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Assessment of archaeometallurgical residues from Dwr-y-Felin School, Neath, (GGAT 674)

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Abstract

The material from this site comprised approximately 4.1kg of archaeometallurgical residues and related materials, of which approximately 2.5kg was retrieved from Roman, or probably Roman, contexts.

Most of the residues are from ironworking (blacksmithing). The presence of microresidues in two contexts suggests that some of the ironworking took place within the excavated area – probably in at least two distinct phases. The later phase of ironworking, associated with the 'industrial area' is unusual for this site in being coal-fuelled, rather than charcoal fuelled (although coal-fuelled smithing is common on other Roman sites in South Wales).The dispersed smithing residues are largely charcoal-fuelled.

The' industrial area' also yielded a single sherd of crucible of Roman/early medieval type that would have been used for non-ferrous metalworking, but which contained no visible diagnostic residues. A single fragment of copper slag/dross was also recovered from the initial road surface, indicating the working of copper alloys at an earlier point in the site's history.

There is a very small amount of bloomery iron smelting slag, at least some of which is securely stratified, although most is residual.

Post-medieval to modern contexts contained a variety of metallurgical residues from the later iron and possibly copper industries, as well as a quantity of clinker, at least some of which is probably non-metallurgical.

Contents

Abstract 1

Methods 1

Results 2

Description of materials
- coke 2
- friable red clinker 2
- other clinker 2
- smithing hearth cakes (SHCs) 2
- vitrified hearth lining 2
- gravelly lining slag 2
- other lining/FAS 2
- tapped bloomery slag 2
- other dense 3
- blast furnace or cupola slag 3
- indeterminate slags 3
- crucible and copper slag 3
- hammerscale 3

Distribution of materials 3

Interpretation 4

Evaluation of potential 4

References 5

Table 1: summary catalogue of materials 6
Table 2: residue classes by context 14

Methods

All materials were examined visually with a low-powered binocular microscope where required. As an evaluation, the materials were not subjected to any high-magnification optical inspection, not to any form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional. The summary catalogue of examined material is given in Table 1.

This project was undertaken for Martin Tuck of the Glamorgan-Gwent Archaeological Trust. The materials derive from a gas main replacement project by Wales and West Utilities at Dwr-y-Felin School, Neath, Neath Port Talbot.

Results

The archaeometallurgical residues and related materials derive from a wide range of processes and occur in a rather low density. This indicates that much of the material was residual within the contexts within which it occurred. The following sections describe the residues and their distribution. Materials in the sample determined not to be, or not likely to be, of metallurgical origin have been excluded from this descriptive section, but are listed in full in the catalogue (Table 1).

Description of materials

Coke: these materials are highly porous, low-density, carbonaceous materials. They are the dominantly organic residues of incomplete combustion of coal. It is likely that they will be mainly residues from the use of coal, rather than deliberately manufactured coke.

Sixteen pieces weighing a total of 35g were recovered.

Friable red clinker: this material occurs mainly in sheet-like form, up to about 40mm thick. The materials are very friable and contain a high proportion of un-fused shale fragments. It typically has a bright red colour. The material is suggestive of clinker formation during the relatively low-temperature combustion of coke. Such materials are not necessarily metallurgical in origin – but may arise from coal combustion in steam boilers – or during the manufacture of town gas.

A total of 636g of this material was recovered.

Other clinker: these materials are more conventional clinkers, showing a higher degree of partial melting of the coal shale inclusions, indicative of higher temperature or more prolonged burning of coal. They typically show a matrix of black glass, containing pale, often bloated, partially-melted relicts of coal shale. They typically have a maroon to purple surface colour.

Clinkers of this type may be the residues from a wide range of processes, both metallurgical and non-metallurgical. In a metallurgical context, they indicate a process where the reaction contributes little to the residue, which is composed almost entirely of the fuel residue. This may be the case in much light blacksmithing work, in which forge clinkers may be almost indistinguishable from those formed in steam boilers for instance.

A total of 732g of conventional clinker was found.

Smithing hearth cakes (SHCs): SHCs are mainly presented by fragments. The only certainly complete example is a very small SHC from context 152 (128g). Two substantial fragments from larger SGCs (from contexts 37 and 154) each weigh 212g.

In this study examples of materials identified as smithing hearth cakes show evidence for the use of both coal (three examples from context 134; one from content 152) and charcoal (context 154), as fuel. Very little of the material appeared to derive from what might be termed 'conventional', solid, iron-rich SHCs (those from contexts153 and 160 are exceptions, but are very small). Most of the SHCs are either poorly-developed slag masses developed along the wall well below the blowhole, or are poorly consolidated prilly masses.

Both the small size and poor consolidation of the SHCs probably emphasis an origin in relatively light iron-working.

Fragments of SHCs provided 1198g of the assemblage, the largest class of material present.

Vitrified lining: twenty nine fragments of vitrified oxidised fired lining were found, with a total weight of 300g. This material was very fragmentary with no pieces revealing detailed information about the blowing hole. The relative abundance of this class of material is typical of assemblages from close to sites where smithing was undertaken.

Gravelly lining slag: this facies of residue is formed of rounded masses of partially melted ceramic and stone bound by dark (usually), sandy, lining slag. In some instances the stone clasts are glazed with a thin transparent green glass and similar isolate glazed stones were found. The green glaze is indicative of involvement of only wood-ash as a flux.

In some cases gravelly lining slags form masses related to smithing hearth cakes (and sometimes called slag 'tongues': Young 2013). Most of the material from this site was too fragmentary to demonstrate such an overall morphology (in comparison to other parts of the Dwr-y-Felin site, where well-developed slag tongues were common, Young 2012a).

Gravelly lining slags are indicative of slag masses formed near the blowhole, in systems with little metal contamination entering the hearth (and also no contamination from clinker). They imply partial melting of a gravel-rich material, which appears dissimilar, on current evidence, from the hearth wall composition suggested by the vitrified lining fragments.

Some 485g of this class of residue was recorded, mainly from contexts 113 and 127.

Other lining slag / FAS: this category includes just 70g of material, mainly smaller particles of lining slag lacking the gravelly inclusions of the previous category, or of very low density materials derived either from extremely bloated ceramic, or equivalent to the material commonly called fuel ash slag (FAS; typically a partially melted sediment or ceramic fluxed by wood ash). Although clinker is technically a fuel ash (being the partially melted residue of coal) it is normally excluded from this group of materials.

Although this material is likely to included mostly hearth lining materials, or materials derived from the walls of a hearth pit, FAS can be produced in non-metallurgical contexts, such as cereal-drying kilns (Young 2010, 2012c).

Tapped bloomery iron-smelting slag: bloomery iron smelting slag is just one of a number of classes of dense fayalitic slags. It can be identified through its ropey texture of flow lobes, which typically show a slightly maroon surface where oxidised in contact with air, a typically rather modest overall size of slag cake formed usually in a simple fuel or soil bowl or trough and usually by a fairly low iron content. Similar textures occur in fayalitic slags produced during the puddling of iron, during fining of iron and during copper smelting –

certain differentiation of these materials is difficult, particularly with very fragmentary material.

In the present assemblage the presence of small, often fragmentary flow lobes with a strong maroon surface colour, has been taken as an indicator of the presence of tapped bloomery smelting slags. Where these occur in securely dated Roman contexts, that identification is secure (e.g. context 127), but in other places the discrimination from other fayalitic slag types (of post-medieval age) is less certain. Examples of fayalitic and other dense slags with good evidence for an origin other than in bloomery iron smelting have been placed in the following category.

Other dense slag: these materials are examples of dense slags, mostly with flow lobes, for which textural or other evidence indicates an origin other than bloomery iron smelting.

Two flow-lobed dense slag blocks (total 242g) occurred amongst the unstratified material. Both of these showed non-wetted bases and both were very dark. One sample showed a slightly wrinkled top to its flow lobes, the other were fractured through a series of large vesicles just below the original top. One had attached matrix bearing clinker spheroids In neither case is the origin certain, though an origin in the finery or puddling processes, or in copper production, would appear more likely than the bloomery process.

Blast furnace or cupola slag: three pieces of glassy slag compatible with an origin either in a blast furnace (post-medieval iron smelting) or in a cupola furnace (late 18th century to modern iron foundry) were recovered.

Context 3 produced a single piece of a dark, flow foliated glass (28g) and context 6 yielded two pieces of khaki-coloured glass (24g).

This material is not closely attributable to any particular process without analysis; however, the dark glass resembles that from coke-fired cold-blast blast furnaces elsewhere in South Wales and the khaki glass is similar to high-manganese slags from cupola furnaces described by Young (2011).

Indeterminate slag: material in this category (231g) lacks sufficient diagnostic features to be able to be attributed to a particular class of residue. Much of this category is probably smithing slag.

Crucible and copper slag: this category combines the limited evidence for early non-ferrous metalworking.

Context 133 produced a single sherd of thin-walled crucible. The sherd contains no apparent internal residues and the outside has a light wood-ash glaze, but no discolouration from metal contaminants. The metal for which it was employed is therefore unknown. The sherd shows a moderate quartz content and abundant moulds of a fibre-like organic temper. It appears to be from the lower side of a small crucible. The curvature varies across the sherd, possibly indicating the crucible was angled (triangular to 'D'-shaped), rather than circular in plan.

The sherd is rather thin compared to most Roman crucibles, although not impossibly so. The fabric , which would be reasonably refractory, resembles thinner Roman crucibles as well as early medieval examples. Although fine organic temper was common in Roman crucibles, extremely elongate, fibrous material (perhaps including hair) might, perhaps, be best paralleled in early medieval crucibles (e.g. Young 2006b).

Context 147 produced a single small angular fragment of a brownish slag, with bright green copper weathering products in its vesicles.

Hammerscale: two contexts (113, 156) yielded concretions which contained some hammerscale. Both were small, and the hammerscale at low densities. Both spheroidal and flake hammerscale was present. It is assumed these concretions were formed *in situ* and reflected the composition of their host sediment. Unfortunately, no supporting evidence in the form of bulk sediment samples was available for these or other contexts. Both contexts may be close to hearths.

Distribution of the residues

The distribution of residue classes by context is given in Table 2.

Stratified residues of Roman age include several discrete components as well as a background of residual material.

One group of contexts is characterised by the presence of 'gravelly lining slags'. This type of residue, indicative of use of a charcoal-fired hearth and a process entailing little metal contamination of the hearth, occurred in contexts 111, 113, 116, 127, 147 and 168. Of these, context 113 may be significant in being rich in charcoal and also containing hammerscale; it is likely this fill is closely associated with blacksmithing. Three of these contexts are road surfaces and it is unclear whether the metallurgical resides were deposited with the road makeup, or were subsequent losses. The road deposits also provided some of the stratified tapslag, some of the SHCs and the small fragment of copper slag.

A second group of contexts is formed by the 'industrial area' bound by context 134 and including the fills of pit 215 (124, 125, 126, 133, 135,136 and 137). These contained a small suite of residues (621g in total), which does not include any 'gravelly lining slag', but does include SHC fragments and various clinkers. These deposits are therefore likely to have been associated with coal-fuelled blacksmithing. Context 133 is also important for producing a single sherd of ceramic crucible.

Other possible evidence for coal-fuelled blacksmithing comes from the basal fill of ditch 140, but this is less certain.

The post-Roman to modern contexts provided much of the coke and clinker, as well as late dense fayalitic slags (possibly from fining, puddling or copper-making) and glassy slags (from a blast furnace or cupola). These deposits also contain a certain amount of material that is likely to be residual material of Roman origin.

Interpretation

The abundance of low density archaeometallurgical residues, rather than dense conventional SHCs is a feature observed at several Roman military sites during recent investigations (e.g. Calstock, Caerleon, Caergwanaf, Cardiff). This suggests that blacksmithing undertaken at these sites might have been more associated with repair, maintenance and light fabrication tasks (e.g. nail-making) rather than the fabrication of complex objects, requiring significant amounts of forge welding. There is, however, a lack of understanding about the 'gravelly lining slags' that appear so characteristic of such sites. These indicate a low input of metal contamination to the hearth – which might be associated either with light blacksmithing or with non-ferrous metalworking (or indeed, with both). The evidence from elsewhere at Dwr-y-Felin (Young 2013b) suggests that here the gravelly lining slags are likely to be a product of blacksmithing.

The evidence for secondary smithing using coal as fuel can be paralleled at many local sites, including Bulmore (Young 1999), Caerleon (Young & Kearns 2010; Young 2013a), Caerwent *basilica* (Young 2006a), Trowbridge (Young 2009a, 2009b) and Cardiff Castle (Young & Kearns 2011). For most of those comparative sites there is evidence for the use of both charcoal and coal.

It is usually assumed that the use of coal ceased at the end of the Roman period, with its use for smithing reappearing in about the 12th -13th centuries. However, there are no sites which provide any detail for these transitions; the use of coal in the 'industrial area is very likely to be of Roman age, but cannot automatically be assumed to be such on the basis of the coal-use.

The presence of small quantities of bloomery tapped slag is indicative of there having been some bloomery iron smelting in the area. The occurrence of such materials in stratified contexts indicates the general early timing of the smelting, but the precise contexts (e.g. road surfaces and a 'late' timber slot) mean that the relative date of the smelting is still somewhat unclear.

The non-ferrous metalworking indicated by the crucible sherd and the fragment of copper slag is typical of a low level of casting of copper-alloy artefacts in Roman forts, with most forts showing such activity. The uncertain date of the crucible sherd at present, however, does leave some doubt as to whether the crucible is contemporary with the fort.

Evaluation of potential

The majority of the archaeometallurgical residues from Site 674 have little potential to provide additional significant information from further detailed investigation or analysis.

Accordingly, no further analysis is recommended for the ironworking residues. The sole recommendation for further work is that the crucible sherd should be analysed by XRF to determine the metal it contained, because it bears no visible residues beyond a simple external glaze.

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Glossary

Blacksmithing: the working of iron and steel. Often restricted to the secondary smithing – i.e. the smithing of iron to produce or repair artefacts, as opposed to the smithing involved in the production of billets or bar iron from raw iron blooms.

Blast furnace: a tall shaft smelting furnace. Particularly used of the iron smelting blast furnace, introduced to Britain in the late 15th century and which replaced the *bloomery* furnace. The iron blast furnace differs from the bloomery in producing iron as liquid cast iron which is tapped from the base of the furnace.

Bleb: a small rounded particle or textural component, often a droplet or prill.

Bloomery: a furnace for smelting iron from ore in which iron is produced as a solid material. The bloomery process was employed mainly prior to the introduction of the later blast furnace from the late 15th century.

Bloom-refining: Usually taken as an alternative term for bloomsmithing, but may encompass techniques other than physical working (such as re-melting).

Bloomsmithing: The process of reworking a raw bloom, through repeated reheating and hammering, to reduce its content of slag, to remove unwanted inclusions and to draw out the remaining slag into elongate inclusions. The end product may be a bar or billet. Usually taken as an alternative term for *bloom-refining.*

Blowhole: A hole through a furnace or hearth wall through which air is blown.

Clinker: the partially-melted (fused) inorganic residue from the combustion of coal.

Coke: a vesicular carbonaceous residue from the burning of coal. Deliberately produced from the 18th century as a cleaner mineral fuel than coal, for coking removes the volatiles and reduces the sulphur content of the fuel.

Cupola: a late 18th century to modern shaft furnace used to remelt iron (either fresh pig iron or scrap) for casting, in a foundry.

Dendrite: a branched crystal form, often associated with rapid growth.

Fayalite: the iron-rich end member of the olivine group, Fe_2SiO_4.

Finery: a process used from the 16th to 19th centuries for converting cast iron to wrought iron in a charcoal fuelled hearth.

Forging: the process of hot-forming a metal by beating it.

Fuel Ash Slag (FAS): slag formed by the partial melting of hearth wall or substrate under the fluxing influence of the ash (inorganic component) of the fuel. Fuel ashes are often very rich in alkali and alkali earth elements that may lower the melting point of silicates.

Lining Slag: Slag formed from the complete or partial melting of hearth or furnace lining.

Olivine: a group of silicate minerals of the form $(M^{2+})_2SiO_4$ where M can commonly be iron, magnesium, calcium (up to half the M^{2+} ions) or manganese. Includes the end-members fayalite (Fe_2SiO_4), forsterite (Mg_2SiO_4), tephroite (Mn_2SiO_4), kirschsteinite ($CaFeSiO_4$) and monticellite ($CaMgSiO_4$).

Prill: a small aggregate of a material, either a spheroidal droplet or a runnel, formed from a melted liquid and either occurring as a discrete particle or as an inclusion within another material.

Puddling: a late 18th to mid-20th century process for converting cast iron to wrought iron in a reverberatory furnace.

Secondary smithing: see blacksmithing.

Smithing: the activity involved in forming a metal object, including, but not limited to, forging metal and joining metal by welding.

Smithing hearth cake (SHC): the slag cake formed in a smithing hearth by reaction of iron oxides lost from the workpiece with silicate material from hearth ceramic and/or fuel, below and in front of the tuyère/blowhole. They are very variable in form, but are typically plano-convex in shape (although concavo-convex and biconvex forms are common), frequently with a dense lower crust and a less well consolidated upper part. In some cases the top is formed of glassy slag.

Tap slag (or *tapped slag*, sometimes *tapslag*): slag that has been *tapped* from a furnace as a liquid to solidify outside the furnace.

Tapping: the process or act of allowing a liquid to flow from a furnace. In the bloomery process it is the slag that may be tapped; in a blast furnace both slag and iron are tapped.

Tongue: a slag mass formed from lining slag, particularly in smithing hearths, where it forms a sheet –like slag cake extending forwards from below the blow hole. The top is usually roughly planar and often glassy; the base is typically prilly and formed of more fluid slag.

Vesicle: a void or pore, usually rounded and formed as a preserved gas bubble in a solidified melt.

Table 1: Summary description of archaeometallurgical residues and associated materials from project 674, ordered by bag

Context	wt	no	notes
u/s	28	1	large lump of lining slag attached to oxidised-fired lining
	12	3	small slag blebs
	1	1	probable tapslag
u/s 001-003	120	1	slab of very fine grained tapslag, wrinkled top, non-wetted planar base, hint of irregular vertical bound to one side. Probably not a bloomery slag
	16	1	tapped slag in small lobe with slightly maroon surface
	1	2	blebs of black, glassy, vesicular clinker
u/s 001-002	4	1	red friable clinker fragment
	<1	1	dark shiny slag prill
	122	1	fragment of slag sheet, exposed large vesicles form top, base is in non-wetted lobes, c25mm thick, matrix dark with clinker spheroids, probably not a bloomery tap slag
2	44	1	very worn slag piece, grey dense vesicular slag with a curved face - SHC burr from fairly small SHC
3	2	1	dark slag bleb
	8	1	small fragment of vesicular clinkery slag
	28	1	piece of dark flow-foliated glass becoming pale towards one margin (BF slag?)
3	82	2	concretion on iron in gravel
3	<1	1	coke
3	6	2	coke
3	40	5	small worn fragments of apparent tapslag, small lobes, maroon surface
	32	2	worn fragments of grey vesicular slag - probably smithing slags
6	24	2	dark khaki glass - probably blast furnace or cupola slags

Context	wt	no	notes
6	24	2	red friable shale-rich clinker
	4	1	fired clay - possible brick fragment
7	2	1	clinker prill
	4	5	coke
	26	1	bitumen coated pebble
7	122	1	broken biconvex mass of red clinker, friable, with much shale debris
13	486	12	clinker rich in shale fragments - largest piece sheet-like, 236g
15	24	1	crushed claystone ironstone nodule
	1	1	lining slag
16	8	1	lobate dense slag - possibly tapslag
32	6	1	coke
32	1	2	coke
32	14	1	brick red vesicular fine grained slag, slightly lobate surface, very fine grained
	16	1	sheet of pale, low density concretion of coal dust, slag, spheroids etc. No flake hammerscale.
	10	1	variegated red-pale lining slag with some internal lobed surfaces
32	4	1	potsherd
	8	1	reddish clinker bleb
	38	1	semi-circular fragment of clinker - just possibly an SHC fragment
	22	2	concretions
35	64	1	sheet of clinker - smooth top, base with some lobes and much shale debris
35	16	1	slightly odd well flow-lobed slag, dark, dense, with abundant sand inclusions, probably part of thin sheet with lobed top and with sandy base or wall attachment
37	14	1	coke

Context	wt	no	notes
37	28	2	tap slag fragments
	212	1	very irregular piece of vesicular dense iron slag - most likely a fragment of a large SHC
	20	1	lobate dense slag, possibly tapslag
	8	2	fragments of concretion/ferricrete
38	30	1	concretion
	6	1	oxidised-fired lining
	4	1	slagged material including probable potsherd
38	28	3	vitrified oxidised-fired lining
	2	1	roasted ironstone nodule
	8	1	coarse grained tapslag fragment with possible ore grains adhering to base
	38	1	probable underside of an SHC's wall attachment, deeply dimpled on lower face of iron slag
	86	9	small concretions - one splitting open to reveal iron inside
	1	1	small iron slag prill
40	16	1	claystone ironstone
	6	1	vitrified and slagged oxidised lining
	24	1	lobed/dimpled rounded nub of dark, possibly clinkery, slag
	1	1	concretion
40	1	1	vitrified oxidised-fired lining
54	6	1	brown vesicular siliceous-appearing slag with dark surface - possibly a discoloured clinker
54	2	2	coke
56	<1	1	coal
89	8	1	concretion
98	10	1	concretion
	38	2	lobate maroon slags with coke/coal clasts
	12	1	dense deeply lobate/prilly slag with charcoal inclusion

Context	wt	no	notes
102	40	1	ferricrete on gravel
102	14	2	ferricrete on gravel
103	28	2	ferricrete on gravel
108	12	1	very abraded dense slag with dimpled base, probably a tapslag
	4	1	chert
110	<1	1	concretion with coal-dust and shale
	2	1	bleb of dark slag forming dimples/prills into ashy matrix
111	44	3	concretions on iron
	28	1	mass of dark low density lining slag on veneer of lining (dark, with organic temper)
	6	2	small fragments of blebby clinker
	18	1	lightly vitrified pebble
	1	1	vitrified stone or lining fragment
	20	1	microprilly dense grey slag with maroon surface with probable coke inclusions
	34	1	grey slag with maroon surface and poor flow lobes, fuel moulds where present look like charcoal
111	4	1	coal
112	2	2	coal
113	152	11	gravelly lining slag
	4	1	vitrified lining
	18	5	stones
	42	7	small concretions, at least some on iron, some have small quantity of hammerscale in sandy sediment
114	1	1	ashy concretion

Context	wt	no	notes
116	4	1	bleb of bitumen
	72	5	blebby low density lining slags, some gravelly
	152	2	dense slags, convoluted appearance - both possibly SHC-related - one may be underside of cake, other some slight down-wall flowage, one has possible shale inclusion
	138	1	cobble-like concretion, possibly reworked with slag and coal residue - not clear if this is a piece of slag with thin skin of concretion or simple concretion with slag
116	6	2	small blebs of low-density maroon-surfaced slag, one fused to small white stone
124	1	1	blister of green glass containing a small sandstone clast, spalled from a planar ashy surface
124	4	3	elongate scraps of fine ferricrete - possibly on iron
125	<1	1	hollow bleb of sandy lining slag
126	40	1	irregular mass of dark glassy clinker
127	172	5	gravelly lining slag
	14	1	lobe of probable tapslag
	26	1	dense slag nub, partially lobate with dimpled base and slightly maroon top, weathered
	12	2	concretion
	<1	2	fragments of clinkery slag
128	1	2	vitrified oxidised fired lining
130	<1	1	coke
133	48	1	exploding fragment of grey vesicular slag - probably an SHC fragment
	82	5	concretions on iron - sediment sandy, rich in charcoal, a few coal fragments, some slag and hammerscale
	10	2	blebs of FAS/lining slag
133	2	1	sherd of fibre-tempered moderately quartz-rich crucible, light external vitrification, no internal residues, probably lower part of side of cup-shaped crucible, curve irregular, partially flattened, but suggests c.50mm diameter
134	1	1	coke

Context	wt	no	notes
134	298	1	SHC-like object of finely vesicular clinkery slag, 'base' shows pad of attachment to wall - thus orientation not clear, 100x90x50mm; most likely orientation is about 45 degrees below blowhole with internal sheets extending forwards approximately horizontally.
	78	1	mass of coalesced prills in ashy matrix- possibly lower part of a small SHC. Descending prills surround coke
	36	1	small fragment of clinkery crust- similar to slag in SHC above
	18	1	vitrified oxidised fired clay
	50	4	blebby dense slags in small masses
	4	1	very low-density - probably vitrified and bloated stone
134	2	1	glazed sandstone
135	12	1	dark glaze on pale grey quartz-rich ceramic
	10	3	lining slag blebs
136	122	4	concretions - larger ones worth X-ray
	6	1	bleb of low-density lining slag with maroon surface
137	2	1	small worn fragment of highly vesicular slag
142	4	1	clinkery thin crust (7mm) with dark red ceramic to front and rear
147	24	1	small mass of well-formed lobes of sandy lining slag
	16	5	lining slag, glazed stones and mixtures of the two
	1	1	stone
	10	1	slagged and vitrified ceramic - very fine paste, not like other ceramics seen here - possibly tile?
	4	1	slagged orange ceramic - probably a sandy fabric potsherd
	2	1	potsherd with ferricrete
	4	1	small angular fragment of vesicular brown slag with copper weathering products in vesicles
149	4	5	ferricrete crust fragments
152	1	1	vitrified lining
	<1	1	ashy concretion
153	128	1	75mm x 50mm x 30mm, rather blebby, obscured slag, probably a small iron-rich SHC, more conventional if so, than other examples here

Context	wt	no	notes
154	212	1	irregular crust of dense slag, lots of charcoal inclusions, irregular downward protrusions of very slightly prilly slag. Probably the base of a large SHC, but could be a basal crust from a bloomery furnace
	8	4	fragments of ironstone
	20	2	vitrified oxidised-fired lining, one piece with a very strongly maroon slag surface
156	26	1	concretion with various slag clasts and some FHS
	16	1	vitrified pebble with maroon surface layer
	26	1	complexly slagged oxidised-fired lining,
160	142	31	concretions - possibly mainly on small iron pieces - some appear flat and scale-like, bright yellow-brown, some coal fragments but mainly organics in ochreous material
	10	4	ironstone fragments
	86	1	small fragment from a conventional small plano-convex SHC. Slag very weathered and pale, outside has orange accretionary material as all material from this sample
	116	5	pale slags similar
	72	1	edge of SHC similar to larger fragment above
160	66	5	slagged and vitrified oxidised-fired lining
	102	9	rather blebby appearing slags, some with maroon surface, some with possible coke clasts - somewhat similar in appear to slags attached to lining from same context
	10	1	small concretion
	4	1	stone
	70	1	rounded nub of blebby slag, lobate base ,dark top, possible SHC fragment
160	8	1	concretion on iron
	26	3	pebbles with some accretion
167	12	1	vitrified oxidised-fired lining, adhering matrix rich in coal dust and coked material
168	2	1	grey shale, slightly slagged on surface (not a crucible sherd)
168	6	2	concretions on small iron objects (nails?)
	62	2	pebbles with ferricrete from decomposition of iron
	14	2	vitrified lining
	18	1	vitrified lining with attached maroon slag - probably the wall contact for a clinkery SHC, but not definitely true clinker
	30	3	sandy/gravelly lining slag

Table 2. Summary of archaeometallurgical residue types by weight (g) and by context

Context	Supplied context details	Supplied context details	coke	friable red clinker	other clinker	SHC	Vitrified lining	gravelly lining slag	other lining slag / FAS	tapslag	other dense slag	Blast furnace slag?	Indeterminate slag	crucible and Cu-slag	hammerscale	*total*
u/s	001/002/003			4	1		28			17	242		12			*304*
2	Subsoil/ploughsoil	Post Roman				44										*44*
3	Ploughsoil	Post Roman	6		8					40		28	34			*116*
6	Coal and cinder	Modern		24								24				*48*
7	Fill of pipe trench 005. Smaller diameter pipe	Modern	4	122	2											*128*
13	Fill of pit 043	Modern		486												*486*
15	Metalled surface - roadway	Roman					1									*1*
16	Plough struck cluster of large angular stone possibly from gateway	? Roman								8						*8*
32	Clay deposit backfilled material	Modern	7		48				10				14			*79*
35	Clay deposit backfill possibly from adjacent pipeline	Modern			64								16			*80*
37	Equivalent of 003 clay soil	Post Roman	14			212				48						*274*
38	Clay deposit cleaning number	Roman				38	34			8			5			*85*
40	Clay deposit possibly backfill	? Modern					7						24			*31*
54	Stone deposit demolition rubble from gateway?	Roman	2		6											*8*
98	Sandstone deposit rubble. Redeposited road stone	Post Roman			38								12			*50*
108	Clay loam fill of beam slot 109?	? Post Roman								12						*12*
110	Metalled surface-road	Roman											2			*2*
111	Clay deposit	Roman			6	20	28	19					34			*107*
113	Clay and charcoal deposit possible timber position	Roman					4	152							YES	*156*
116	Metalling - road	Roman				152		72	6							*230*
124	Clay deposit, industrial?	? Roman							1							*1*
125	Clay deposit, industrial?	? Roman							1							*1*

Context	Supplied context details	Supplied context details	coke	friable red clinker	other clinker	SHC	Vitrified lining	gravelly lining slag	other lining slag / FAS	tapslag	other dense slag	Blast furnace slag?	Indeterminate slag	crucible and Cu-slag		hammerscale	total
126	Clay deposit, industrial?	? Roman			40												*40*
127	Clay and pebbles road surface	Roman			1			172		14			26				*213*
128	Metalling, road surface	Roman					1										*1*
130	Sandy clay cobbles and pebble deposit - road	Roman	1														*1*
133	Sandy clay (? industrial deposit)	? Roman				48			10					2			*60*
134	Arc of pebbles and clay smithy?	? Roman	1		412		18		8				50				*489*
135	Hard packed clay deposit-floor?	? Roman					12		10								*22*
136	Clay deposit adjacent to the industrial area	? Roman							6								*6*
137	Hard packed clay deposit-floor?	? Roman											2				*2*
142	Natural orange brown clay	Natural			4												*4*
147	Metalling road (initial surface)	Roman					10	40						4			*54*
152	Sandy clay fill of pit 151	Roman					1										*1*
153	Fe rich clays with pebbles and cobbles - road	Roman				128											*128*
154	Clay fill deposit possibly continuation of 099	Roman				212	20										*232*
156	Sandy clay and pebbles	Natural					26		16							YES	*42*
160	Silty clay basal fill of ditch 140	Roman			102	344	66										*512*
167	Fill of ditch/pit 166	Roman					12										*12*
168	Fill of ditch 169	Roman					32	30	2								*64*
		Total	***35***	***636***	***732***	***1198***	***300***	***485***	***70***	***147***	***254***	***52***	***231***	***6***			*4134*

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