use. Both fills showed similarities in their composition, particularly in that they both contained numerous oat (*Avena* sp.) or oat/brome (*Avena*/*Bromus*) type caryopses. Both contain a range of weed taxa of cultivated and disturbed ground, including plantains (*Plantago* spp.), goosefoot/orache (*Chenopodium*/*Atriplex*), and grasses (Poaceae). Stinking chamomile (*Anthemis cotula*) is also present in both samples. Although this taxon is known from Roman sites, particularly those dating to later in the period, an increase in frequency has been observed in the early medieval period that has been attributed to cultivation of heavier soils (Greig 1991, 319).

Little cereal chaff was recovered from either sample and this, together with the poor preservation of many of the remains, means that it is more difficult to identify the cereals to species. Two rachis bases of free-threshing wheat were present in the early medieval sample, but these lacked the characteristics required to distinguish between *Triticum aestivum* (bread wheat) and *T. turgidum* (rivet wheat). However, no records of rivet wheat have been dated to earlier than the Late Saxon period in England, and where it is recorded in the later medieval period it generally has a more southerly distribution (Moffett 2006, 49). Compact, rounded grains recovered during evaluation of the enclosure ditch (OA 2013, 18) were identified as likely to be *T. aestivum*, and it is highly likely that the rachis in sample 14 is also of bread wheat. Bread wheat, which occurs at relatively low frequency from Romano-British sites, rapidly overtook the glume wheats from the fifth century onwards to become, alongside barley, the main crop cultivated in the early medieval period in England (Moffett 2006, 47; McKerracher 2016, 2).

No diagnostic floret bases were present to show whether the oats in either sample were cultivated or occurred as a weed of other cereal crops. However, a recent review of Middle Saxon charred plant assemblages from central and eastern England (McKerracher 2016) has suggested that oat, as well as rye, played an important role in the cultivation regimes of this period, with occurrences increasing particularly during the seventh to ninth centuries and in association with poorer soils. It is notable therefore that a section of probable rye rachis occurs in the later sample, but no trace of rye is present in the Roman fill.

The remains from both phases, which are dominated by grains of cereals and their associated weeds and are often poorly preserved and fragmentary, are suggestive of cereal processing waste. The material in the upper fill in particular may well have been reworked and incorporated into the iron-working debris that was dumped into the ditch. Fragments of hazelnut shell may hint at domestic activity, as discarded shells were thrown into hearths and later cleaned out into the ditch, or may alternatively have arrived in the ditch alongside the hazel fuelwood that has been identified amongst the early medieval charcoal (below). The presence of both flake and spheroid hammerscale in one of the evaluation samples from the enclosure ditch demonstrates that smithing was taking place in the vicinity.

Wood Charcoal

Four samples were selected for charcoal analysis on the basis of the preliminary assessment. These were a sample from cremation 82, dated to the Roman period, and three samples of early medieval date (Table 6). Up to 50 fragments (where available) were selected for species identification from each sample. Each fragment was fractured on the transverse, radial and tangential sections to observe anatomical characteristics. Identifications were made using a Brunel Metallurgical SP-400BD microscope at up to x400 magnification, and with reference to Schweingruber (1990).

The cremation contained a fairly small charcoal assemblage with a limited number of fragments large enough to attempt identification. Half of these larger fragments were too poorly preserved to be identifiable and several of the others could only be identified as diffuse porous, including items of roundwood. All the better-preserved items showed characteristics of the Betulacaeae family of woods, which includes hazel, alder and birch, but the only taxon that could be definitely identified was hazel (*Corylus avellana*). It is likely therefore that many of the other fragments are also hazel.

Of the three early medieval samples, both the charcoal from the base of the smelting furnace and the deposit from the possible charcoal-burning pit 37 were dominated by oak (*Quercus*), with fragments from both samples often containing tyloses in their vessels that indicate heartwood. Although analysis of the slag from the smelting furnace found imprints of cereal or grass stems which were interpreted as having been used as packing, only a very small number of poorly preserved grains were recovered from the sample, suggesting this fine, light material was almost completely burnt away during the smelting process. Gale (2003) showed that oak was the ‘consistently dominant’ fuel used at iron smelting sites dating from the early Iron Age through to the mid medieval period, with heartwood often used in preference. Oak, especially heartwood, is a very dense wood that burns at a high temperature. When converted to charcoal, which has the added advantage of burning in reducing conditions, it is highly suitable for use in iron smelting (Cowgill 2003). The use of oak heartwood at Staveley Lane suggests that the fuel was obtained from a mature woodland or a woodland that was managed on a long rotation. Cowgill (2003, 51) notes that heartwood does not develop in oak until the tree is at least 35 years old. Many of the oak fragments from the smelting furnace had closely spaced growth rings, suggesting they came from slow-growing trees such as might be found in a dense woodland with high competition for resources.

In contrast, the charcoal from the upper fill of the enclosure ditch comprises oak as less than a third of the examined fragments, and these did not show definite signs of being heartwood. The remainder of the assemblage consisted of a range of taxa often found in secondary or more scrubby woodland, including cherry/blackthorn (*Prunus* sp.), birch (*Betula*) alder (*Alnus glutinosa*), hazel, hawthorn-type (Pomoideae) and probable field maple (*Acer campestre*). Assessment of charred remains from the ditch during the evaluation phase showed that macrofossils of hedgerow shrubs, including elder (*Sambucus nigra*), bramble (*Rubus* sp.) and blackthorn/cherry (*Prunus* sp.) dominated the assemblage and it was suggested that these derived from the use of hedgerow shrubs as fuel (OA 2013). However, none of the charcoal from context 123 appeared to be roundwood, suggesting the material is not small branchwood or hedgerow clippings. The difference in composition in comparison to the two contemporary samples suggests that the material in the enclosure ditch relates to, or is mixed with, debris from a different activity. The sample also suggests that more open woodland was present than might be suggested by the mature oak from the other samples, perhaps from the understory layer of a managed oak woodland. There is no evidence of the fast-growing roundwood that a coppice with standards system would be expected to produce, so no definite woodland management can be inferred, although if smelting was occurring on anything more than a sporadic scale some form of management to guarantee fuel supplies would be expected.

ANIMAL BONE

By Martyn Allen

Soil conditions at the site were not conducive for the preservation of animal bones. Only pit 37 and an environmental sample from pit/posthole fill 69 produced animal remains. In both contexts, these comprised only a few fragments of tooth enamel from cattle teeth.

RADIOCARBON DATING

By Andrew Simmonds

During the evaluation a sample from a charred hazelnut from the lower part of the enclosure ditch was submitted for radiocarbon dating at the Scottish Universities Environmental Research Centre (SUERC) AMS Facility, Glasgow (SUERC-48229, Table 7). A further three samples of material from the excavation were subsequently submitted, comprising charcoal and charred plant remains associated with deposits of slag. The radiocarbon ages are quoted in conventional years BP (before AD 1950) and as calibrated calendrical dates at 95.4% confidence. The error includes components from the counting statistics on the sample, modern reference standards, background standards and the random machine error. The calibrated age ranges were determined using the University of Oxford Radiocarbon Accelerator Unit calibration program OxCal 4 (Bronk Ramsey 2009) and the IntCal13 curve (Reimer *et al*. 2013). All radiocarbon date ranges cited in the text of this report are those for the 95% confidence level (2 sigma) and have been rounded out to the nearest 10 years, following Mook (1986).

DISCUSSION

The excavation has revealed two distinct phases of activity. The first relates to an enclosed settlement, established either at the very end of the late Iron Age or in the early Roman period, that continued to be occupied until the late 2nd or early 3rd century AD. The second episode is characterised by evidence for iron production dated to the 7th and 8th centuries AD. There is no evidence for continued activity in the intervening period, when it appears that the site had been abandoned. However, it is likely that the enclosure was still a visible earthwork, as waste from the early medieval iron processing was dumped into the partly-silted ditch of the Roman enclosure.

The late Iron Age/early Roman settlement

Chronology

The settlement comprised a sub-circular enclosure with internal features consisting of shallow pits, postholes and gullies. It was certainly occupied by the third quarter of the first century AD, when this region was brought under Roman control (Taylor 2006, 141-3), but the dating evidence was ambiguous as to whether it was established after the conquest or earlier, during the late Iron Age. The radiocarbon date range of 50 cal BC-cal AD 80 that was obtained for a fragment of hazelnut shell recovered from the primary silt of the enclosure ditch during the evaluation stage could support either argument. No pottery that was incontrovertably of Iron Age date was recovered, but seven sherds of grog-tempered ware with a date range of *c* 50 BC-AD 100 were recovered from the enclosure ditch, albeit stratified above a fill that contained 20 body sherds in a reduced sandy fabric, some with clay pellets or grog, dated to *c* AD 70-200. Unfortunately, ingress of groundwater prevented excavation of the basal fills of the enclosure ditch in most of the interventions and so no dating evidence was recovered from these deposits. Several sherds of this early grog-tempered pottery were also recovered from the basal fill of pit 37, but this feature was used for dumping iron slag in the early medieval period and is unlikely to have been open in the late Iron Age/early Roman period. It is not always possible to reliably distinguish between late Iron Age and early Roman occupation in this region from pottery evidence; many sites appear to have been largely aceramic during the late Iron Age, while at others some hand-made vessel types of Iron Age form continued to be used into the early Roman period (Ottaway 2013, 148).

The presence of Derbyshire ware and Black Burnished ware indicates that activity continued into the second half of the 2nd century AD, and possibly into the early 3rd century. However, there are no distinctly late Roman wares at the site, such as Dales ware which was fairly ubiquitous in this region during the 3rd and 4th centuries (Tyres 1996, 190), or later Roman coinage which might suggest continued occupation. It seems likely therefore that the settlement was abandoned around the turn of the 3rd century. Notably, this chronology would broadly follow the regional pattern for rural sites on the Coal Measures, where there was an apparent increase in settlement numbers during the late Iron Age, a trend that continued to the end of the 2nd century before significant decline from this point to the end of the 4th century AD (Brindle 2016, 288-9). The reasons for these changes are not well understood.

Settlement form

By far the most prominent feature of the site is the boundary ditch that formed a circular or sub-circular enclosure around the settlement. Although the entire settlement was not exposed during the excavation, it was shown to measure *c* 72m across from east to west and potentially a similar distance north-south. Enclosed farmsteads are a widespread and frequently identified settlement type across late Iron Age and Roman Britain. A notable cluster of enclosed settlements is present on the Coal Measures and the adjacent Magnesian Limestone, mostly to the north of the current site (Allen and Smith 2016, 23-6). Many of these settlements were rectilinear in plan, though there is some variation within the region, including curvilinear, irregular and D-shaped examples. The nearest comparable curvilinear enclosures have been investigated at Raymoth Lane, Worksop, Nottinghamshire (Palmer-Brown and Munford 2004) and Holme Hall Quarry, Doncaster, South Yorkshire (ARCUS 2007). These enclosures measured *c* 125m and *c* 32m across respectively, indicating the wide range of settlement sizes present in the region.

At Eckington, all the internal features dating to this phase were located within the south-western part of the enclosure, though it is uncertain how much of the archaeology survives within the unexcavated northern half. The uneven distribution of features is unusual and suggests that later ploughing, evidenced by ridge and furrow across the site, had removed most of the shallower features and the upper parts of existing features, particularly in the eastern half of the site which appears to be empty. Such truncation undoubtedly restricts our understanding of the settlement. There is little evidence for buildings, for example, and although there are several postholes in the western half of the enclosure, none of these could be resolved into a structure. Curvilinear gully 132 may be the surviving part of a gully that encircled the location of a structure, but again the truncation of this feature makes this uncertain. The difficulty in identifying buildings of this period is an issue at most rural sites in this region. No structures were found at Raymoth Lane or Holme Hall Quarry (ibid.), for example, though finds and environmental evidence for domestic activity was present.

Early medieval iron smelting

The discovery of iron-smelting waste in the upper fills of the enclosure ditch and other internal features presents evidence of a second episode of activity at the site, occurring several hundred years after the cessation of the Roman settlement. Radiocarbon dating of three samples related to iron slag deposits gave three very consistent results that together provided a date range of cal AD 650-780. Iron production was the focus of activity in the early medieval phase, with no evidence for contemporary occupation. Some crop waste was recovered from the metalworking features but in the absence of other evidence for settlement it is likely that this material was brought to the site from elsewhere for use as fuel in the furnaces. There was no evidence for activity at the site between the later 3rd and the early 7th century AD and it can only be assumed that the site was abandoned in the intervening period.

Technology

Young's analysis of the iron slag residues has indicated evidence for two styles of smelting technology, one of which used grass packing in the base of the furnace whereas the other used wood. Pit 52 in the south-western part of the enclosure was the only feature to contain *in situ* slag deposits, suggesting that the feature was part of a furnace. The smelting residue had collected and cooled in the base of the feature, the sides of which had reddened from heat exposure. The pit measured *c* 0.30m across its upper surface, though no evidence for the superstructure survived. The slag type indicated the presence of a non-slag tapping furnace of a type common in the Iron Age but which saw a resurgence in the early medieval period. Imprints of cereal and/or grass stems were observed on some of the slag and though no organic remains other than charcoal survived, it is possible that this was used as packing or lining in the base of the furnace. The use of cereal/grass packing is not thought to have been as common as wood. Nonetheless, other examples of this practice have been identified at Yorkley (Young 2015) and Clearwell Quarry (Paynter 2002), Gloucestershire, in the Forest of Dean. Both sites produced radiocarbon dates of 8th-9th century AD, slightly later than the Eckington dates.

A much larger quantity of iron-production waste, representing *c* 90% of the total weight of slag from the site, was recovered from features in the south-eastern part of the site. Two interventions across the enclosure ditch in this area together produced 37.8kg of slag, and a further 15.8kg was recovered from pit 37 which lay immediately adjacent. These features contained waste dumped after smelting and the remains suggest a slightly different technique to that observed in the slag from furnace 52, with split- and round-wood used for packing rather than cereal/grass. The residues formed a bowl-shaped layer of dense-flow, lobed slags containing moulds of wood, which was overlain by a layer of open-textured, granular slag. This differed from the residues in furnace 52 which appeared to have been more free-flowing, dripping into the slagpit well below the level of the bloom.

There was no evidence of the furnaces responsible for the slags found in the south-eastern part of the site. It is possible that posthole 92, located 20m to the north-east, was a furnace pit, since it was of an appropriate size, although the feature lacked sufficient quantities of slag and exhibited little sign of *in situ* burning. It is highly unlikely that pit 37 represents the remains of a furnace as it was too large, although this feature may have been a charcoal-burning pit associated with the ironworking that was subsequently backfilled with iron processing debris. It is uncertain whether the two smelting techniques were in use at the same time, or whether they represent different technological phases.

Iron ore sources

The source of the iron ore used at the site is uncertain. Young notes a particularly low magnesium and calcium content in the slag, which may indicate the use of bog iron from Eckington Marsh, which formerly occupied an area close to the River Rother and may have provided suitable conditions for its formation. However, no bog iron is currently known in this area, and a more likely source may be one of the bands of ironstone that are located in the Coal Measures, with which the trace element content of the slag provides a very strong link. The closest known example is the Pinder Park Ironstone, an outcrop of which has been recorded *c* 1.5km SSW of the site, although the geochemical evidence suggests a possible source in the more minor ironstones, some of which have a predicted outcrop within a few metres of the site. These sources are not consistent with the low magnesium and calcium content of the Eckington slag, but it is possible for the ore composition to have been altered by weathering at the outcrop or by the process of ore roasting prior to smelting.

The significance of the site

Overall, the remains of iron bloomeries at Eckington indicates the presence of a fairly small-scale production site during the mid 7th-8th centuries AD. This adds important new evidence to our understanding of the iron industry in early medieval England. There is a relative lack of early medieval smelting sites, in contrast to the wealth of evidence from the Roman period (McDonnell 1989). Indeed, Birch could identify only eight known sites dating from the early and middle Anglo-Saxon periods in the entire country (Birch 2011). This is despite the considerable quantity of iron and ferrous-alloy objects known from the period. Many high-status iron artefacts were probably imported at this time, although this origin is unlikely to account for a wide range of more utilitarian items. Birch (2011, 12-15) argues that metalworking craftsmen were fairly mobile and may have lived and worked at the periphery of rural society; there is little evidence that iron-working was undertaken as a 'side industry' at agricultural settlements. One notable aspect of the Eckington ferrous-waste assemblage is that there is almost no evidence for smithing, as only minimal quantities of hammerscale were identified. It may be that raw iron was exported from the site soon after it was produced. It is likely that the smithing of the raw iron down to a usable material was usually undertaken in the early medieval and medieval periods at centralised estate (later manorial) smithies, whereas smelting took place in dispersed locations close to the ore source, and particularly to the woodland resources required.

The re-use of an abandoned early Roman site also appears to have been significant. The enclosure may have provided a suitable place to undertake iron smelting within a convenient and ready-made ditched boundary, while its position towards the bottom of a natural slope would have provided some protection from the weather. The antiquity of the Roman site may also have been important. The re-use of prehistoric and Roman sites in the Anglo-Saxon period is often seen as having an ideological significance for those involved, indicating their perception of the landscape and their place within it (Williams 1997; Semple 2010). If Birch (2011) is correct in his assertion that Anglo-Saxon blacksmiths were associated with magic and myth, the re-use of an ancient enclosure located away from domestic settlement may therefore have provided the perfect place to undertake their work and cement their identity, although it is alternatively possible that the location was selected for more pragmatic reasons, as a relatively level area adjacent to a stream and possibly protected by the remnants of the Roman enclosure.

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The full site archive will be deposited with Weston Park Museum (Museums Sheffield).

BIBLIOGRAPHY

Allen, M. and Smith, A. (2016) Rural settlement in Roman Britain: Morphological classification and overview. In A. Smith, M. Allen, T. Brindle and M. Fulford, *New Visions of the Countryside of*

Roman Britain, Vol. 1: The Rural Settlement of Roman Britain. Society for the Promotion of Roman Studies Monograph 29, London: 17-43.

Anon. (1980) *The W. H. Wilcockson Nature Reserve, Duckmanton Railway Cutting Geological Trail*, Derbyshire Naturalists Trust.

ARCUS (2007) Final report of archaeological excavation at Holme Hall Quarry, near Stainton, Doncaster, South Yorkshire. Archaeological Research and Consultancy at the University of Sheffield report.

Bayley, J., Dungworth, D. and Paynter, S. (2001) *Archaeometallurgy: Guidelines for Best Practice* (D. Dungworth, revised 2015), Portsmouth: English Heritage.

BGS. (1963) Geological Survey of England and Wales 1:63,360 geological map series, New Series No. 112, Chesterfield. Solid and Drift.

Birch, T. (2011) Living on the edge: making and moving iron from the ‘outside’ in Anglo-Saxon England. *Landscape History* 32.1: 5-23.

Boesenberg, J. S. and Hewins, R. H. (2010) An experimental investigation into the metastable formation of phosphoran olivine and pyroxene. *Geochimica et Cosmochimica Acta* 74: 1923-1941.

Booth, P. (2014) Oxford Archaeology Roman pottery recording system: an introduction. Unpublished report.

Brindle, T. (2016) The Central West. In A. Smith, M. Allen, T. Brindle and M. Fulford, *New Visions of the Countryside of Roman Britain, Vol. 1: The Rural Settlement of Roman Britain*. Society for the Promotion of Roman Studies Monograph 29, London: 282-307.

Bronk Ramsey, C. (2009) Bayesian analysis of radiocarbon dates. *Radiocarbon* 51(1), 337–60.

Campbell, G., Moffett, L. and Straker, V. (2011) *Environmental Archaeology: A Guide to the Theory and Practice of Methods, from Sampling and Recovery to Post-excavation*. 2nd Edition. Portsmouth: English Heritage.

Cappers, R. T. J., Bekker, R .M. and Jans, J. E. A. (2006) *Digital Seed Atlas of the Netherlands*. Groningen: Institute of Archaeology.

Challis, K. (1998) Stanley Grange Derbyshire: Interim Excavation Report and Post-Excavation Assessment, Trent and Peak Archaeological Unit Report SGD3.

Cowgill, J. (2000) Assessment report on the slags recovered from the excavations at Billingley Thorpe, Thurnscoe, South Yorkshire (BDT99). Archive report produced for Northern Archaeological Associates.

Cowgill, J. (2003). The iron production industry and its extensive demand upon woodland resources: a case study from Creeton Quarry, Lincolnshire. In Murphy and Wiltshire (2003): 48-57.

Cowgill, J. (2008) Report on the slag and associated finds from Normanton Industrial Estate (NOI 06). Archive report produced for West Yorkshire Archaeology Service.

Cowgill, J., Mack, I. and McDonnell, G. (2007) Slags and related material. In L. Jones, A. Woodward and S. Buteux, *Iron Age, Roman and Saxon Occupation at Grange Park: Excavations at Courteenhall, Northamptonshire*. British Archaeological Reports, British Series 425. Oxford.

Crew, P. (1987) Bryn y Castell hillfort: a late prehistoric iron working settlement in north-west Wales. In B.G. Scott and H. Cleere (eds) *The Crafts of the Blacksmith*. Belfast: Ulster Museum/UISPP Comité pour la Sidérurgie ancienne: 91-100.

Crew, P. (1989) Crawcwellt West excavations 1986-1989: a late prehistoric ironworking settlement. *Archaeology in Wales* 29: 11-16.

Crew, P. (1991) The experimental production of bar iron. *Historical Metallurgy* 25: 21–36.

Crew, P. (1998) Excavations at Crawcwellt West, Merioneth, 1990-98: a late prehistoric upland ironworking settlement. *Archaeology in Wales* 38: 22-35.

Crew, P. (2009) *Iron working in Merioneth from prehistory to the 18th century*. Darlithiau Coffa Merfyn Williams Memorial Lectures No. 2, Snowdonia National Park/Plas Tan y Bwlch, Maentwrog.

Gaffney, V., White, R. H. and Goodchild, H. (2007) *Wroxeter, The Cornovii, and the Urban Process: Final Report on the Wroxeter Hinterland Project 1994–1997, Vol. 1: Researching the Hinterland*. Journal of Roman Archaeology Supplementary Series 68, London.

Gale, R. (2003) Wood-based industrial fuels and their environmental impact in lowland Britain. In Murphy and Wiltshire 2003: 30-47.

Gater, J. (2013) Geophysical survey report G1334: land off Staveley Lane, Eckington. Unpublished report.

Greig, J. (1991) The British Isles. In W. van Zeist, K. Wasylikowa and K-E. Behre (eds), *Progress in Old World Palaeoethnobotany*. Rotterdam: A. A. Balkema: 299-334.

Jacomet, S. (2006) *Identification of Cereal Remains from Archaeological Sites*. 2nd edition. Basal University.

Jones, A. (1995) Sherwood Lodge, Bolsover: archaeological investigations 1992-3. *DAJ* 115, 84-106.

Jones, M. (1981) The development of crop husbandry. In M. Jones and G. W. Dimbleby (eds), *The Environment of Man: The Iron Age to the Anglo-Saxon Period.* British Archaeological Reports, British Series 87. Oxford: 95–127.

Keys, L. (2006) The iron slag. In L. Keys and R. Shaffrey Small finds from Leda Cottages, Westwell, Kent (ARC 430 01/83+200). Channel Tunnel Rail Link Specialist Archive report: 3-16. https://doi.org/10.5284/1000230

Leary, R. S. (2001) Romano-British pottery. In A. Palfreyman, Report on the excavation of a Romano-British aisled building at Little Hay Grange, Ockbrook, Derbyshire 1994–97. *DAJ* 121: 95-130.

Leary, R. S. (2003) The Romano-British pottery from the kilns at Lumb Brook, Hazelwood, Derbyshire. *DAJ* 123: 71-110.

McDonnell, J. G. (1989) Iron and its alloys in the fifth to eleventh centuries AD in England. *World Archaeology* 20.3: 373-382.

McKerracher, M. (2016) Bread and surpluses: the Anglo Saxon 'bread wheat thesis' reconsidered. *Environmental Archaeology* 21: 88-102.

McKinley, J. I. (2000) Phoenix rising; aspects of cremation in Roman Britain. In J. Pearce, M. Millett and M. Struck (eds), *Burial, Society and Context in the Roman World*. Oxford: Oxbow Books: 38-44.

McKinley, J. I. (2004) Compiling a skeletal inventory: cremated human bone. In M. Brickley and J. I. McKinley, *Guidelines to the Standards for Recording Human Remains*, IFA Paper No. 7, British Association for Biological Anthropology and Osteoarchaeology and IFA: 9-13.

Moffett, L. (2006) The archaeology of medieval plant foods. In C. M. Woolgar, D. Serjeantson and T. Waldron (eds), *Food in Medieval England: Diet and Nutrition*. Oxford: Oxford University Press.

Mook, W.G. (1986) Business Meeting: recommendations/resolutions adopted by the twelfth International Radiocarbon Conference. *Radiocarbon* 28: 799.

Murphy P. and Wiltshire, P.E.J. (2003) *The Environmental Archaeology of Industry. Symposia of the Association for Environmental Archaeology 20*. Oxford: Oxbow Books.

Ottaway, P. (2013) *Roman Yorkshire: People, Culture and Landscape*, Pickering

Oxford Archaeology (2013) Land off Staveley Lane, Eckington, Derbyshire: archaeological evaluation report. Oxford Archaeology unpublished report. http://library.thehumanjourney.net/1356/

Palmer-Brown, C. and Munford, W. (2004) Romano-British life in North Nottinghamshire: fresh evidence from Raymoth Lane, Worksop. *Transactions of the Thoroton Society* 108, 19-86.

Paynter, S. (2002) Iron-working slag. In A. Holmes Clearwell Quarry Extension, Stowe Hill, Gloucestershire. Oxford Archaeology, unpublished report: 6-7.

Paynter, S. (2007) Innovations in bloomery smelting in Iron Age and Romano-British England. In S. La Niece, D. Hook and P. Craddock (eds), *Metals and Mines: Studies in Archaeometallurgy*, London: Archetype Publications: 202-10.

Reimer, P. J., Bard, E., Bayliss, A., Beck, J. W., Blackwell, P. G., Bronk Ramsey, C., Buck, C. E., Cheng, H., Edwards R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Haflidason, H., Hajdas, I., Hatté, C., Heaton, T. J., Hoffmann, D. L., Hogg, A. G., Hughen, K. A., Kaiser, K. F., Kromer, B., Manning, S. W., Niu, M., Reimer, R. W., Richards, D. A., Scott, E. M., Southon, J. R., Staff, R. A., Turney, C. S. M., and van der Plicht, J. (2013) Intcal 13 and marine13 radiocarbon age calibration curves 0–50,000 years cal BP'. *Radiocarbon* 55: 1869-87.

Sauder, L. and Williams, S. (2002) A practical treatise on the smelting and smithing of bloomery iron. *Historical Metallurgy* 36: 122-131.

Schairer, J.F. and Yagi, K. (1952) The system FeO- Al2O3- SiO2. *American Journal of Science* (Bowen volume): 471-512.

Schweingruber, F. (1990) *Microscopic Wood Anatomy*. 3rd edition. Birmensdorf, Swiss Federal Institute for Forest, Snow and Landscape Research.

Semple, S. (2010) A fear of the past: the place of the prehistoric burial mound in the ideology of middle and later Anglo-Saxon England. *World Archaeology* 30.1: 109-126.

Stace, C. (2010) *New Flora of the British Isles*. 3rd edition. Cambridge: Cambridge University Press.

Swiss, A.J. and McDonnell, G. (2001) Report on the analysis of 'Iron Age grey' slag from the Conoco site at Killingholme, Lincolnshire, CNK00. Archive report produced for Humberside Field Archaeology.

Taylor, J. (2006) The Roman period. In N. J. Cooper (ed) *The Archaeology of the East Midlands: An Archaeological Resource Assessment and Research Agenda*. Leicester Archaeology Monographs No. 13. London: 137–60.

Taylor, S. R. and McLennan, S. M. (1981) The composition and evolution of the continental crust: rare earth element evidence from sedimentary rocks. *Philosophical Transactions of the Royal Society* A301: 381-399.

Thomas, G. (2000) A chemical and mineralogical investigation of bloomery iron-making in the Bristol Channel Orefield, UK. Unpublished PhD thesis, Cardiff University.

Thomas, G. R. and Young, T. P. (1999a) Bloomery furnace mass balance and efficiency. In A. M. Pollard (ed.) *Geoarchaeology: exploration, environments, resources.* Geological Society of London, Special Publication 165. London: 155-164.

Thomas, G. R. and Young, T. P. (1999b) A graphical method to determine furnace efficiency and lining contribution to Romano-British bloomery iron-making slags (Bristol Channel Orefield, UK). In S. M. M. Young, P. D. Budd, R. A. Ixer, and A. M. Pollard (eds), *Metals in Antiquity*, British Archaeological Reports International Series 792. Oxford: 223-226.

Tomber, R. and Dore, J. (1998) *The National Roman Fabric Reference Collection: A Handbook*. London, MoLAS Monograph 2. London.

Tyres, P. (1996) *Roman Pottery in Britain*, London: Rouledge.

Williams, H. (1997) Ancient landscapes and the dead: the reuse of prehistoric and Roman monuments as early Anglo-Saxon Burial Sites. *Medieval Archaeology* 41, 1-32.

Young, T. P. (1993) Sedimentary ironstones. In R. A. D. Pattrick and D. A. Polya (eds), *Mineralization in Britain*, London: Chapman and Hall: 446-489.

Young, T.P. (2015) Assessment of archaeometallurgical residues from Yorkley, Gloucestershire. GeoArch Report 2015-24.

Young, T. P. (2016a) Archaeometallurgical residues from Churchills Farm, Hemyock, Devon. GeoArch Report 2015-31.

Young, T. P. (2016b) Archaeometallurgical residues from Fleet Hill Farm, Finchampstead, Berkshire. GeoArch Report 2016-35.

Young, T. P. (2017a) Assessment of archaeometallurgical residues from Staveley Road, Eckington, Derbyshire (SLE13 / ECSL17). GeoArch Report 2017/13.

Young, T .P. (2017b) Archaeometallurgical residues from Staveley Road, Eckington, Derbyshire (SLE13 / ECSL17). GeoArch Report 2017/15.

Young, T. P. (in prep) Archaeometallurgical residues from Folly Court, Wokingham, Berkshire. GeoArch Report 2017-09.

Young, T. P. and Poyner, D. (2014) 'Two medieval bloomery sites in Shropshire: the adoption of water-power for iron smelting'. *Historical Metallurgy* 46: 78-97.

A ROMAN ENCLOSED SETTLEMENT WITH EVIDENCE FOR EARLY MEDIEVAL IRON SMELTING AT STAVELEY LANE, ECKINGTON - Tables

Table 1: Quantification of the pottery by fabric. MV – minimum number of vessels, EVE – estimated vessel equivalent. Fabric codes from Booth (2014), NRFRC fabric codes in brackets (Tomber and Dore 1998)

Fabric	Description	Sherds	Weight (g)	MV	EVE
B11	Dorset black-burnished ware (DOR BB 1)	1	7		
E80	Grog-tempered ware; some occurrences also contain shell	15	116	1	0.35
O20	Sandy/gritty oxidised wares	5	17	1	0.09
R20	Sandy reduced wares	59	705	3	0.95
R211	Derbyshire coarse ware (DER CO)	4	17		
R30	Medium sandy reduced wares	25	175		
R90	Sandy reduced fabric with clay pellets/grog	18	148	1	0.05
TOTAL		127	1185	6	1.44

Table 2: Quantification of vessel types by fabric. CD – medium-mouthed jar, CJ – lid-seated jar, HC – curving-sided bowl, I – indeterminate bowl or dish, JA – bead-rimmed straight-sided dish, EVE – estimated vessel equivalent. Fabric and form codes from Booth (2014)

Fabric	**CD**	**CJ**	**HC**	**I**	**JA**	**Total EVE**
E80	0.35					0.35
O20		0.09				0.09
R20			0.10		0.85	0.95
R90				0.05		0.05
Total EVE	0.35	0.09	0.10	0.05	0.85	1.44

Table 3: Summary of metallurgical residue material class by context. Abbreviations: FB furnace bottom; FAS fuel ash slag; BFS blast furnace slag. Weights in g.

context		FB	flow slag	indet slag	lining/ lining slag	iron	scale	ore?	FAS	BFS	*total residue*
	Hand-picked material										
sle13											
12	Upper fill of enclosure ditch 131 in Evaluation Trench	28,566									*28,566*
28	Fill of pit 17									6	*6*
ecsl17											
35	Upper fill of enclosure ditch 131	494									*494*
38	Upper fill of pit 37	5472									*5472*
53	Fill of furnace 52	4894			36						*4930*
97	Fill of pit 92	1695									*1695*
100	Middle fill of pit 37	8929		480	712				210		*10,331*
123	Upper fill of enclosure ditch 131	6646			1168	1390					*9204*
	Material from bulk samples										
ecsl17											
20	Sample <12>			y			y	y			
35	Sample <2>			tr			tr	?			
49	Sample <4>			y			y				
53	Sample <6>, furnace 52 (>4mm total)		1012					y			*1012*
55	Sample <5>						tr	y			
70	Sample <9>, fill of pit 69 (>10mm total)	298	474	820	86	196					*1874*
113	Sample <13>			y			tr	y			
total		*56994*		*1300*	*2002*	*1586*			*210*	*6*	*62148*

Table 4: Metallurgical residue samples

Sample	context	Context description	Sample description	Bulk analysis	SEM
Smelting residues					
EKN1	53	Fill of basal pit of furnace [52]	dense flow slag	Y	
EKN2	53	Fill of basal pit of furnace [52]	straw-marked crust	Y	
EKN3	12	Upper fill of enclosure ditch [131] in Trench 10	lower lobes of dense slag below EKN4	Y	Y
EKN4	12	Upper fill of enclosure ditch [131] in Trench 10	vesicular layer above EKN3, ‘coralline’ slag	Y	
EKN5	12	Upper fill of enclosure ditch [131] in Trench 10	prilly, charcoal rich, ‘coralline’ slag	Y	Y
Hearth/furnace ceramic					
EKN6	123	Upper fill of enclosure ditch [131] in Cut 80	furnace ceramic	Y	
Iron ore					
EKN7		Duckmanton: central part of Pinder Park Ironstone	ironstone	Y	
EKN8		Duckmanton: ironstone 0.35m above Chavery coal	ironstone	Y	

Table 5: Summary of charred plant remains

		Sample no.	**12**	**14**
		Context no.	**20**	**123**
		Cut no.	**17**	**80**
		Feature type	**Ditch terminus**	**Ditch terminus**
		Phase	**Roman**	**Early medieval**
		Processed Volume	**36L**	**28L**
cf *Triticum* sp	cf wheat	grain		1
Hordeum vulgare	barley	grain		3
Avena sp.	oat	caryopsis	15	27
Avena/Bromus	oat/brome	caryopsis	37	45
Indet Cereal		grain	3	66
Indet Cereal		grain fragments	+++	++++
Triticum aestivum/turgidum	free threshing wheat	rachis base		2
cf *Secale cereale*	cf rye	articulated rachis		2
Avena sp.	oat	awn fragments	16	7
Fabaceae	legume	cotyledon fragments	10	
Trifolium/Medicago/Melilotus	clover/medick/melilot	seed		3
Corylus avellana L.	hazel	nutshell fragments	3	8
Polygonaceae	knotweed family	seed		2
Rumex sp.	dock	seed		7
Chenopodium/Atriplex	goosefoot/orache	seed	2	7
Galium sp.	bedstraw	seed		1
Veronica hederifolia L.	ivy-leaved speedwell	seed	6	8
Plantago major L.	greater plantain	seed	1	
Plantago cf *lanceolata* L.	cf ribwort plantain	seed		1
Lapsana communis L.	nipplewort	seed		3
Anthemis cotula L.	stinking chamomile	seed	5	14
Poaceae - small	small grass	seed	2	3
Poaceae - medium	medium grass	seed	3	3
Arrhenatherum elatius var *bulbosum* (Willd.) St-Amans	onion couch grass	tuber	1	
Bromus sp.	brome	caryopsis	1	1
indet		seed	15	18

* < 5 items; ** 5-25 items; *** 25-50 items; **** >50 items

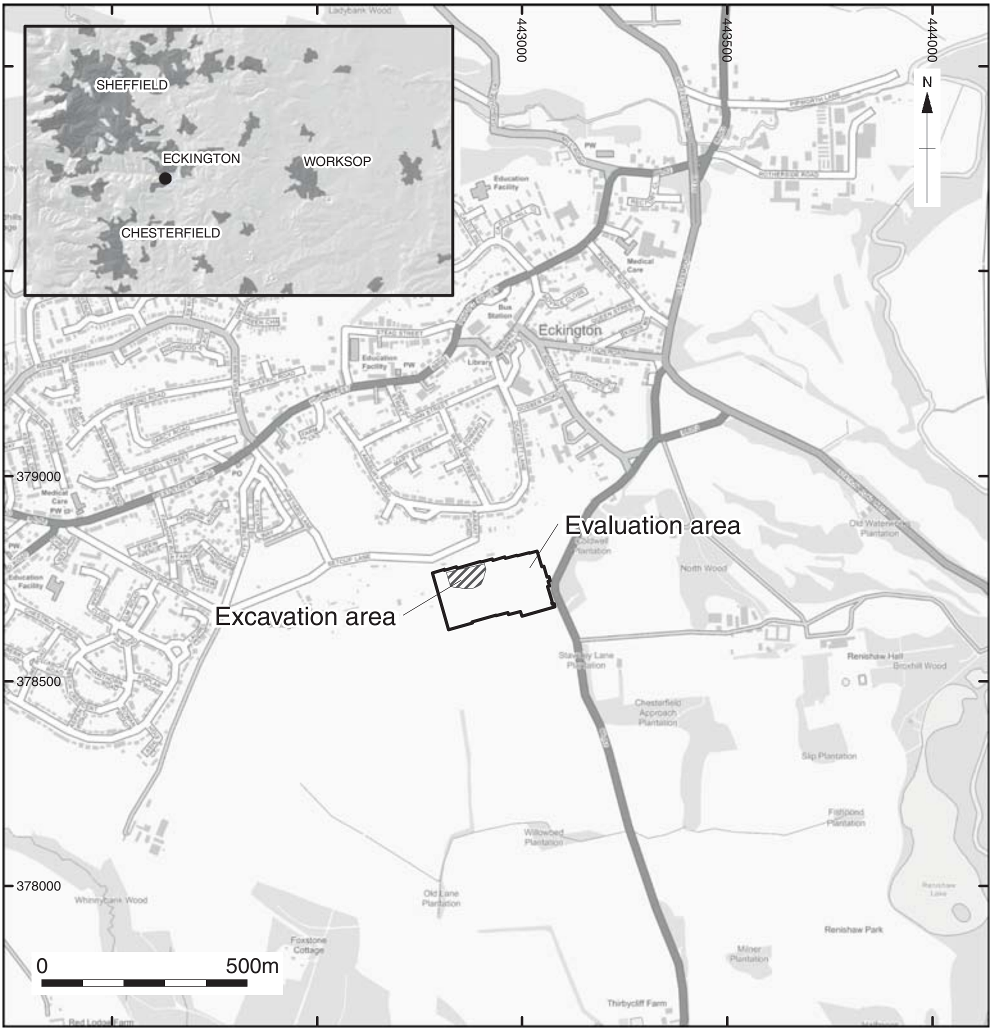
Table 6: Summary of wood charcoal

	Sample no.	**10**	**6**	**9**	**14**
	Context no.	**105**	**53**	**38**	**123**
	Cut no.	**82**	**52**	**37**	**80**
	Feature type	**Cremation**	**Furnace**	**Pit**	**Ditch**
	Phase	**Roman**	**Early medieval**	**Early medieval**	**Early medieval**
Prunus sp.	cherry/blackthorn/plum				1
cf *Prunus* sp.	cf cherry/blackthorn/plum				1
Pomoideae	hawthorn/rowan/ whitebeam type			1	
cf Pomoideae	cf hawthorn/rowan/ whitebeam type				2
Quercus sp.	oak		50 (h)*	39 (h)	15
Betulaceae	birch family	1			1
Betula sp.	birch			1	6
cf *Betula* sp.	cf birch				3
Alnus glutinosa (L.) Gaertn	alder				4
Corylus avellana L.	hazel	6		5	9
cf *Corylus avellana* L.	cf hazel	2			
Corylus/Alnus	hazel/alder	2			3
cf *Acer campestre* L.	cf field maple				1
ring porous					3
diffuse porous		4 (r)			
indet		15		4	1
Total		**30**	**50**	**50**	**50**

***** incl slow grown wood
r roundwood
h heartwood

Table 7: Summary of radiocarbon results

Lab. ID	**Context**	**Feature**	**Material**	**Radiocarbon age (BP)**	**δ^{13}C (0/00)**	**Calibrated date (95.4% confidence)**
SUERC-48229	21	Ditch 131	Charred hazelnut (Corlus avellana)	1977 ± 27	-23.2	50 cal BC- cal AD 80
SUERC-75177	38	Pit 37	Charcoal (*Corylus*)	1315 ± 30	-23.9	cal AD 650-770
SUERC-75181	123	Ditch 131	Charcoal (*Betula*)	1303 ± 31	-26.5	cal AD 650-770
SUERC-75182	53	Furnace 52	Charred grain (*Triticum* sp.)	1272 ± 31	-23.2	cal AD 660-780 (92.2%) cal AD 790-830 (1.6%) cal AD 840-860 (1.7%)



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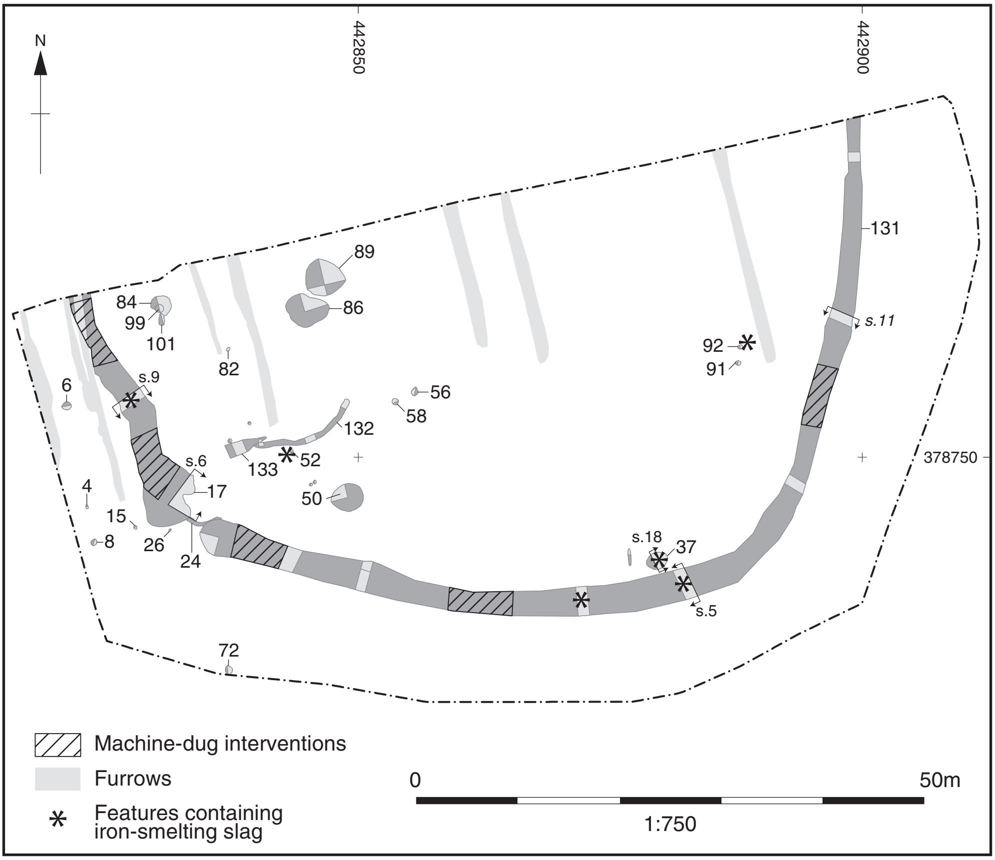

Figure 2: Plan of excavation

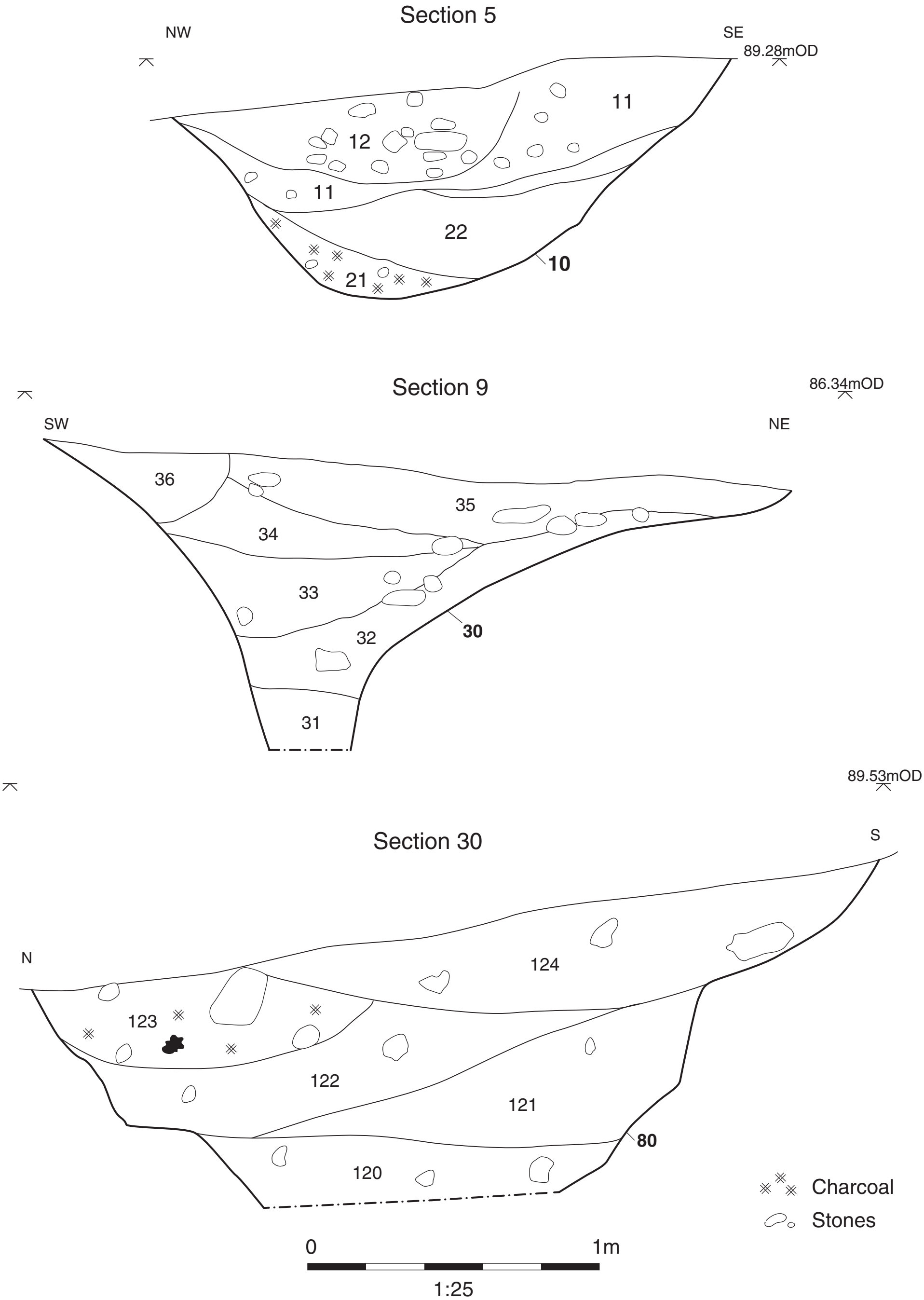

Figure 3: Sections of enclosure ditch 131

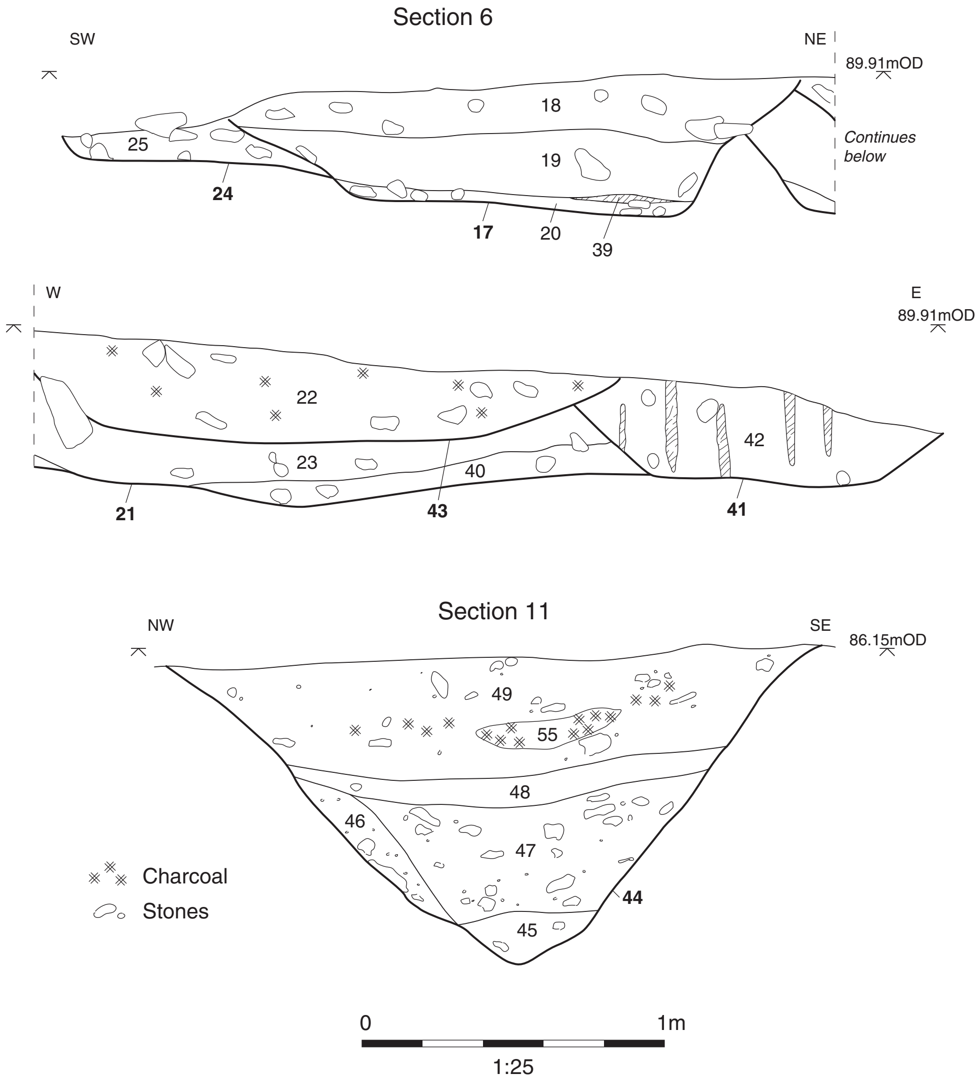

Figure 4: Sections of enclosure ditch 131

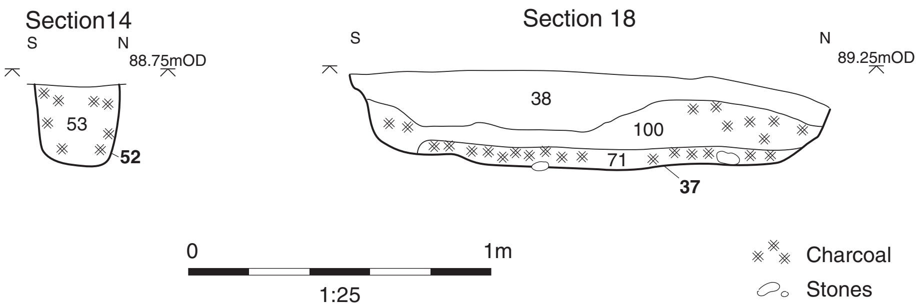

Figure 5: Sections of early medieval features

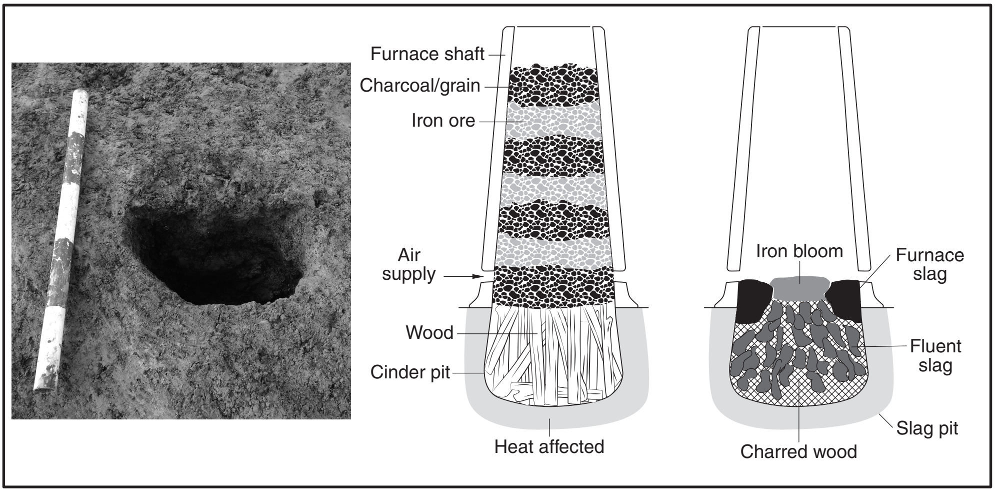

Figure 6: Photograph of furnace base 52 and schematic diagram of a slag pit furnace

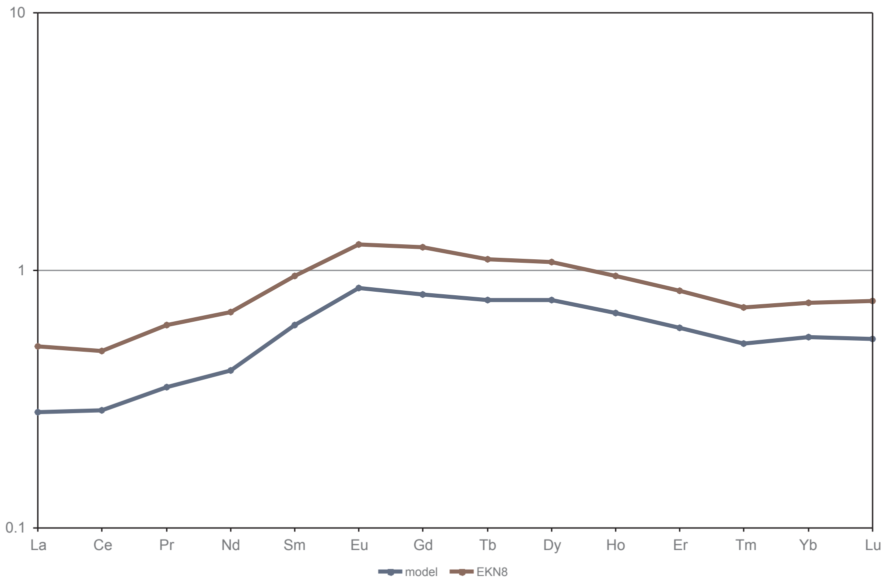

Figure 7: (REE) upper crust-normalised rare earth element profiles (normalisation after Taylor & McLennan 1981.) for a modelled ore composition (for details see text), compared with the actual profile of iron sample EKN8, a sideritic ironstone from 0.25m above the Chavery Coal in the Duckmanton Railway Cutting.

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