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Evaluation of archaeometallurgical
residues from Willow Street and Mill
Street, Worcester.

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Abstract

The Willow Street assemblage comprises some 17.2kg of material, largely comprising smithing hearth cakes (68% of the assemblage by weight), with a moderate amount of vitrified lining and lining slag (11% and 4% of the total respectively) with a similar amount (13% of indeterminate iron slag).

The smithing hearth cake (SHC) assemblage includes 8.9kg (28 specimens) which are either certainly complete (or very nearly so) or which are likely to be complete. These have a mean weight of 327g (range 86g – 770g), with 82% of the SHCs weighing less than 500g.

This size distribution (notwithstanding the rather small number of specimens involved) suggests that the SHCs at Willow Street are smaller than those from the contemporary phases at Deansway, where there was a 12th –13th century smithy. The size distribution suggests that the activity at Willow Street was probably blacksmithing (the 'end-use' of iron for artefact manufacture and the repair of artefacts) rather than bloomsmithing (the refining of primary blooms into billet or bar iron). The possibly slightly earlier (11th –12th century) age for the smithing at Willow Street compared with Deansway, may also be a factor in the smaller SHC size.

Hearth lining and lining slags formed about 15% of the assemblage and were indicative of air supply through a blowhole in a clay wall. A large proportion of the SHCs showed evidence for deformation on extraction from the hearth, demonstrating that they were removed when hot. These features included folding and tearing of the SHCs, tool holes in the SHCs and tool marks on flaps of vitrified lining. All the residues providing evidence for the nature of the fuel indicated the use of charcoal.

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Methods

All materials were examined visually, using a low-powered binocular microscope where necessary. All materials were weighed and recorded to a database (presented as tables 1 and 2).

As an evaluation, the materials were not subjected to any high-magnification optical inspection, nor to any other form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional.

Results

Description of residues

Smithing hearth cakes

The dominant form of residue was provided by smithing hearth cakes (SHCs). These made up 68% of the Willow Street assemblage by weight (11.7kg) with 8.9kg being 28 examples which were either certainly more-or-less complete or probably so. Identification of the degree of completeness of small, poorly consolidated SHCs is always problematic, particularly in cases where they have been deformed on extraction, as appears to have been the case with at

least 8 of these examples. It is possible, therefore, that the original weights would actually have been slightly higher than those recorded here. None the less these 28 examples provide reasonable evidence for the size distribution of the assemblage. The mean weight was 327g (range 86g – 770g). 82% of the SHCs in the assemblage were of less than 500g.

Most of the SHCs show some included charcoal. Many show a glassy upper surface. Some examples show clay adhering to the base, suggesting the hearth was very shallow below the blowhole.

The deformation exhibited by the SHCs varies from holes on the margins of the cakes, suggesting the use of a poker or tongs to lever out the slag, to tearing and folding of the cake. Several examples show morphologies suggestive of the complete folding of part of the cake onto the top of the remainder. These features are all indicative of hearth clearance when the slag was hot and soft.

Indeterminate iron slags

About 13% by weight of the Willow Street assemblage comprised slags that were of indeterminate origin. In many cases this was because the pieces were too small to reveal characteristic morphology, and in others any characteristic morphology was masked by adhering accretionary material. In particular, slags with a high proportion of included charcoal were all included here, if there was not certain morphological evidence of being part of an SHC.

Some of these slags have morphologies suggestive of slags developed within a smithing hearth, but not forming a discrete smithing hearth cake. These include some tabular pieces with dimpled surfaces and some forming rounded blebs.

One particular piece included as indeterminate, was the large block recovered from c507. This equant block of dark dense slag with one possibly hammered face, shows some internal brecciation and resembles slags from within a smelting furnace, although identification as a smelting slag is not certain. Such furnace slags are commonly associated with other indicators of smelting, such as tap slags, and are abundant within the Roman smelting slag assemblages from Worcester. This piece is distinct from all other components of the slag assemblage, and is therefore very likely to be residual.

Lining slags and vitrified lining

These classes comprised 0.65 and 1.94kg of the assemblage respectively.

The material included both oxidised- and reduced-fired hearth ceramic. Although many pieces of lining were not diagnostic, the assemblage included pieces from both above (e.g. c513) and below (e.g. 384g piece from c552 and smaller pieces in c513; 112g block from Mill Street c13) the blowhole (seen only in material from c513). The pieces recovered reflect a typical profile with a concave erosion of the strongly vitrified wall above the blowhole and flows of sandy, dark, glassy slag overlying largely unvitrified wall below. The single fragment showing the margin of a blowhole does not allow reconstruction of blowhole size, although it would appear to be around 25mm diameter on the basis of this small arc.

A single convexly curved sherd from c552 resembles material from other sites which have been interpreted as being derived from a tuyère. In this instance

however, there is no other evidence to support such an interpretation.

The lining slags comprise 3 types of material: fragments from the sub-blowhole down-wall flow, isolated blebs of partially melted lining from within the hearth and a single example (from c552) of an SHC-like mass, entirely formed of lining-dominated slags.

Concretions

The assemblage included 15 pieces (over 580g) of concretionary material. In a few cases these concretions were developed around iron-rich slag, but most were either certainly or probably formed around metallic iron.

Most of the concretions were not indicative of the form of the included iron, but one from c513 shows a piece of thin iron sheet, folded into a “Y” shape, 30mm tall and 20mm wide. A piece from c552 has a shape suggestive of half a small horseshoe, but X-ray investigation would be required to determine whether the concretion shape does reflect such an artefact.

Other

A piece from clinker from c562 contains an embedded length of clay pipe stem, locally showing a strong glaze. The clinker bears coal and coal residue. Clinkers may result from metallurgical processes, but in this instance, although superficially resembling a metallurgical slag, it is unlikely to be the case. Although the piece might represent a pipe discarded into a coal-fired hearth, the intense vitrification of the clay pipe is suggestive that the piece is a waster from a pipe kiln.

Description of stratigraphy of residues

The early Saxo-Norman deposits bear little slag. There was a small assemblage from gully (571) and a possibly residual slag block from the primary fill of ditch (506).

The principal slag-bearing deposits are those of Pit (515) and ditch (418), which together provided 89% of the residues from the site. A lesser amount occurs in pit 569.

It is noteworthy that for both pit (515) and ditch (418) the larger volumes of slag, and the higher proportions of lining are associated with the earlier fills. It seems likely, therefore, that the smithing activity was mainly undertaken in the 12th century. Both fills (516) and (552) of Pit 515 were also noted to have hammerscale present in the environmental samples. Hammerscale was also noted to be present in fill (570) of pit (569), alongside the slag described here. Context (520), the fill of cut (519) was unusual in that it produced hammerscale but no slag.

Interpretation

The residues from Willow Street are dominantly of a constant nature and style of preservation, suggesting that a single period of activity is represented. The stratigraphic evidence, both for the slag and hammerscale, suggests that the iron-working may have been largely during the 12th century. The 2004 evaluation trench located a possible smithing hearth associated with 11th-12th century pottery (c11/c13).

The weight-frequency distribution of the SHCs from Willow Street is broadly comparable (Table 4) with that of other sites interpreted as indicative of blacksmithing

(the end use of iron), rather than bloomsmithing (the working of the bloom or billet during the iron-production process). Sites such as Marsh Leys Farm (a Roman iron-working assemblage from Bedfordshire; Young 2005) and Carmarthen (a Roman assemblage; Crew 2003) are fairly closely comparable, but some other medieval assemblages (including those from Deansway, Worcester; McDonnell & Swiss 2004) contain rather larger SHCs on average. This size difference may reflect a difference in activity, or may be a product of the apparently slightly earlier age of the Willow Street assemblage.

The significant proportions of lining in the assemblage, together with the reported occurrence of hammerscale in some of the features (see Pearson, below), support the proximity of the source of the iron-working residues to the Willow Street site.

Evaluation of potential

The detailed analysis of smithing assemblages does not figure strongly in the published literature. A small body of data is slowly being generated, and although new analytical data are always welcome additions to that corpus, the more valuable additions are those from sites with large assemblages and/or structural evidence for metalworking. Thus although chemical and microstructural evidence from the SHCs of this assemblage would be useful in the broader analysis of ironworking, it is unlikely to provide much further evidence for the interpretation of this site.

It is recommended that all the concretions are X-rayed to determine whether they contain iron – and if so whether the iron is raw stock iron or artefactual. The relevant material has been sent for X-raying and the results will be included with the archive.

References

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<i>context</i>	<i>label</i>	<i>weight</i>	<i>description</i>
476	slag glassy	32	Dark sandy glassy slag with maroon surface. A lining slag, but resembling clinker.
		4	2 tiny scraps of vitrified lining.
		182	7 pieces of dimpled slags, some certainly glassy, some uncertain, some have adhering flake hammerscale.
		152	Dense SHC fragment, top has deep dimples, base obscured, accretion includes flake hammerscale.
477	slag glassy	236	Cup-shaped SHC, broken at one end, 70x90x57mm, hollow 20mm deep, broken end shows some maroon steep flows, top has irregular adhering blebs, main slag very friable, vesicular, charcoal rich, base with irregular prilly blebs.
		126	Small irregular SHC or fragment, top dense, lower part rough and charcoal rich, 70x60x35mm.
		28	Broken fragment possibly from SHC burr, has dark lining slag breccia in clearer greener glassy matrix.
477	half shb	302	Irregular SHC, has indentation on one side suggesting 13mm poker being used as a lever to remove SHC, top rough irregular with charcoal, base with small prills and dimples with charcoal, 85x80x45mm.
477	slag undiagnostic	46	Ashy concretion with flake hammerscale
477	shb	636	SHC, 120x100x65mm of which 35mm main bowl. Dense, base prilly, dimpled onto charcoal and hearth lining (grey sandy lining). Top obscured by accretion - but may be a folded cake, or double layer - lots of sandy accretion.
507	slag undiagnostic	524	Equant slag fragment of very dense dark slag. Shows some internal brecciation and one smooth surface - suggests this piece might have been hammered. One end very rusty suggests inclusion of native iron. Not certain if smithing or smelting slag.
512	slag glassy	48	Block of vitrified oxidised fired lining, lining fabric at about 30° to vitrified surface
		206	13 pieces of grey vesicular hearth slag - possibly a disintegrated SHC.
		12.5	Bleb of dark sandy glassy slag, flown over paler clearer glassy surface.
		36	Granular appearance grey charcoal rich slag fragment.
		116	Block of lining with glassy lining slag attached, slag turns through right angle and has curious linear grooved depression in concave side - suggesting extraction with a tool.
512	shb	488	120x85x55mm, irregular SHC, has smoothly dimpled glassy upper surface, wedge shaped section (thickest proximally), rather "lumpy" look basal surface. Profile complicated - the thickest part seems to be in burr, then thins rapidly, with rather discrete bowl beyond, 35mm thick, central part of upper surface is palest glass which is raised in small lump 35mm diameter and up to 12mm high. One edge appears to have vertical indentation - probably where cake extracted using poker.
512	slag undiagnostic	146	4 lumps of concretion - probably all containing iron - visible on two of the pieces
		16	Ashy(?) concretion around square cross sectioned piece of iron rod/nail
		10	3 pieces of ashy/calcareous concretion
		66	2 pieces of charcoal-rich grey slag

<i>context</i>	<i>label</i>	<i>weight</i>	<i>description</i>
513	slag glassy	258	13 pieces of lining with vitrified material attached, in some cases very thick, with dark lobes encased in pale glass. Presumably sub-blowhole material.
		378	11 fragments of grey charcoal rich slags - mainly or even entirely SHC fragments
		220	19 lining slag fragments
		1	Charcoal
		40	Maroon-surfaced clinker-like lining slag, dark sandy internally with some quartzose gravel.
513	half shbs	312	85x75x40mm, rather square in plan, but probably most of original small SHC.
		342	Torn and folded thin SHC, 100x80x50mm (of which 25mm original thickness), top deeply dimpled, bottom slightly and finely dimpled.
513	slag undiagnostic	176	Small SHC or part of, possibly double layered with slab on top of bowl- but accretion makes details obscure 65x65x45mm.
		208	Highly accreted small SHC, top covered in thick gravelly deposit - but small area of glass visible, bowl conical with dimpled surface, 70x55x55mm.
		96	Small slab of charcoal-bearing slag, dimpled base, possibly part/all or poorly develop SHC.
		78	Proximal end of SHC, with well-developed small thin bowl, crust overlain by slab of glassy material with deeply dimpled surface.
		180	Majority of small SHC, with proximal end missing, charcoal rich but dense.
		10	Green glassy lining slag fragment.
513	slag glassy	52	Brownish red clay with isolated sand grains - probably a fired clay lump.
		36	5 small vitrified lining fragments
		6	Dimpled lining slag bleb
		6	2 tiny vesicular slag fragments
		36	Oxidised fired vitrified lining piece, showing upper part of blowhole and start of concavity above.
513	slag tube	98	Sandy concretion (around iron?)
513	slag undiagnostic	332	Rather spherical SHC, irregular, 70x75x70mm, of which bowl 40mm, pile of material on top at one end, base of granular appearance.
		68	Sandy concretion around iron binding? Y shape, 30mm tall x20mm wide, with upright segment 10mm. Iron of uncertain thickness, but apparently thin.
		488	5 fragments of SHCs
		134	4 small pieces of grey vesicular slag
516	shb	702	130x110x45mm, square slab-like SHC. Details rather obscured by accretions.
		70	Small rounded nub of dense slag
516	slag glassy	164	7 pieces of vitrified lining
		154	9 pieces of lining slab in dimpled lobes.
		6	2 small slag fragments
		70	Grey slag - possible SHC fragment
		128	Small irregular SHC, 75x60x40mm, possibly only a part, porous charcoal rich.

<i>context</i>	<i>label</i>	<i>weight</i>	<i>description</i>
516	slag undiagnostic	414	Deformed SHC, shows one side of cake with additional lump on top - not clear if all of missing side is represented by material on top, 125x(60)x65mm (of which bowl 40mm), top partly glassy, base rough with sandy accretion contain flake hammerscale.
		206	Piece of twisted and torn SHC, charcoal rich, internally prilly,
		144	Charcoal-rich hearth slag fragment.
		166	Central part of small SHC with edges missing, 30mm thick, lots of adhering sandy accretion.
		18	Small piece of wrought iron in accretion - could be unfinished nail?
		28	Small piece of slag cake edge, top with raised lobes, beneath is friable with charcoal, so probably an SHC margin
		98	Lump of indeterminate slag covered in sandy accretion, vesicular, charcoal-bearing and iron rich.
		50	Lobate dense slag with deep dimples covered in sandy accretion.
		46	Sub-spherical sandy concretion bearing lining slag lobe - but also probably something more iron-rich?
		1	Accretionary fragment
		16	Sandy accretion around lining slag fragment.
		40	Ashy accretion around slag fragment with a slightly glazed surface - so probably an SHC fragment.
		28	Ashy accretion around grey pale vesicular slag fragment.
516	half shbs	444	Irregular lobate SHC covered in ashy concretion, 120x90x50mm (of which 30mm probably original bowl). Strange shape may indicate folding but this is not certain.
		244	Irregular charcoal-rich SHC material - not clear if this is a fragment or another deformed more-or-less whole cake.
518	slag undiagnostic	16	Sandy/gravelly concretion
		6	Bone
533	slag undiagnostic	170	Ashy concretion- possibly around small SHC
		144	All or most of small charcoal-rich SHC, 80x55x35mm.
533	half shb	392	90x95x50mm, small dense SHC in ashy concretion, has steep sides and is dished (but that may be deformation), details obscured by ashy accretion
552	half shb	294	SHC with probable welded-on slab on top, 100x70x45mm of which 30mm original bowl, top deeply dimpled, base microdimpled
552	shb	724	SHC, 115x115x45mm, well-formed, dense, sub-circular outline, very regular, but details obscured by accreted calcareous material
552	slag glassy	284	11 pieces of vitrified lining, some oxidised but mainly reduced fired
		158	2 pieces of thick lining slag accumulations against lining.
		384	Large dense block of lining dominated slag, forming accumulation below blowhole.
		130	Lining slag forming SHC-like block, 80x65x40mm.
		464	8 pieces of slag with charcoal, in irregular blocks, some of these may be SHC fragments.
		30	3 small lining-influenced slag pieces
		244	Irregular SHC (?), top deeply lobate, base finely prilly, very irregular shape, hole in centre may be a poker hole, 120x70x45mm.

<i>context</i>	<i>label</i>	<i>weight</i>	<i>description</i>
552	slag undiagnostic	592	Complete SHC, 120x100x45mm (of which bowl 35mm), surface details obscure - but charcoal shows on top and bottom, dense.
		102	Curved sandy concretion, suggestive of half horseshoe shape?
		252	Fragment of thick SHC, or possibly thin SHC folded in two since has central seam, 95x50x40mm.
		164	Small crude SHC? 70x50x30mm.
		102	Slab of lining slag, above dense material with charcoal, poorly formed SHC/tongue? 85x60x25mm.
		88	Dimpled dense slag, probably part of a small SHC.
		120	Curved slab of dense slag with one straight edge- probably a cut SHC
		92	Piece from irregular small SHC with very smooth top and prilly base - possibly most of cake
		56	Slag fragment with glassy top and well developed prilly base around charcoal fragments - probably from small SHC
		102	Dense SHC fragment
		94	Irregular slag fragment in accretionary sand
		86	Probably most of tiny SHC with lining-rich glassy top and rough base, 45x60x30 mm.
		78	Probable SHC fragment, heavily accreted.
		92	Probably most of brecciated small SHC, remains of bowl has curiously angled glassy slab attached to top.
		34	Convexly curved reduce-fired ceramic with sandy vesicular slagged layer. Curvature just hints that this might be tuyère?
		210	18 small fragments of heavily accreted slag.
		30	4 fragments of blebby slagged lining.
		4	Reduced fired lining with slagged surface.
562	slag undiagnostic	30	Corroded material attached to clay pipe stem. Pipe appears to be an over-fired waster, attached material included clinker, coal and coke as well as charcoal and fired clay.
570	slag glassy	18	Pebbly (?) lining slag, forming rounded coalesced blebs, sandy with green glass.
570	slag undiagnostic	19.6	3 small fragments of grey slag, dense, 2 with abundant charcoal.
		22	2 pieces of sandy concretion - probably around iron.
572	slag glassy	4.1	Vitrified reduced-fired lining.
		5	Black glass with sand grains in blebs bound by white glassy phase.
		7.4	Charcoal rich rusty concretion.
575	slag undiagnostic	52	2 sandy concretions - 1 with visible iron.

Table 1: Catalogue of material from AA05-70, Willow Street, Worcester, organised by context and bag.

<i>context</i>	<i>label</i>	<i>weight</i>	<i>description</i>
11	slag glassy	238	Proximal end of SHC. Has well developed burr region and apparently some reduced fired clay entrained internally. It is not clear how large the SHC was originally - this may be all. Base shows sandy contact, top hollow with lining rich material inside, with smooth glassy top, 65x80x55mm.
		82	Small piece of dense slag, probably a fragment from a small SHC. Curved base, flat top, details obscured by rusty weathering and adhering sand.
13		112	Slab of probable wall below blowhole. Shows green-surfaced oxidised clay, with slag layer cutting-in at the top and overlying the clay lower down.
		88	8 other fired clay pieces- might be part of above.
		536	Part of SHC, probably c.70% but uncertain (giving c. 770g original weight). Flat top with dimples, thickest proximally, 105x95x55mm, base strongly lobate with some charcoal.
		6	Dimpled bleb of lining slag (dark sandy)
13	slag glassy	30	Sandy iron-rich concretion - probably around corroded iron

Table 2: Catalogue of material from AA04-67, Mill Street, Worcester, organised by context and bag.

		<i>context</i>	<i>SHC</i>	<i>of which intact SHCs</i>	<i>indeterminate slag</i>	<i>lining slag</i>	<i>lining</i>	<i>concretion around iron</i>	<i>other</i>	<i>total</i>
Gully 571	<i>Saxo-Norman?</i>	572			20	5	4	7		36
Ditch 506 Primary	<i>11th</i>	507			524					524
Pit 517 upper fill	<i>late 11th-12th</i>	518						16		16
Hearth 13	<i>late 11th-12th</i>	11 13	320 536			6	200	30		320 772
Pit 515 middle	<i>11th-12th</i>	552	2984	(2448)	768	132	1024	102		5010
Upper		516	2402	(1932)	482	170	164	19		3237
Ditch 418 primary	<i>12th</i>	513	2590	(1646)	140	276	382	166		3554
middle	<i>12th-14th</i>	512	694	(488)	102	13	164	172		1145
Upper	<i>12th-14th</i>	477	1328	(1174)				46		1374
Pit 569 fill	<i>11th-14th</i>	570			20	18		22		60
Post-medieval										
	<i>p-med</i>	476	152		182	32	4			370
	<i>p-med</i>	562							30	30
Other roots	<i>?</i>	533	706	(706)						706
upper fill of Pit 578	<i>?</i>	575						52		52
Total			11712	(8394)	2218	652	1942	580	30	17134

Table 3. Stratigraphic distribution of residues classes from Willow Street.

	Willow Street	Marsh Leys Farm	Carmarthen	Worcester Deansway (period 8) 11 th – 13 th	Worcester Deansway (period 9) 13 th -15 th	Burton Dassett
		Roman	Roman			14 th - 15 th
count	28	30	136	61	32	60
min	86		100	168	144	130
max	770	824	820	1490	1800	1670
average	327	333	227	492	499	550
<500	82%	77%	94%			
<1000	100%	100%	100%			
>1000	0%	0%	0%			
>3000	0%	0%	0%			
modal class	(100-300)	100-200	100-200			

Table 4. Comparison of the Willow Street assemblage of smithing hearth cakes (aggregated from all contexts) with other similar assemblages. Burton Dassett from McDonnell 1992; Marsh Leys Farm from Young 2005; Carmarthen from Crew 2003; Worcester Deansway from McDonnell & Swiss 2004.

GeoArch



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