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Evaluation of archaeometallurgical residues from N30 Moneytucker – Jamestown, sites 1, 4, 5 and 7 (04E0329, 04E0326, 04E0325 and 04E0323)

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Evaluation of archaeometallurgical residues from Moneytucker – Jamestown, sites 1, 4, 5 and 7 (04E0329, 04E0326, 04E0325 and 04E0323)

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Abstract

Site 1 yielded two examples of moderately-sized smithing hearth cakes. They derive from iron-working, but are not indicative of any particular age.

A sediment sample from site 4 was confirmed as an Fe-Mn pan deposit. Without chemical analysis the Fe:Mn ratio could not be confirmed, but the appearance suggested this was an Mn-rich pan, and therefore of no economic interest.

Sediment samples from Site 5 were investigated to evaluate their potential to answer particular questions raised by the excavation.

Site 7 produced a wide range of residues from blacksmithing, from three separate zones of the site. The northern area included a pit with rich blacksmithing microresidues, but very little slag. Adjacent to the pit was an area that may have been a dump from the forge, which yielded 10.3kg of slag. The south-western area contained a hearth, similar to that in the northern area, again with a very rich assemblage of smithing microresidues. The south-eastern area was larger and apparently comprised a dump yielding 14.6kg of picked macroscopic slag. Sieving of some of the dump's deposits at 5mm produced a further 10.6 kg of residues, sieving of some of the dump at 3mm and sieving of selected soil samples at 200µm indicated that there was also a very large quantity of blacksmithing microresidues in the dump. The collection of gridded samples was unfortunately not systematic enough reliably to detect systematic variations across the deposit, but the NE zone of the circular deposit seems to have the highest proportion of smithing fines, with the NE extension being gravelly and rich in macroscopic slags. Other features associated with the south-eastern area yielded a further 8.6kg of slag. Later and modern features produced a total of 5.9kg of slag, presumably derived from the earlier deposits.

The slags include over forty examples of smithing hearth cakes (SHCs) for which the original weight is preserved or can be estimated. 95% of the cakes for which an original weight can be measured or estimated weighed less than 1000g, with 83% being less than 500g. The dominance of small SHCs is unusual when compared with other well-studied Irish assemblages from early medieval and later contexts. This difference may indicate a difference in age between this assemblage and the others, or a limited range of task being undertaken on this site, or possibly a cultural difference, since small SHCs are the norm in Britain. The difference in the assemblage style is also marked by the absence of any certain tuyère fragments, which are almost ubiquitous on Irish post-early medieval iron working sites.

Contents

Methods

The submitted material comprised three grades of sample. For samples of macroscopic slag identification was made after inspection on a low-magnification binocular microscope. Individual pieces of slag were weighed and are listed in the catalogue (Tables 2 and 3). For the sieved samples of fine-grained slag residues and microresidues, these were also inspected using a binocular microscope, but only notes on overall sample composition are listed in the catalogue (Table 4). In addition, soil samples were processed by flotation to extract charcoal, followed by sieving at 200mm. The raw residues and magnetic separates were both examined by low-powered binocular microscope (Table 5).

Two soil samples were examined by X-Ray Diffraction (XRD) using a Philips Automated Powder Diffractometer, in the School of Earth, Ocean and Planetary Sciences, Cardiff University.

Site 1

Site 1 produced the remains of two, fairly large, smithing hearth cakes (Table 2). Neither cake was associated with other evidence from metalworking and neither showed hammerscale in attached concretionary material, so both appear to be isolated finds, indicating iron-working in the general area.

Find 16 weighed 422 and represented approximately 60-70% of the original SHC, which must have weighed approximately 650g therefore. Find 56 was small part of an SHC estimated to have been approximately 140mm in diameter and 55mm deep. By comparison with SHCs from other sites a cake of this size would be likely to weight between 750g and 1500g. The two cakes are typical of SHCs recovered from sites from the early christian period onwards, but are markedly larger than most of the material from Site 7 on this project.

Site 4

A soil sample from context 50 was examined at the request of the director to determine whether it might have had any economic significance. Although chemical analysis has not been undertaken for the evaluation, inspection suggests that this is a manganese-rich deposit, and therefore not of economic significance.

Site 5

Five soil samples (samples 29, 42, 43, 44 and 45) were submitted with the purposes of determining whether any evidence of firing temperature might be determined and secondly whether any usage information for the hearth deposits could be obtained.

To address the question of firing temperature two samples #42 and #43 were selected for investigation by X-Ray diffraction (XRD). The traces for the two samples are included at the rear of this report. The two traces are very similar, differing significantly only in the height and sharpness of several of the peaks for illite, which are much more marked in the unburnt material than the burnt. This is not likely to be a result of heating, but is much more likely to indicate a simple difference in original mineral content between the two samples. No other minerals were detected which might be useful temperature indicators.

Sub-samples from samples 42, 44 and 45 were processed in the same manner as the other bulk soil samples to be examined for metallurgical fines. No slag or hammerscale was observed, and the magnetic fraction of the fines was mainly burnt stone fragments.

Site 7

Results

Distribution

Data from Site 7 are presented in tables 1, 3, 4 and 5.

Slag was retrieved from several late or modern features, but this did not appear to differ from the material retrieved from earlier stratified contexts.

The majority of the slag from contexts interpreted as coeval with the metalworking activity was derived from the two large dumps (C15/26 and C56). These two contexts provided 38.8kg of the 53.4kg total assemblage. The two dumps were sampled in different ways, but the available evidence suggests their make-up was very similar.

Grid	unmarked	5mm	3mm	Total	Soil sample
I	158		82	240	
II	1160		234	1394	
III	144	76	52	272	
IV			244	244	Scale-rich
V	638			638	
VI	88	826		914	
VII	32			32	
VIII		1380	132	1512	
IX	23	758	66	847	
X				-	
XI				-	
XII	156			156	
XIII	30			30	
XIV				-	
XV	88	358		446	
XVI				-	
XVII	2064	820		2884	Scale-rich
XVIII	1107			1107	
XIX				-	
XX				-	
XXI				-	
XXII				-	
XXIII				-	
XXIV				-	gravel
XXV				-	
XXVI	18			18	
XXVII				-	
XXVIII				-	

Table 1. Weight of residue in g from the collections from the gridded parts of C56.

The southern dump, C56, was sampled in great detail (Tables 1, 3, 4, and 5), but it is not possible to produce a detailed robust analysis of distribution from the material because of a lack of uniformity in the sampling. The circular part of the keyhole-shaped deposit was subdivided into quadrants (A, B, C, D), the

two eastern of which (A, D) were each further divided into nine 0.5m grid squares (numbered I to IX and XX to XXVIII respectively). The NE directed extension of the feature (E) was also divided into ten 0.5m grid squares (numbered X to XX).

The collection of large bagged samples includes 5.42kg of slag from c56 SW (presumably meaning quadrant C) and 3.86kg from quadrant B. There is further 5.31kg of slag marked area D, possibly from the context in general (C56 lies in Area D of site 7) rather than from quadrant D.

The distribution of residues in the gridded samples from areas A, D and E (Table 1) shows a concentration of material in the central part of quadrant A grids ii, v, vi, viii and ix, with a second concentration in the "extension" E xvii and xviii. This conclusion is, of course, dependent on samples having actually been taken from all of the labelled grids.

If the material labelled area D is actually from quadrant D, then the grand total of material retained is Area A 6.1kg, Area B 3.86kg, Area C 5.42kg, Area D 5.33kg and Area E 4.62kg, which would suggest rather little variation. The soil samples, however, indicate that parts of Area D actually contained rather little slag or hammerscale, but were richer in charcoal than other parts of the deposit.

Other features in the area around the south-eastern metalworking area also yielded a considerable amount of residue, with 8.4kg of slag being retrieved from C77, the fill of the rectangular ditch C76. This context yielded 10 of the 41 SHCs for which total weight could be measured or estimated; there was no indication of particular abrasion to this material, so it is quite possible that this ditch, with its medieval pottery, is coeval with the iron-working. The ditch fill does appear to have bias towards larger pieces of slag, but this is often found in such situations, presumably because individual lumps of slag could be thrown into the feature, but the wholesale dumping of fines was not occurring.

Residue description

The slag content of the collection of larger specimens has a total weight of 38.2kg. Of this material the largest part comprises smithing hearth cakes (SHCs). 28 SHCs weighing 7.0kg are complete, with a further 14.7kg of certain SHC fragments. The original size of 41 SHCs can be measured or estimated. The SHCs have an original mean weight of 386g (range 62g – 2588g), with 83% of the SHCs weighing less than 500g. The SHCs are dominantly close to circular in plan. An SHC of average weight would have a diameter of approximately 90mm and thickness of 35-40mm. It must be remembered that the size distribution of the SHC assemblage is biased towards smaller examples (the average weight of intact SHCs is 250g), with larger cakes under-represented because they are more liable to fragmentation and more difficult to estimate an original size for from broken material.

The SHCs have a slightly concavo -convex shape in general, although a plano-convex shape is seen on some specimens. Many of the SHCs show some evidence for having been deformed on extraction, with twisting the most common effect.

In addition to certain SHC material, the macroscopic slag collection contains a further 13.1kg of slags which are indeterminate, but in practice much of this material will be small fragments of SHCs. Lining-dominated slags make up a further 3kg of the assemblage, together with just 0.4kg of lining material.

A total of 15.7kg of material was retrieved by sieving and the collection of the gridded samples undertaken by the excavators. A considerable quantity of very fine residue has been retrieved by sieving of soil samples during the preparation of this report.

This fine material can be divided into several classes:

- Comminuted slag debris
- Slag fines (flats, blisters, "coffee bean" spheroids)
- Hammerscale (flake and spheroidal)
- "Smithing floor"

It is not possible yet to quantify the proportions of these components.

Comminuted slag debris is common among coarser fractions of the fines. In some cases the material can be identified as debris from fractured SHCs, but more commonly an origin cannot be determined.

The slag fines (a term used here to identify a group of residues with an originally small particle size, excluding hammerscale) include material known as flats. These thin (<2mm) sheets of slag are probably mainly the result of slag dislodged from the smith's tools. The blistered and bubbly slag sheets may be related to the flats, but require further investigation. The coffee-bean spheroids (so-named because they frequently have a dimple, rather than being fully spherical) are probably the result of slag dripping through the fuel in the hearth.

Hammerscale includes flake hammerscale, which is the result of surface oxidation of the workpiece when hot, and spheroidal hammerscale, which is the result of the expulsion of slag droplets during fire welding.

"Smithing floor" is a term applied to the concretionary material formed during the alteration of the mixture of slag, hammerscale, charcoal and metallic iron, which often accumulates on the floor of the smithy. The term is retained here, although it seems likely that much of the material from Site 7 become concreted during reaction on the slag dump rather than on the smithy floor (although it is possible that the slag dumps recorded here are indeed smithy floors). In many cases the "smithing floor" lumps are the result of discontinuous cementation in a scale-rich deposit, by corrosion of the occasional pieces of metallic iron. Thus they may not necessarily differ significantly in origin from the uncemented hammerscale-rich soil.

Notes on the structural evidence

Site 7 provided evidence for three separate foci of iron-working activity. In the northern part of the site the principal feature was a pit (C27) 1 x 0.9m and 0.2m deep. The fill (C14) was apparently rather variable with lenses of clay (some burnt). The supplied bulk soil sample (Table 5) contains a very high proportion of hammerscale.

In the south-western metalworking area a similar pit (C59) was 0.92 x 0.82m and 0.30m deep. It had a heterogeneous fill, including sterile clay and dark layers rich in iron and charcoal. The supplied bulk soil sample was from one of the upper dark fills (C63) and was an incredibly rich deposit of hammerscale. The sides of the feature were cut by a series of stakeholes.

In the south-eastern metalworking area a similar shallow pit (C100), 1.2 x 0.8m, was amongst features found beneath the spread of iron-working debris (C56).

These three features are similar enough to be suggested to have had the same function. It is important not to confuse the evidence from feature disuse with that from use, and the contexts descriptions are not sufficient to distinguish these in some instances. For instance, the sterile clay layers found in two of these features might be interpreted as re-linings, but equivalently might simply be clay washed in from a degrading wattle and daub surround (as evidenced by the stakeholes in C59) on abandonment of the feature.

It is significant that none of these shallow pits produced any significant quantity of macroscopic slags. It would not be expected that the smith would have tolerated large pieces of debris to remain in a hearth, even if the ashy material in the hearth base was rich in scale.

The three features are approximately the same size as the base of a modern smithy forge, and may well have performed a broadly similar task. In a smithy fire of this sort the forge hearth provides a container within which, or upon which, the active fire is formed, but does not itself form the boundary to the fire. In a modern side-blast forge the tuyère intrudes into the hearth on one side, and all sides of the hearth are kept fairly cool. In some early forge hearths there was no tuyère, and the hearth surround acts to divide the fire from the bellows. In this case, the blast enters the fire not through a tuyère, but through a blowhole and so the hearth surround is exposed to high temperatures in this area, although other parts of the surround may stay cool.

This site has produced no evidence for tuyères and it seems likely that it employed a blowhole to ventilate the fire. The limited area over which the ceramic of the hearth surround would have been raised to firing temperature explains the paucity of vitrified ceramic material.

There is, however, an alternative, although probably les-likely, explanation for large shallow pits within the iron working sites, and that is as the remains of anvil bases. Although evidence for the nature of anvil structures has not yet been determined archaeological in Ireland, in most European areas early anvils (indeed modern ones too!) are iron objects attached to large wooden bases. The complex stratigraphy of pit C59 probably argues against its interpretation as an anvil base. These two alternative interpretations of the structures should be distinguishable by examination of the associated microresidues, for hearths accumulate droplets of slag and other melted or semi-melted residues, whereas the areas around anvils would be dominated purely by hammerscale.

These three probable hearth features are associated with deposits of slag-rich material: C27 has the spread C15/26 just to its east, C100 was overlain by deposit C56. These deposits are rich in macro-residues, as well as microresidues, and are therefore likely to be the dumps of material cleaned from the forge (both from the fire and the sweepings from the floor). The complete suite of residue present would argue that these are primary deposits.

The smaller features associated with the metalworking areas are harder to interpret. Burnt stakeholes occur close to the WNW side of the presumed hearth in both the northern (where the stokehole is 0.5m from the hearth and 0.14m in diameter; C21) and south-western (where the stakehole is 0.35m from the hearth; C43) metalworking areas. These stakeholes are hard to interpret. At 0.14m in diameter they are too small for an anvil base. They might be associated with support for bellows, in which case the burning might be coincidence. It is also possible that they represent a hole in the smithy floor where the smith placed or cooled his tools.

It is unfortunate that the level of truncation has removed any evidence for structures enclosing the metalworking areas. The evidence that does survive is sporadic, in the form of mainly isolated stake- and post- holes.

Interpretation

The assemblage, as described above has several key features:

1. The SHCs are small. They differ markedly from the assemblages of SHCs recovered recently on Irish iron working sites of Early Christian and Medieval age. The size distribution is similar to that recorded on smithing sites of broad range of ages in Britain and Europe (Crew 1996).

2. The assemblages contain small pieces of vitrified hearth ceramic material, but none of this can be positively identified as deriving from tuyères. This is in contrast to other Irish sites of Early Christian and Medieval age where tuyère debris is relatively abundant (Clonmacnoise: 1.7kg of tuyère to 48kg smithing slag, Young 2005b; Clonfad: 18kg tuyère to 903kg macroscopic smithing assemblage, pers. obs; Ballykilmore: 48kg tuyère to 55kg smithing slag, pers. obs.)

3. The pit features forming a key component of each of the three metalworking areas within the site are broadly similar and it seems reasonable to interpret them as hearths. They appear to functionally close to the hearth base in a modern forge.

4. The northern metalworking hearth has a closely associated area of dump (C15/26) which yielded 10kg of macroscopic slag resides. No soil samples were submitted from this dump, but residues from sieving at 3mm by the excavators show that it contained smithing fines in addition to the larger pieces. The south-western metalworking area has no associated dump surviving, but that in the southeast overlies hearth C100 and thus cannot (unless being partially reworked) represent just the waste from hearth C100. This large dump (C56) yielded at least 28kg of macroscopic slag. Soil samples from C56 show that the dump contained large quantities of smithing fines too.

5. It is hard to evaluate the scale of working, for it is likely that much of the residue from the iron-working is not preserved. At a very simple level one could estimate the minimum amount of activity represented by looking at the total slag weight.In this case the total amoutn of mcroscopic slag is estimated to be approximately 54kg. If this had been present entirely as average-sized SHCs, then there would have been 140 SHCs, with each likely to have been produced during a days work. However, this is certain to be an absolute minimum.

It would appear likely (subject to confirmation by more detailed investigation) that the two groups of assemblages are complementary, with the probable hearths containing the fine grained residues which accumulated in the hearth base, and the dumps containing the coarse grained material from cleaning out the hearths, together with fine grained material both from hearth cleaning and possibly from floor sweeping.

Evaluation of potential

The assemblage from Site 7 provides a remarkably complete suite of materials, with the hearth fills and the adjacent dumps providing good collections of macroscopic slags, but also the smithing fines. The site itself is extremely simple, so the iron-working residues have not been dispersed into other deposits. The impression is given that the residue assemblage is about as representative as is ever likely to be the case. On most iron-working sites the assemblages are not complete; the fines are often not present, or not recovered on excavated iron working sites or at best a small fines assemblage is recovered from the hearth. This site offers the opportunity of improving understanding the relationship between the fines and the macroscopic slag residues.

That relationship is all the more significant on this site, because the limited range of SHC size means that the processes undertaken may be rather fewer than on sites with a wide range of SHC sizes and morphologies, and thus the different grades of residue can be linked together more confidently.

The assemblage is also important for the major differences between this and other recently-investigated assemblages. As already discussed, the significance of those differences will not be apparent until Site 7 has some radiometric dates. What is clear is that describing, characterising and furthering understanding of this particular style of metalworking will be complimentary to the work currently being undertaken on Early Christian and Medieval technologies as evidenced on other sites.

This material has the potential to enhance understanding of the development of iron-working techniques and technology in Ireland.

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Table 2. Metallurgical residues from Site 1.

context	*find*	*find note*	*total wt* (g)	*description*
1604	16	area 3-4	422	Single SHC, proximal end broken off, probably leaving 60-70% of cake, lower surface smoothish and very regular, top covered by concretion of gravel with no hammerscale or slag, below concretion is a charcoal-covered top.
831	56	area 1/2 4m NE of other ditch 597	394	Part of single SHC broken in 3. Original size hard to judge; probably c140mm diameter, 55mm deep, crust 30mm thick in centre. Fairly vesicular with some vertical tubular vesicles. Lower surface dimpled, upper shows concentric raised ridges of friable, charcoal-rich material.

Table 3 Metallurgical residues from Site 7, listed by bag

context	sample	find	find note	number	total wt (g)	description
Modern/late features				***total***	***5852***	
10				1	315	SHC fragment, base incorporates lots of shale gravel. Top shows a little black surface but otherwise this material is pale grey
				1	352	another similar very dense SHC weathered entirely pale grey, base of this one smoothish and vesicular, top smooth blown
				1	160	SHC fragment with preservation as two above, it has fallen lining on top surface with red fired clay and a small pebble, base vesicular as example above
				2	50	fragments of material as above
					877	very odd preservation to this material!
10				4	28	vitrified lining
				2	44	lining slag balls
				8	176	assorted dense slag fragments, mainly smoothed and concreted
					248	
10				1	126	small part of large SHC, base rather prilly, appears smooth but has ridge of lining slag stuck on, crust 25mm thick, probably rather deformed on extraction
				6	18	vitrified lining
				1	54	lobe of well flowed material penetrating into all, probably from burr region.
				2	78	small SHC fragments - probably from very small cakes
				1	50	worn very weathered SHC fragment with thick crust
				1	68	crudely flow lobed dense slag with dimpled lower surface
				15	178	various assorted indeterminate iron slags
					572	curious white weathering/coating
29				1	754	wide dense SHC, slightly dished smooth top, base slightly microprilly 120x110x45mm
				1	42	vitrified lining
				2	26	small weathered rounded slag nubs
				1	522	slightly incomplete double layer SHC, 110x70x80mm. Lower cake 90mm diameter, 25mm thick ,upper incomplete
					1344	
30				1	550	perfect SHC. 115x100x30mm, blown hollow top, base finely dimpled with some slight tool marks
				1	300	probably 60% of small SHC highly concreted top, base finely dimpled - cake probably very similar to above
				3	330	SHC fragments
				1	14	lining slag ball
				4	130	irregular dense slag fragments
					1324	
58				8	248	concretion; one piece probably a nail?
				1	1035	probably about 40% of thick crust SHC, approximately 180x140x70mm is best guess for original size, crust 35mm thick in centre, smooth top flown edge, no filling, heavily concreted
					1283	

Table 3 (contd.)

context	sample	find	find note	number	total wt (g)	description
Northern metalworking area						
c27 - circular feature 1 x 0.9m x 0.2 deep, filled by c14. Has burnt stake hole 0.14 diameter, 0.5 to NE (c21) and posthole c17 filled with c16 to north						
				total	***2012***	
14 ex27				29	288	smithing floor with flake and some spheroidal hammerscale, slag and charcoal in abundance
				5	68	dense SHC fragments
				6	22	lining slags
				6	16	fired and vitrified lining
				2	8	light blebby, almost flown, lining dominated slag
					402	
14				7	100	vitrified lining
14					***1510***	(total of sieved residues - see table 4)
area to NE may be dump (C15=26)				***total***	***10280***	
15				80	722	various assorted indeterminate iron slags
				24	186	lining and lining slags
				3	6	flown prill and 2 subspherical blebs
				3	12	rusty concretionary slags
				1	142	70x50x25mm very dense small SHC with smooth dished maroon top, lower face finely dimpled
				1	64	tongue of slag probably small SHC, smooth maroon flat top, finely but deeply dimpled base
					1132	
15				103	2186	various assorted indeterminate iron slags
				20	216	lining slag
				4	24	dense prilly horizontal flows
				1	78	Slag tongue 95x50x15mm lining slag on top, dimpled underneath, look as if formed in inclined position
				2	52	concretionary material
				15	816	pieces of thinnish crust, folded, presumably deformed on extraction, none a complete piece
				1	218	c45% of dense open bowl shaped SHC with linear bit protruding at top on one side, crust c 10mm thick uniformly, probably originally c100mm diameter and 35mm deep
				1	132	probably a complete small, deformed SHC 70x50x40mm smoothish top, well dimpled base
				1	206	thick crust SHC fragment, crust to 28mm, tubular vesicles, top with free crystals. Estimated to be from cake c 140mm across, 40mm deep
				1	200	probably c 60-70% of dense SHC, specimen rather worn, base appears v slightly dimpled, top probably smooth
				5	326	pieces from fairly small SHCs
				1	92	c40% of SHC with dimpled base, c80mm diameter, top with additional 15mm of localised rather rough material
				6	360	small pieces of SHCs with thick crusts (I.e.>20mm thick), one of these is 66g piece from almost identical cake to the 92g piece above.
					4906	

Table 3 (contd.)

context	sample	find	find note	number	total wt (g)	description
15				2	122	SHC fragments, 1 from v small one from larger cakes
				3	12	vitrified lining
				15	84	lining slag blebs and balls
				99	896	irregular dense slags in various nubs and fragments
					1114	
15				1	290	complete SHC, slightly dished smooth top, edges slightly flowed, then dimpled zone, but most of base is charcoal rich, top slightly irregular 80x80x35mm
				1	276	90x80x25mm SHC, smooth top (mostly masked by concreted material) base rather irregular with some charcoal; some dimpled concreted material may be collapsed wall, layer of charcoal sealed between two, top smooth but irregular
				1	324	2 pieces probably from same thick crust SHC, base micro dimpled smooth and hard, crust has maximum thickness of 40mm, relatively few vesicles, top has free crystals, very small part of big cake
				6	714	SHC fragments, range from pieces similar to first two, to a piece with a 22mm crust
				5	82	lining slag lumps
				8	172	miscellaneous dense slag nubs, lobes and fragments
					1858	
15				8	136	lining slags
				1	8	lining
				6	348	SHC fragments, better bits show dimpled bases
				43	778	assorted indeterminate dense slags
					1270	
26 (total of sieved residues - see table 4)					***126***	

Table 3 (contd.)

context	sample	find	find note	number	total wt (g)	description
Metalworking area 2						
c59 - circular bowl 0.92 x 0.82m x 0.3m in depth, filled with c60, 61, 62, 63, 44. Has burnt stake hole 0.35m from edge, c43.						
no macroscopic slag samples						
	63				***148***	(total of sieved residues - see table 4)
SE Metalworking area						
burnt deposit c56 overlies bowl 100 (1.2 x 0.8m), bowl 101 (0.85 x 0.3) and a line of stake holes						
				total	***28521***	
	56	area B		6	66	vitrified lining fragments
				22	288	vitrified deformed, lobate material from lining slags
				6	42	dense slag prills, probably mainly horizontal flows
				2	46	fragments from crust of dense slag cake, base microlobate, not very vesicular
				10	188	charcoal rich rusty irregular slags with some concretion. Both flake and spheroidal hammerscale seen
				35	884	denser lobate slags, all very irregular hearth slags, some show development of prills
				1	140	possible deformed small concavo-convex SHC - looks broken and twisted on extraction, originally 70x70x20, top smooth, bottom charcoal rich
				1	62	irregular disk of lining slag - possibly an Fe-poor SHC
				1	68	approx half of small bowl-shaped SHC, 65mm diameter x 30mm deep
				1	52	possible very irregular SHC fragment
				1	48	small piece from small SHC, rough base, smoothish maroon top, c65mm diameter and 20mm deep
					1884	
	56	area B		30	498	irregular to lobate dense slags
				32	306	irregular but generally lobate to slightly prilly lining slags
				1	12	oxidised lining fragment
				5	104	extremely dense lobate slag flow - looks like tap slag but generally only one lobe thick
				13	214	irregular fragments of charcoal bearing rusty grey slag - charcoal generally fine and one case straw-like
					1134	also 5 stones weighing 36g
	56	area B			50	fine debris
				9	8	lining fragments
				14	116	dense flowed material, mainly heavily fragmented poor flows
				12	108	rusty material, mainly rich in fine organics
				36	420	irregular, mainly slightly lobate material, formed of moderately dense slag,
				33	140	irregular, mainly slightly lobate material, formed of low density lining slag
					842	also 6=214g stones

Table 3 (contd.)

context	sample	find	find note	number	total wt (g)	description
56		SW		1	148	probably 80% of small SHC, rather folded, excellent mineralised organics on base including bracken, 60x80x25mm (proximal end gone), top smooth, base smooth but covered by accreted impregnated organics
				1	404	85x88x40mm, very neat SHC, slightly dished smooth top, base very regular microdimpled, cake very nearly circular
				1	194	small SHC with lots of accreted debris, nearly circular dished cake approx. 80mm diameter
				3	292	irregular dense slag pieces probably from SHCs
				10	1210	fragments of SHCs, all probably fairly small as those above
				1	42	tiny cake, possibly a SHC
				1	170	approximately half of an SHC with an organic coated base, top with very marked charcoal dimples and points, approx 90mm diameter, 30mm deep of which crust is 17mm in the centre and thinning to edges
				1	202	small piece from presumably big SHC, 50mm thick of which 30mm crust, approx 50x50mm
				1	200	double layer SHC with abundant charcoal and vesicles, upper part c 70mm diameter, lower on one side only, total 50mm thick
				10	216	irregular pieces of rounded lining slag
				1	138	lining dominated probable shc, v irregular
				1	82	lining dominated irregular lump possible shc
				3	214	SHC-related slags with deeply charcoal dimpled bases (almost prilly)
				4	256	irregular probably slightly flowed flattened pats of dense slag
				10	226	irregular fragments of dense slag
				1	8	oxidised lining
					4002	
56		SW		1	90	possibly corroded tiny SHC, 60x50x25mm, smooth top dimpled base
				44	596	indeterminate iron slag fragments
				2	36	lining
				14	94	fragments and nubs of lining slag
				1	10	slagged pebble fragment
				8	590	SHC fragments
					1416	
56				1	***18***	well lobed horizontal flow of dense slag
56		area d	3 of 3	8	436	irregular but generally rather lobed slab like masses with mainly Fe-rich dense below and lining dominant above
				7	416	irregular slags, dominantly dense
				10	532	dense, fragments including a crust
				3	122	lining slags
				3	54	concretionary
				2	60	dense slags with very strong dimples/microprills
				1	196	extremely irregular SHC, blown upper sheet 80x60x20mm with prilly base, on lower cake with microprilly/dimpled base 80x40x30mm - not clear but probably a double-layer cake. The 436g category above contains several flaps rather like the upper cake.
				1	344	very irregular cake with prilly base, upper part and margins broken
					2160	

Table 3 (contd.)

context	sample	find	find note	number	total wt (g)	description
56		area d	2 of 3	26	484	irregular dense smithing hearth slags
				3	38	vitrified lining
				6	90	lining slag lumps
				2	84	heavily concreted material
				1	22	flown slag lobe
				6	206	dense fragments including a crust
				1	210	dished SHC with smooth top and finely deeply dimpled base 80x105x30
				1	168	small SHC greatly deformed on extraction, cut in half with lots of flowage
				1	142	small SHC with deeply dimpled base and extreme charcoal lobes/dimples on top 75x60x25mm with further 25mm of lobes on top
				1	100	60x65x25mm smooth topped SHC with fines dimpled base with up to 15mm of amorphous material stuck to top - very neat cake
				1	280	approx 60%? of SHC cut in half on extraction .smooth blown top, bowl shaped probably approx 120mm diameter 30mm deep, cake only 7mm thick in centre- thicken at edges
				1	120	irregular prilly mass, probably a poorly formed SHC, but may be missing its top
					1944	
56		area D		95	872	irregular dense slags
				3	110	SHC fragment
				2	26	concretion around artefacts?
				19	108	concretionary material
				17	84	lining slag blebs
				2	4	dense slag flowed material
					1204	
56					***13917***	(total of sieved residues - see table 4)

Features associated with SE metalworking area

				total	***8834***	
48				6	204	dense slags of various types with 1 SHC fragment, concreted surface with organics and in one case hammerscale
66				1	110	thin dense slab - probably a broken part of small SHC, concreted material is very rich in hammerscale, both flake and scale, as well as small pieces of broken slag.
				1	94	very irregularly lobate small sub b/h slag. Some lobes dense some more lining dominated 60x65x30mm
					204	

Table 3 (contd.)

context	sample	find	find note	number	total wt (g)	description
77				2	40	lining
				18	630	lining slags, some of the largest have denser iron rich parts - so these are mixed hearth slags
				1	128	small dish-shaped SHC, probably c80% c60x90x28mm
				1	98	contorted lining rich slag - probably a low density SHC
				1	460	small piece of large thick crust SHC, crust 30mm in centre, base with irregular tool marks, top smooth, has small puddle of black sediment rich glass in centre of smooth dished top. Probably less than 30% of whole.
				28	794	amorphous pieces and nubs of dense slag, all slightly to moderately concreted
				1	156	small piece of basal angle of "thin crust" granular to microprilly SHC. Side at 80 deg to base. What crust there is has maximum thickness of 5mm. Internally lots of fine charcoal
				6	662	various SHC fragments, most standard type, one is more prilly internal like example above
					2968	
77				1	456	very curious triangular SHC, probably pinched up on extraction, main part 50x130x55mm with tongue extending distally at top
				1	320	incomplete, probably deformed SHC, base slightly prilly as example above
				1	268	small SHC with heavy concretion of material rich in organics, 80x114x40mm, smooth top
				1	126	broken piece of complex and probably deformed SHC
				1	110	lobate slab of lining slag with concretion attached
				7	60	vitrified lining
				1	20	lining slag nub
				39	608	irregular pieces of dense slag - many heavily concreted
					1968	
77				1	344	pyramidal granular to finely prilly slag SHC. Highly rusted and exploding protrusion on the top - suggestive of an adhering iron piece. Ignoring protrusion cake is 60x75x55mm, protrusion adds another 20mm
				1	162	small SHC - or part SHC, very charcoal-rich 80x60x45mm, base smooth to microdimpled with tool (or fold?) mark
				4	96	lining and lining slag
				4	106	indeterminate dense slags
					708	
77				1	18	piece of iron bar,38 wide, 5 thick, 1 edge perpendicular, 1 cut oblique - so 13 long one side and 18 the other, bar margins appear to thin slightly
				1	938	double SHC, lower one 65x85x35mm, upper 100x110x50mm, both appear to have smooth blown tops and be dense. Lower surfaces partly microprilly, partly adhering charcoal-rich, minimal contact of cakes, all rather corroded
				1	554	probably c80% of dense wide SHC, 100x100x45mm, smooth blown top, lower probably microprilly but corroded
				1	362	100x75x45mm, most of small dense SHC, but edges knocked off, top very smooth, dished, base, microprilly/microdimpled
				1	270	large part of dense SHC, probably originally 100x120x45mm, crust 35mm or more in centre, just very thin vesicular material on top where not blown
				1	140	smithing hearth slag in form of irregular ball
				8	338	various pieces of dense smithing slag
				8	126	lining slags and small lining fragments
					2746	

Table 3 (contd.)

context	sample	find	find note	number	total wt (g)	description
77 (fired clay)				12	28	vitrified oxidised lining
				1	8	probable corroded nail c15x12mm head, 20mm long shank
					36	

Table 4 Metallurgical resides from site 7: gridded / sieved samples

context	weight	grid	bag label	notes
gridded samples of uncertain processing				
56	158	a i	slag	mainly large lumps of floor around shc fragments, also a few very angular flat prills and a couple of spheroids (large)
56	1160	a ii	slag	158 moderately dense slags; 2g 7 "coffee bean" spheroids; 12g dense prills; 18g flats; 20 bubbly flat fragments; 16g small stones; 884g smithing floor
56	144	a iii	slag	mainly smithing floor; 2 isolated "coffee bean" spheroids; 1 flat fragment and one small piece with flowed prills
56	638	a v	slag	small pieces of floor; some slag prills and blebs; lots of broken bubbly flat material; plenty of flats; some corroded iron metal - mainly as sheet
56	24	vi	slag	flat pieces of slag/scale/flat and abundant spheroids
56	64	vi	slag	amorphous fragments of floor and slag, some poor flats and bubbles
56	34	vii	slag	ashy lumps of floor material - looks as if fine matrix would have been very hammerscale-rich
56	1	ix	slag	flat pieces of slag/scale/flat and abundant spheroids
56	22	ix	vit clay	amorphous bits, couple of poor spheroids and a fragment of flat
56	1035	c	slag	26g stone; 11.2g 8 flats; 70g broken slag lump; 76g small slag pieces; many highly porous flowed slags; rest is good smithing floor
56	258	c	s14 slag	1.35g 4 coffee bean spheroids; also 4 spheroidal hammerscale; 29.3g 6 small pieces of smashed shc; 11.6g 6 other small pieces of prilly or lobate slags; rest smithing floor, with one tiny lining fragment
56	232	c	baked clay	fine debris of fired clay and ash with charcoal. 1 strongly vitrified lining/tuyère fragment with rich green glaze
56	286	c	baked clay natural s14	72g fired clay; 44g 3 pieces vesicular slag; 22g 3 slagged lining; 114g stones; 8g worn dense slag nub
56	18.1	d xxvi	slag	poor concreted slag in small pieces; about half of this stone
56	156	e xii		4 pieces of charcoal-rich floor, probably concreted around iron; a rectangular cross-section of iron, like a nail shank, was seen in one piece
56	30	xiii	slag	lots of rather amorphous looking debris, a few poor spheroids
56	88	xv	slag	moderately abundant spheroids and flat material, but dominated by more amorphous material
56	12	xvii	slag vit clay	amorphous material and small flat fragments
56	766	e xvii	vitrified clay	230g 50-60% of small shc; 168g shc frag; 106g 4 other slag lumps; remainder is smithing floor material
56	30	e xvii	slag	very small slag and smithing floor particles
56	814	e xvii	vit clay/slag	22g stone; remainder is lumps of concreted smithing floor, charcoal rich, with some straw, but only small slag pieces
56	512	e xvii		164g gravel; rest is small smithing floor fragments, including 1 small flow lobe frag
56	518	e xvii	vitrified clay	17g of low density dimpled lobes, remainder charcoal-rich smithing floor
56	26	e xvii	slag	lots of rather amorphous looking debris
56	546	e xviii		gravel with ashy clay matrix. Does contain some spheroidal + flake hammerscale, but only tiny slag pieces and almost no concretionary floor
56	560	e xviii	vitrified clay	74g stone; 266g 2 pieces of thin shc in clay floor; rest small slag pieces in clay-rich smithing floor, including one piece of vitrified clay wall
56	1	xviii	slag	bubbly, prill, floor and flake hammerscale

Table 4 (contd.)

context	weight	grid	bag label	notes
sieved slag samples (5mm)				
56	76	a iii	slag 5mm	slag fragments, bubbles, burnt stones, flats blebs
56	826	a vi	5mm	about 80g of small slag pieces (including 3 "coffee bean" spheroids and 2 flats) - rest is gravel. No smithing floor
56	1380	a viii	slag 5mm	4 substantial pieces of shc; lots of smithing slag; several slagged and melted stones; finer material includes small prills and "coffee bean" spheroids. Several pieces of smithing floor with iron inclusions - 1? Nail head, but two others appear more sheet-like
56	728	d ix	slag 5mm	466g 50% of large shc, dense; 60g smithing slag lump; 4.45g 20 "coffee-bean" spheroids; 25.5g flowed slag pieces, some dense; remainder smithing floor debris
56	786	xiii	slag 5mm	106g 5 small pieces of dense slag; 60g irregular slab of lining slag; 46g 16 pieces of low density nubs and blebs; remainder smithing floor
56	358	e xv	slag 5mm	dark smithing floor rich in slag and scale, but not charcoal and very rich in spheroidal hammerscale; 14g irregular slag nub
56	820	e xvii	slag 5mm	brown fine ashy detritus with lots of scale (subsequently processed with soil samples, see Table 5)
sieved slag samples (3mm)				
56	80	a I	slag 3mm	amorphous material with some flats
56	2	a I	slag 3mm	rather amorphous looking debris
56	234	a ii	slag 3mm	flat pieces of slag/scale/flat and abundant spheroids
56	52	a iii	slag 3mm	flat pieces of slag/scale/flat and abundant spheroids
56	244	a v	slag 3mm	flat pieces of slag/scale/flat and abundant spheroids
56	132	viii	slag 3mm	flat pieces of slag/scale/flat and abundant spheroids
56	66	a ix	slag 3mm	flat pieces of slag/scale/flat and abundant spheroids
14	1050		slag 5mm	7.32g 24 spheroids; 14.4g 32 pieces of flat; 3g pieces of lining slag; remainder smithing floor, amorphous slag and broken bubbly slags. Almost no stone - very rich smithing assemblage.
14	460		s#18, slag 3mm	fantastic assemblage of spheroids (coffee beans) and coarse flake hammerscale
	1510			
63	76	5mm?	s#9 slag	some flats and spheroids but mainly amorphous slag fragments, also glazed pebble and lining fragment
63	72		s#9 slag	flat pieces of slag/scale/flat and abundant spheroids, very rich in scale
	148			
26	126		s#10 slag 3mm	flat pieces of slag/scale/flat and abundant spheroids, flat material more abundant than spheroids?

Table 5. Summary of processing of soil samples

Context	*Grid*	*Sample Notes*	*Sample weight*	*Charcoal notes*	*>200µm sample weight*	*Residue notes*
C56	A IV	somewhat clayey, produced a little bit of charcoal in float, but more seems to be present in residue	8.5kg	a picked sample of 12g a flotation sample of 44g	4.85 kg	Residue very rich in scale. Also some sand/gravel
C56	D XXIV	This was a very charcoal-rich sample	11kg	a flotation sample of 360g	1.20 kg	Residue gravelly, with little slag debris
C56	CI	Very clay rich	11.5kg	very little flot picked large charcoal pieces from slag, 6g	5.32 kg	Residue very rich in scale. Also some sand/gravel
C56	E	lots of slag lumps in clay	7.4kg	no flot at all	4.71 kg	lots of sand and gravel – but v rich in scale; includes small SHC, and other fragments
C56	E XVII	washed sample taken from slag collection not soil samples		a flotation sample of 10g	516 g	Residue gravelly, with little slag debris. Lots of flake hammerscale but masked by non-slag material
C63	*N/a*		9kg	little flot, but did yield possible blackberry pips	3.41 kg	Residue almost pure scale
C14	*N/a*		c8kg	lots of charcoal: a flotation sample of 260g 1g sample picked from slag	3.19 kg	Very scale-rich residue, has some stone and gravel

Table 6. summary statistics of SHC weight, with comparison with other sites

	<500	*<1000*	*>1000*	*<3000*	*Max wt (g)*	*n*	*Mean wt (g)*	
Moneytucker Site7	**83%**	**95%**	**5%**	**100%**	**2588**	**41**	**386**	**1533, 2588 are outliers**
Ballykilmore	43%	69%	31%	89%	4033	35	1099	Post-Medieval?
Clonfad	30%	65%	35%	92%	11000	375	1177	Early Christian
Clonmacnoise	39%	68%	32%	92%	5540	38	1087	Early Christian
Marsh Leys Farm	77%	100%	0%	100%	824	30	333	A Roman site in the English East Midlands, typical of the waste products from an early smithy (Young 2005a)

Table 1 provides summary statistics of the size of SHCs at Site 7. Comparative data are provided from the author's unpublished work at three Irish sites, for which the SHC size distribution is very different, and one Romano-British site with a rather more similar SHC size distribution (although lacking the large outlying SHCs).

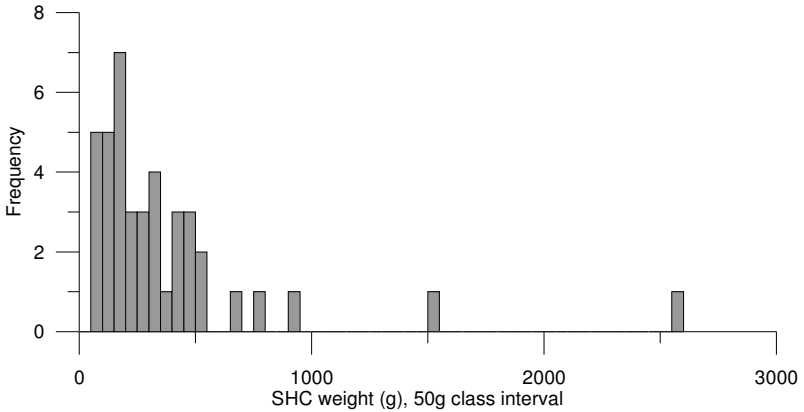

Figure 1. distribution of SHCs by weight, 50g class interval

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