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Evaluation of archaeometallurgical
residues from 35 Mill Street,
Worcester

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Abstract

This small assemblage (10.3kg of archaeometallurgical residues out of 12.1kg submitted material) was dominated (86% by weight) by materials identifiable as residues from iron-working. Only 2% of the material were residues from iron smelting, and these are interpreted as being residual. The small size of the smithing hearth cakes (SHCs) indicates that the work being undertaken was blacksmithing (rather than bloomsmithing). The slags are, in general, very similar to the Saxo-Norman material from the nearby Willow Street site, with the same size range of SHCs, but with a bias towards even smaller cakes than at Willow Street. The proportion of hearth lining in the assemblage was also lower than at Willow Street, suggesting that taphonomic factors may have influenced the composition of the assemblage, with the Willow Street site being closer to the source of the residues than 35 Mill Street.

A single piece of organically-tempered reduced fired clay with a rounded external surface may possibly be a fragment from a mould for casting non-ferrous metals.

The submitted materials contained numerous concretions formed around decomposing pieces of iron. Some of these are sufficiently large as to be worth X-Ray imaging to ascertain if the iron is scrap/stock iron or artefacts.

Contents

Abstract	1
Methods	1
Results	1
Interpretation	2
Evaluation of potential.....	3
References	3
Table 1: Catalogue	4
Table 2. Distribution of material classes	7
Table 3: Comparison of SHC assemblages	8
Figure 1: Bar chart of SHC weight-frequency	9

1. Methods

All investigated materials were examined visually, using a low-powered binocular microscope where necessary. All significant macroscopic materials were summarily described and recorded to a database (Table 1). For microscopic residues a general statement of the nature of each assemblage was recorded. 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.

2. Results

2.1 Description of the residues

Smithing hearth cakes: the smithing hearth cakes (SHCs) in this assemblage are of very variable form. The larger cakes mainly have well-formed homogeneous bowls, but the smaller cakes are frequently formed of prills. The small SHCs fall into two main groups: prilly cakes, frequently deepest at their proximal edge and small dense, discoidal bodies. Both groups usually have a glassy layer (formed from the melting of the hearth wall around the blowhole) on the top of the cake. In some of the prilly cakes the glass coats some of the prills and lobes on the lower surface too. Such cakes are gradational with the *lobate, glassy-surfaced materials* described below. This means that the identification of the smallest SHCs is somewhat arbitrary. The smallest slag piece identified as a complete SHC weighted 74g. In all there were 23 SHCs which were complete. The largest weighed

782g. The mean weight SHC was 233g. 91% of the SHCs weighed less than 500g.

None of the examples of SHCs from the later post-medieval contexts showed significantly different features from those securely stratified in earlier contexts and there were no examples with indications of the use of coal or coke as fuel (as is typical with 19th century smithing slags). All of these SHCs are therefore interpreted as being from the earlier occupation on the site and the whole assemblage is treated as one for the calculation of the statistics (Table 3).

SHCs comprised 79% of the archaeometallurgical residue assemblage by weight.

Lobate, glassy-surfaced materials: these materials are compositionally gradational with the small, prilly SHCs, but lack the coherent morphology of the SHCs. They occur instead as blebs and lumps of slag of varying density, usually with a glassy surface layer.

These are genetically similar to the slags known as “pro-tuyère tongues” (Young 2006) found in Irish tuyère-blown smithing hearths, where they form attached to the lower faces of the tuyères and represent the primary zone of mixing of the molten tuyère ceramic and iron oxides/iron from the workpiece. The development of fluid fayalitic slags in this zone leads to the development of dense iron-rich prills descending below the iron-poor upper glassy layer. Similar processes can be assumed to be operating during the generation of these slags. The distinction between the glass-rich materials such as these blebs and the glass-topped SHCs described above and more conventional SHCs with only a minor glassy component may be a very low rate of addition to the hearth in these examples.

This category made up 9% of the archaeometallurgical assemblage by weight.

Smelting slag: only two pieces of probable smelting slag were identified, both from c111. They were formed of very dense dark slag, which in one case bore the moulds of large pieces of charcoal. The charcoal bearing slag most closely resembled material from a non-slag tapping furnace, although it is possible that it is a furnace slag from a slag tapping furnace; there is insufficient material to determine this with certainty. Small quantities of dense, hard material such as these pieces may well be residual (a small quantity of residual, probably Roman, smelting slag was recovered at Willow Street).

Lining slag: these material are distinguished from the other categories of glassy materials described above, in completely lacking a denser component. Such materials may represent blebs and drips of lining that fall into the hearth.

Three pieces of this category from c112 are extremely low-density and highly vesicular. These resemble materials commonly called “fuel-ash slags”, and cannot be identified as being metallurgical slags with any certainty. Materials such as these can be generated in metallurgical hearths, but also in domestic hearths (particularly if cut into soils of calcareous composition) and structures such as corn-drying kilns.

Hearth lining: this category of residue includes ceramic, usually with a vitrified surface, that represents debris from the hearth wall. Hearths employing a simple blowhole in a clay wall would require constant

maintenance and reforming of the blowhole, so debris from the wall close to the blowhole is common in residue assemblages.

Smithing floor: smithing floor is an accumulation of the microresidues from smithing (typically flake and spheroidal hammerscale, together with iron particles, small fragments of slag and charcoal dust) that has become cemented through remobilisation of the iron. Isolated fragments in residue assemblages may be due either to fragments of smithing floor developed elsewhere being dumped with the other residues, or alternatively may be indicative of local cementation of smithing microresidues (usually cementation caused by corrosion of a small iron clast). In some instances the actual deposit of hammerscale goes unnoticed during excavation and only the local cemented concretions of smithing floor are collected. In this instance, the host deposit is identified as a buried turfline, which is rich in other archaeometallurgical clasts, so an origin as a derived lump of smithing floor formed elsewhere is most likely.

Mould (?): a single curious lump of reduced-fired ceramic was recovered from c100. The ceramic had an abundant fine organic temper. The one preserved surface was bulbous, and pale compared to the body of the ceramic. The size and shape of the lump suggests that it probably isn't a piece of grass-tempered pottery. If of metallurgical origin, it is possible it is part of mould of a mould for casting objects in a non-ferrous metal. Moulds typically, however, show a somewhat more oxidised firing.

Concretions: all sampled contexts showed some development of concretions. These are generated by the cementation by iron oxides of the host sediment surrounding a corroding piece of iron. The presence of iron was checked using a hand-held metal detector (of the kind used to detect fixings and services embedded in walls). In some cases slag lobes were also visible, suggesting that the iron might be present as lumps within smithing slags, but in other cases it seems likely that the core of the concretion is a simple piece of iron – possibly smithing waste, but also possibly an artefact.

Indeterminate slag: this category comprises slags which are too poorly preserved for identification, or in too small fragments to contain diagnostic features.

Distribution of the residues

The residues occur (Table 2) in probably 12th century contexts in two separate features: ditch [119] from, the level of the buried turfline upwards and gully [121]. This distribution parallels that from Willow Street, where the smithing residues were also concentrated in 12th century deposits.

There were no significant differences between the residue assemblages in different contexts.

Interpretation

The interpretation of the material as dominantly residues from blacksmithing is clear. The SHC assemblage compares closely with other examples of early blacksmithing (Table 3). The assemblage, together with that from Willow Street, is distinguished

from the later smithing residues from Deansway, in having much smaller SHCs. Indeed the assemblage from 35 Mill Street contains even smaller SHCs than the assemblage from Willow Street. In discussing the Willow Street assemblage, it was suggested (Young 2007) that the differences with the Deansway assemblages might reflect either the earlier date, or a lighter set of smithing tasks.

The range of SHC size at Mill Street and Willow Street are almost identical but there is a distinctly smaller assemblage in Mill Street (Figure 1) with virtually no SHCs in the 400-600g range. This may reflect again a bias towards light smithing tasks (for instance farrier work), but might also be a taphonomic effect, with the Mill Street assemblage being closer to the forge.

Evaluation of potential

There is little potential for further analysis of these materials to add to understanding of the development and use of the Mill Street site. Further investigation of these slags would be interesting should the actual origin of the residues, the 12th century forge, be revealed by development in an adjacent area.

It is recommended that the concretions be screened by X-Ray imaging in case they contain potentially useful pieces of iron - either as offcut stock iron from the smithy or artefacts.

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Table 1: Summary Catalogue by bag and context:

context		Wt (g)	no	notes
100	(clean over ditch)	20	1	fragment of strongly reduced fired clay with abundant organic temper, surface very smooth, rounded and oxidised (or weathered?) If metallurgical could be a mould fragment
		74	1	45x70x30mm small tongue-like SHC, dense lobate slag with pale glaze below and darker glaze on top
		36	3	indeterminate slag fragments
		2	1	oxidised fired vitrified clay
		26	2	lobate, partially flown lining slags
		64	3	SHC fragments
		64	1	concretion on iron?
101	(fill of post-med gravel pit)	80	1	small dense tiny SHC, neat rounded base, dense slag with black glassy top, 45x60x70mm
		84	1	dense SHC fragment
		42	1	clinker-like, lobed lining slag formed of dark glass with derived grains
		82	1	dark glass binding sand grains into dense, slightly vesicular, block
		2	1	concretion around iron tack?
103	(fill of post-med gravel pit)	216	1	70x90x30mm slightly irregular, slab-like very dense SHC, charcoal impressions on flat top, base fairly regular
		342	1	80x75x65mm irregular block of charcoal-rich slag, denser at top and bottom - possibly an irregular SHC
		268	1	80x85x50mm deep prilly plano-convex SHC with planar non-wetted proximal side, top smooth, haematized, with irregular smooth lobes
		782	1	115x110x85mm (of which bowl 40mm) SHC-like mass with oxidised fired red clay across base - instead of being an SHC this might actually be a steep hearth side, allowing haematized top to be just below blow and mass on top of "bowl" to be charcoal-rich slag on hearth floor
		108	1	concretion - possibly on iron (worth X-Ray)
110	upper fill of [119]	64	18	fragmented vitrified stone
		22	1	oxidised fired vitrified clay with recess
		4	2	oxidised fired clay
		6	1	exploded concretion with iron fragment
		22	1	concretion with iron (elongate shape, so possibly nail? - worth X-Ray)
		210	5	SHC fragments
		74	7	small lobate pieces - possibly flow slag, but may be SHC fragments, some maroon, some with glaze
		128	1	dense iron-containing concretion - possibly a small SHC to judge by concretion shape
111	upper fill of [119]	318	1	75x95x35mm small SHC with lower very thin bowl and upper rusty layer. Rusty layer extends oblique away from crust distally, MD suggests iron within this spike, cake plan-convex
		216	1	65x75x45mm small, disk-like dense SHC with irregular top, base extends down into slightly prilly material below main bowl
		84	1	SHC fragment
		96	1	small SHC with dense smooth top and base with small charcoal moulds, unclear if complete
		80	1	very dense slag with perpendicular shiny non wetted faces. Appears to be a smelting slag

		108	1	very dense slag piece, planar vertical non-wetted margin, base with dense lobes extending down, top fractured with large charcoal moulds. Probably a smelting slag
		44	4	blebby flowed material with glassy surfaces, but some quite dense
		44	1	dense slag with glassy top, probably an SHC fragment
		22	1	large iron nail
		144	3	rounded dense slag lumps
		10	2	tiny flow slags
		6	5	debris
112	deposit above turfline in [119]	316	1	80x80x50mm (of which bowl 25mm) neat dense SHC with raised charcoal rich top
		308	1	50x100x50mm -difficult bock - could be a folded SHC, but more probably a dense burr with rusty slag down-slope and with a wall-facing smooth haematised lobate surface below the burr
		62	1	tongue-like material, maroon lobes with one surface covered in pale green-white glaze
		92	1	probable SHC fragment - small, dense, with glazed top
112	deposit above turfline in [119]	70	1	crescentic piece of slagged reduced fired ceramic with smooth vitrified surface - probably part of the margin of a blowhole
		190	1	70x70x35mm, disc-like, double layer tiny SHC, dense
		138	2	SHC fragments
		56	3	highly vesicular material - lining slag or "fuel ash slag"
		16	1	glassy haematised flowed lobate material
		52	1	concretion
		56	1	tiny dense slag mass - smooth top prilly base - probably just a part of a small SHC
113	deposit above turfline in [119]	116	1	60x60x40mm small rounded lump-probably a deformed tiny SHC - has evidence for slightly lobate smooth top
		270	11	lobate dense slags - possibly tongue-type material
		92	3	lobate lining slags
		86	9	vitrified lining fragments
		34	1	concretion - probably around iron
		220	7	irregular slag fragments - probably from SHCs
		80	31	small slag fragments (there is dust in addition to this)
114	turfline in [119]	458	11	fragments of probably small SHCs
		118	12	indeterminate slag scraps
		160	10	lobate glazed slags - tongue-like materials - possibly fused gravelly lining
		34	1	now in 5 pieces - exploded iron-bearing concretion - iron was inside small slag fragment
		178	1	65x75x35mm small dense biconvex SHC with charcoal-rich top, slight part missing
		14	2	stone
		110	2	dense over-blown slag with haematite - one shows angular margin later rounded off by blown surface
		74	6	vitrified lining fragments

114	turfline in [119]	626	1	100x100x40mm neatly biconvex SHC with some accretion on base - small part missing distally
		730	1	large rounded concretion - in the process of exploding, contains iron (worth X-Ray)
		44	8	fragments from concretion
		150	1	60x80x35mm prilly semicircular SHC, with slightly glassy top
		82	1	(45)x50x35mm part of similar small SHC, prilly top reddened and rich in lining-influenced material
		112	1	60x70x35mm tiny prilly SHC with glassy top, plano-convex
		18	1	lobate flow slag, dense
		54	2	fragments of SHC crust
		32	1	stone
114	turfline in [119]	14	1	lining with thick run of vesicular glass
		18	1	small piece of smithing floor concretion, bears flake and spheroidal hammerscale, slag fragments and charcoal
		164	1	60x60x30mm small concretion, probably containing a small plan-convex dense SHC
		106	1	fragment of very dense SHC, with planar proximal surface, prilly base and smooth glassy top, proportion not determinable
		70	1	dense glassy topped SHC fragment
		42	1	prilly fragment from lower part of SHC
		176	1	dense SHC with glassy top and prilly base, probably planar prilly proximal side, most of base fairly smooth but prilly centrally, possibly slightly deformed on one proximal corner, 60x70x55mm
		76	1	45x60x30mm dense central part of small SHC, dished dense top ,some moderate charcoal moulds in base
		98	1	30x75x40mm crescentic lump rich in fine charcoal - probably part (most?) of a small SHC
		102	6	blebby slag in dense maroon flows with glaze - small SHC fragments or equivalent of tongue fragments
		6	1	oxidised fired vitrified lining
		6	1	poor flow slag
		204	1	concretion - strong MD response to iron or iron-rich slag (worth X-Ray)
		110	1	iron containing concretion - also shows lining slag lobes - so may be iron rich slag
		32	1	small concretion
		114	1	45x70x30mm concreted rusty lump with slag lobes showing - probably a rusted small SHC
122	fill in gully [121]	260	1	70x80x60mm dense glass topped SHC attached to inclined deeply vitrified wall - suggests wall gently curving below blowhole into shallow hearth
		276	1	95x90x50mm glassy SHC - apparently dipping into hearth down wall - spoon shaped , flat top
		116	1	piece of SHC with a dense bowl
		162	1	dense concretion on iron (worth X-Ray)
		64	1	variably glazed irregular maroon blebby complicated lobed flow/tongue piece
		16	2	oxidised fired clay
122	fill in gully [121]	224	1	95x65x20mm flat dense SHC, smooth flat top, slightly prilly base
		150	1	75x50x45mm pyramidal prilly dense mass - loose structured SHC
		38	1	oxidised fired clay
		90	1	60x60x20mm dense tongue-like mass
		68	1	charcoal-rich slag fragment
		40	1	strongly slagged lining
totals		12084	253	

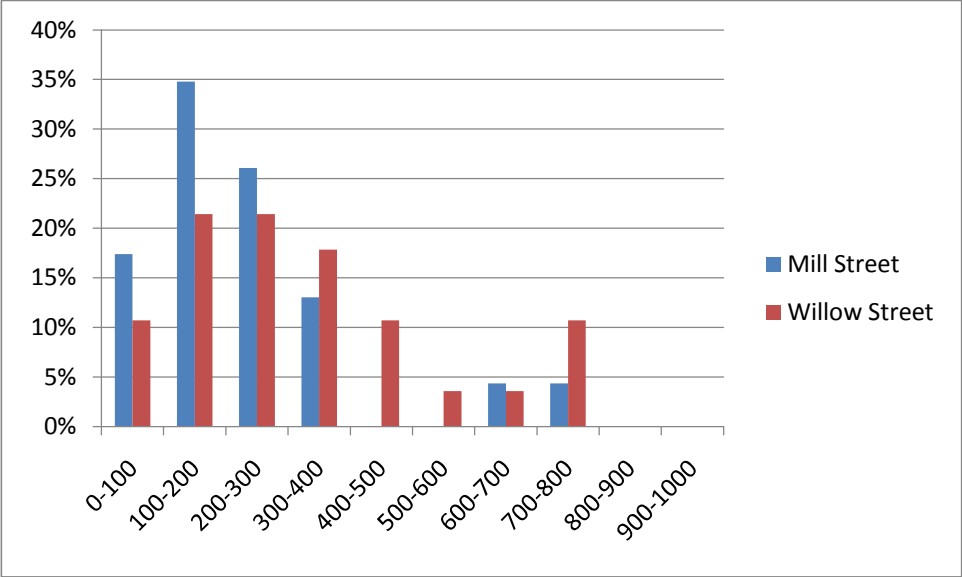
Table 2. Summary of material class by context and feature. Percentage totals are given for the archaeometallurgical residues only.

context	SHC	Lobate glassy materials	indeterminate slag	lining	lining slag	concretion	mould?	vitrified stone	natural stone	smelting slag	smithing floor	total
fill of post-med gravel pit												
101	164	124	0	0	0	2	0	0	0	0	0	290
103	1608	0	0	0	0	108	0	0	0	0	0	1716
Upper fills of ditch [119]												
100	138	26	36	2	0	64	20	0	0	0	0	286
110	284	0	0	26	0	156	0	64	0	0	0	530
111	758	44	160	0	0	22	0	0	0	188	0	1172
112	1100	78	0	70	56	52	0	0	0	0	0	1356
113	336	270	80	86	92	34	0	0	0	0	0	898
turfline in [119]												
114	2664	178	178	94	0	1154	0	0	46	0	18	4332
fill in gully [121]												
122	1026	154	68	94	0	162	0	0	0	0	0	1504
<i>totals</i>	<i>8078</i>	<i>874</i>	<i>522</i>	<i>372</i>	<i>148</i>	<i>1754</i>	<i>20</i>	<i>64</i>	<i>46</i>	<i>188</i>	<i>18</i>	<i>12084</i>
	79%	9%	5%	4%	1%			1%		2%	0%	(10264)

Table 3. Comparison of the 35 Mill Street assemblage of SHCs with that from Willow Street (both aggregated from all contexts) and with other similar assemblages. Willow Street from Young 2007; Marsh Leys Farm from Young 2005; Carmarthen from Crew 2003; Worcester Deansway from McDonnell & Swiss 2004; Burton Dassett from McDonnell 1992.

	35 Mill Street	Willow Street	Marsh Leys Farm Roman	Carmarthen Roman	Worcester Deansway (period 8) 11 th – 13 th	Worcester Deansway (period 9) 13 th -15 th	Burton Dassett 14 th - 15 th
count	23	28	30	136	61	32	60
min	74	86		100	168	144	130
max	782	770	824	820	1490	1800	1670
average	233	327	333	227	492	499	550
<500	91%	82%	77%	94%			
<1000	100%	100%	100%	100%			
>1000	0%	0%	0%	0%			
>3000	0%	0%	0%	0%			
modal class	100-200	(100-300)	100-200	100-200			

Figure 1. Bar chart comparing the size-frequency distributions of the SHCs from 35 Mill Street with those from the Willow Street site (Young 2007).



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