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Evaluation of metallurgical residues from the New Interpretation Centre, Cardiff Castle, Cardiff [ST181765]

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Abstract

102kg of archaeometallurgical residues were retrieved. The majority of the residues (approximately 74kg) were identifiable as being from iron smelting. Some 15kg of the assemblage were of indeterminate origin, although much of this material showed some sign of flow and is likely to also be from iron smelting. There was a much lesser amount of residue that was identifiable with certainty as being from iron smithing, amounting to approximately 5.6kg of macroscopic slags, mainly smithing hearth cakes, and also including smithing microresidues from several contexts.

Interestingly, the macroscopic smithing slags do not appear to have been associated stratigraphically with the smithing microresidues. The microresidues show a close association with the use of coal, which would indicate blacksmithing and at least some of this activity appears to have been in Phase 6. The few recognised smithing hearth cakes are mainly rather large and where they show evidence for fuel, it was charcoal. The smithing hearth cakes, if Roman, would be likely to be from bloomsmithing (primary smithing; bloom refining), rather than from blacksmithing (secondary smithing; the end-use of iron), although smithing hearth cakes of this size may sometimes be associated with blacksmithing in the medieval period.

Detailed interrogation of the stratigraphic record of the residues is not yet possible, but provisionally, the lack of clear evidence for in-situ furnace remains, suggests that the processes associated with iron production, both smelting and primary smithing, may have taken place outside the excavated area. In contrast, the hammerscale-rich features suggest that there may have been some blacksmithing within the area, both during Phase 6, and less certainly, in the Medieval period.

The morphology of the smelting slags would suggest that most, if not all, are of Roman age. They are remarkably similar to Roman smelting slags from Caergwanaf, with which they share a similar ore resource mineralogy and this may indicate a particularly unusual local style of furnace design and technology.

Contents

Methods

All investigated materials were examined visually, using a low-powered binocular microscope where necessary, and were summarily described and recorded to a database (Table 1). As an evaluation, the materials were not subjected to any form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional.

The material described here forms an approximately 102kg collection from excavations in 2005-6 by GGAT. Archaeometallurgical residues were collected mainly by hand picking, without a uniform collections policy, so the weights and proportions described here may not necessarily be representative of the materials on the site.

Preparation of the assessment report has employed the stratigraphic phasing of the Post-Excavation Assessment Report (Dunning 2010). Unfortunately, only a minority of the archaeometallurgical residue-bearing contexts had been assigned to phases at this

stage. Of the 102kg of the overall assemblage, only 12.7kg comes from contexts for which phasing is available, 1.5kg is not assigned at present to a context, 4.1kg was unstratified and 83.7kg is from contexts for which no stratigraphic information was available. Some contexts described in the Assessment Report as being slag-rich (e.g. context 2006, a metalled road surface formed of slag) are not represented in the collection.

Results

Description of the materials

Iron-smelting residues

The materials that can be associated with confidence with iron smelting comprise two intergradational types of slag.

Firstly there are slags which have been tapped from the smelting furnace to cool and freeze outside. These are represented by dense flowed materials with lobate structures, either as single layers of flow lobes, or as multiple accumulations.

The upper surface of the tapped smelting slags is generally a maroon colour, indicating oxidation of the cooling surface and the generation of a thin surface veneer of haematite. Internal flow surfaces and tubular porosity may not have been open to the air and may not show such a colour – and in fresh examples may show an almost mirror-like surface. The lower surfaces of the tapped slags are mainly dimpled, but some show contact with sand, suggesting that the central part of the tapping pit at least was filled with charcoal. The tapped slags are frequently brittle, and because of the inherent weaknesses along the margin of the chill-lobes, they are often fragmented into rather small particles. There are very few tapped slag blocks of any significant size, certainly none to allow reconstruction of the size of the overall furnace tapping. The largest is a 1865g block (from c2035) of thin tap slag cake, 160 x 200 x 40mm, which may have been stronger because the prills are not well-developed.

One block from c9153 was a 1929g elongate (210 x 100 x 40mm) flow of slag, which instead of forming small rivulets was a single broad flow, whose top had become deformed through flow of slag below a semi-solid crust, with the upper surface being thrown into a series of arcuate narrow ridges.

The tapped slags in the form of sheets are closely associated with examples of slags that have formed with constrained channels, presumably with the tapping arch/tapping channel of the furnace. One of the clearest examples (c3005) was a 464g fragment of “runner” 40mm wide, 60mm high and 120mm long with a curious multiple flows, possibly suggesting that the tapping hole has been re-rodded.

Some tapped slag blocks show gradation into the second main class of smelting slag, those extremely dense slags with poorly-developed flow structures and containing abundant moulds of coarse charcoal or wood. One such block (from c 90000 weighed 382g and showed a 50mm thick flow of slag, with good flow lobes on the upper surface (locally with some ore particles on the surface), but internally a chaotic texture of large wood moulds.

The fully-developed examples of this facies of slag show moulds of roundwood charcoal commonly to 40mm diameter, together with more rectangular cross-sectioned moulds up to 60mm across. These slags also characteristically contain pieces of unreduced ore of up to 30mm across, although usually less. These slags have almost no internal vesicularity (not including the porosity due to the fuel moulds). They may show some flow-lobing on their upper surfaces, rarely internally chilled surfaces and occasionally steep lateral non-wetted contacts. Despite the large size of many of these pieces (up to 2kg) they are mainly bounded by fractures and contain little clue to the overall form of the masses from which they derive. The iron-rich corrosion exhibited by some examples, suggests that some pieces at least contain significant pieces of metallic iron.

A further class of slag that is also probably to be associated with iron smelting are slag rods. These elongate slag bodies are 15-25mm in diameter and formed of dense, though usually somewhat vesicular, slag. There were very few examples in the present assemblage.

As well as the ore particles contained in these smelting slags, a few isolated fragments of ore were recovered. Some of the isolated particles appeared to have been initially goethite, but most showed some degree of heating, so the dominant mineral was haematite. Several examples showed concentric layering suggesting they derived from the fracturing of coarsely botryoidally-textured ore.

Iron-working residues

Residues from iron working include some deposits rich in microresidues (including hammerscale), but with little slag, and more isolated finds of microscopic smithing slag (particularly smithing hearth cakes; SHCs).

Smithing microresidues may include various classes of materials, including degraded fragments of slag, hearth lining and fuel debris, but the most characteristic particles are flake hammerscale (a thin surface veneer of iron oxides formed when the hot workpiece is exposed to air and which spalls from the iron when it is hammered or through differential thermal contraction) and spheroidal hammerscale (small, typically less than 1mm diameter, droplets of the oxide layer when it becomes molten at high temperature and is expelled from the workpiece by hammering – typically during forge welding). Although the speed of expulsion of the spheroidal hammerscale may mean it can travel several metres, flake hammerscale tends to fall very close to the anvil and sometimes within the hearth. Accumulations of hammerscale are therefore closely associated with the smithy floor. Patterns of disposal of microresidues tend to differ from the macroscopic slags produced in the smithy that typically are carried (or thrown) a greater distance from the point of origin.

The microresidue assemblages were recovered from sieved samples from eleven contexts. Of these, nine samples showed flake and spheroidal hammerscale, together with other materials including coal and/or coal residue, one sample showed hammerscale without the presence of coal and one showed fuel remains but no hammerscale.

The occurrence of coal in the microresidue samples can be taken as indicative that coal was a significant, if not the only, fuel employed in the smithy. This is

significant for the sulphur content and the high ash content of most coal makes it unsuitable for use in primary smithing, where such impurities have a deleterious influence on the bloom – and may make it impossible to work. Charcoal is always used for primary smithing. This coal therefore indicates that the smithing is secondary smithing, the end use of iron for making or repairing artefacts, more commonly known as blacksmithing.

Fragments of SHCs (the typically plano-convex slag cake that forms below and in front of the blowhole in a smithing hearth) were recovered from several contexts, but only four examples were recovered that were complete enough to give any indication of form. SHCs are formed by reaction of iron (as metal or oxides) that is lost from the workpiece into the hearth, in reaction with ceramic melting from the hearth wall around the blowhole or tuyère. They will be larger if the hearth is cleared less often, but more importantly will be large if the rate of loss of iron is high, as it is when the iron is worked at high temperature for welding or particularly for primary smithing.

Only one of these four SHCs was recovered from a context (c1512) which also yielded coal – and this example weighed 194g. A second slag block from the same context might be an SHC that became deformed during extraction; this weighed 384g.

Three substantially complete SHCs were recovered from other contexts: one (from c1525) weighed 705g, one from c1670 was 90% of an SHC which originally weighed 750g and one from c2758 was 80% of an SHC originally of 1090g.

Other slag materials of similar texture to an SHC, but lacking the form, have been included in the general smithing slag category in Table 2.

Undiagnostic materials

Indeterminate iron slag: iron-rich slag which could not be referred to any of the previous categories with any certainty has been categorised as indeterminate. In practice, much of this material showed evidence for some flow, but since some flowage of slags within a smithing hearth is possible (and indeed common), unless characteristic features of tapped slag could be seen the material was deemed indeterminate.

lining slag: this class of material includes slags which are dominated by material derived from the hearth or furnace wall and it grades into materials of very low density commonly referred to as fuel ash slags. This material cannot be referred to either a smelting furnace or a smithing hearth with certainty – and indeed similar slags could be produced in hearths working non-ferrous metals.

lining: This category includes hearth or furnace lining with a vitrified surface, whether oxidised or reduced fired. It is not practical to attempt to differentiate between hearth and furnace lining – except in rare circumstances where coal dust was noted adhering to the ceramic, indicating an origin in a blacksmithing hearth.

fired clay: Where a vitrified surface was not observed, fired technical ceramic has been included in this category. It is possible that some materials might be included here that are of non-metallurgical origin, such as fired daub, or material from domestic ovens.

clinker: clinker is partially vitrified fuel ash, used here specifically to refer to coal residues. Clinkers are not necessarily generated in metallurgical hearths and other high temperature burning of coal may produce identical residues.

Other materials

coal: coal is included here as a presence/absence marker for both the microresidue samples and for coal observed in concretionary coatings on other materials. In practice, although coal might have been used for other purposes, its distribution here is entirely consistent with it being used solely here as a fuel for smithing.

copper alloy: this category marks the occurrence of materials possibly associated with the working of copper alloys in three contexts:

> c1392 – tiny fragments of corroded copper alloy occurred in sieved smithing residue sample, and is therefore suggestive of the smith having also worked with copper alloy.
>
> c2540 – rounded vitrified ceramic fragments with possible copper oxide staining from this context may indicate copper alloy working residues and may possibly be could be failed crucible fragments.
>
> c2657 – small fragment of copper oxide corrosion products with staining on other items from the same smithing microresidue sample are suggestive of the smith having also worked with copper alloy.

None of these occurrences are conclusive evidence for the working of copper alloys, but this would be common practice for a Roman blacksmith.

iron & concretions: this category includes fragments of corroded iron together with concretionary lumps, which are likely to contain iron. Small particles of this type commonly occur in smithy floor deposits along with hammerscale, and larger particles may be common in the residues from iron smelting.

Some of these materials (c1525, c2239, c3060, c9072, c9116?) may simple be concretions around iron artefacts that have been placed into the 'slag' collection. Others appear to be smithy floor concretions (c1392, c9000, c9031) and add to the body of evidence for smithing. The concretionary material from c2931 has probably formed around weathered iron-rich slag, rather than discrete iron particles.

Of all this material, that from c9066, which is a heart- or crescent-shaped piece of iron weighing 146g is probably the most interesting and may, since it occurs in an assemblage with much smelting debris, be a fragment of raw iron (a so-called *gromp*).

Distribution of the materials

Unfortunately, since the phasing/stratigraphy of the contexts bearing most of the slag is currently unavailable, a detailed evaluation of the significance of the distribution, either spatially or temporally, cannot be made.

Table 2 presents the classes of residue by stratigraphy as currently available – and future refinement of this is desirable.

However, it is clear that although some of the Phase 6 smithing activity may be essentially in-situ, the vast bulk of the archaeometallurgical residues are present in secondary contexts.

As currently presented, smelting evidence is present from phase 3e (single fragment of tap slag from c9249) onwards, but little of the smelting assemblage is tied to the phasing.

Interpretation

It is not known at present whether any of the evidence for smelting is associated with the medieval period. The assemblage mainly resembles other material from the Roman period.

The most characteristic, and unusual, aspect of the smelting assemblage is the facies of thick, dense, smelting slags with abundant inclusions of unreacted ore together with the moulds of large pieces of round and split wood or charcoal. There are many pieces of dense slag so rich in these moulds that they resemble some types of slag from the basal pits of slagpit, non-slag-tapping furnaces. Such furnaces occur in Britain in the pre-Roman Iron Age (e.g. at Truro, Young 2008) and again in the post-Roman period (e.g. Haslam 1980, Reed *et al.* 2006). The current material is securely tied to a slag tapping technology through its intergradation with more conventional tapped slags, but provides a reminder of the dangers inherent in identify process from small fragments of such material.

The Bristol Channel area is differs from most areas of Roman iron-making in Britain in so far as an extremely pure iron oxide ore was the material exploited. These ores (the Bristol Channel Orefield of Young & Thomas 1998, 1999) are dominated by the hydrated iron oxide goethite in the Forest of Dean, but in South Wales (particularly the Glamorgan Border Vale) the anhydrous oxide haematite is common, and in the same areas the ores also tend to be rich in quartz. There are two main areas in which the ores actually crop out: the Taff Gorge (mainly at Lesser Garth on the west side) and in the area around the later Mwyndy and Bute Mines to the south of Llantrisant. Thus there might be expected to be regional features of the iron smelting technology (different for instance from the technology of The Weald or the 'Jurassic Ridge' for instance), but also that subtle differences might exist between the way the Glamorgan ores were smelted compared to those from the Forest of Dean.

Certainly some aspects of the smelting slags seen here can be compared with examples from the Forest of Dean (or those localities smelting Forest of Dean ore, for it was moved widely outside the forest for smelting). Certain aspects of this assemblage can be paralleled at, for instance Caerwent (Young 2006; the presence of wide flows with deformed surficial ridges, as well as conventional tapped slags) and Alvington (Young 2009b; the presence of exceptionally thick flows with a large burden of part-reacted or unreacted ore). Massive slags with considerable unreacted ore were also an important component of the late Roman (with the period AD250-380) iron smelting at the Chesters Villa, Woolaston (Fulford & Allen 1993), where they are recorded as forming a "spoon-shaped" mass of 17kg weight within the base of one of the furnaces.

The presence within the thick flowed slags of large pieces of split- or round-wood is a remarkable feature paralleled to date only at Caergwanaf. Post-excavation analysis of the Caergwanaf slags is on-going at present, but the morphology of the slag there is extremely close to the present material. Caergwanaf was the site of Flavian fort (Young 2010b), but became the site of a major iron-production operation between the late first century and the early third century. The source of the ore for the Caergwanaf operation was apparently the area around the Victorian Bute and Mwyndy mines. The mineralogy and geochemistry of the ores is very close to those of the Lesser Garth.

A pilot project to provenance Roman smelting slags recovered from Cardiff Castle by Webster (1982) was undertaken by Thomas (2000). He employed an inverted version of the mass balance calculations of Thomas & Young (1999a, 1999b) to model the likely ore composition, and a good match was found in the Lesser Garth ores (employing comparative analyses from the database of Young & Thomas 1998, 1999 and Young 2000). No actual samples of ore from Cardiff Castle were available for analysis for Thomas.

The close similarity of the smelting slags from Cardiff Castle and Caergwanaf suggests, at very least, a common approach to smelting these difficult ores (difficult both because of their density and low porosity, which decreases their reducibility and also because pure iron oxide ores require complex interaction with the furnace lining to slag correctly in the bloomery). The similarity of process may, however, be more than that, for Young (in press) has postulated centralised military control over the smelting operations at Cardiff, Caergwanaf and Usk.

However, the actual purpose of the wood or charcoal contained within these slags is uncertain. In a slagpit furnace the basal pit is packed before smelting with a combustible material, which in eastern Europe was commonly grass or cereals, but in Britain and Ireland was typically split wood. The moulds left after the descent of the slag into the pit preserve the wood morphology well. The same is true in this instance – the inclusions show no sign of being fuel remnants (they are too large for typical fuel particles) and it seems likely that they may have been a wood packing rather than charcoal fuel. It is possible that the furnaces employed at Cardiff and Caergwanaf may have worked on some sort of hybrid technology – employing something akin to the pit packing employed in the slagpit furnace, but within a slag-tapping furnace. Such a technology would be unique at the current level of understanding.

The second part of the iron production process, the primary smithing, is not well represented amongst the assemblage. If the large (700-1l00g) SHCs are of Roman age, then they are probably from primary bloomsmithing. Measured assemblages of blacksmithing slags of Roman age have had maximum sizes of about 820g at both Carmarthen (Crew 2003) and Marsh Leys Farm (Young 2005), with mean weights of 230 and 330g respectively. Similar sizes have been recorded for earlier medieval SHCs from blacksmithing (e.g. Young 2009c). During the later medieval period there are some assemblages for which the SHC size is larger (overlapping with Roman bloomsmithing SHCs), for instance at Burton Dassett (McDonnell 1992) and Worcester (McDonnell & Swiss 2004).

The evidence for secondary smithing using coal as fuel in Phase 6 can be paralleled at several local sites, including Bulmore (Young 1999), Caerleon (Young & Kearns 2010), Caerwent basilica (Young 2006) and Trowbridge (Young 2009a, 2010a).

The presence of minor copper alloy working amongst the smithing activity is not unusual and many Roman smithies appear to have handled both metals, either as separate items or for the fabrication of artefacts with polymetallic components.
Although at present none of the ironworking can be demonstrated to be medieval, it is entirely possible that some might be.

Evaluation of potential

The principal area of potential of the assemblage for furthering understanding is within the processes of iron production. Within the current understanding of the stratigraphy, there is no evidence for the processes of iron production (neither for smelting nor primary smithing) having actually been undertaken within the excavated area. However, that should be kept under revision as understanding of the stratigraphy develops, particularly in light of the recognition that the furnaces employed for smelting at Cardiff and Caergwanaf may have been rather unusual.

The potential of the site for understanding iron smelting is within two areas – firstly the understanding of the technology itself. Further detailed observation and analysis is required to clarify the nature of the smelting slags and to attempt to reconstruct the location of formation of the massive, wood-bearing slags, within the furnace. Detailed chemical analysis may help explain the occurrence of so much unreacted ore in these slags and elucidate the purpose of the wood inclusions. Not only may the furnace technology be a local adaptation in response to the local ores and be of interest on that basis, but the smelting of the high grade ores in bloomeries is not well understood in general, and this unusual assemblage may help understand the route by which the problems of smelting such ores were overcome.

The second area of importance is to shed light on the context of the smelting activity. The relationship between the iron smelting in the Cardiff area and the military is of great importance, but currently somewhat speculative (Young in press), so comparison should be made of both technology and details of sourcing between the Castle site and the nearby smaller, almost certainly purely civilian, smelting operations at Ely (Storrie 1894), Rumney Great Wharf (Fulford *et al* 1994) and Trowbridge (Young 2010a), as well as the large, probably military, site at Caergwanaf. A strong database of ore analyses exists (Young 2000) to support this.

The investigation of the second stage of iron production, primary smithing, can also be addressed through the present assemblage. Once the stratigraphic context of the smithing residues can be confirmed, then, if they are Roman, their chemical composition should be investigated to identify the chemical signature of any inherited smelting slag and thereby confirm their role within the *chaîne operatoire*. These data could be compared with that from a pilot study of the Caergwanaf area primary smithing slags (Thomas 2000). Such analysis should then enable the recognition of primary smithing slags from this source that occur away from evidence for smelting.

The evidence from the site for secondary smithing and for the working of copper alloys has less potential for further analytical investigations. Should samples of coal of sufficient size be available for analysis, however (there is no suitable material within the metallurgical collection), then it is recommended that provenance studies of the well-dated samples from Roman contexts would be describable, since there is currently no provenance for coal found west of Caerleon.

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Table 1. Summary Catalogue by context (SR = sieved residue)

context	*sample*	*weight*	*quantity*	*description*
?	103	3720	26	fragments of dense tap slag, three of the larger fragments are particularly thick (39-52mm)
?	103	386	1	rounded chunk of slag with blebby, dimpled texture
1000		124	11	small dense tap slag fragments
1000		20	1	rounded ball of clinkery slag
1000		62	1	lobate ?lining slag with charcoal inclusion and hammerscale-bearing accretion
1024		4	1	tap slag fragment
1065		48	3	small fragments of tap slag
1110		3	1	small fragment of indeterminate slag
1113		77	5	small fragments of tap slag
1146		86	3	pieces of small dense tap slag flows, one single layer 5-8mm prills, one single layer 15-30mm prills, one multilayer, runner like base, 10mm prills
1155		150	5	mostly small fragments of fired clay, largest fragment contains one small coal residue
1161		26	1	small fragment of indeterminate slag
1200		14	1	indeterminate slag
1208		130	1	fragment of weathered slag with one large mould - possibly charcoal
1208		26	1	fragment of glassy slag, pale blue to pale green hue in areas, occasional clay attached
1208		9	2	small fragments of slag, heavily weathered lower surfaces, possibly fragment of slag lobes with maroon tinge
1211		102	5	fragment of light grey vesicular slag - indeterminate
1212		82	1	twisted flap of tap slag like material attached to oxidised fired lining
1212		54	1	flow with small tap slag like flows on the top , but large moulds of fuel below
1254		2	1	tiny fragment of probable low density tap slag
1260		37	1	fragment of indeterminate slag
1280		70	1	flat fragment of slag, crystalline in section

context	*sample*	*weight*	*quantity*	*description*
1294		3	1	very small fragment of flowed slag
1304		1	1	tiny fragment of indeterminate slag
1304		2098	1	fragment of dense crystalline slag, iron rich in one small area - one large pebble attached
1340	43	9	1mm SR	mainly flake hammerscale, few spheroids, small quantity of coal and slag
1340	43	9	250µm SR	very fine magnetic dust
1369		2	1	probable tapslag fragment
1385	48	300	250µm SR	very fine magnetic dust
1385	48	105	1mm SR	flake hammerscale (30%), few spheroids, very small fragments of coke and slag
1386	50	164	250µm SR	very fine sand rich magnetic dust
1386	50	9	1	small fragment of rusty slag
1386	50	66	3	natural stones
1386	50	130	1mm SR	(1mm) fired clay, coal, flake hammerscale and occasional spheroids
1391	49	<1	1	small fragment of limestone
1391	49	200	250µm SR	very fine sand rich magnetic dust
1391	49	195	1mm SR	fragments of slag, fired clay, coal; small quantity of flake hammerscale and occasional spheroids
1392	51	226	250µm SR	very fine sand rich magnetic dust
1392	51	107	1mm SR	small stones, fired clay, slag, coal, flake hammerscale
1392	51	44	1	iron rich concretion
1392	51	386	1mm SR	rich in flake hammerscale, some fired clay, small stones; approx. 10 thin fragments of corroded copper alloy
1392	51	83	4	iron rich concretions
1392	51	1150	250µm SR	sand rich magnetic dust
1395	55	64	1mm SR	small quantity of flake hammerscale (approx 10%) and iron scale, small fragments of fired clay, coal and coke
1395	55	156	250µm SR	very fine magnetic dust
1404		95	1	fragment of frothy, vesicular slag
1404	53	176	250µm SR	very fine magnetic dust
1404	53	113	1mm SR	small fragments of slag, coke, fired clay, small quantity of flake hammerscale (approx 5%), very few spheroids.
1405	54	82	1mm SR	very small fragment of slag, fired clay and small quantity of flake hammerscale (approx 5-10%)
1405	54	366	250µm SR	very fine magnetic dust
1405	58	6	10	fragments of reduced fired ceramic
1405	58	36	250µm SR	very fine magnetic dust

context	*sample*	*weight*	*quantity*	*description*
1410		37	1	flat fragment of slag - extremely smooth upper surface
1431		195	1	fragments of fired clay, all with vitrified, occasionally bloated surfaces on one surface
1458		31	1	fragment of flat, crystalline slag
1459		16	1	small lobe of slag, reddish tinge on upper surface
1471		13	1	small fragment of iron rich slag, rusty in areas
1493		29	1	fragment of low density material, composed of fired clay and slag
1512		94	1	vaguely plano-convex fragment with irregular but locally smooth top, prilly base and abundant clasts of coal residue
1512		194	1	vaguely plano-convex block with lots of accretion, probable coal residues
1512		384	1	irregular, possibly contorted block, deeply and finely dimpled surface in places with possible coal residues. These three probably all coal-fuelled smithing slags
1512		130	2	dense tap slags, one with side of flow against non-wetting surface
1512		62	1	reduced fired, vitrified and slightly slagged/corroded reduced fired wall with maroon surface glaze
1512		59	1	fragment of fired clay, one surface is vitrified with rough texture
1521		12	1	small fragment of flowed slag
1525		12	1	fragment of blebby, indeterminate slag
1525		53	2	fragments of fired clay both are vitrified on one surface, one piece has few coke/coal residues
1525		705	1	dense SHC with deep central depression and occasional coal residues (121x(73)x31mm) (approx 90% complete)
1525		113	11	fragments of corroded iron, several are probable nail fragments with surrounding concretions. One certain nail without concretion. One larger fragment, possibly merits X-ray
1536		23	2	fragment of flowed slag lobe; fragment of indeterminate slag
1558		26	1	fragment of tap slag, maroon tinge on upper surface
1574		117	1	small fragment of slag cake, possible SHC
1577		443	1	large chunk of slag with large organic moulds (30-60mm) - wood or charcoal
1577		36	1	fragment of indeterminate slag - crystalline with one small fuel inclusion to small to determine
1587		2	1	tap slag fragment
1597		80	1	fragment of indeterminate slag, iron rich in one area, appears to be crystalline towards the base
1597		19	2	thin fragments (4-8mm) of fired clay vitrified on one surface, oxidised on the other

context	*sample*	*weight*	*quantity*	*description*
1598		1087	1	large, long fragment of slag (approx. 185x56x59mm), flowed textures on upper surface and blebby base
1598		24	2	possible ore fragments
1598		18	4	small fragments of oxidised fired clay
1598		3171	c.250	very small fragment of mostly tap slag; few coffee bean spheroids; indeterminate slag; fired clay
1598		1079	c100	fragments of tap slag
1598		84	2	fragments of low density fuel ash slag, vitrified in areas
1598		8	1	small fragment of oxidised fired clay with some slag attached
1598		18	2	fragments of flowed slag
1604		194	1	curved slag sheet, smooth, non-wetted? Externally, large tabular fayalite terminations internally, constant thickness of 15mm, single fayalite zone, c300mm radius of curvature
1624		30	1	20mm diameter crude rod of slag, variable thickness, dimpled on all surfaces
1642		21	1	fragment of fired clay with frequent quartz inclusions, oxidised on one surface, heavily vitrified on other
1660	66	113	1mm SR	very small fragments of coal, coke, fired clay and small quantity of flake hammerscale
1660	66	66	3	fragments of low density slag with few coal residues
1660	66	88	250µm SR	very fine magnetic dust
1660	63	112	250µm SR	very fine magnetic dust
1660	63	166	9	small fragments of indeterminate slag, largest piece with yellow residue
1660	63	145	1mm SR	mostly small fragments of coal, small quantity of flake hammerscale, few spheroids; few fragments of fired clay and probable mortar
1670		89	1	iron rich slag
1670		679	1	SHC (approx. 90% complete), rough upper surface, occasionally glassy, convex base with few charcoal moulds
1687		32	1	fragment of fired clay, oxidised fired on one side, weathered and highly vitrified on the other
1692		6	1	low density vesicular tap slag fragment
1699		4	1	small fragment of slag, glassy in areas
1699	68	61	1mm SR	small quantity of flake hammerscale, few spheroids, remainder consists of very dark residues of coal, coke and slag
1699	65	164	250µm SR	very fine magnetic dust
1699	68	130	250µm SR	very fine magnetic dust
1699	65	71	1mm SR	very small fragments of charcoal, coke, slag, very little hammerscale (approx 2%)
1701		115	1	fragment of low density, highly vesicular 'fuel ash slag', pale green hue in places
1702		34	1	fragment of slag rod, approx. 15mm diameter

context	sample	weight	quantity	description
1729		10	1	fragment of flowed slag
1739		4	1	dense tap slag lobe
1739		10	1	sky blue fuel ash slag, lobate base surrounds charcoal fragments
1747		6	1	small crust of fired clay
1761		12	1	fragment of flowed slag
1781		14	1	small fragment of heavily fired clay, oxidised fired clay
1803		1978	1	large dense chunk of slag, occasional flow structures and small fuel residues (possibly coal?)
1803		1080	1	large dense chunk of slag, contain small fragments of bone, occasional organic moulds and few small coal residues
1803		738		fragment of tap slag, one large, the rest are very small
1803		311	1	Large fragment of dense slag
1804		2	1	tap slag fragment
1820		102	1	fragment of flowed slag
1828		15	1	fragment of fired clay, oxidised on one side, vitrified on the other
1830		550	1	very odd extremely dense slag, single unit possibly with slightly smoothly flow lobed top, base appears inclined and is covered in blocks of ore to 30mm, end of block has bobbled texture perpendicular to this with sand adhering - is slag broken then dumped on ground hot- or is this a build up against a tap arch block? very hard to orientate
1830		200	3	slagged and vitrified oxidised fired lining
1830		12	1	single slag prill, up to 12mm wide, dimpled base
1830		34	1	curved slag sheet, 5-7mm thick, smooth-dimpled on outside, perfectly smooth on inside, vesicular, has rounded margin - looks like sherd from large crucible - but is slag, well developed sheaves of crystals pass right through wall
1830		298	1	fragment of dense weathered slag with occasional coal residues
1836		84	1	fragment of flowed slag (distorted rod shape)
1840		4	1	single thickness small fragment of tapslag
1840		2	1	vitrified oxidised lining, probably representing top of blowhole passing into deep erosion above?
1851		76	1	irregular shaped chunk of fired clay, vitrified and bloated on one surface
1851		529	2	one oblong fragment of dense slag, rusty appearance with occasional coal residues (131x51x44mm), one smaller fragment with one flat surface which was possibly attached to some iron

context	*sample*	*weight*	*quantity*	*description*
1865		16	1	small fragment of indeterminate slag
1869		53	1	fragment of slag lobe, red tinge on upper surface
1869		21	1	fragment of heavily fired clay, oxidised on one surface
1869		106	1	fragment of weathered indeterminate slag, occasional fuel residues possibly coal
1871		86	3	fragments of weather indeterminate slag, one with tiny coal inclusions
1910	129	<1	5	small flakes of flake hammerscale
1917		148	1	margin of cake with smoothish top, rounded lateral margin with adhering sand, internally highly vesicular and altered with a few charcoal clasts - probably the margin of an SHC
1918		54	2	rather contorted-appearing pieces of lining slag, glaze varies from green to maroon and has rusty accretion, so presumably from iron working
1918		32	2	small fragment of fired clay oxidised on one surface
1937		4	1	fragment of curved sheet, mirror surface on concave side, dimpled on convex
1938		1216	1	large fragment of dense slag, maroon tinge in places, 1 rusty area, 1 small natural stone attached - probable furnace slag
1943		25	1	fragment of slag rod, approx. 20mm diameter
1943		20	1	fragment of flowed slag
1943		28	1	fragment of weathered slag with two small fuel inclusions
1943		30	1	fragment of oxidised fired clay, bright orange on one surface
1946		128	1	lining slag
1947		34	1	flown mass of pale grey lining slag with clast of sandstone. Has plastic-like resinous lustre
1947		12	1	microdimpled slag lump, rather amorphous, possibly twisted form, vesicular dense slag, but also has rather resinous lustre
1947		38	1	fragment of fired clay, slightly curved profile, one surface heavily vitrified
1956		15	2	fragments of fired clay, oxidised fired on one side, vitrified on the other
1987		763	4	fragments of heavily weathered indeterminate slag
1988		593	1	fragment of dense slag and clay with small coal residues
1996		32	2	fragments of fired clay, one is heavily vitrified on one surface
2001		22	1	fragment of fired clay, oxidised fired on one side, vitrified on the other

context	*sample*	*weight*	*quantity*	*description*
2006	87	5	1mm SR	mainly fragments of coke, fired clay, very small fragments of slag - very few magnetic residues
2006	87	5	250µm SR	very fine magnetic dust
2017		64	1	1 fragment of deformed lining slag, blebby on one surface, maroon tinge in places, one area with oxidised fired clay
2035		1865	1	large slab of thin tap slag cake, 160x200x40mm, highly vesicular slag, top barely lobate - prills have merged and are very wide, base sandy with pockets of ore lumps to 20mm
2035		70	2	fragments of tap slag
2041		15	1	indeterminate slag
2042		191	4	fragments of relatively low density indeterminate slag, occasionally glassy in areas
2043		148	2	fragments of low density slag, one has dimpled blebby texture and small fuel residues (possibly coal)
2043	82	17	1mm SR	flake hammerscale; small fragments of slag and fired clay
2043	82	17	250µm SR	very fine magnetic dust
2043		83	1	irregular shaped fragment of fired clay, oxidised fired, one surface almost vitrified
2049		339	1	fragment of dense slag, few flow structures on upper surfaces
2049		95	1	fragment of indeterminate slag - dimpled texture on two surfaces
2050		29	1	fragment of weathered flowed slag, maroon tinge on what remains of upper surface
2052		6	1	black glass on oxidised vitrified lining
2055		77	1	fragment of slagged lining, oxidised fired on one surface, rough, heavily fired texture on the other with maroon tinge in places
2069		70	5	fragments of blebby flowed slag, includes one narrow flowed piece 55mm long
2115		54	2	fragments of dense slag, highly metallic lustre
2115		5	1	thin slag crust
2155		2	1	deeply dimpled probable tap slag fragment
2163		13	1	fragments of low density fuel ash slag, vitrified in places
2163		15	1	small fragment of fired clay, heavily vitrified on one surface, oxidised on the other
2179		<1g	1	small spheroid of slag
2201		5	1	small fragment of reduced fired clay

context	*sample*	*weight*	*quantity*	*description*
2202		9	1	small fragment of slag, fairly smooth upper surface
2231		18	1	fragment of low density fuel ash slag, very glassy in areas
2239		50	5	fragments of corroded iron, one is probable nail, one fragment has small quantity of slag attached
2263		105	1	fragment of high fired clay, vitrified on one surface - possible lining
2331		60	2	fairly large fragments of pale orange fired clay with smooth surfaces
2540		2	4	rounded fragments of pale vitrified ceramic material with green clear wood ash glaze, except in one area where glaze is red. Suggests these are Cu-alloy working materials and may even be failed crucible
2550		113	1	fragment of probable SHC
2550		23	1	fragment of fired clay, oxidised on one side, vitrified and smooth on the other
2566		144	2	light orange fired clay, heavily tempered, slightly curved smooth internal and external surfaces (possibly unused)
2632		211	4	fragments of indeterminate slag
2657	127	554	250µm SR	very fine, sand rich magnetic residues
2657	127	31	3	fragments of iron rich concretions, one has small area of green staining
2657	127	2	1	rim fragment of samian ware
2657	127	2	2	fragments of tooth - stained green
2657	127	<1	1	very small fragment of green residue, possibly copper alloy
2657	127	185	1mm SR	flake hammerscale (20%), few spheroids, fired clay, iron rich concretions, occasional coal residues and tiny green residues
2699		19	1	fragment of high fired clay, vitrified on one surface
2758		51	2	fragments of low density slag, glassy in areas - probably high clay and fuel ash component
2758		222	1	possible fragment of SHC
2758		92	6	fragment of oxidised fired clay, vitrified on one surface - possible tuyère
2758		74	4	fired clay - one fragment vitrified on one surface
2758		874	1	probable fragment of dense thick crust SHC (approx. 80% complete), rough upper texture with glassy areas
2758		160	3	fragments of low density vesicular slag, one highly vitrified fragment
2758		578	1	probable fragment of SHC, stone protruding from base, rough upper surface
2758		111	1	low density glassy slag
2758		276	2	fragments of fairly dense slag, possibly fragment of SHC
2763		10	1	fragment of fired clay, oxidised fired on one side, heavily vitrified on the other

context	sample	weight	quantity	description
2844		6	1	small fragment of blebby slag
2869		187	1	fragment of small slag cake, possibly SHC - dimpled base, upper surfaces glassy in areas
2869		149	4	fragments of low density fired clay and slag - vitrified in areas
2869		56	1	fragment of indeterminate slag with rusty appearance
2931		291	10	fragments of low density fuel ash slag, heavily vitrified in areas
2931		653	8	fragments of iron rich concretions with rusty appearance, several contain organic moulds and abundant inclusions of flake hammerscale and fired clay. One is possible fragment of small SHC (121g)
3005		464	1	40mm wide, 60mm high 120mm long runner fragment with curious multiple form suggesting the hole has been re-rodded. Bases of flows (there appear to be four) are smooth and very slightly dimpled, the overall top is messy with lots of rusty cavities - perhaps fuel moulds, runnels themselves are dense
3005		46	1	fragment of oxidised fired lining with maroon surface glass and with suggestion of a wedge-like relining
3055		18	2	small fragments of flowed slag, one with maroon tinge on one surface
3055		53	1	fragment of bright orange fired clay with small fragment of quartz attached, thin white weathered residue on one surface
3057		1	1	tap slag fragment in concretion
3058		71	3	fragments of indeterminate slag with small fuel residues
3058		17	1	fragment of flowed slag
3059		923	1	large lump of iron rich slag, rusty appearance, occasional coal residues, probably a throat slag carrying iron
3060		46	2	iron rich concretions, one contains small fragment of bone
3060		348	9	fragments of indeterminate slag, several with rusty appearance
3060		21	2	fragments of fired clay, both vitrified on one surface, dark orange on the other
4041		1283	1	large fragment of dense crystalline slag, iron rich in areas, possibly furnace slag
4041		238	1	dense weathered slag
4041		20	1	indeterminate slag
9000		288	9	dense tap slag flows with low vesicularity, lobe widths of 10-30mm, mainly single flow thickness, but several pieces are more
9000		20	1	concretion around iron with slag, stones & charcoal
9000		34	1	40x20x20mm dense even fine goethite ore - probably broken from a very large botryoid (faintly concentrically banded)
9000		382	1	flow of slag with moderately thin, bulbous-tipped flows with wrinkles on top - with lumps of roasted ore on top surface, below top layer it is chaotic, 50mm thickness seen, with large wood moulds and end of 8mm diameter roundwood
9000		284	1	dense slag with prilly base, has moulds of coarse charcoal - 35mm diameter roundwood and 60mm wide face of split wood, top not seen
9000		182	3	rather amorphous dense slag fragments with dimpled bases, vesicular
9000		66	1	reduced fired and vitrified furnace lining

context	*sample*	*weight*	*quantity*	*description*
9000		44	1	dense slag with irregular charcoal moulds - possibly fragment associated with 382g and 284g blocks above
9020		7	1	fired clay
9026		253	5	fragments of indeterminate slag
9026		280	1	fragment of dense slag, occasional coal residues
9026		12	1	fragment of tap slag
9031		74	4	tap slag fragments
9031		182	1	probable tap slag piece with lobate top with broad smoothly rounded lobes, fairly dense, but passes down into highly vesicular material - and is then fractured
9031		218	1	strongly haematised block of slag, with crudely lobate top and internal structure - presumably a furnace throat slag?
9031		84	2	dense coarsely crystalline slag flowed round fuel to make moulds of large pieces
9031		338	1	vesicular slag from margin of cake, large charcoal fragments on base, raised maroon lobes on top - but looks more like smithing slag than tap slag
9031		224	1	dense worn slag block, rusty, has possible fuel moulds on one end
9031		76	1	dense irregular slag fragment in the form of two thin sheets meeting at right angle
9031		106	3	iron rich concretions with slag debris and coal, some also have flake hammerscale scale
9031		3	1	dimpled dense slag with coal residues attached to vitrified oxidised lining fragment
9031		6	1	vitrified oxidised fired lining with purple surface
9031		8	1	clinker attached to oxidised fired lining fragment
9031		18	1	clinker
9031		8	2	small concretions around possible nail shanks
9031		68	2	dimpled dense slag with coal residues, rusty
9031		30	3	charcoal-rich rusty concretion in ball, with rounded apparently vitrified surface
9031		66	1	dense rusty slag fragment with adhering concretion
9031		10	1	vitrified white sandy material with local green glaze surviving in hollows
9033		40	2	fragments of tap slag
9039		22	2	small fragments of indeterminate slag, possibly tap slag - too small to be certain
9040		12	2	fragments of indeterminate crystalline slag
9042		5	1	fragment of flowed slag with slight maroon tinge
9049		288	1	fragment of high fired clay, vitrified towards one end, probable lining
9049		82	1	tap slag
9049		354	1	long fragment (122mm) of slag, rusty in areas, possibly contains small amounts of unreacted ore
9049		310	1	fragment of indeterminate slag with large organic mould on lower surface
9049		30	1	irregular fragment of fired clay

context	sample	weight	quantity	description
9050		1093	13	fragments of tap slag, one with large organic moulds, possibly wood or charcoal
9050		167	1	fragment of lining slag, rusty appearance in places with occasional small organic moulds
9050		141	1	fragment relatively dense blebby slag with occasional organic moulds
9050		221	3	fragments of indeterminate slag, one rusty in places with frequent small coal residues
9050		276	1	fragment of indeterminate slag with oxidised fired clay at one end, iron rich in places, probably derived from smithing.
9050		33	1	fragment of high fired clay
9050		2287	5	fragments of dense slag, iron rich in places with occasional flow textures and organic moulds
9050		143	2	fragment of dense indeterminate slag, one fragment has small coal residues
9055		1032	3	fragment of dense tap slag
9055		224	1	fragment of dense slag with occasional coal? Residues
9059		518	12	fragments of tap slag, occasionally with maroon tinge on upper surfaces
9059		115	2	fragments of indeterminate slag, one with oxidised fired clay on one surface
9060		348	1	fragment of dense tap slag, layered appearance on one surface (layers approx. 10mm each), large organic mould probably wood, crystalline in section
9060		63	7	small fragments of flowed slag
9060		103	1	fragment of indeterminate slag
9061		153	8	small fragments of tap slag
9062		252	1	fragment of dense slag with maroon tinge
9062		268	8	fragments of tap slag
9063		9	1	fragment of probable fuel ash slag, in varying shades of blue
9066		3640	111	dense tap slags, mainly in thin sheets with narrow flows, but several are thick, several carry small ore fragments, but no large pieces, bases mainly dimpled, but some appear as sand contacts, tops mainly maroon, bases either maroon or grey
9066		3770	16	large blocks of flowed slags, sometimes with clear internal flows, most pieces show coarse roundwood charcoal moulds up to say 40mm diameter, pieces generally have a massive appearance. A few show free surfaces, which are lobate, gradational to tap slag-like surfaces. Surfaces are variably reddened, some flows near wood are certainly not red. Slag very dense - has little or no internal vesicularity
9066		1115	32	tap slag pieces with high internal vesicularity. Variably reddened, mainly from small flows. Most show dimpled basal contacts.
9066		78	2	grey flow slag with fine vertical amalgamated prills around medium charcoal voids
9066		614	45	small fragments of tapped slag. 1 piece very rich in iron.
9066		26	2	small fragments of highly slagged material that is probably sandstone rather than clay
9066		3660	18	angular fragments of very dense slag, variably reddened, frequently containing large ore particles, low vesicularity. As 16 pieces above, but lack the fuel moulds
9066		170	4	highly vesicular lining slag, mainly coarsely sandy. Mainly pale grey
9066		146	1	crescentic piece of corroding iron
9066		60	2	oxidised fired vitrified lining
9066		6	1	reduced fired vitrified lining

context	*sample*	*weight*	*quantity*	*description*
9066		32	1	complexly lobed lining slag - maroon on one surface, rest pale grey to greenish
9066		348	4	angular fragments of open textured coarse "coralline" slag
9066		44	1	indeterminate iron slag fragment with white ?stone contact
9066		56	1	flat rounded slag - like a tiny shc but probably not
9066		20	1	maroon slag crust
9066		6	1	low density greenish slag prill
9066		232	3	low density charcoal-bearing iron slags, one is a ball-like mass probably with a high lining content
9066		3097	9	large chunks of dense slag, several have rusty appearance. The largest piece has long organic moulds - possibly wood 50-60mm long and crystalline structures visible in fractured surfaces. Several have fuel impressions - probably charcoal
9066		152	1	fragment of lining slag with frothy internal texture
9066		3221	52	fragments of crystalline tap slag with upper lobed flow structures
9066		1132	1	large fragment of dense crystalline slag, lobed structures on two sides
9066		1440	12	fragments of tap slag
9066		3346	155	small fragments of tap slag
9066		72	2	concretions surrounding fragments of corroded iron with occasional charcoal inclusions
9066		6	1	fragment of iron nail
9066		754	6	fragments of lining slag
9066		859	14	fragments of indeterminate slag, several pieces have metallic lustre
9066		31	3	small fragments of oxidised fired clay
9066		7	1	possible fragment of ore
9066		41	1	small subcircular fragment of light grey slag, metallic lustre on two surfaces, bloated upper surface
9067		5	1	small, almost flat fragment of crystalline slag
9068		335	3	fragments of dense tap slag; 4 smaller fragments of slag lobes
9069		406	14	fragments of tap slag, maroon tinge on upper surfaces
9069		201	1	fragment of possible SHC
9069		571	1	possible fragment of SHC, few coal residues
9069		424	1	fragment of indeterminate slag, frequent charcoal moulds and frequent inclusions
9069		303	1	fragment of slag possibly containing fragments of unreacted ore
9070		2098	3	large chunks of dense slag with occasional flowed textures
9070		676	14	fragments of tap slag
9070		501	8	fragments of indeterminate slag, one with very small coal residues
9070		42	2	fragments of fired clay, largest fragment has vitrified layer, smaller fragment is oxidised fired
9071		6	1	indeterminate slag and clay
9072		34	4	fragments of corroded iron

context	sample	weight	quantity	description
9072		1262	1	large fragment of dense crystalline slag with organic moulds (10-30mm) at one end (wood or charcoal)
9072		903	20	fragments of tap slag
9072		57	1	fragment of high fired clay
9073		191	1	indeterminate slag
9073		25	1	fragment of dense crystalline slag
9075		40	1	fragment of indeterminate slag with few small coal inclusions
9082		397	1	fragment of dense slag with occasional flowed textures
9082		34	3	small fragments of probable tap slag
9089		32	2	fragment of flowed slag (probably tap slag)
9116		57	3	concretions surrounding fragments of corroded iron
9116		57	4	fragments of fired clay
9116		1437	89	small dense fragments of tap slag, average 25mm, several have maroon tinge on upper surface and dimpled base
9116		1994	92	small fragments of mostly dense slag, occasionally blebby texture, many are likely to be the bases of tap slag flows
9116		2097	85	fragments of dense tap slag, mostly dimpled bases, varying thickness 5mm-30mm
9116		141	1	fragment of small plano convex SHC
9116		1195	9	fragments of mainly dense slag; one fragment of lower density
9116		199	10	fragment of high fired clay with occasional quartz inclusions
9116		866	38	small fragments of indeterminate slag
9116		1563	136	small fragments of tap slag, one has small inclusion of unreacted ore
9116		124	13	fragment of high fired clay
9117		48	3	fragments of indeterminate slag, one with oxidised fired clay on one surface
9131		18	2	small pieces of tap slag with dark tops and pale slightly dimpled bases
9151		83	4	fragments of tap slag; fragment of indeterminate slag, maroon in colour
9151		112	2	fragments of indeterminate slag with rusty appearance and occasional organic moulds. 1 with small coal inclusion
9152		206	9	fragments of small, dense conventional tapslag
9152		20	1	flat sheet of slag with raised edge, one side mirror surface, the other slightly dimpled- probably contact between extremely large vesicle and base of flow
9152		222	1	large block of reduced fired and lightly vitrified lining
9152		674	1	dense angular block of slag with several fractures showing internal lobes, despite massive appearance
9152		156	1	fragment of highly vesicular tap slag flow, lobate top with broad flat incomplete lobes, several lateral contacts - so may have flowed into fuel
9152		74	1	extremely dense base to tapped flow, very wide dense lower lobes on flat base, fractured off upwards where flow becomes more vesicular
9152		132	1	extremely dense rather massive flow with inclined margin, little sign of internal lobes, but base and margin slightly lobate - probably entered ground worn

context	*sample*	*weight*	*quantity*	*description*
9152		134	1	complex piece with ?base of runner fused to earlier lobate flow fragment, and to lump of ore
9152		22	1	poorly preserved lobate flow with sandy base and large internal cavities - from a runner?
9153		1929	1	large long chunk of dense slag, vesicular rough texture on one surface (210x100x40mm), ridged tap slag
9153		11	1	small fragment of flowed slag
9208		272	1	fragment of dense crystalline slag with metallic lustre
9208		355	9	fragments of tap slag, most of which are quite small and thin (<10mm). One larger example is 30-40mm thick
9208		108	2	fragments of indeterminate slag with blebby textures
9239		116	1	rounded lump of low density vesicular lining slag
9239		94	6	small tapslag fragments
9239		14	1	part-reacted ore lump, coarsely crystalline but with voids with soft haematite
9239		20	2	small rounded and weathered lumps of charcoal-rich slag
9239		4	3	small fragments of indeterminate vesicular slag with tiny lobes
9242		263	1	fragment of dense slag with one organic mould relatively smooth upper surface
9242		72	3	small fragments of tap slag with upper lobed structures
9242		28	1	small fragment of indeterminate slag
9244		14	1	tap slag fragment - weathered
9244		8	1	smooth slag sheet fragment, weathered - probably similar to mirror finish samples originally
9246		415	14	fragments of crystalline tap slag
9246		256	1	fragment of fairly dense indeterminate slag
9249		136	1	fragment of tap slag
9249		70	1	fragment of dense crystalline slag

Table 2. Archaeometallurgical residue classes by context. Weight in grams or presence (x).

		Iron smelting				Iron smithing			indeterminate					other			
Phased contexts		massive	tapped	slag rod	ore	SHC	smithing	scale	iron slag	lining slag	lining	fired clay	clinker	coal	copper alloy	iron & concretions	total
2163	natural									13	15						28
1918	phase 1									54	32						86
2550	phase 3a					113					23						136
9249	phase 3e		136						70								206
1304	phase 4a	2098							1								2099
2052	phase 4b										6						6
2055	phase 4b										77						77
1937	phase 5								4								4
2001	phase 5										22						22
2006	phase 5													x			0
2202	phase 5								9								9
1395	phase 6e							x						x			0
1404	phase 6e							x	95					x			95
1405	phase 6e							x				6					0
1254	phase 6f		2														2
1340	phase 6f							x						x			0
1385	phase 6f							x						x			0
1391	phase 6f							x						x			0
1392	phase 6f							x						x	x	127	0
1597	phase 6f								80		19						99
1598	phase 6f	1087	4250		24				18	84	26						5489
1642	phase 6f										21						21
1660	phase 6f							x	166					x			166
1836	phase 7a			84													84
1431	phase 7b										195						195

		Iron smelting				Iron smithing			indeterminate					other			
		massive	tapped	slag rod	ore	SHC	smithing	scale	iron slag	lining slag	lining	fired clay	clinker	coal	copper alloy	iron & concretions	total
1761	phase 7b								12								12
1558	phase 8		26														26
1574	phase 8					117											117
1577	phase 8	443							36								479
1687	phase 8										32						32
1604	phase 8?								194								194
1065	phase 9		48														48
1200	phase 9								14								14
1211	phase 9								102								102
1410	phase 9								37								37
1525	phase 9					705			12		53			x		113	770
1146	phase 11b		86														86
1624	phase 11c			30													30
1536	phase 11d								23								23
1869	phase 11d	0	53						106		21						180
1871	phase 11d								86					x			86
1113	phase 11e		77														77
1161	phase 11e								26								26
1208	phase 11e								139	26							165
1747	phase 11e											6					0
2155	phase 11e		2														2
1024	phase 11j		4														4
1110	phase 11j								3								3
1155	phase 11j											150		x			0
1212	phase 11j		54							82							136
1459	phase 11j		16														16
1471	phase 11j								13								13
1701	phase 11j									115							115
1987	phase 11j								763								763

		Iron smelting				Iron smithing			indeterminate					other			
		massive	tapped	slag rod	ore	SHC	smithing	scale	iron slag	lining slag	lining	fired clay	clinker	coal	copper alloy	iron & concretions	total
1458	phase 11j								31								31
Unstratified material																	
1000			124					x	20	62							206
9000		892	288		34						66					20	1280
Unphased contexts																	
#103	?		3720						386								4106
1260	?								37								37
1280	?								70								70
1294	?		3														3
1369	?		2														2
1386	?							x	9					x			9
1493	?									29							29
1512	?		130			672					121			x			923
1521	?		12														12
1587	?		2														2
1670	?					679			89								768
1692	?		6														6
1699	?							x	4					x			4
1702	?			34													34
1729	?								10								10
1739	?		1							10							11

		Iron smelting				Iron smithing			indeterminate					other			
		massive	tapped	slag rod	ore	SHC	smithing	scale	iron slag	lining slag	lining	fired clay	clinker	coal	copper alloy	iron & concretions	total
1781	?										14						14
1803	?	3369	738						311								4418
1804	?		2														2
1820	?								102								102
1828	?										15						15
1830	?	550	12						34		200						796
1840	?		4								2						6
1851	?								529		76						605
1865	?								16								16
1910	?							x									0
1917	?					148											148
1938	?	1216															1216
1943	?			25					48			30					73
1946	?									128							128
1947	?								12	34	38						84
1956	?										15						15
1988	?								593					x			593
1996	?										32						32
2017	?									64							64
2035	?		1935														1935
2041	?								15								15
2042	?								191								191
2043	?							x	148		83						231
2049	?	339							95								434
2050	?		29														29
2069	?								70								70
2115	?								59								59
2179	?								1								1

		Iron smelting				Iron smithing			indeterminate					other			
		massive	tapped	slag rod	ore	SHC	smithing	scale	iron slag	lining slag	lining	fired clay	clinker	coal	copper alloy	iron & concretions	total
2201	?											5					0
2231	?									18							18
2239	?															50	0
2263	?										105						105
2331	?											60					0
2540	?														2		0
2566	?											144					0
2632	?								211								211
2657	?							x						x	x		0
2699	?										19						19
2758	?					1950				322	166						2438
2763	?										10						10
2844	?								6								6
2869	?						187		56		149						392
2931	?					121		x		291						532	412
3005	?		464								46						510
3055	?		18									53					18
3057	?		1														1
3058	?								88								88
3059	?								923					x			923
3060	?								348		21					46	369
4041	?	1283							258								1541
9020	?											7					0
9026	?		12						533					x			545
9031	?	526	256						548		19		26	x		117	1349
9033	?		40														40
9039	?								22								22
9040	?								12								12

		Iron smelting				Iron smithing			indeterminate					other			
		massive	tapped	slag rod	ore	SHC	smithing	scale	iron slag	lining slag	lining	fired clay	clinker	coal	copper alloy	iron & concretions	total
9042	?		5														5
9049	?	354	82						310		288	30					1034
9050	?	2287	1093						781	167		33		x			4328
9055	?		1032						224					x			1256
9059	?		518						115								633
9060	?		411						103								514
9061	?		153														153
9062	?	252	268														520
9063	?									9							9
9066	?	11737	13376		7				1600	1140	66	31				224	27926
9067	?								5								5
9068	?		335														335
9069	?	303	406			772			424					x			1905
9070	?	2098	676						501		42			x			3317
9071	?								6								6
9072	?	1262	903								57					34	2222
9073	?								216								216
9075	?								40					x			40
9082	?	397	34														431
9089	?		32														32
9116	?		7091			141			2061		323	57				57	9616
9117	?								48								48
9131	?		18														18
9151	?		83						112					x			195
9152	?	674	744								222						1640
9153	?		1929						11								1940
9208	?		355						380								735
9239	?		94		14				24	116							248

		Iron smelting				Iron smithing			indeterminate					other			
		massive	tapped	slag rod	ore	SHC	smithing	scale	iron slag	lining slag	lining	fired clay	clinker	coal	copper alloy	iron & concretions	total
9242	?	263	72						28								363
9244	?		14						8								22
9246	?		415						256								671
	totals	***31430***	***42692***	***173***	***79***	***5418***	***187***		***15147***	***2764***	***2737***	***612***	***26***		***2***	***1422***	
		74295				***5605***			***21286***								

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