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Assessment of archaeometallurgical residues from Castle Street, Conway (G2324/AB1513)

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Abstract

This collection was the result of excavations through an urban stratigraphic succession of medieval and post-medieval date. The archaeometallurgical residues in most samples comprised a sparse assemblage of microresidues and comminuted debris from macroresidues, all derived from blacksmithing. Richer assemblages of microresidues occurred occasionally through the succession, and hint at possible period or locations of greater activity, but the absolute quantities of material remain small, creating an impression of the widespread and perhaps residual dispersion of the microresidues from the point of origin.

There appears to have been a mixed use of fuel throughout. Coal (or coke) was common in many of the samples, with slag materials that were either certainly or probably clinker present in most samples. Charcoal fragments were also present in small quantities (and observed with concretions), and charcoal fuel particles were present within some of the smithing hearth cakes.

Contents

Abstract 1

Methods 1

Results
- Description of Residues
  - Smithing: macroscopic slags 1
  - Smithing: microscopic residues 2
  - Fired clay 2
  - Other 2
- Distribution of residues 2
- Interpretation 3
- Discussion 3
- Further work 3
- References 6
- Table 1: 7
- Table 2: 20

Methods

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

The examined materials are listed in Table 1. The site code was G2324/AB1513.

This project was commissioned by Laura Parry, of Brython Archaeology.

Results

Description of residues

The submitted materials amounted to an overall total of approximately 2.5kg, with material from 104 separate contexts. The material was submitted as two separate collections (metallurgical resides and fired clay). These are presented separately in the summary catalogue (Table 1), but are integrated in the stratigraphic summary (Table 2). The collection included both archaeometallurgical materials from blacksmithing and fragments of structural materials (brick, burnt daub, mortar…).

Smithing: macroscopic slags

There were only two slag pieces that were sufficiently large as to present the characteristic features enabling their identification as **smithing hearth cakes** (SHCs):

(1053) – 296g, 80x85x45mm,
(1198) – 150g large part (60%??) of small SHC

SHCs are the typical form of slag mass formed in a smithing hearth. They form from the reaction of melted furnace ceramic, fuel ash and debris (iron, iron oxide) lost from the workpiece. Their size indicates, amongst other things, the amount of iron lost to the hearth during a work-period.

Context (1027) produced an unusual ‘birds foot’ structure formed of clinkery glassy slag. These structures originate where slag flows down a surface before the flows radiate outwards onto a floor. They

are rare in smithing hearths (where the slag typically solidifies high in the hearth as an SHC. They are common in both bloomery iron smelting assemblages and in slags from finery forges; in both cases, fluid slag may solidify as it moves from the high temperature environment of the furnace or hearth towards a low temperature area (either inside or outside the furnace/hearth depending upon the type of structure involved). In this instance, given the overwhelming evidence for the remainder of the assemblage being from ironworking, an alternative source of fluid slag within the forge hearth must be sought.

Where the fuel employed in the hearth was coal, then the inorganic component (the ash) may form a slag-like material, **clinker**, which may contain fragments of only partially melted coal shale. Not all clinker has a metallurgical origin, and in hand specimen it can be impossible to discriminate between clinker generate during smithing and clinker generated in non-metallurgical hearths, kilns and ovens.

Smithing: microscopic residues

In contrast to the paucity of macroscopic archaeometallurgical residues, the microscopic residues were present in a very large number of samples, even if not at a high density.

The most important group of microresidues is hammerscale. When iron is heated to a high temperature in order to be forged or welded, it will oxidise. Within the hearth, the iron is heated high within the fuel pile to allow combustion to have removed as much of the oxygen as possible from the incoming air blast. When the hot iron is in air however, the oxidation will be rapid, leading to formation of an oxide layer on the surface of the iron as oxygen diffuses in. This oxide scale will contract differently to the hot iron as it cools, so it tends to spall from the iron – a process that may be compounded by the deformation of the iron during forging, leading to the accumulation of flat oxide scale (**flake hammerscale**) around the anvil.

The oxide scale presents a barrier to forge welding, since it prevents the two pieces of iron metal coming into contact. The welding process therefore entails melting the superficial oxide layer so it can be squeezed out as the weld is closed. This can be enhanced by use of a flux (e.g. sand) to lower the melting point of the oxide scale. The molten scale will cool rapidly as the droplets are sprayed out from the closing weld – these tiny (typically <3mm diameter) spherical particles are known as **spheroidal hammerscale**. The spheroidal hammerscale may be distributed further across the forge floor than the flake particles, but will be less abundant.

Both these particles occur widely - flake hammerscale in 83% of the examined samples and spheroidal hammerscale in 48%.

Superficially similar to spheroidal hammerscale are **slag droplets**. These are typically larger, less perfectly spheroidal, and commonly dimpled, particles, with a range of composition from that of lining slags to a similar composition to the SHCs. They form from the solidification of droplets of slag descending through the fuel bed of the hearth – and thus tend to show patterns of disposal in common with that of the ash from the hearth.

Other microresidues include small fragments of comminuted slag and clinker.

Fired clay

The collections included a relatively large quantity of fired clay. Only some 9g of fired clay out of 920g was demonstrably metallurgical hearth material. In Table 2, four categories are employed: **lining** (metallurgical hearth material with evidence for vitrification), **brick?** (reddish sandy ceramic with planar surfaces), **daub1** (fine grained orange ceramic with some coarse temper, but with very high levels of organic temper, probably mainly straw) and **daub**2 (a gritty fired clay, with a small amount of organic temper, typically brownish).

The brick(?) fragments are small, precluding their certain identification as brick, but their uniform firing, even texture and prepared surfaces indicate that they are almost certainly CBM, and they do not have a morphology indicative of being thin tile. Therefore, an origin as thick tiles or bricks appears likely. The fabric is always extremely quartzose sand-rich, and some surfaces appear almost entirely sand.

Fired clays that may be burnt daub, or other structural material, were present in two varieties: a strongly oxidised-fired, fine, fabric with abundant straw temper (#1) and a silty fabric with some gravel and only a little organic temper (#2). Both varieties showed approximately planar smoothed external surfaces, none showed evidence for the substrate to which it was attached.

This general category also embraces lining slags (slag developed from the melting of the hearth lining with little influence from additional iron from the workpiece), of which there was very little present as macroscopic material, but which probably provided a large proportion of the material simply entered as ‘slag’ in the microresidues. It also includes the material listed under the bloated heading. These bloated materials appear to be dominated by natural clay-rich materials (rock) that have been heated to temperatures producing partial melting and loss of volatiles from decomposing or dehydrating minerals – thereby generating vesicles of gas that cannot escape. The materials involved may possibly have been impurities (concretions) within coal fuel.

Other

The collections included, in addition to the material described above, concretions that have formed around decomposing (oxidising) metallic iron artefacts, fragments of coal (and coke, partially burnt coal), fragments of sand-rich lime mortar, and abundant rusty material. The rusty material is typically in the form of poorly fissile sheets, and probably represents both rust from the surfaces of metallic iron and altered fragments of shale (mostly probably from the impurities in coal).

Distribution of residues

The stratigraphic distribution of the residues is illustrated in Table 2.

The archaeometallurgical residues show a high degree of uniformity in make-up and abundance throughout the succession. The macroscopic slags do not occur in metallurgical deposits, but as elements of otherwise stony deposits and even as wall material. The microresidues show little pattern in their distribution,

being present throughout the succession from the medieval deposits onwards.

Interpretation

The assemblage described here indicates a mixture of metallurgical residues from blacksmithing, with some structural materials (brick, daub, mortar). There are no extremely rich assemblages of smithing microresidues such as typically accumulate on the forge floor and in adjacent cut features. The richest assemblages of blacksmithing microresidues (i.e. those from (1008), (1054), (1089), (1106), (1132), (1133), (1147), (1163), (1179), (1190), (1192), (1194), (1203), and (1207)) are all of very modest size. If anything links these slightly richer assemblages it is that these contexts include a high proportion that are structural (walls, surfaces…). The generally lack of macroscopic residues is also noteworthy, although again, there is some occurrence of macroscopic slag blocks within walls.

These different characteristics indicate that the contexts are unlikely to be directly related to the focus of the smithing activity. The macroscopic slags would be disposed of in a deliberate manner – they can be picked from the hearth and dumped. The disposal of the hammerscale would be a slightly different issue – with a smithy floor typically being swept clean. Disposal of the fines might be through disposal of those sweepings into a waste pit or dump – but simply sweeping them out into a yard or onto a road might suffice. Reworking of the sweepings to produce the persistent, but low density, of residues seen in this study might occur through other agencies – such as rain action. The occurrence of hammerscale within walls might indicate usage of the adjoining rooms, but the archaeological observations of the nature of the wall matrix and its relationship to the rooms would need revisiting.

The small quantities of structural materials present would also be compatible with the progressive secondary accumulation of detritus.

Discussion

The assemblage has produced evidence of blacksmithing, probably using both coal and charcoal as fuel, either together or different periods. The use of coal as fuel in North Wales, even away from the coalfields, has been well documented in the Middle Ages. Coal was widely moved along the coast of N Wales during the major period of castle construction in the late 13th century from the coalfields of NE Wales, particularly for the burning of lime, but also for other purposes (Nef 2013, 364-5). By the 16th century the same sources were major exporters of coal around the Irish Sea. Coal and clinker appear to be present in the succession on this site from medieval deposits onwards.

During the later medieval and early post-medieval periods several changes occur in the evolution of blacksmithing – the progressive switch from charcoal to coal as fuel, the demise of the floor level hearth with the almost universal adoption of the waist-level hearth and the adoption of iron tuyères. Unfortunately, the present assemblage sheds little light on this. There is evidence for both fuels (although the SHCs only show charcoal) and the internally prilly nature of the SHCs might just possibly be associated with the use of an iron tuyère (which would reduce the flow of silicate material to the hearth) – but the evidence is weak.

Further work

The assemblage is derived from deposits of a time interval of great potential research-interest for the study of the development of smithing, but the material is not present in sufficient abundance or in sufficiently certainly primary contexts, to justify a detailed scientific investigation of the residues.

According, no further work on the residues is recommended.

References

NEF, J.U. 2013. The Rise of the British Coal Industry, Routledge.

Table 1: summary catalogue. Assm = assemblage, FHS = flake hammerscale, SHS = spheroidal hammerscale, SHC = smithing hearth cake.

Context	F#	S#	Label	Sample weight	Item weight	Item number	Item notes
Fired Clay							
1008	27		clay	89	55	4	slightly reddish ceramic with planar surfaces, two with adhering mortar - so fragments of CBM, all in very sandy fabric with occasional gravel. Mortar very sandy, with pale quartz and dark particles in white lime
					32	1	rounded bloated ceramic, surface variegated colours, internally pale grey, surface shows fine-scale expansion cracking, probably natural nodule that has been burnt
1008	377	9	fine brick fragments	67	67	assm	very sandy orange red sand-rich ceramic, mostly in rounded debris. Largest piece shows approximately planar surface with white limey coat
1011	867		cay	<1	<1	1	very sandy fired clay with planar surface, probably CBM, but possibly pottery
1029	347		burnt clay	5	4	1	irregular lump of extremely straw-rich clay with some gravel, one end highly fired and fragmenting
					1	1	very sandy reddish fired clay similar to possible brick fragments
1041	37		burnt clay	8	8	9	slightly orange-coloured fired clay with some gravel and extremely rich in straw
1042	539		fired clay	25	25	4	dense fired silty clay with some gravel, no organics, orangey buff
1045	309		fired clay	17	17	77	very highly fragment slightly orange fired clay with abundant straw temper
1045	345		burnt ceramic	102	102	43	very heavily straw tempered gravelly clay, one piece with planar surface, other angular fragments
1048	361		fired ceramic	<1	<1	1	oxidised fired, tiny, fragment of straw-tempered clay, has thin film of transparent coating - just possibly glaze but most likely lime
1053	60		burnt clay	6	6	2	orangey fine clay with large rounded grits, slightly paler smooth surface
1061	343		burnt clay	1	1	1	poorly fired clay with large rounded grit

Context	F#	S#	Label	Sample weight	Item weight	Item number	Item notes
1075	71		burnt clay/daub	126	126	1	evenly oxidised fired fissured block of fired clay, has gravel and also heavy temper of straw
1117	124		daub	239	104	5	irregular fracture-bound blocks, typically darker in colour than other material, one passes into a silty brown ceramic almost without inclusions
					135	10	blocks bearing a planar smoothed surface. Always very moderately dense organic temper, surface never quite planar and pale buff, interior may be darker, reduced with 4mm of surface. None of the material is orange in colour
1117	587		fired clay	47	47	10	fine fired clay, dark below surface slightly orangey buff near surface. Rich in straw and some small leaves.
1120	359	41	possible furnace lining (fired clay)	11	11	36	small fragments of oxidised and reduced fine silty clay, with some coarse granules, abundant straw and leaf debris. Some pieces show flat surface, sometimes with apparent 2-3mm thickness - rear flat surface might be temper
1122	728		burnt ceramic	12	12	4	fine silty ceramic rich in straw/reed (some coked in situ). Matrix grey mostly, going buff near surface, but only small area of smoothed surface survives
1125	782		fired clay	77	4	12	slightly orange fired clay cf <71> with very rich organic temper and angular fractures
					71	23	buff fired clay with occasional gravel temper and more modest organic temper, some pieces show planar surface, fabric silty
					2	1	as item above but shows buff planar surface over grey interior
					1	1	tiny concretion on weathering iron
1152	722		burnt ceramic	10	10	12 (+ bits)	gravelly fired dark brown-buff fired clay
1208	889		clay	51	51	1	hard fired, slightly reddish ceramic, very sandy with minor organic temper. Surface fired to cream colour and almost entirely sand (by washing or dipping?), has the appearance of brick, very even in colour and texture, no internal foliation
1218	200		daub	24	24	1	fine even fired clay with sandy temper and some voids suggesting minor organics, an original planar surface fired to a much dark colour and burnished? Possible brick?

Context	F#	S#	Label	Sample weight	Item weight	Item number	Item notes
1218	203		burnt clay/fire waste	24	24	1	rounded mass of bloated clay, possibly pendent, variously coloured and shows splits in surface, one quadrant has formed a dark melt, rest of surface not flowed
1219	205		daub	37	37	4	silty and sandy ceramic with rare coarser grains and sparce organic material jut below slightly darker surface, possibly poorly fired brick, but may be temper-poor daub?
Metalworking							
1005	451	8	f mwd	1		assm	sand with modest amount of slag/clinker, SHS and FHS
1008	866		slag	227	30	2	bloated stones
					27	1	square piece of iron
					169	1	broken dense concretion in gravelly sediment
1008	357	9	f mwd	2		assm	rich clinker, slag, droplets, FHS, SHS
1013	807	5	f mwd	<1		assm	stone, trace FHS
1020	333	4	f mwd	<1		assm	stone, trace FHS
1022	427	3	f mwd	3		assm	sand with a little rust
1024	460	6	f mwd	4		assm	stone with trace of FHS and slag
1027	17		slag	231	231	1	unusual birds foot structure formed of clinkery glassy slag, surface variegated with red and green areas, full of charcoal fragments. Presumably an unusual build-up of flow slag in a forge hearth
1029	462	21	f mwd	5		assm	mainly sandy gravel, some rusty shale, traces of slag and FHS
1035	795	7	f mwd	<1		assm	stone, trace FHS
1036	510	1	f mwd	<1		assm	stone

Context	F#	S#	Label	Sample weight	Item weight	Item number	Item notes
1040	340	2	f mwd	3		assm	sand and gravel with just trace of SHS and slag
1042	526	18	f mwd	<1		assm	lots of FHS with stone and fired clay, trace of SHS
1044	641	12	f wmd	<1		assm	mainly sand but modestly rich in FHS, some slag fragments
1045	432		mwd	2		assm	corroded iron, stone, clinkery slag, coke, coal, tiny amount of FHS and SHS
1047	337		slag	<1	<1	1	small tubular concretion
1047	805		mwd	4		assm	stone, rust, shale, FHS with trace SHS
1048	370		mwd	<1		assm	tiny quantity of dark khaki glass
1053	358	60	slG	296	296	1	80x85x45mm, approximately plano-convex SHC, appears to formed largely of amalgamated small prills, giving prilly base, but more solid top, abundant charcoal inclusions throughout
1053	415	60	f mwd	2		assm	sand with abundant very fine clinkery slag and some FHS
1054	387		slag	9	9	7	clinker - one piece mainly coal shale
1054	393	38	f mwd	3		assm	rich in both FHS and SHS, with some slag and possible clinker, 1 concretion (nail frag?), small amount of stone
1054	681		fired clay	4	2	1	potsherd
					2	1	concretion
1059	625		mwd	<1		assm	sand, FHS, clinkery slag
1061	342	16	f wmd	<1		assm	sand with some FHS and slag debris
1063	507	10	mwd	3		assm	clinker stone, FHS, SHS, mortar

Context	F#	S#	Label	Sample weight	Item weight	Item number	Item notes
1063	481	10	slag	1	1	1	glassy slag (clinker??)
1065	840		mwd	<1		assm	stone, FHS, SHS, clinker, mortar, rust
1065	454		slag	2	<1	<1	dense maroon surface iron slag prill
					<1	2	pale prilly slags - unclear if slag of clinker
					<1	1	concretion
					2	5	exploding corroded iron
1071	619	22	mwd	2		assm	mainly stone, moderate FHS and probably angular slag fragments
1072	895	24	mwd	1		assm	stone, moderate FHS, rust, trace slag/clinker
1077	303	19	f mwd	3		assm	stone, rust, some FHS and SHS, probable slag
1078	622		mwd	<1		assm	some sand, a small concretion, FHS, trace SHS, many tiny fragments of slag
1081	351	25	mwd	<1		assm	stone, FHS, SHS, slag
1082	429		slag	1	1	1	lining slag prill
1082	620		mwd	3		assm	rust, some stone, abundant FHS and SHS, plenty of clinker - rich assemblage
1085	331	27	f mwd	1		assm	stone, a little FHS and a trace of SHS
1089	375	28	mwd	<1		assm	some stone, abundant FHS, lots of slag fragments including large green glass piece
1093	304	29	mwd	1		assm	slag droplet, FHS, some stone and possible corroded iron
1099	367		mwd	4		assm	stone, clinker, slag, rust, FHS and SHS
1101	355		slag	<1	<1	1	concretion or fired clay

Context	F#	S#	Label	Sample weight	Item weight	Item number	Item notes
1101	463		mwd	1		assm	stone, FHS, slag
1102	475	33	mwd	1		assm	stone, FHS, bone
1103	538	34	f mwd	<1		assm	fuel ash slag, stone, rich in FHS (but very small sample)
1104	394	35	core slag	32	1	1	concretion
					1	1	slag with charcoal
					13	1	clinker with coal shale and internal clast/prill of lining slag
					10	1	bleb of clinker
					8	1	concretion
1104	397	35	f mwd	4		assm	mostly clinkery slag, some stone, modest FHS and SHS
1105	509	36	f mwd	1		assm	stone, trace of FHS
1106	448	23	slag and mwd	127	79	16	blebby clinker pieces, a few with shale
					4	1	coal shale
					7	4	concretions on iron
					34	1	large sandy concretion on iron, attached to clinker piece
1106	586	23	mwd	24		assm	assemblage dominated by clinkery-looking slag debris, but also some concretions. Abundant FHS and SHS.
1107	455	61	mwd	2		assm	stone with very modest slag and FHS and trace of SHS
1111	886		fire waste	7	7	1	bloated stone/ceramic, variable surface colour and degree of melting, outside coated in white sandy material, presumably mortar
1116	621	39	f mwd	1		assm	stone, clinker, trace FHS
1117	667	40	f mwd	<1		assm	mostly rusty sheets of shale/rust, but also FHS and some SHS

Context	F#	S#	Label	Sample weight	Item weight	Item number	Item notes
1120	527		mwd	6		assm	most of weight is concretion, stone, with trace of FHS, lots of rusty shale
1122	692		mwd	<1		assm	stone, a little slag, trace FHS
1124	572	43	mwd	<1		assm	mostly stone, trace of FHS
1125	543	44	mwd	3		aasm	stone and fired clay, with one nail point, just trace of slag and FHS
1125	541		slag	10	7	1	vitrified lining, lining fragmented, reduced fired with abundant straw, vitrified material highly vesicular with maroon/grey variegated surface
					<1	1	tiny fragment of frothy glassy with variegated maroon grey shiny surface
					2	1	vitrified and bloated stone
					<1	1	coke fragment
1126	498	62	f mwd	<1		assm	mostly sand, but some slag debris, FHS
1128	690	45	f mwd	3		assm	stone, minor FHS, slag, clinker, trace SHS
1129	623	46	f mwd	<1		assm	mostly sand, but some slag, FHS and a little SHS
1131	491	53	f mwd	1		assm	sand with abundant FHS, some FHS and clinker
1132	488	54	mwd	4		assm	half of weight is concretion - remainder is rich assemblage of FHS, SHS, clinker and slag
1132	501	54	iron slag	2	2	2	concretions on flat iron scraps
1133	624	33 fine	mwd	16		assm	assemblage rich in FHS and SHS, larger particles stone, corroded iron, bone and clinkery blebs (and coated stones)
1133	688		slag	2	2	1	fragment of clinker bleb with greenish tinge to maroon surface
1136	407	47	mwd	3		assm	clinker, concretion, mortar, stone, FHS, SHS

Context	F#	S#	Label	Sample weight	Item weight	Item number	Item notes
1144	693		mwd	3		assm	stone slag FHS, SHS, mortar
1144	689		slag	1	1	7	small clinkery slag fragments (2 of these may possibly be natural, but probably not)
1147	614	57	mwd	<1		assm	rich in FHS and SHS with some sand
1148	599	57	f mwd	1		assm	rusty concretionary material with a trace of FHS
1149	442		mwd	3		assm	stone, rust, FHS, slag, trace SHS
1149	815		slag	4		assm	dominated by 9 concretions, some probably small nails, remainder stone and ?burnt bone
1150	403	50	mwd	3		assm	rust, sand, FHS, SHS
1151	513	49	f mwd	<1		assm	rust, slag, lots of FHS, lots of mortar, some stone
1152	816	58	f mwd	14		assm	stone, rust, small amount of probable clinker and small amount of FHS
1153	652	52	f mwd	<1		assm	mostly stone but plenty of FHS and some SHS
1153	786		slag	5		1	sandy lining slag
1157	495	59	slag	12	10 2	5 1	concretions on iron stone
1157	492	59	f mwd	2		assm	stone with small amounts of clinker, slag, rust, SHS and FHS
1163	691	100	f mwd	4		assm	clinker, slag, lots of FHS, some SHS, stone, possible coke
1179	774		mwd	<1		assm	small assemblage but rich in FHS, possible SHS and slag
1180	398	64	mwd	<1		assm	stone, SHS, trace slag

Context	F#	S#	Label	Sample weight	Item weight	Item number	Item notes
1184	153		vitrified stone	8	8	1	black slag with several inclusions, one quartz one lining slag, black slag has enormous fresh olivine crystals, very unusual
1185	885		slag	1	1	1	corroded ?nail
1186	743		mwd	2		assm	some stone, FHS and SHS, clinkery-looking slag fragments
1187	571	66	mwd	7		assm	mostly stone, moderate FHS and SHS, larger pieces include 4 probable nail shanks, clinker bleb and shell
1187	806	66	c slag	4	4	1	concretion on iron
1188	563	67	mwd	12		assm	mostly iron nails and stone, some bone too. Only a trace of FHS
1190	626		mwd	3		assm	stone, rusty shale, abundant FHS, slag, clinker, trace SHS
1191	470	69	f mwd	1		assm	stone, rusty shale, trace of FHS, trace slag
1192	600	75	mwd	16		assm	mostly stone, lots of bone, but very abundant FHS and SHS, slag fragments, tiny fow slag block, clinker-like droplets etc
1193	529	71		3		assm	stone with abundant FHS, SHS, slag fragments, rusty shale, corroded iron (nail point?)
1194	552	72	mwd	6		assm	mostly rust and stone, but good amount of FHS and SHS, just one nail fragment
1195	497	73	f mwd	18		assm	mainly stone, many pieces of corroding iron, some slag and some FHS, but minor
1197	575	74	f mwd	1		assm	stone, shale, trace of FHS
1198	647	75	metal/slag	150	149	1	large part (60%??) of small SHC with granular texture, microprilly base, lots of small charcoal inclusions

Context	F#	S#	Label	Sample weight	Item weight	Item number	Item notes
					1	1	small slag fragment similar to SHC
					<1	1	probably natural
1200	773	76	mwd	10		aqsm	mainly stone, but some FHS and slag, also strange fragment of stone bead (or is it a fossil?), lots of rusty ?shale and some quite large pieces of glassy slag
1202	788	77	mwd	<1		assm	sand, trace of FHS
1202	858		slag	15	15	1	concretion in gravelly and charcoal-bearing sediment
1203	779	78	mwd	8		assm	contains stone, but good assemblage of FHS and SHS, with some clinker particles and wood
1206	749		mwd	<1		assm	stone, glassy slag, trace of FHS and strange needle-like concretions
1207	710		slag	<1		assm	probably iron fragments
1207	808		mwd	1		assm	small assemblage dominated by stone, but lots of FHS and SHS, with probable clinker droplet
1208	775	81	mwd	2		assm	mostly probable mortar - some of which is attached to clinker, also clinker, slag, tiny amount of FHS
1209	584	82	iron slag	5	4	2	corroded iron
					1	1	natural iron rich concretion?
1209	582	82	mwd	2		assm	stone, rust, shale, some FHS, trace of slag
1210	668	83	mwd	2		assm	mostly stone, but also clinker, slag, FHS and some possibly calcareous concretions
1213	754	86	mwd	<1		assm	stone, slag, FHS
1214	818	87	mwd	4		assm	stone, rust, clinker, modest amounts of FHS no SHS
1215	721	88	f wmd	6		assm	mainly stone and mortar, some clinker and trace FHS, much of weight is corroded iron nails(?)

Context	F#	S#	Label	Sample weight	Item weight	Item number	Item notes
1215	785	88 coarse	mwd	3	3	1	concretion on iron in charcoal-rich sediment
1216	839		mwd	1		assm	stone, rust, slag, FHS, SHS, charcoal, elongate concretion (nail?)
1218	209		vit stone	2	2	1	dimpled bleb of vitrified and glazed lining
1218	677	90	f wmd	4		assm	mostly stone, one iron concretion (nail?), some clinker, traces of FHS and SHS
1219	822	91	mwd	1		assm	stone rust, trace of FHS and SHS
1211	777		mwd	5		assm	mainly concretions in straw-rich matrix, but also stone, FHS and a little slag
1212	799	85	f mwd	3		assm	stone, rust, shale, FHS, trace SHS
1222	720	92	f wmd	4		assm	plenty of clinker, some FHS and SHS, dominated by fine stone and rust
1223	778	93	mwd	2		assm	mostly stone but some FHS and SHS
1225	733	94	mwd	<1		assm	mainly fine stone, but some SHS and clinker fragments, with trace of FHS
1231	838	95	c slag	2	2	1	burnt particle of iron rich material - possibly an iron ore, but possibly roasted rusted material
1231	800	95	mwd	2		assm	stone, coked bone(?), some slag, FHS, trace SHS, rust
1232	797		mwd	3		qassm	concretionary material bearing abundant coal, trace of slag and FHS
1233	776	97	mwd	<1		assm	stone, on tubular concretion, some slag debris, a few pieces of SHS and FHS
1235	735	98	mwd	12		assm	most of weight corroded iron and elongate concretions - probably nails, remainder is stone with FHS, SHS and slag, some of the material shows white lime coats

Table 2: summary of residues, by type and context. SHC = smithing hearth cake, FHS – flake hammerscale, SHS = spheroidal hammerscale. Numbers = wts in grams, numbers in brackets = coal weights determined by separate investigation of coal. Tr = trace , y = present, yy=common. For details of the classes see text.

context	SHC	dense	clinker	bloat	lining slag	lining	slag'	FHS	SHS	droplets	brick?	Fired clay 1	Fired clay 2	rust	iron	concn	coal/coke	mortar	other
1005			y					y	y										
1008			yy	62				yy	yy	yy	122				27	169	(11.9)		
1011											<1								
1013								tr											
1020								tr											
1022														y			(8.9)		
1024							tr	tr									(2.8g)		
1027		231																	
1029							tr	tr			1	4		y					
1035								tr											
1036																	(1.7)		
1040							tr		tr								(2.1)		
1041												8							
1042								yy	tr				25				(		
1044								y									(1.9)		
1045							y		y			119			y		y(1.5)		
1047								y	tr					y		y			
1048					<1?							<1							
1053	296		y					y					6				(11.5)		
1054			9				yy	yy	yy							2	(3.6)		
1059																			
1061							y	y					1						
1063			1					y	y								(2.7)	y	
1065		<1	<1					y	y					y	2	<1	(107.5)	y	
1071							y	y											
1072			tr					y						y			(1.5)		
1075												126							
1077							y	y	y					y					
1078							y	y	tr							y	(1.6)		
1081							y	y	y										
1082			yy		1			yy	yy								(1.1)		
1085								y	tr								(1.2)		

context	SHC	dense	clinker	bloat	lining slag	lining	slag'	FHS	SHS	droplets	brick?	Fired clay 1	Fired clay 2	rust	iron	concn	coal/coke	mortar	other
1089							yy	yy									(12.3)		
1093								y		y					y		(10.3)		
1099							y	y	y					y					
1101							y	y					?			?			
1102								y											
1103						y		yy									(1.0)		
1104		1	23					y	y							9	(6.7)		
1105								tr									(1.8)		
1106			79					yy	yy							41	(9.0)4		
1107								y	tr										
1111				7															
1116			y					tr									(1.3)		
1117								y	y			47	239	yy					
1120								tr				11		yy					
1122							y	tr				12					(0.7)		
1124								tr									(1.8)		
1125				2	<1	7	tr	tr				77				1	<1 (2.1)		
1126							y	y											
1128			y				y	y	tr								(3.6)		
1129							y	y	tr								(1.1)		
1131			y					yy	y										
1132			yy				yy	yy	yy							4			
1133			2					yy	yy						y		(2.0)		
1136			y					y	y									y	
1144			1				y	y	y								(13.0)	y	
1147								yy	yy								(1.30		
1148								tr								y	(0.9)		
1149								y	tr					y	2	2	(3.1)		
1150								y	y					y			(3.7)		
1151								yy						y			(5.1)	yy	
1152			y					tr					10				(1.2)		
1153					5			yy	y								(2.0)		
1157			y				y	y	y					y		10	(2.2)		
1163			y				y	yy	y								? (1.4)		
1179							y	yy	?								(1.0)		

context	SHC	dense	clinker	bloat	lining slag	lining	slag'	FHS	SHS	droplets	brick?	Fired clay 1	Fired clay 2	rust	iron	concn	coal/coke	mortar	other
1180							tr		y								(8.6)		
1184		8																	
1185															1				
1186			y					y	y								(3.3)		
1187			y					y	y						y	4			
1188								tr								12			
1190			t				y	yy	tr					y					
1191							tr	tr						y			(2.1)		
1192		y	y				y	yy	yy								(1.6)		
1193							y	yy	y					y	y		(1.8)		
1194								yy	yy					yy	y		(2.2)		
1195							y	y							yy				
1197								tr						y			(1.8)		
1198	150																		
1200			y				y	y						yy			(3.3)		
1202								tr								15			
1203			y					yy	yy										
1206							y	tr								y			
1207			y					yy	yy						<1				
1208			y				y	tr			51							yy	
1209							tr	y						y	4	1			
1210			y				y	y								y	(60.6)		
1211							y	y							yy		(1.3)		
1212								y	tr					y			(3.0)		
1213							y	y											
1214			y				y	y						y					
1215			y					tr						y	yy	3		yy	
1216							y	y	y					y		y			
1218			y			2		tr	tr		24					y	(4.8)		
1219								tr	tr				37	y					
1222			yy					y	y					yy			(2.0)		
1223								y	y								(1.5)		
1225			y					tr	y								(1.8)		
1231							y	y	tr					y			(288)		2 iron ore?
1232							tr	y								y	(1103)		

context	SHC	dense	clinker	bloat	lining slag	lining	slag'	FHS	SHS	droplets	brick?	Fired clay 1	Fired clay 2	rust	iron	concn	coal/coke	mortar	other
1233								y	y							y	(2.1)		
1235							y	y	y						yy	y	(3.0)		

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