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Evaluation of archaeometallurgical residues from the Forest of Dean Archaeological Survey, Stage 3B phase 2 (37920/37921/37923/37924)

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Abstract

The submitted material was collected from four separate sites (Gloucestershire HER nos. 37920, 37921, 37923 and 37924).

The collection from site 37920 comprised approximately 113kg of residues. The collection was a representative assemblage from a bloomery iron smelting operation. The vast majority of the residues were slags that had been tapped from a smelting furnace. They exhibited a variety of morphology from the abundant thick dense flows that may have cooled close to the tapping arch, though to more conventional lobate tapped slags, thin sheets of what must have been extremely fluid slags that flowed over a planar substrate, to chaotic masses of prills that cooled within a fuel bed. Slags formed closer to, or within, the furnace include a variety of crust-like slags that may represent slag cooling on the furnace floor or tapping arch. Slags rich in charcoal probably cooled within the furnace, close to the bloom. The diversity of morphology makes interpretation of the tapping technique uncertain, but it seems likely that a moderately deep tapping pit was employed, but that use of the pit varied – sometimes being filled with charcoal during tapping, but at other times tapping occurred over a clear surface. Frequent vertical non-wetted bounding surfaces on the tapped slag flows suggest that the tapping channel may have bounded by stones. In addition to the slags the collection included a significant quantity of furnace ceramic, a small number of pieces of local iron ore and a few pieces of iron (covered in concretion), including two substantial examples that may be significant pieces of bloom. The abundance of thick, massive, dense slags with flow-lobed tops and moulds after pieces of round-wood, is a feature seen in several assemblages of slags of Roman age from both the Forest of Dean and South Wales. Unfortunately, none of these occurrences has yet provided good evidence for the furnace morphology. Notwithstanding this similarity, the occurrence of the slag in a 15-20m diameter area is a feature more typically associated with bloomeries of medieval date.

Site 37921 produced a small assemblage (just 18 items) of residues which are broadly similar to those from 37920.

Site 37923 yielded a small, but diverse assemblage of material, with some certain smelting slags and several pieces of iron ore. Some of the slags were overgrown by concretion, suggesting the slags may have originally been rich in metallic iron and two of these might possibly be smithing slags (discrimination is not possible on simple inspection in their current state).

The sole item from site 37924 was a piece of dense iron ore with a smooth, worn surface and which might have been present through entirely natural agency.

Methods

All materials were examined visually with a low-powered binocular microscope. 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, with the residue classes presented by context in Table 2.

This project was undertaken for Gloucestershire County Council Archaeology Service.

Results

Site 37920

The assemblage from this site amounted to a total of 113.4kg, of which 109.7kg were archaeometallurgical residues, 0.6kg iron ore and 3.7kg were concretions cored on corroding iron.

The residues are dominated by dense flowed slags. Approximately half by weight of these flowed slags are examples with flow lobes or rivulets, typically 10-20mm wide, but occasionally up to 80mm in width, which show a distinctly maroon upper surface. Closely related to these are varieties in which the slag flows appear to have been very fluid and formed broad thin sheets, These varieties are those which are typically describe as tapslags (or tapped slags), with the surface colour being produced by surface oxidation of the slag flows in air at high temperature.

The tapped slags may carry small inclusions of stone, ceramic or iron ore. The basal surfaces of the flows are very variable. Some show a non-wetted surface, with a planar, dimpled or prilly morphology (the latter two classes probably representing flow over charcoal). Some examples show a higher degree of interaction with their substrate, with the incorporation of sand or shale fragments.

These materials grade into slags with a more massive texture, frequently displaying flow-lobed surfaces only close to their upper surface and frequently a prilly or lobate zone close to the base; the core of these slags often appears uniform. These massive slags typically occur in the form of sheets or lenses 60 to 120mm in thickness, but their overall morphology is unclear because they tend to occur as fist-sized angular fragments, bounded by fractures. The upper surfaces are often reddened (sometimes to a brighter, cherry, red than the conventional tapped slags) and in some examples the fracture surfaces are also slightly reddened.

Some of the flowed slags, both with massive and flow lobed internal textures, show evidence for non-wetted lateral contacts which are vertical and frequently slightly curved. These would appear to be surfaces chilled against stones.

A few examples of flowed slags are of the 'bird's foot' morphology – indicating flow of slag from a source at a raised level forming a stalagmitic growth.

Many examples of the flowed slags show a basal zone of almost chaotic prills, where the slag flows appear to have sunk downwards into an underlying charcoal bed. The fine slag material recovered from c105 is mainly of this form. It is not clear whether the bulk sampling of c105 has resulted in the recovery of fine material missed by the collection of residues in other contexts, or whether c105 was genuinely richer in this class of residue.

Other materials generated within a charcoal bed include flows, otherwise identical to tapslags but with a dark, unreddened upper as well as lower, surface. These materials must have cooled in the absence of sufficient oxygen to produce haematite on the upper surface. A further facies of slag from the fuel bed are fine-grained flow slags, with lobes penetrating between the moulds of coarse charcoal or wood. These closely resemble the flow slags found in the basal pits of non slag-tapping, slagpit furnaces.

All of the slag types described above appear fine-grained, or if coarse-grained, show a finely elongate crystal growth. Some slags from the site tend to be rather more coarse-grained with relatively equant crystals shown on the fracture surfaces. The most common form of such slag is characterised by abundant inclusions of fine-grained charcoal. These pieces were angular and bounded by fractures. It is assumed that most of this type of slag will be from the slag-mass below the bloom (although similar slags may form in other processes, the dominance of certain smelting materials from this site indicates that these slags will also be from smelting).

Many of the slags forming basal crusts and channels are also fairly coarse grained. The crusts show, usually, a non-wetted basal contact, although other varieties do occur, a crust of less than 10mm thickness (often with some development of tubular vesicles) and an upper surface that may pass up into charcoal-rich slags, a matte smooth surface, or most commonly, a poorly lobate slag of rather viscous appearance. Examples of narrow channels ('runners') are extremely rare. They also show lower crusts with tubular vesicles and just a narrow upper zone of smooth slag.

The final major division of the slags are the lining slags and associated vitrified and fired furnace linings. Most of the larger pieces of vitrified/fired lining are of reduced fired material, mainly rather heavily bloated laminated ceramic. The lining slags are mainly rather similar – and suggest significant sloughing of the lining. The oxidised-fired vitrified lining fragments are mostly rather small pieces. The most important fragment of furnace lining was a strongly vitrified section of reduced-fired ceramic with a neat planar face, perpendicular to the vitrified face, that was associated with a thin superficial oxidised firing. This piece is extremely unusual and might perhaps be from the wall adjacent to a tuyère or tuyère block.

Amongst the assemblage of slags there were 3.7kg of concretions cored on corroding iron. Most of these provided no clue as to the nature of the included iron (artefact, product, semi-product...). Two pieces from c1010 and c105 (weighing 596g and 246g respectively) were crudely wedge-shaped blocks and may possibly represent fragments from the margins of blooms (they are too large to be termed 'gromps').

Iron ore was also present in the collection, with 21 pieces weighing 592g. This collection included ores with a variety of textures, with massive fine-grained and stalactitic goethite ores. Such materials are typical of the diversity of texture common in Forest of Dean ores, even within the confines of a small ore pocket.

Site 37921

There was very little material from this site, but all the materials recovered were similar to those from site 37920. The assemblage would a[[ear to be entirely the product of iron smelting.

Site 37923

The lower ditch fills at this site produced an assemblage of just four pieces of slag (weighing 981g). These pieces were all from bloomery iron smelting; one, from c907, appeared possibly worn – and so may have been residual when incorporated into the bank. Several of the pieces are clearly from tapped slags.

The higher levels of ditch fill contained much more archaeometallurgical material (52 pieces; 5102g). The majority of the material was attributable to bloomery iron smelting, but some of the pieces were rather heavily concreted – perhaps suggesting they contain, or contained, a significant level of metallic iron. Although this is common in bloomery slags, the morphology of these two pieces raises the possibility that they are smithing slags. Unfortunately, this cannot

be determined without cutting the specimens. The certain smelting slags were mainly in forms broadly similar to the material from sites 37920 and 37921.

There were three pieces of ore, including a fibrous vein fill and a piece of boxstone ore.

Site 37924

The single piece recovered from this site was a fragment of dense goethite iron ore, which had been worn slightly smooth. This piece need not have arrived at the site through human agency.

Interpretation

Site 37920

This assemblage is substantial and provides good evidence for iron smelting. The geophysical evidence appears to suggest that the site is small and therefore it is likely that the residues form a coherent assemblage (see also the discussion of small sites under site 39721 below). All of the residues are from iron smelting. It is likely therefore, that no working of the bloom, beyond its initial compaction, was undertaken at this site.

The slags are mostly flowed, and it is interpreted that most of these cooled after flowing (tapping) outside the furnace. In detail, the slags appear to show cooling on a variety of different substrates, varying from deep charcoal beds (leading to the formation of rather chaotic prills) to more conventional firm substrates (including charcoal, clay and probably stone). The high degree of fragmentation of the slags, particularly the breaking-up of the massive-textured slags, means that reconstructing the tapping regime is very difficult. At some sites (e.g. that at Tisbury , Wiltshire, authors unpublished work) the tapped slag cakes of up to 11 kg each are largely intact – allowing simple comparison with the morphology of the tapping area, but here some detailed comparative work would be required to determine whether tapping was similar to that at Tisbury or not. The presence of vertical flow in the examples of bird's foot slags and the chaotic-texture of the prilly slags, suggests that tapping took place into a fairly deep pit. The lack of significant 'runners' suggests that the pit was adjacent to the furnace.

The presence of roundwood fragments in the massive flowed slags is significant. Similar occurrences have been reported from Roman sites in South Wales at Cardiff Castle (Young & Kearns 2011) and Caergwanaf (author's unpublished data). Some similarities were also noted between the Cardiff Castle assemblage and a Roman assemblage from Alvington, Glos. (Young 2009). The problem with the roundwood is that this represents fresh material, not fuel that has been exposed to the bloomery furnace for long. Somewhat similar textures are seen in non slag-tapping furnaces, slagpit furnaces, in which the slags descend into a pit filled with wood during the smelt. It is possible that this use of roundwood in a slag tapping furnace represents some sort of intermediate technology in which the lower part of the furnace has an organic packing, as in a non slag tapping furnace, but that the slag descending through this packing is subsequently tapped. An alternative explanation is the addition of fresh fuel to the open tap arch during smelting. One characteristic of the Cardiff Castle material not frequently matched in the present collection is that the massive-textured slag frequently contained large clasts of almost unreacted iron ore.

Clearly, the similarities being drawn between the residues at this site and those of Roman sites elsewhere, is at variance with the suggestion that the site type most closely resembles examples of medieval age. Clearly further refinement of the date and perhaps of the site context, would be most useful for the further interpretation of the significance of the assemblage.

Site 37921

This assemblage is small, but provides evidence for a similar iron smelting operation to that seen with rather more substantial evidence at site 37920.

The location of these two sites, away from the outcrop of the main iron ore bodies, is strongly suggestive that they were positioned to take advantage of charcoal resources. This use of managed woodland is a common feature seen in medieval iron production areas in particular – and it is possible that the two sites, 39720 and 37921 represent two locations of furnaces moving through the same area of coppice. The presence of furnaces constructed to take advantage of areas of woodland as they came into the appropriate stage of management (probably coppicing) is suggested by the terms *forgia itinerante* and *fabrica arrante* (Nicholls 1866, p. 15-16). A good fourteenth century example of a bloomery migrating around forestry following the coppicing cycle has been described from Coed y Brenin in North Wales (Crew & Crew 2001; Smith 1995).

Site 37923

This small assemblage is less complete than that from 37920 and it is unclear whether smithing residues are present in addition to those from smelting. The possible smithing residues are encased in secondary iron oxides generated, probably, by the decomposition of metallic iron. The smelting residues are too few to determine whether they were generated under an technology similar to that of sites 37920 and 37921, but clearly a slag tapping furnace of some sort was employed.

Site 37924

This single piece of ore need not have arrived at this site through human agency.

Evaluation of potential

Site 37920

This assemblage is substantial and provides good examples of all the residues likely to have been produced by iron smelting at this site. The collection also includes some ore specimens and, more remarkably, two samples which may be fragments of bloom. The apparently limited spatial distribution of the residues makes it likely that this was a short-lived smelting operation, and that therefore, although it is not possible to sample residues from a single melt, the residues are likely to be the products of a single smelting system (a combination of a single set of

resources being worked by a single technological process).

The assemblage provides, therefore, an excellent basis for the investigation of the smelting process, its chemical mass balance (*sensu* Thomas & Young 1999a and 1999b) and for the investigation of its product (if the two possible bloom fragments are indeed such).

The potential of this system to produce highly significant analytical data is currently tempered, however, by two shortcomings. Firstly the age of the activity is currently uncertain. Secondly, there was no actual furnace structure discovered (although it is likely to have been very close to the excavation).

Although construction of a detailed mass balance account for this smelting operation would be very useful, the key step needed in this region is for the understanding of mass balance for particular furnace types or particular ages. There are still no fully satisfactory descriptions of bloomery iron smelting furnaces in the Forest of Dean or adjacent districts. Any major campaign of analysis might, perhaps, be best targeted on a site with actual furnace remains. Indeed, should there be opportunity to return to his site and target the excavation of the furnace itself (which is likely to be identifiable by geophysics), the investigation would have a very high research potential.

Analysis of the present residues does have great potential for significant results in one particular area: the presence of possible bloom fragments within such a complete set of accompanying residues could provide an important test of any correlation between the smelting slag composition and that of the slag inclusions in the bloom. Such a study would be very timely (cf. Blakelock *et al.* 2009) and given the likely tight association between the different residue classes, this could be a study of international significance. Such an investigation would, of course, depend on the possible bloom fragments to be proved to be just that.

Given that the present site is with the central area of the forest, away from the main ore sources, analysis of the ore fragments might help to determine the provenance of the ores (using the ore composition database of Young (2000) and Young & Thomas (1998, 1999).

Site 37921

This assemblage is very limited in its scope. This material has no potential for production of useful additional data from further analysis.

Site 37923

This assemblage is small and has little potential for further analysis producing additional information. Clarification of whether the concreted slag specimens are indeed smithing slags might enhance understanding of site activities, and could be achieved with a minimum f additional extra work.

Site 37924

This material has no potential for production of useful additional data from further analysis.

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Table 1: summary catalogue

context (by bag/box)	no	weight	notes	av. weight
37920-100	*79*	*4735*		60
	1	134	dense goethite ore	134
	11	312	dense slags spread fluidly over flat surface. Largest piece looks deflated and has a matt crust	28
	10	100	dense slags forming prills between fuel moulds	10
	38	2015	conventional dense tapped slags	53
	1	182	plano-convex lump, has10mm crust with tubular vesicles overlain by a dense slag, which is vesicular and has an apparently lobate, but brecciated upper part. The base is non-wetted, dimpled with crude lobes near one original margin. Presumably furnace base/tapping channel?	182
	4	888	dense slags with prilly/lobate bases and locally lobate tops, but with massive core. One bears sandstone clast. At least two pieces show steep lateral containment - with extremely non-wetted lobe contact.	222
	8	794	fired and vitrified furnace lining, most pieces are reduced fired ,but a couple of small ones are oxidised. One reduced fired slab as oxidised surface perpendicular to vitrified surface - could this be a margin for a tuyère block?	99
	4	244	angular fragments of iron slag bearing fine charcoal	61
	1	20	bleb of lining slag	20
	1	46	fragment from margin of possible channel/runner - shows rough surfaced lower curved margin and overlying tubular vesicle-rich crust, and some remnants of a smooth or lobed top	46
37920-100/101	*12*	*578*		48
	6	338	conventional tapslag	56
	2	32	fired clay and oxidised vitrified lining	16
	4	208	charcoal rich slags, some with lobes - but probably descending prills rather than flows	52
37920-101 (box 10)	*233*	*16737*		72
	115	7145	conventional dense tapslag, mainly 15-20 x 10 flows, but some lobes spread to 70/80mm wide	62
	6	322	concretions on iron	54
	1	34	ore	34
	13	1020	lining and lining slag	78
	7	1465	flowed slags with massive section, dense	209
	11	1480	Tapped slags with lobes on top - raked? Some tapped on charcoal, some on sand	135
	18	1225	flowed tapped slags with flow around or into charcoal disrupting texture	68
	11	270	sheets and flows of dense flows with charcoal impressions and dark surface - no exposure to air	25
	1	628	large dense birds foot, massive appearing internally (though presumably not!). Apparently involves a 70mm thickness onto a 45 degree charcoal slope	628

context (by bag/box)	no	weight	notes	av. weight
	8	892	charcoal dominated slag with occasional lobe internally	112
	37	1400	indeterminate miscellanea - almost all show some evidence for flow, but do not characteristics of material in other categories	38
	2	522	dense slabs with planar bases - one rough one non-wetting. Non wetting one has basal layer with tubular vesicles. Remainder of both probably formed of flowed material but not clearly so - wispy blebs in one, large smooth void in the other	261
	1	98	complicated lining slag dominated blebby lump also bearing iron	98
	1	116	planar based rusted slag lump	116
	1	120	flowed slag with rectangular sectioned? 25x40 mm step in base - possibly flowed over piece of wood	120
37920-101 (box 1)	*164*	*10692*		65
	1	596	wedge shaped bloom fragment 80x55x60	596
	6	192	small pieces of thin sheets - basal contacts either with charcoal or clay/shale, tops mainly charcoal dimpled	32
	8	158	indeterminate fragments	20
	16	710	rather variable scruffy fragments of flowed slags, with some lobes, but dominated by porous vesicular, often charcoal bearing material	44
	2	132	iron ore - 1 possibly roasted fragment broken in two and one highly polished piece of stalactitic ore	66
	1	18	friable slag rich in fine charcoal	18
	4	328	rounded lumps of lining slag	82
	16	728	fired and vitrified lining, larger pieces mainly reduced fired	46
	11	1890	variety of dense slags bearing pieces of large wood/charcoal - including 10-15mm roundwood. Some is lobes passing between fuel moulds, but grades into massive slags with sporadic moulds	172
	6	1890	dense massive thick slags with locally lobed tops and prilly bases. Most have some moderately large ellipsoidal voids	315
	7	208	small pieces of dense slag penetrating between fuel moulds. 15mm roundwood common, some lobate some more massive	30
	6	222	concretions on iron	37
	80	3620	conventional tapslag	45
37920-101 (box2)	*123*	*13614*		111
	14	656	indeterminate charcoal-bearing slag fragments	47
	6	658	Tapped dense slag in thin fluid sheets	110
	54	5505	conventional dense tapslag	102
	15	840	lining and lining slag	56
	1	202	small plano-convex slag piece with gravel on convex side - not clear if SHC, reacted flow tip - or even a burr	202
	14	4355	very dense, massive fragments, sometimes with lobed tops, sometimes with prilly bases and charcoal moulds	311
	4	258	concretions on iron	65
	8	452	dense slag with abundant small moulds	57

context (by bag/box)	no	weight	notes	av. weight
	1	26	fluid flow into ceramic	26
	4	322	10mm crust with charcoal mould rich slag above	81
	1	20	ore	20
	1	320	thin crust overlain by vesicular large flow lobe, rusty brown	320
37920-101 (box7)	*106*	*12907*		122
	44	3410	conventional dense tapslag	78
	7	1954	conventional tap slag with material on top, largest piece has major lateral obstruction	279
	7	432	lining and lining slag	62
	7	970	rather variable material with a contact surface but mainly low density or charcoal rich materials above	139
	20	2035	slags with some evidence of lobes, but with significant contacts with wood/charcoal visible. Variable from to high to low density	102
	11	3190	dense slag, lobed tops and sometimes base - but typically massive, often with ore inclusions.	290
	1	82	poorly preserved section of runner - mainly semicircular/horseshoe section with tubular vesicles	82
	2	460	tapped flows with chaotic lobes in lower part (into charcoal?) with inclusions of broken slag and ore	230
	2	210	fragments of slag sheet with brecciated clay on one surface - one has solid clay on the other face and may be an intrusion)	105
	1	32	concretion on iron	32
	3	74	dark surfaced sheet and prills - presumably within fuel bed	25
	1	58	arcuate piece with raised slag lip - looks like lip on an Aristotle furnace slag cake - but probably the top of a burr	58
37920-102	*19*	*3838*		202
	3	1830	large angular blocks of dense slags, the lower part of which bear some lobes or down ward prills and there are some moulds of very large wood/charcoal fragments	610
	2	438	flowed slag with irregular reddened upper lobes, but rather vesicular interiors with charcoal	219
	3	360	dense tap slag flow with odd debris attached to uppermost neat surface	120
	7	640	conventional tapped slags	91
	1	488	dense tapslag flow with prilly /lobate base, some large rounded voids in lower part, main part massive, mauve on fracture, top surface shows prills	488
	1	4	vitrified oxidised lining	4
	2	78	pieces with thin <10mm basal crust, one overlain by rough material, the other by charcoal dimpled lobes	39
37920-105 (box 4)	*108*	*10278*		95
	57	3435	conventional tapped slag	60
	9	520	tapslag in v thin fluid sheets with planar shiny base	58
	1	10	ore?	10

context (by bag/box)	no		weight	notes	av. weight
	1		754	fragmented mass of dense slag with rounded outline, some with chaotic lobes, some large fuel/wood moulds	754
	7		1825	massive blocks of slag with flowed components, some with localised chaotic prills, a few fuel moulds	261
	2		456	blocks with 10mm crust with shiny surface overlain by rather disorganised lobate slags with charcoal and ore	228
	3		56	3 thin crust fragments, one with tubular vesicles	19
	9		338	lining and lining slag	38
	2		692	concretions on iron (much of weight is probably slag)	346
	1		1030	tap slag flow with good upper flows but below is chaotic pills	1030
	13		846	slag rich in moulds/pieces of charcoal	65
	2		202	tapped slag in sheets/poorly lobed with dark top - rather messy appearance	101
	1		114	two pieces of fused tapped lobe in different orientations	114
37920-105	*169*		*12759*		75
	1		246	concretion on iron wedge/fan shaped - possibly a bloom fragment	246
	2		160	concretions on iron	80
	13		724	vitrified and slagged furnace lining - mostly reduced	56
	77		4270	conventional tap slag	55
	9		646	mainly rather massive, rough slag, coarsely crystalline with abundant vesicles	72
	16		3445	massive slags, finely vesicular, occasional roundwood moulds, sometime prilly base, locally lobate top seen	215
	9		536	massive slags, coarsely crystalline, abundant charcoal moulds including roundwood	60
	11		538	dense fine flow slag penetrating between large fuel/wood moulds	49
	7		830	tapped slag in the form of runners with marked lateral non-wetted constraints	119
	1		116	dense smooth reddened block of iron ore	116
	4		260	dense flowed slags with slight basal crusts, lobate flows, but with dark tops and moulds - flowed below fuel bed	65
	11		532	slags with basal sheets and a variety of rough/coarse slags above - mostly rather vesicular	48
	3		202	fragments of dimpled or rough flow bases with rather massive dense slag above	67
	5		254	miscellaneous lumps and nubs of vesicular slag	51
37920-107 sample 6 fines	*13*		*14*		1
	5		4	iron ore	1
	1	<		3mm glass spheroid	
	2		2	dimpled slag blebs from fuel bed	1
	5		8	concretions on iron	2
				small amount of flake hammerscale	
37920-114	*424*		*13636*		32
	9		142	iron ore	16

context (by bag/box)	no	weight	notes	av. weight
	51	860	lining and lining slag	17
	32	800	more or less friable charcoal -bearing (moulds) slag	25
	2	126	burr like interactions	63
	27	3030	atypical dense flowed slags with evidence of wood/fuel clasts, often bright red surfaces and ore - and also other flow around obstructions	112
	16	214	prills and flows with no surface red	13
	13	400	concretions on iron	31
	16	358	slag sheets - includes many deflate flow fragments?	22
	9	1165	various atypical, mainly rather flat-topped flows	129
	202	5815	conventional dense tapslag with red surface	29
	47	726	indeterminate, mainly rather rusty, fragments	15
37920-114 furnace lning	*10*	*178*		18
	10	178	oxidise and vitrified furnace lining	18
37920-115&116	*57*	*7043*		124
	4	342	rather rusty-appearing charcoal rich porous slags	86
	1	466	somewhat plano-convex prismatic slag piece. Probably from the floor of a furnace mouth rather than being an SHC. Good lower crust, top smoothish blebby, internally porous and charcoal-bearing, base well formed but variable - possibly one end on clay, the other charcoal?	466
	19	1420	conventional dense tapslag	75
	7	1575	dense tapped slags with material above uppermost neat surface - suggests messy tapping- or possibly tapping into charcoal	225
	1	432	complex tap slag block with lobate surfaces at odd angles and dense massive components, possibly lies below a birds foot	432
	4	742	concretions on iron, some substantial, most/all contain at least some slag	186
	3	74	fired clay/vitrified lining	25
	6	254	lobate/prilly slag pieces with significant flow around fuel voids	42
	5	656	fragments of sheet, some with tubular vesicles, mainly with little on top , bases vary non-wetting, smooth/lobate, rough. One may be base of large slag bubble	131
	3	364	slag sheet as above nut overlain by lobate flowed slags	121
	1	96	charcoal rich slag	96
	1	410	chaotic dense furnace type slag with thin (3mm) slag sheet on base	410
	2	212	dense furnace slags with occasional lobes and fuel moulds - rather chaotic	106

context (by bag/box)	no	weight	notes	av. weight
37920-116 kiln lining	*4*	*40*		10
	4	40	fired and/or oxidised vitrified clay	10
37920-116 sample 4 fines			tiny amount of flake hammerscale (not all of sample is hammerscale)	
37920-116 sample 4 >4mm	*303*	*3327*		11
	54	830	flowed slag forming chaotic prills into fuel bed	15
	66	1851	flowed slag in neat conventional tapslag	28
	13	220	rough slag with charcoal moulds	17
	2	42	fired/vitrified lining	21
	168	384	fine indeterminate debris	2
37920-116 sample 4 >4mm	*340*	*2928*		9
	75	1120	flowed slag in neat conventional tapslag	15
	76	390	flowed slag forming chaotic prills into fuel bed	5
	4	662	dense massive slags with roundwood fragments , locally lobate tops and prilly bases	166
	12	242	slags rich in charcoal debris and moulds	20
	3	164	crudely lobate flows on basal crusts with charcoal dimples	55
	4	50	vitrified lining and lining slag blebs	13
	166	300	fine indeterminate debris	2
37920-116 sample 4 >4mm	*8*	*16*		2
	8	16	fired/vitrified lining	2
37920-116 sample 4 >4mm	*11*	*100*		9
	11	100	fired/vitrified lining	9

context (by bag/box)	no	weight	notes	av. weight
37921-200	*2*	*58*		29
	1	40	thin slag sheet with non-wetted base and charcoal dimpled, slightly wispy top	40
	1	18	small weathered fragment of dimpled vesicular slag	18
37921-201	*4*	*436*		109
	1	44	small piece of dense slag penetrating between large fuel/wood voids (cf non-tapping)	44
	1	288	piece broken in two (further piece missing) of dense massive slag, slightly lobate top and base, mauve surfaces to fracture	288
	1	22	vitrified oxidised furnace lining	22
	1	82	lobate slag, looks as if was viscous, rather vesicular	82
37921-201	*1*	*12*		12
	1	12	conventional dense tapslag	12
37921-201 (lower end)	*10*	*506*		51
	7	346	conventional dense tap slags	49
	3	160	lower density flowed material in more viscous-appearing crude vesicular lobes	53
37921-205	*1*	*162*		162
	1	162	tapslag flow with dimpled base, dense massive core and flow lobed or charcoal rich top, probably from near inclined margin of tapping pit	162
37923-902	*19*	*700*		37
	16	252	dark dense tapslag fragments in rather small pieces	16
	1	60	iron ore, narrow (25mm) vein with fibrous/stalactitic fill	60
	1	66	small chip of massive texture dense slag	66
	1	322	plano convex piece - probably rather massive flow with an upper more vesicular layer	322
37923-903	*25*	*1920*		77
	1	462	dense compact mid grey ore with small stalactitic zones in voids	462
	11	468	conventional dense tapslag	43
	1	48	strongly layered boxstone ore	48
	3	146	charcoal rich vesicular slag	49
	4	224	almost clinker-like vesicular slag with nub like form and reddened surfaces	56
	2	70	vitrified lining/lining slag	35
	2	428	concretions on iron	214
	1	74	short section of tip of runner - lower half convex with sand contact, upper half smooth and broadly lobate	74

context (by bag/box)	no	weight	notes	av. weight
37923-904	*8*	*2482*		310
	1	656	very rusty block (contains iron) with a curved steep dimpled end with suggestion of layering. Might be large part of an SHC, but rust makes identification uncertain	656
	1	560	very rusty block of slag - some faces definitely fractured, others less certain - again, could be part of an iron-rich SHC	560
	1	292	10mm slightly curved crust with somewhat lobate margin overlain by irregular vesicular and possibly brecciated slag - probably a furnace floor deposit	292
	1	466	angular block of tap slag with lobed upper and lower surfaces but internally massive with pink/grey surfaces	466
	1	132	slab of very thin broad fluid tapped flow	132
	1	46	conventional dense tapped slag	46
	1	252	slightly concreted block of furnace slag rich in charcoal voids (large)	252
	1	78	concretion on iron	78
37923-905	*3*	*744*		248
	1	544	massive angular block with some slightly lobed surfaces of dense furnace slag, all surfaces with local pinkish-purple surface	544
	1	30	small flows of typical dense tapslag, probably isolated	30
	1	170	narrow piece of tapped slag with at least one vertical lateral constraint, flow ins in very narrow fluid runnels <10mm wide, probably near tap arch	170
37923-907	*1*	*237*		237
	1	237	dense angular block (but worn) of charcoal bearing massive slag	237
37923-911	*4*	*142*		36
	1	44	corroded and exploding iron	44
	1	72	concretion on iron	72
	1	10	conventional dense tap slag	10
	1	16	vesicular and charcoal bearing grey slag with some flow lobing	16
37924-304	*1*	*24*		24
	1	24	worn pebble of dense goethite ore	24

Table 2: Summary of residue class by site and context

	Iron ore		Tapped slags in fluid sheet		Conventional dense tapped slags		Dense prills in charcoal		Slag crusts & channels		Dense, massive slags		Charcoal-rich slags		Indeterminate slags		Lining and lining slag		Concretions on iron metal		Possible bloom fragments	
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
37920-100	1	134	11	312	38	2015	10	100	2	228	4	888	4	244			9	814				
37920-100/101					6	338							4	208			2	32				
37920-101	4	186	6	658	333	25547	21	552	25	2936	49	12790	51	4053	62	2326	57	3472	17	834	1	596
37920-102					13	1926			2	78	3	1830					1	4				
37920-105	2	126	9	520	145	9881	15	798	16	1044	45	7408	13	846	5	254	22	1062	4	852	1	246
37920-107	5	4													3	2			5	8		
37920-114	9	142	16	358	211	6980	16	214	2	126	27	3030	32	800	47	726	61	1038	13	400		
37920-115/116					26	2995	6	254	9	1486	4	1054	5	438			3	74	4	742		
37920-116 s4					141	2971	133	1384			4	662	25	462	334	684	29	248				
37920 total	*21*	*592*	*42*	*1848*	*913*	*52653*	*201*	*3302*	*56*	*5898*	*136*	*27662*	*134*	*7051*	*451*	*3992*	*184*	*6744*	*43*	*2836*	*2*	*842*
37921-200									1	40					1	18						
37921-201					12	600	1	44			1	288					1	22				
37921-205					1	162																
37923-902	1	60			16	252			1	74	1	66			1	322						
37923-903	2	510			11	468							3	146	4	224	2	70	2	428		
37923-904			1	132	1	46			1	292	1	466	1	252	2	1216			1	78		
37923-905					2	200					1	544										
37923-907											1	237										
37923-911					1	10							1	16					2	116		
37924-304	1	24																				

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