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Assessment of archaeometallurgical residues from Milbury Farm, Exminster, Devon (ACD478)

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Abstract

The site has produced an assemblage of smithing slags of medieval age. The residues are dominated by small smithing hearth cakes (SHCs; 48% of the assemblage by weight), many of low density. The classification of very small slag masses as smithing hearth cakes is difficult, especially where they do not demonstrate direct contact with the hearth wall. In this assemblage, the term is applied, with some reservation, for slag cakes with regular morphology, even where their weight is very low. The assemblage of 107 SHCs thus classified includes examples ranging from 32g to 482g, with a mean weight of 127g.

Assemblages of SHCs of this type are under-represented in the literature. Most early smithing assemblages are of somewhat larger SHCs; the analogues for this assemblage are to be found mainly in post-medieval settings. This assemblage is therefore important in demonstrating the medieval occurrence of the rural smithy.

In addition to the 13.7kg of intact SHCs, there was a further 1.3kg of SHC fragments (5% of the assemblage by weight), and 7.9kg of other slags (28% of the assemblage by weight), These other slags included blebby, prilly or massive slags which lacked the characteristic morphology of an SHC, but which, nonetheless, may confidently be attributed to an origin in smithing. The collection also included 3.5kg of vitrified hearth lining (12% of the assemblage by weight).

There was also 1.6kg of concretions formed around corroding iron. Many of these concretions had a charcoal-rich matrix, but in examples from ten contexts there was a significant proportion of hammerscale. In seven contexts the concretionary material was sufficiently rich in hammerscale to resemble material informally described as 'smithing floor concretion'. Although such materials may potentially be derived, they suggest that examples of hammerscale-rich sediment may have gone otherwise unrecorded.

The hearth lining showed no good examples of blowholes, but two fragments showed a partial curving margins with an equivalent diameter of approximately 25mm, which are probably blowhole fragments.

The distribution of the residues was focused on a small area of the site, but a full stratigraphic account was not available at the time of the production of this assessment.

The assemblage therefore provides evidence for a smithy undertaking light and/or intermittent work, similar to that undertaken in many post-medieval village smithies. To date, most studied medieval smithing assemblages show evidence for heavier use in artefact manufacture.

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Methods

The materials were examined visually (with a low-powered hand lens or microscope when 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 summary catalogue of examined material is given in Table 1.

This project was commissioned by Naomi Payne, of AC Archaeology.

Results

Distribution of the residues

The archaeometallurgical residues were mainly derived from a limited area of the site, assumed to indicate the location of the smithy. A full stratigraphic account of the site is not currently available, and therefore a further discussion of the distribution and of the nature of the features containing the residues would be desirable at such time as that information becomes available.

A summary of the distribution of the various classes of archaeometallurgical residue by context is provided in Table 2.

Description of the residues

Smithing hearth cakes
Essentially intact SHCs comprised 13.7kg of the assemblage (approximately one half). Probable SHC fragments comprise a further 1.3kg. There were 107 complete SHCs (as defined here, see discussion below), of which 91 were recovered from the fills of just five features (pits or 'post pits' [219], [244], [268], [290] and [293]). The other 16 examples were from a further nine contexts.

The SHCs showed a variety of form and texture. At one end of the compositional spectrum, examples with very low iron contents resemble the slag masses described as 'pro-tuyère tongues' by Young (2012). As originally envisaged, these masses developed from the faces of ceramic tuyères (typical in Irish medieval iron-working) and were possibly separate from a larger SHC-like mass formed lower in the hearth. The characteristic morphology of a 'tongue' is to be slab-like, with a smooth, glassy, silicate-rich top and a base that may comprise pendant prills of slightly more iron-rich slag. Tongues are usually elongate and often sub-rectangular. In more conventional settings, tongue-like masses are known from many sites where the input of iron into the smithing residues was low. In this assemblage, the term 'tongue' is employed where the upper and lower surfaces of the slag mass are sub-parallel, where the two faces show an indication of differing iron content and where the mass has a low iron content.

As has been discussed previously for such assemblages (e.g. Young 2009c), the recognition of smaller slag masses is problematic. Where regularity of shape is a criterion, then there will be a lower size limit at which that form is no longer recognisable with any certainty. In this case, the typical plano-convex SHC shape is not fully formed below about 70g weight; more open bowl-shaped incipient SHCs may be recognisable at a lower weight, as may small tongues. Some of the smallest recognisable masses suggestive of incipient SHCs were button-like slag blebs with glazed tops, which were recognisable down to under 50g. Regularly-shaped gravelly masses were also recognisable down to a small size. Justification of the inclusion of some of these types of slag mass in consideration of SHC size distribution was the occurrence of several examples of small slag masses attached to fragments of sub-blowhole hearth wall.

Where items were of identical texture to the SHCs, but lacked the characteristic morphology, they were counted in the 'other smithing slags' category of Table 2.

Other smithing slags
This category included fragments with a composition/texture related to the SHCs, but which had a morphology unlike the SHCs. These materials were mainly glassy and/or gravelly materials in various blebs and irregularly-shaped masses.

Such materials were abundant, with a total weight of approximately 7.9kg.

Hearth lining
Fragments of vitrified hearth lining were abundant, with approximately 3.5kg of pieces, but which had an average weight of just 25g (these figures refer just to the hand-picked residue collections, not to the occurrence of fired clay in sieved samples).

Most of the fired and vitrified clay was a fairly silty material with sporadic coarser grains and clasts. The material was not typically rich in any organic temper.

One unusual fragment from c275 was rich in included flake hammerscale (FHS).

None of the hearth lining included a substantial part of a blowhole, and none provided any evidence for the use of a tuyère. Two small pieces provided limited evidence for the margins of blowholes of approximately 25mm diameter. Neither of these fragments provided enough of the circumference for certain measurement, but blowholes of this size would be typical of smithing hearths.

Flow slag
One context (c266) yielded two examples of well flowed slags, probably in the form of horizontal prills, with a combined weight of 120g. Prills of slag are sometimes generated in smithing hearths when a particularly fluid slag happens to be formed. Such flows may be within the hearth, or occasionally into gaps in the hearth structure around the blowhole. The context within the hearth of these pieces is not known.

Iron and concretions
Small concretions, mostly cored on corroding iron, were extremely common. They had a total weight of 1.63kg.

In most cases the nature of the iron inclusion was not known, being entirely hidden by the accretion, but two fragments were visible: a small fragment of thin sheet iron from c289 and a fragment of iron bar (30mm x 15mm x 6-8mm) occurred in c217. It is likely that the iron inclusions were mainly fragments lost during smithing (because they were associated with smithing microresidues), rather than being artefacts.

The sieved residue from c247 contains a broken iron object, probably from a fractured concretion, which shows very thin square shank apparently associated with a 5mm tall iron cone - possibly suggesting a fragmented small stud.

Hammerscale (mainly flake hammerscale, FHS, with a much smaller proportion of spheroidal hammerscale, SHS; Young 2011d) occurs in high abundance in the concretionary material from contexts 217, 247, 289, 292, 296, 305 and 306, as well as in lower concentrations in concretions from contexts 242, 245 and 334. Concretionary material rich in hammerscale and fuel (charcoal) particles is sometimes referred to as a 'smithing floor' concretion, for such materials may accumulate on the floor of the smithy and become cemented into a ferricrete by the corrosion of included iron particles. Once such materials have been formed, then they may be reworked within a site in the same way as a fragment of any other residue type. However, they were commonly formed *in situ* within the deposits where recovered. In this case, the occurrence of significant amounts of hammerscale-bearing concretion may be indicative of a hammerscale-rich host sediment, which may not otherwise have been sampled, or even recognised during excavation.

Isolated microresidues

Unlike the rather common occurrence of hammerscale incorporated into accretionary material, the recovery of smithing microresidues by deliberate sampling was rare. No sieved samples appear to have been on a sufficiently fine mesh to have retained significant quantities of hammerscale.

Context (247) produced a small assemblage including one slag sphere, two slag blisters and two wispy slag fragments as well as concretions rich in FHS and charcoal.

Context (334) yielded a larger assemblage of slag fragments, slag flats, vitrified and slagged stone, vitrified lining and smithing floor concretion debris

Interpretation

This collection forms a coherent body of residues from a smithy undertaking work in which the amount of iron-loss to the hearth in each work period was very small, leading to the production of small, strongly wall-influenced SHCs. Although it is likely that this indicates a general lack of heavy forging/welding projects, it is also possible, indeed likely, that the very small SHCs were produced during very short work periods. This may, in turn, suggest that work may have been intermittent.

There are no directly analogous assemblages of a similar age. Very few English medieval SHCs assemblages have been recorded in detail (Table 3a). All these assemblages contained a significant proportion of SHCs that were heavier than any from Milbury Farm. The described assemblages are however either urban (four sites from Worcester; Young 2007, 2009b, McDonnell & Swiss 2004) or from major villages/small towns (Cricklade, Young 2008b; Burton Dassett, McDonnell 1992). The assemblages from the adjacent 11th/12th century sites in Mill Street and Willow Street, Worcester, included SHCs close in texture and style of those from Milbury Farm, but even here the SHCs ranged up to approximately 780g as opposed to only 480g at Milbury Farm.

The gravelly, low-iron content, type of SHC present at Milbury Farm, may be paralleled in several assemblages of Roman age (Caergwanaf, author's unpublished data; Caerleon Priory Field and Endowed Schools Field, author's unpublished data and Young & Kearns 2010; Exeter, Young 2011b; Calstock, Young 2011a; Neath, Young 2013, 2014). The size of SHC present on these sites is, however, again larger than those at Milbury Farm (the largest SHCs on these sites typically in the range of approximately 600-800g; Table 3c). In these cases, the similarity of SHC style is attributed to a similarity in style of hearth design (floor-level hearths, blown through a simple small blowhole in the wall, no use of tuyères), whereas the difference in size can be attributed to differences in work activity and/or duration. The chemical evolution of a suite of such slags (from Neath) was recently investigated (Young 2014). It may be significant that many of these assemblages are from Roman military forge sites, rather than from sites of a truly 'industrial' character.

Rather closer analogues to the present assemblage may be found in examples from Ireland. It has been argued (Young 2009d) that smithing assemblages from the earlier medieval period in Ireland contain a proportion of very large SHCs (columns towards the right of Table 3b) because of the distribution of iron in an incompletely refined form (similar to the medieval and early post-medieval distribution of iron as partly-consolidated billets, *cloder,* in Denmark described by Pleiner, 2000, 241-2). Since that suggestion, the further complication of the various hearth refining and carbon-control techniques (Jensen 1968; Wagner 1990), which may produce large slag cakes, has also become recognised (e.g. Sauder 2013).

In the late medieval and post-medieval periods in Ireland, however, the distribution of finished iron appears to have been more typical and there is a corresponding reduction on the size of SHCs present on smithing sites. An additional factor promoting the development of smaller SHCs at this period was the gradual introduction of iron tuyères which reduced the impingement of the hot-zone onto hearth ceramic, and thus the supply of silicate melt to the hearth.

Of the later medieval/post medieval assemblages from Ireland, those from Moyveela (Young 2009c) and Ballykillaboy (Young 2010) are particularly similar to the present material, in terms of the SHC weight statistics (Table 3b, left hand side). Ballykillaboy was a simple, apparently cob-built (essentially a *bothán*), rural smithy, handling both light ironwork and some copper alloy work; its landscape setting is unknown. It is dated as 15th – 17th century in age. Rather more is known about Moyveela (Delaney *et al.* 2010), which appears to have been a *clachan* (an informal, low-status, rural settlement) of which Building 5 appears to have been the smithy. The site is interpreted to be of 17th to 18th century date. In contrast, the contemporary smithy at Gorteens, associated with the estate centre of Gorteens Castle (Cummins 2003), shows a higher proportion of larger SHCs, suggesting heavier work was undertaken there.

Thus, in summary, despite the rather poor representation of such assemblages in the literature, it would appear that parallels for the assemblage from Milbury Farm are to be found in low-status rural smithies, rather than those of towns or estate centres. The smithy in such settings is likely to have been involved in support of other the day-to-day activities of the settlement (dominantly the maintenance of tools, equipment and fittings), rather than representing an 'industrial' activity in its own right.

Conclusion

This assemblage is an example of a residue assemblage from a medieval rural smithy. Such assemblages have been rarely reported in the literature, despite expectations that the site-type might have been common. The material is therefore important and should be deposited with the site archive in its entirety.

The assemblage does not have potential at the present time for revealing further useful information from additional

analysis, so no further investigative work is recommended on this assemblage. However, further consideration of the nature of some of the productive contexts is strongly recommended. Although high levels of both micro- and macro-scopic residues may occur within structural features inside smithies, the level of residue in some of the features currently interpreted as structural may suggest otherwise. Further consideration of the nature/location of the hearths for the smithing activity is also recommended, since it would be very valuable to tie such a valuable residue assemblage into understanding of the hearth types involved in their production.

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Table 1: summary catalogue by bag/context.

context	sample	label	sample wt (g)	item wt (g)	number	notes	SHC wt (g)
105		slag	380				
				266	1	SHC with very large transverse ridges on base - as in Roman bloomsmithing cakes; 90mm x 85mm x 20mm with further 25mm depth of two ridges	266
				110	2	rounded nubs of smithing slag, possibly incipient SHCs	
106		slag	110				
				76	1	55mm x 55mm x 40mm (bowl 35mm); small deep dark glassy SHC with some gravel and prilly base	76
				34	1	vitrified oxidised lining	
165		slag	406				
				286	1	bulbous rounded mass detached from planar wall - reaction zone at top near blowhole, but more non-wetting lower; slot in top of lining dominated slag may be in front of blowhole - but no actual blowhole preserved; base deeply dimpled with entrained fuel, top rounded masses of lining slag.	
				112	5	blebby-lobate lining slags; some with lining material - all potentially incipient tongues or tongue fragments	
217			2690				
				338	1	well-formed plano-convex SHC; 110mm x 105mm x 45mm, with very slight burr, base lumpy, irregular, top smooth and glassy;, edges slightly raised	338
				104	1	irregular gravelly tongue like mass	104
				180	1	gravelly SHC, probably about 5% missing, 85mm x 70mm x 40mm; top dimpled, glassy; base dimpled; well formed	180
				108	1	60-65mm diameter 30mm deep, dense SHC-like small puck; glassy top; neat but accreted base	108
				96	1	60mm x 70mm x 30mm gravelly SHC with slightly concave glassy top and smoothly dimpled base	86
				112	1	65mm x65mm x 50mm irregular low density SHC with very slightly lobed top	112
				120	1	70mm x 80mm x 35mm gravelly SHC with irregular surfaces	120
				88	1	70mm x 80mm x 30mm incompletely formed sandy tongue with hole	88
				138	1	dense slag, possibly all of a slag mass, but not a well-formed SHC, probably formed against wall	
				116	1	65mm x 65mm x 35mm small SHC, small part missing	116
				48	1	irregular dimpled gravelly mass - possibly incipient tongue	48
				148	1	85mm x 70mm x 45mm mass formed of low density slag with concentric layers and central rounded concavity	
				26	1	accreted small iron bar fragment, mineralised, bar fragment 30mm x 15mm x 6-8mm	
				370	12	oxidised vitrified lining fragments	
				680	32	fragments of slags similar to above, or independent blebby/dimpled lumps	
217				216	1	50mm x 80mm x 50mm medium density irregular slag mass- deformed SHC?	216
				170	1	55mm x 80mm x 45mm irregular SHC	170

context	sample	label	sample wt (g)	item wt (g)	number	notes	SHC wt (g)
				132	1	slightly broken very gravelly SHC with dimpled base	132
				58	1	55mm x 60mm x 30mm small plano-convex SHC with dimpled base	58
				110	1	90mm x 50mm x 35mm irregular glassy-topped tongue/SHC	110
				92	1	55mm x 65mm x 25mm medium-density small SHC	92
				74	1	45mm x 70mm x30mm semi-circular low- density gravelly SHC	74
				108	1	(55mm) x (55mm) x 40mm fragment from SHC with low density and slightly lobate top and stone clasts	
				100	1	65mm x 80mm x 25mm, neat gravelly SHC or pad from wall	100
				60	1	60mm x 60mm x 25mm irregular low density tongue-like piece	60
				226	6	oxidised vitrified lining fragments	
				472	14	fragments of slags similar to above, or independent blebby/dimpled lumps	
217				246	1	well-formed plano-convex SHC, 80mm x 95mm x 40mm including a few prilly extensions; top appears lobate, but probably gravelly; base well-rounded micro-dimpled	246
				88	1	poor incomplete tongue of extremely gravelly material	
				32	1	iron-containing concretion, rich in charcoal/plant material and some probable hammerscale	
				46	1	smithing floor concretion with slag, lining, fuel and abundant FHS	
				176	5	fragments of slags similar to above, or independent blebby/dimpled lumps	
218		slag	510				
				90	1	Small SHC	90
				242	8	blebby slags, mainly moderately dense, none in SHC or tongue morphology	
				66	1	Well-formed tiny burr, attachment approximately 50mm wide and 30mm deep; attached cake has been torn off leaving just a strip of slag with prilly/dimpled base	
				108	9	fragments of vitrified lining	
218	12	5.6mm magnetic residue			assm	many tiny fragments, dust-like - mostly probably slag fragments rather than hammerscale	
218	12	5.6mm residue	398		assm	large assemblage dominated by lining fragments (including one small fragment from a 40mm - 50mm equivalent diameter blowhole fragment), lining slag, glazed stones, and stones fused into gravelly slag. Also drips prills and blebs of denser slag. One significant smithing floor concretion around iron	
220		slag	40		1	irregular lump of lining slag with dark glaze on almost all faces	
242		slag (1 of 3)	2190				
				50	1	15mm x 55mm x 20mm sub-discoidal tongue - even glassy top with rough slag below	50
				62	1	65mm x 45mm x 30mm small dense slag mass with dimpled base and stones in various stages of melting stuck to top	62

context	sample	label	sample wt (g)	item wt (g)	number	notes	SHC wt (g)
				338	1	80mm x 80mm x 45mm somewhat irregular SHC. Well-formed lower bowl, moderately dense, top very irregular with lumps of lining-related slag	338
				106	1	80mm x 70mm x 45mm (bowl 25mm) thin regular tongue with black glass top; unclear if raised lip on one side is original or as a result of folding on extraction	106
				40	1	45mm x 60mm x 36mm, semi-circular tiny tongue like piece with moderately smooth glassy top and long prills below	40
				96	1	60mm x 60mm x 40mm irregular rather lobate SHC/tongue lobate dimpled base and pale glassy top	96
				62	1	55mm x 45mm x 30mm neat glass button with lobes of denser slag descending below	62
				66	1	50mm x 65mm x 30mm, semi-circular, slight dished gravelly incipient SHC/tongue	66
				70	1	50mm x 60mm x 35mm, smooth glassy button with dimpled descending denser lag below	70
				94	1	65mm x 60mm x 35mm (excluding rising spike on one side), very gravelly low density SHC	94
				400	10	fragments of vitrified oxidised lining, one of which seems to show slag descending from front above right angled outwards return	
				774	21	irregular slag blebs and fragments similar to material in SHCs/tongues above	
				28	1	concretion on iron rich in charcoal and plant moulds, but no hammerscale	
242		slag (2 of 3)	3195				
				224	1	85mm x 80mm x 40mm (30mm bowl) dense SHC with dimpled top with adhering blebs, plano-convex, base rough	224
				158	1	70mm x 100mm x 35mm, thin concavo-convex SHC/tongue, gravelly, base dimpled, top with partially melted stones and wisps of lining slag in dished bowl	158
				96	1	70mm x 70mm x 40mm (30mm bowl) low-density gravelly SHC, gravel on top, dimpled and slightly prilly below	96
				340	1	70mm x 110mm x 60mm (35mm bowl), dense semi-circular SHC with possible tool mark through core to base, base prilly, top rusty	340
				88	1	65mm x 95mm x 35mm low density gravelly tongue	88
				110	1	70mm x 70mm x 25mm small tongue, dimpled/prilly base dimpled top, attached to wall with contact 65mm wide, margin of c20mm blowhole just above, tongue is folded up in front of blowhole - deformed during extraction	110
				68	1	60mm x 65mm x30mm gravelly tongue	68
				92	1	55mm x 80mm x 35mm, strange thin tongue with one margin very rough and rising at a right angle	92
				98	1	60mm x 60mm x 40mm, small gravelly tongue curved into a channel - unclear if this is primary or deformation	98
				76	1	60mm x 60mm x 40mm small gravelly tongue with large (>15mm) feldspar clasts on one upturned margin	76
				68	1	60mm x 50mm x 35mm small conical gravelly tongue, basal part dimpled and dense	68
				100	1	complex attachment of tongue to oxidised-fired wall	
				52	1	65mm x 45mm x 40mm (20mm bowl) tiny tongue with flat top to bowl overlain by further lumpy lining slag; base slightly lobate and dimpled	52
				112	1	70mm x 60mm x 30mm highly vesicular small SHC with dimpled base and irregular, locally rough top	112
				76	1	65mm x 60mm x 30mm, slightly broken low density SHC	
				58	1	55mm x 60mm x 25mm tiny SHC with glazed top and prilly base, slightly dished top	58
				32	1	45mm x 40mm x 15mm small glazed button, smooth top and dimpled base	32

context	sample	label	sample wt (g)	item wt (g)	number	notes	SHC wt (g)
				54	1	65mm x 50mm x 35mm irregular, slightly spiky tongue, fairly flat top and slightly prilly base	54
				240	15	oxidised vitrified lining, some pieces showing attachment of slag	
				122	2	concretions on iron	
				868	33	irregular slag blebs and fragments similar to material in SHCs/tongues above	
242		slag (3 of 3)	2385				
				172		80mm x 65mm x 35mm, dense irregular slightly elongate lobate SHC with raised glazed lobes on upper surface, dense lower	172
				132		75mm x 80mm x 35mm, dished low-density SHC, raised gravelly lip on (?) proximal side	132
				82		55mm x 65mm x 25mm tiny disk like dense gravelly SHC	82
				140		75mm x 75mm x 30mm well-formed tiny SHC, lobate margin	140
				156		50mm x 90mm x 35mm small semi-circular tongue with wide attachment, on reduced fired wall	156
				124		65mm x 70mm x 40mm small dense gravelly SHC	124
				482		80mm x 100mm x 40mm dense well-formed SHC with wide attachment to wall fragment, probably slightly incomplete	482
				104		50mm x 65mm x 40mm small folded-looking irregular SHC	104
				36		50mm x 40mm x 25mm low-density gravelly disk	36
				74		60mm x 75mm x 30mm gutter shaped irregular thin gravelly sheet (cf 104g piece above but more open)	74
				52		50mm x 55mm x 25mm small irregular gravelly mass	52
				76	1	concretion on iron - sediment with charcoal and some hammerscale	
				180	6	oxidised vitrified lining, some pieces showing attachment of slag	
				546	30	irregular slag blebs and fragments similar to material in SHCs/tongues above	
243		slag	1450				
				130	1	75mm x 75mm x 35mm, good tongue, dimpled lower face, smooth glassy top, arcuate wall contact	130
				148	1	65mm x 75mm x 45mm detached plano-convex tongue-like SHC, gravelly, shows cracking	148
				92	1	oxidised wall with root of a tongue	
				120	1	70mm x 85mm x 35mm concavo-convex gravelly tongue	120
				142	1	dense prilly, slight incomplete rather amorphous SHC, 75mm x 60mm x 40mm	142
				126	1	strange very dense plano-convex conical SHC with strongly blown top, 55mm x 75mm x 35mm	126
				300	1	mass of lining slag attached to semi-elliptical wall fragment	
				112	1	oxidised wall fragment with large vitrified ball of ceramic at one end - probably air penetration around blowhole	
				58	2	gravelly lining slag fragments	
				32	2	oxidised clay	
				192	10	oxidised vitrified wall fragments	

context	sample	label	sample wt (g)	item wt (g)	number	notes	SHC wt (g)
245		slag	144				
				124	3	concretions on iron, rich in charcoal, with some scale	
				10	1	oxidised vitrified lining	
				6	1	lining slag fragment	
247	15	5.6mm magnetic residue			6	one slag sphere; two slag blisters; two wispy slag fragments; one rust fragment	
247	15	5.6mm technical residue	40		7	fragments of smithing floor deposit, concreted around weathered iron. Rich in FHS and charcoal. One piece shows very thin square shank passing towards, probably associated tall iron cone - possibly suggest a small stud.	
247	15	5.6mm residue	78		assm	fragments of spiky slag, slag in sandy concretions and lining slag, with glazed and vitrified stones. Mostly rather blebby materials	
256		slag	60		2	very irregular, possibly deformed lining slag pieces	
263		slag	718				
				208	1	very dense gravelly and prilly SHC, 80mm x 70mm x 45mm	208
				122	1	50mm x 80mm x 40mm, tongue-like SHC attached to oxidised fired wall fragment	122
				132	1	rectangular SHC, 80mm x 55mm x35, lots of fuel clasts, no gravel, dense	132
				210	6	gravelly slag fragments	
				48	2	vitrified lining fragments	
263		slag 2	198				
				142	6	blebby gravelly slag pieces	
				56	2	oxidised-fired lining	
266		slag	1440				
				124	1	70mm x 80mm x 40mm extremely gravelly SHC, dished top,	124
				2	1	elongate dense prill with maroon surface, 7mm x 5mm x 40mm	
				88	1	55mm x 75mm x 40mm, gravelly SHC with somewhat maroon top,	88
				60	1	60mm x 60mm x 25mm, gravelly tongue like SHC	60
				46	1	45mm x 50mm x 30mm, ball of maroon surfaced slag, probably an incipient SHC, somewhat lobate	46
				136	1	50mm x 70mm x 50mm, semi-conical dense, but gravelly, deep SHC	136
				124	1	60mm x 70mm x 35mm, triangular SHC	124
				56	1	50mm x 50mm x 30mm, button like slag with lumps of gravel on upper surface	56
				66	1	55mm x 55mm x 25mm rounded button like vesicular slag bleb	66
				86	1	55mm x 60mm x 50mm (30mm bowl) plano-convex porous sintery SHC with elongate protrusion down from base	86
				118	1	18mm x 22mm x 80mm with some extra on one end - slag prill or tool cast	
				530	15	fragments of cakes similar to above and other blebby slag masses not obviously SHCs	

context	sample	label	sample wt (g)	item wt (g)	number	notes	SHC wt (g)
275		slag	796				
				104	1	vitrified lining in thick block with fissured face	
				110	3	charcoal rich concretions on iron	
				122	5	gravelly low-density slag fragments	
				36	1	oxidised fired lining - with ceramic very rich in hammerscale	
				18	1	flap of lining slag hanging from oxidised fired lining	
				64	1	small slightly dished mass, probably a small folded SHC	64
				98	1	dense circular SHC starting to explode, dense, 65x55x35(20)	98
				234	1	irregular mass, appears to be small bowl of SHC, with upper layers drawn out irregularly to one side 70x120x45	234
277		slag	1085				
				182	1	60mm x 100mm x 50mm, irregular rounded, lobate/prilly SHC, probably twisted on extraction	182
				478	14	lobate rounded masses of mainly lining slag - none in the form of SHCs	
				104	3	vitrified oxidised fired lining	
				30	1	partially vitrified and bloated stone	
				88	1	deformed prilly/lobate gravelly SHC, probably deformed on extraction	88
				140	1	fragment of dense gravelly SHC	
				72	1	rounded mass of lining slag - planar slightly dimpled base and convex, locally maroon top	
289		slag2	1895				
				216	1	80mm x 85mm x 50mm slightly dished top very gravely SHC; prilly base; top with angular stone fragments and slightly maroon on one side	216
				164	1	70mm x 60mm x 45mm, angular and irregular SHC of dense slag	164
				96	1	70mm x 70mm x 35mm sheet like low density gravelly SHC, concavo-convex.	96
				82	1	90mm x 80mm x 40mm sheet-like low density gravelly SHC	82
				106	1	60mm x 75mm x 45mm moderately dense SHC	106
				10	1	concretion very rich in FHS	
				336	8	concretions on iron, accretionary material shows scale and charcoal	
				166	11	fragments of gravelly low-density SHC	
				180	11	vitrified lining – all oxidised-fired except for one piece	
				256	4	Substantial parts of SHCs	
				226	11	lining slag fragments and blebs	
289		slag1	1480				
				716	29	various slag fragments - either fragments of possible small SHCs or other blebby slags, varying from iron rich to lining influenced	
				60	1	concretion including possible burr fragment	

context	sample	label	sample wt (g)	item wt (g)	number	notes	SHC wt (g)
				46	1	concretion containing mineralised sheet iron	
				462	21	vitrified lining - all except two pieces oxidised fired	
				138	1	very irregular lump of dense slag- possibly an SHC deformed during extraction	138
				60	1	very low density somewhat maroon, tongue-like pad - dimpled on base, fuel impressions on top, very low density, 70mm x 70mm x 35mm	60
292		slag1	1290				
				338	1	irregular SHC, 90mm x 110mm x 55mm (bowl 45mm); glazed top distally, raised ridged iron slag; proximally base appears to be sediment contact, marginally prilly	338
				96	1	70mm x 65mm x 30mm tongue-like SHC, glazed top, with concentric lobed ridges, rough prilly base. Adhering hammerscale	96
				168	1	55mm x 90mm x 55mm, small SHC-like mass with lobate base, plenty of gravel, and small area of glaze on top	168
				266	1	70mm x 110mm x 40mm, porous, iron-rich sintery SHC, slightly concavo-convex, adhering sediment is hammerscale rich	266
				118	2	fragments of bur like SHC material - deeply fused base, dense interior and pale green glassy top	
				128	3	irregular slag fragments, mostly lining related, but one piece shows flowed iron rich rivulets	
				22	1	Charcoal-bearing concretion on slag fragment	
292		slag2	1315	206	1	80mm x 90mm x 45mm, slightly concavo-convex SHC, very gravelly glazed top	206
				144	1	70mm x 75mm x 40mm, gravelly SHC, plano-convex with one upturned margin, porous sintery iron rich base	144
				218	1	75mm x 100mm x 45mm, gravelly plano-convex SHC, base prilly, top with glazed pebbles	218
				122	1	small twisted flap of lining slag or tongue, pinched by tongs or poker.	122
				108	1	50mm x 80mm x 35mm, transverse tongue-like mass attached to oxidised fired vitrified wall	108
				128	1	65mm x75mm x 45mm SHC like mass with bulbous glassy top in large lobe, base slightly prilly, internally vesicular grey iron slag	128
				114	1	55mm x 70mm x 45mm twisted gravelly mass	114
				132	1	heavily accreted probable SHC, accretion has hammerscale	132
				52	2	accreted slag blebs - accretion has both FHS and SHS	
				112	4	slag and vitrified oxidised-fired lining	
294		slag	218				
				98	3	charcoal rich concretions on iron	
				60	1	mass of lobes, probably cored on gravel	
				58	1	part of a flat topped glassy gravelly SHC	
296		slag	148				
				84	1	dense iron rich SHC, 65mm x 55mm x 35mm	84

context	sample	label	sample wt (g)	item wt (g)	number	notes	SHC wt (g)
				42	4	oxidised fired lining	
				8	1	elongate concretion on iron - extremely rich in FHS	
298		slag	630				
				306	1	85mm x 100mm x 55mm (bowl 35mm) large SHC with abundant fuel moulds, base slightly multi-layered, dense, at least prominent half-roundwood mould in top	306
				36	1	small tongue- like gravelly mass 45mm x 50mm x 25mm	36
				204	10	blebby lining-dominated slags	
				18	1	vitrified oxidised-fired lining	
				58	1	dense slag sheet - possibly an odd SHC, c15mm thick	
305		slag	80				
				72	1	smithing floor type concretion containing possible nail (and pebble)	
				6	1	vitrified oxidised-fired lining fragment	
306		slag	516				
				222	3	concretions around iron in smithing floor deposits. One of these contains sediments almost entirely FHS	
				84	3	slagged vitrified oxidised-fired lining	
				146	4	amorphous rounded lumps and fragments of lining-influenced slag	
				60	1	possible poorly developed tongue - but may be thicker lining slag removed from wall - smooth upper surface lobate, base red with patches of ceramic	
306	28	magnetic residue			14	small fragments of slag and smithing floor	
306	28	5.6mm residue	150		assm	many fragments of mostly lining-influenced slag, but with some denser pieces . Most of slag is vesicular and some is a black glass. The assemblage lacks lining fragments, but contains a fragment of blowhole margin (25mm diameter).	
318		slag	64				
				62	2	rounded masses - one porous low density, the other more gravelly	
322		slag	84				
				82	1	45mm x 60mm x 30mm tiny SHC with lobed glassy top and dense base, starting to fragment so presumably high density is caused by iron inclusion	82
333		slag		58	1	tiny concavo-convex SHC of slightly maroon slag, with irregularly dished top and strongly lobate base, 50mm x 60mm x 20mm	58
				38	1	incipient SHC or tongue - possibly a fragment - very gravelly top, lobate base, 40mm x 45mm x 30mm	

context	sample	label	sample wt (g)	item wt (g)	number	notes	SHC wt (g)
334	35	5.6mm magnetic residue			3	two slag fragments, one possibly slag flat; one concretion probably on iron fragment	
334	35	5.6mm slag residue	28		assm	assemblage of slag, slag flats, slagged stone, vitrified lining and smithing floor debris	
384	36	5.6mm slag residue			2	botryoidal goethite? Crust on indurated sand/sandstone; tiny hollow sandy green concretion	
399		slag/fired clay	6		1	variably reduced fired clay, shows one concave face with central groove with white, possibly vitreous adhesion - possibly fired daub, mould or irregular hearth wall.	
421		slag	20				
				20	3	tiny slag scraps, 2 heavily accreted	
432		slag	248				
				26	1	slag binding totally bloated white quartzo-feldspathic clasts suggestive of an originally granitic gravel	
				200	16	rounded lumps and fragments of vesicular dark grey lining slag passing into more glassy lining slag	
432		slag	24		2	one exploded concretion with vitrified clay and vesicular slag; one piece of pale grey vitrified sandstone (or possibly sandy ceramic)	
433		slag		20	1	concretion on iron	
				24	2	lining slag fragments	
				8	1	slaggy layer spalled from oxidised-fired lining	
				2	1	flowed bleb of lining slag	
				4	1	fragment of vitrified oxidised lining, very sandy, contains mould of twig/straw, glaze is dark (black) sandy glass	
446		slag	24				
				24	1	broken fragment of charcoal rich dense slag, extending downwards into dense slag prills	
446	39	5.6mm slag residue			1	small fragment of porous fired clay with weathered vitrified surface	
460		slag		238	1	55mm x 90m x 45mm (40 bowl), neat dense transverse SHC , base obscured, top has dimpled top to bowl overlain by pad of smooth maroon slag, very neat, much denser than most SHCs in this collection	238

Table 2: distribution of residue types by context.

context	SHC	prob SHC	other smithing	lining	flow slag	iron/ concretion	microresidue (loose)	microresidue (in concretion)	total	SHC count	
105	266	110							376	1	Surface finds (90/110-120)
106	76			34					110	1	Surface finds (70/100)
165			112	286					398		Upper fill (of 4) of ditch [169]
217	2558	196	1614	596		104		y	5068	20	Upper fill (of 2) of post hole [219]
218	90	66	242	108					506	1	Lower fill (of 2) of post hole [219]
220			40						40		Possible rake out from industrial structure 180
242	4440		2188	820		226		y	7674	37	Upper fill (of 3) of pit [244]
243	666	92	358	336					1452	5	Middle fill (of 3) of pit [244]
245			6	10		124		y	140		Single fill of truncated pit or scoop [246]
247							y	y			Lower fill (of 3) of pit [244]
256			60						60		Single fill of post pit [257]
263	462		356	104					922	3	Fill of gully [264]
266	786		530		120				1436	9	Primary fill (of 3) of post pit [268]
275	396		140	140		110			786	3	Single fill of probable post hole [276]
277	270	140	550	134					1094	2	Single fill of possible linear [278]
289	862	422	716	642		552		y	3194	7	Single fill of possible post pit [290]
292	2040	118	128	112		74		y	2472	12	Fill of possible pit [293]
294		58	60			98			216		Fill of possible cut [295]
296	84			42		8		y	134	1	Single fill of drainage gully [297]
298	342		262	18					622	2	Single fill of post hole [299]
305				6		72		y	78		Upper fill (of 2) of pit-like or structural feature [307]
306		60	146	84		222		y	666		Primary fill (of 2) of pit-like or structural feature [307]
318			62						62		Upper fill (of 2) of probable oven or small furnace [321]
322	82								82	1	Upper fill of ditch [425]
333	58	38							96	1	Upper fill (of 2) of probable furnace [335]
334							y	y	28		Lower fill (of 2) of probable furnace [335]
399				6					6		5th fill (of 7) of ditch [425]
421			20						20		Single fill of curvilinear gully slot [422] / F418
432			226			20			250		Upper fill (of 2) of linear [434]
433			24	12		20			56		Lower fill (of 2) of linear [434]
446			24						24		Lens of charcoal-rich hearth waste dumped within ditch [425]
460	238								238	1	Single fill of pit-like feature [467]
Total	*13716*	*1300*	*7864*	*3490*	*120*	*1630*			*28306*	*107*	

Table 3: Comparison of the SHC weight-frequency distribution with that of other comparable sites.

a. medieval sites in Britain

Site:	**Exminster**	Worcester	Worcester	Prior Park Cricklade	Worcester Deansway	Worcester Deansway	Burton Dassett
		35 Mill St	Willow St	total	(period 8)	(period 9)	
Reference:	**this study**	Young 2009b	Young 2007	Young 2008b	McDonnell & Swiss 2004	McDonnell & Swiss 2004	McDonnell 1992
Age:		12th	12th	11th-15th	11th – 13th	13th-15th	14th- 15th
SHC count	**107**	23	28	17	61	32	60
SHC min. wt	**32**	74	86	156	168	144	130
SHC max. wt	**482**	782	770	794	1490	1800	1670
SHC mean wt	**127**	233	327	329	492	499	550
% <500g	**100%**	91%	82%	82%			
% <1000g	**100%**	100%	100%	100%			
% >1000g	**0%**	0%	0%	0%			
% >3000g	**0%**	0%	0%	0%			

b. medieval/post-medieval sites in Ireland

Site:	Moyveela	Ballykillaboy	Gorteens	Garryleagh	Clonmacnoise	Coolamurry
County:	Galway	Kilkenny	Kilkenny	Cork	Offaly	Wexford
Reference:	Young 2009c	Young 2010	Dabal & Young 2011	Young 2009d	Author's unpub. data	Young 2008a
Age:	17th-18th	16th-17th	17th-18th	13th-14th	medieval	12th-13th
SHC count	15	106	27	25	33	41
SHC min. wt	44	50	52	84	68	62
SHC max. wt	388	478	748	802	1457	2588
SHC mean wt	134	134	206	316	341	386
% <500g	100%	100%	93%	76%	79%	80%
% <1000g	100%	100%	100%	100%	94%	93%
% >1000g	0	0%	0%	0%	6%	5%
% >3000g	0	0%	0%	0%	0%	0%

c. Roman sites in Britain

Site:	Neath	Carmarthen	Bulmore	Caerleon Priory Field	Marsh Leys Farm	Cowbridge
Reference:	Young 2013	Crew 2003	Young 1999	Author's unpub. data	Young 2005 & 2011c	Barford 1996
SHC count	47	136	?	18	30	?
SHC min. wt	74	100	127	146	60	175
SHC max. wt	630	820	770	600	824	700
SHC mean wt	244	227	270	294	333	403
% <500g	89%	94%	?	83%	77%	?
% <1000g	100%	100%	100%	100%	100%	100%
% >1000g	0%	0%	0%	0%	0%	0%
% >3000g	0%	0%	0%	0%	0%	0%

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