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Evaluation of archaeometallurgical residues from Calstock 2011

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Abstract

The examined residues came from two locations – Trench C, a cutting through the large Roman military enclosure ditch and Trench D. Both trenches produced residues from iron-working (smithing), but the two sets of assemblages differed somewhat in character.

The macroscopic materials from Trench C included hearth ceramics, fuel ash slags, lining slags, vitrified stones and some small, low-density smithing hearth cakes (SHCs). In some instances, the residues were accompanied by small concretions containing iron objects, most of which appear to be small nails, including possible hobnails. The microresidues included smithing residues (hammerscale, mainly flake hammerscale, slag flats, slag droplets and small slag debris), but did not appear particularly abundant.

Trench D provided rich assemblages of smithing waste, including fragments from relatively large, dense SHCs. The SHCs were accompanied by abundant iron-bearing concretions, largely formed of hammerscale. The most likely interpretation is that concretions formed in-situ *and this suggests that the deposit as a whole was extraordinarily rich in hammerscale.*

The two sets of smithing debris therefore suggest two different styles of activity. That represented by the material from Trench C was smithing that entailed a low iron-loss – for instance potentially compatible with the manufacture of the nails found with the residues. The activity represented by the residues in Trench D was probably more intense and entailed a greater loss of iron to the slag – perhaps indicating a higher use of welding and other high temperature techniques. Although some of the SHCs from Trench D were originally relatively large, they still fell within the known weight range of blacksmithing SHCs from Roman and earlier medieval sites.

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Methods

All materials were examined visually, with a low-powered binocular microscope where required. As an evaluation, the materials were not subjected to any high-magnification optical inspection, nor 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 undertaken for Dr Chris Smart of Exeter University.

Results

The summary catalogue of the submitted materials is presented in Table 1.

The material was mainly from the 2011 excavations, but there were also a few small bags of sieved residues from earlier work. These all came from contexts from which samples had been examined at an earlier stage in assessment of material from the site (Young 2011a). These samples were all similar to previous materials from the same contexts, but in general showed fewer archaeometallurgical residues; it

is possible they represent residues from which some of the earlier material had been extracted magnetically. Since these materials add no further understanding to the site, they will not be discussed further here.

Collections from samples from the 2011 excavations are summarised in Table 2. Archaeometallurgical residues were recovered from contexts 4010, 4911, 4014, 4032, 4033, 4048, 4069, and 4077 in Trench 'C'; a few other contexts yielded fired clay not certainly of archaeometallurgical origin. Trench 'D' yielded archaeometallurgical residues from contexts 4512 and 4520.

The materials from Trench 'C' included low levels of hammerscale and other forms of microresidues from iron-working. Contexts 4014, 4032 and 4048 produced reasonably good assemblages of such residues. Macroscopic residues from this trench included a moderate amount of fired and vitrified ceramic hearth materials (principally contexts 4010, 4011, 4032, 4077). Examples of small low-density smithing hearth cakes (SHCs) were recovered from each of contexts 4011 and 4033 (together with a small fragment of second similar example). The SHCs weighed between 70 and 80g each.

Several contexts (4014, 4033, 4048) produced small concretions containing corroded iron. In some cases (although proper radiographic examination would also be desirable) these appear to contain nails with thin shanks and also hobnails.

In addition to the archaeometallurgical fired clays, which were typically coarsely tempered with slate and other rock fragments, there were fired clays with little coarse inorganic temper, but with voids indicative of moulds after organic temper, possibly straw (since in at least one example they showed a strongly striated surface). These materials may be fired clay from non-metallurgical structures.

A lesser amount of material was available for inspection from Trench 'D' – with fine sieved residues from c4512 and macroscopic residues from c4520. These materials were, however, rich in archaeometallurgical residues, both micro- and macro-scopic. The macroscopic residues included several fragments from dense SHCs, with the largest fragment indicative of an original SHC of between 550 and 800g.

Much of the material from Trench 'D' c4520 was material that is commonly described as 'smithing floor'. This need not necessarily be actually from a floor, but represents an accumulation of smithing fines (hammerscale, flats, slag droplets, charcoal, slag fragments...) that has been cemented by the redistribution of iron from corroding iron particles to form secondary iron minerals. Such materials may form a continuous concretion on working floors or within waste disposal features, but may also form discontinuous concretions around the iron particles. In this case, the latter scenario seems likely and c4520 may be a context extraordinarily rich in hammerscale that has just cemented into 'smithing floor' in the areas surrounding larger fragments of iron. In no case was the nature or form of the iron determinable here.

Interpretation

In both trenches 'C' and 'D' the archaeometallurgical residues are indicative of iron-working (smithing), but are very different in style.

The residues from Trench 'D' are suggestive of being either the major location of waste disposal from a smithy, or part of the smithy itself. The SHCs are dense and well-formed and the single example for which the original size could be estimated (550-800g) lies towards, but within, the upper end of the size range for a Roman (or indeed medieval) smithy involved simply in blacksmithing, rather than bloomsmithing (see Table 3). The macroscopic SHCs are accompanied by very rich microresidue assemblages, concreted into 'smithing floor'.

In contrast, the assemblage from Trench 'C' is dominated by fragments of hearth wall and a variety of low density slag types, together with rather sparse micro-residue assemblages. Here the recovered SHCs are at the very low end of the range of weights for SHCs.

The difference in the two assemblages (notwithstanding the rather small total amount of material available on which to base an interpretation) suggests that the two operations may have been undertaking rather different tasks. The material from Trench 'D' is perhaps more typical of smithy waste and may represent residue from a typical range of smithing activities. The lower density slags and small SHCs from Trench 'C' may be tentatively taken to suggest smithing operations with a lower loss of iron. Such activities might be those perhaps involving a lesser amount of forge welding and other high-temperature techniques. The residues in Trench 'C' were associated with finds of small nails, and a nailing operation, particularly if using pre-forged rod, might be the sort of activity that could have generated these residues.

Clearly further material to broaden the database on which to make such conclusions would be highly desirable, as would clarification of the age of the assemblages.

Evaluation of potential

Further work could be undertaken to investigate the difference between the two smithing assemblages. The archaeological utility, and hence desirability, of such work would rather depend on the age of the smithing. In the previous phase of study (Young 2011a) it was established that smithing appeared to have been undertaken during at least three phases of the site – associated with the large Roman military enclosure, associated with the fort and associated with the medieval occupation.

The correlation between the present two assemblages and these phases is not yet certain. If it could be demonstrated that the Roman military occupation entailed two distinct types of smithing activity at two different periods, then further detailed analysis to characterise those activities might well be highly desirable.

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Glossary

Blacksmithing: the working of iron and steel. Often restricted to the secondary smithing – i.e. the smithing of iron to produce or repair artefacts, as opposed to the smithing involved in the production of billets or bar iron from raw iron blooms.

Flake hammerscale (FHS): flake-like particles formed by the surficial oxidation of hot iron in air (Young 2011c). The iron oxide layer will detach from the workpiece because of differential thermal contraction or during deformation of the workpiece when hot-worked at the anvil. The thin scales fall from the workpiece and will accumulate mainly close to the anvil (although some will be lost elsewhere in the forge and even in the hearth). Flake hammerscale has planar surfaces, one of which is typically very smooth and reflective, the other only slightly less so.

Secondary smithing: see blacksmithing.

Slag flats: formed from an accumulation of slag on the surface of the workpiece (or sometimes on the surface of the smith's tools or other substrate). This accumulation may be formed from slag escaping from the inclusions in the workpiece, formed from melting of the surface oxide layer, or formed from contact with slag drips in the hearth. Slag flats are thicker than flake hammerscale, have one planar but rough surface and one irregular surface.

Slag spheroids: sub-spheroidal particles, often dimpled (coffee bean spheroids), dull in lustre, and less perfectly spherical the spheroidal hammerscale. These spheroids are typically up to about 10mm in diameter. These are mainly slag droplets formed by the dripping of slag within the fuel bed of the hearth. Isolated spheroids may form in non slag-tapping smelting furnaces as a variety of sparse flow slag, but are more common in smithing hearths.

Smithing hearth cake (SHC): the slag cake formed in a smithing hearth by reaction of iron oxides lost from the workpiece with silicate material from hearth ceramic and/or fuel, below and in front of the tuyère/blowhole. They are very variable in form, but are typically plano-convex in shape (although concavo-convex and biconvex forms are common), frequently with a dense lower crust and a less well consolidated upper part. In some cases the top is formed of glassy slag.

Spheroidal hammerscale (SHS): spheroidal particles of typically less than 2mm. Often these are vesicular or hollow. Mainly formed (Dungworth & Wilkes 2009; Young 2011c) when, mainly during forge welding, the iron is heated sufficiently for the surficial oxide layer to melt; when the two sides of the weld are closed, the molten oxide is expelled. This process is often enhanced by the addition of a welding flux – particularly where quartz sand is used. The melt coalesces into droplets and chills in flight to form spheroidal hammerscale. Typically they have a shiny surface with a metallic lustre and a close to perfectly spherical shape (unless deformed by impact).

Table 1: Summary catalogue by context, sample and bag. Assm = assemblage of fine sieved materials, BOM = burnt organic material, FAS = fuel ash slag, SHC = smithing hearth cake, SHS = spheroidal hammerscale, FHS = flake hammerscale

C	S	label	wt	no	description
1572	1307			assm	stone, with rare slag fragments, rust and some BOM
1589	1308			assm	stone, with rare slag fragments, one slag bleb and a very few pieces of FHS
1593	1309			assm	mainly rock fragments, coated in buff powder - unclear if this is derived from sediment or a fired clay. Rock particles include a few dark goethite (?) grains
1671	1314			assm	stone, minor possible bone and BOM
1672	1321			assm	stone, minor BOM and some rust/pan
2299	1350			assm	stone with some FHS, rare slag fragments and BOM
4010	12	sieve	248g bag		
			24	1	Top-shaped concretion - contains iron (large nail head or similar?)
			8.04	7	fragments of thin (<3mm) highly bloated gritty ceramic with thin slag layer on outside and locally extending round or through onto planar inner surface; whole c40mmx40mm - clay coat from brazing or heat treatment - or simply peeled off stone in fabric?
			20.6	1	concretion with iron
			14.5	1	granular dense mass around exploding iron
			78	10	heavily accreted slags with an overall blebby form - accreted blebs or poor flow slags?
			54	2	stones
			28	1	dense slag fragment
4010	12	sieve	66	assm	5 pieces of vitrified hearth wall, thin slag, then c5mm vitrified and grey, then oxidised fired below 1 pot rim 1 slag/ash/charcoal concretion, contains iron 1 burnt stone
4010		slag	418g bag		
			192	1	stone
			88	1	rounded mass of lining slag with charcoal impressed into base - piece of failed hearth wall?
			84	8	fragment piece of slag with good dense prills on base, passing up into a friable rusty upper part - possibly a lump from a prilly SHC but now too broken to interpret properly
			8	1	corroded iron
			32	2	two rounded pieces of very rusty slag- apparently iron-bearing slag - though just possibly concretions containing both slag and iron

C	S	label	wt	no	description
4010		fired clay	240g bag	assm	around a dozen pieces of fragmented piece of deeply vitrified and slagged wall, oxidised fired with gravelly texture, reduced surface and slag locally to 20mm.
4011		fired clay	62g bag	assm	well-vitrified oxidised fired clay broken into rather small fragments - similar to 4010 material
4011			76	1	approximately plano-convex mass, internally prilly, coarse lining slag with maroon surface - probably a crude SHC
4014	17	sieving finds	7.4	1	oxidised fired gravelly ceramic, convex surface with black glass with fuel impressions
			4.4	1	small concretion
			23.7	10	small blebs and sheet fragments of dimpled highly vesicular slag with charcoal inclusions and impressions
4014	17	slag hand sorted	41g	assm	6 stones, 5 corrosion around small long nails?, 2 corrosion around ?hobnails, 10 small corrosion/concretion fragments (one with a piece of SHS), 4 pieces slagged gravel, 1 vitrified bloated ceramic or stone, 8 pieces of blebby slag with charcoal, 7 fragments of angular dense dark slag, 10 blebs of iron slag, 19 blebs / fragments of lining slag with derived crystals (2 of which are almost pure green glass)
4014	17	hammerscale hand-sorted		assm	stones with good amount of FHS, with blisters, angular slag fragments, rust particles and vesicular sandy grey lining slag with maroon surface
4016	2	stage 2 hand sieve, magnetic residue, 1000micron		assm	stone, some probably oxidised and reduced fired clay particles, possible BOM?
4032	9	stage 2 hand sieve, magnetic residue, 1000micron	23g	assm	stone with moderately abundant FHS, some slag fragments, droplets, and SHS
4032	9	stage 2 hand sieve, hammerscale, 1000micron		assm	mainly good large flake hammerscale, 1 droplet fragment and a couple of pieces of slag flats
4032	9	stage 2 hand sieve, slag, 1000micron	112g bag		
			70	3	slagged, vitrified and in one case bloated, pebbles
			45	assm	small fragments and blebs and droplets of lining-influenced slags
4033		fired clay	26	1	broken lump of oxidised fired material containing large amounts of shillet and some large quartz grains
4033		fired clay	2	1	very fine grained pale daub-like fired clay
4033		slag	118g bag		
			36	1	low density rounded mass of slag with deeply-impressed charcoal moulds, similar to those on the top of the SHC below, highly vesicular. Has one fractured face - so might be the margin from an SHC
			2	1	small concretion on iron
			74	1	low density plano-convex mass, somewhat dimpled well formed base, internally vesicular with some charcoal moulds impressed from top, most of top missing - probably a very small SHC

C	S	label	wt	no	description
4048	15	hammerscale hand sorted		assm	stone with good amount of FHS and few angular slag fragments
4048	15	slag - hand sorted	26g		1 piece fired clay, 1 piece charcoal, 3 blebby lining slag pieces, 4 pieces of pumice-like FAS, 3 stones, 9 pieces of concretion - 1of which possible flat-headed nail?
4048		fired clay	7	assm	fine buff fired clay, possibly daub, has tubes of few mm diameter - straw? (well striated...)
4049		fired clay	8	1	small fragment of buff fired gravelly clay with smoothed grey surface with white surface
4052		fired clay	4	1	orange gravelly fired clay with thin grey surface layer
4069	14	sieving finds	38g bag	assm	badly fragmented vesicular lining/FAS, 1 more dense but very irregular slag becoming more lining-rich to one end, plus two small pieces of pottery
4074	10	stage 2 hand sieve, magnetic residue, 1000micron		assm	stones, small fragments of Fe-Mn pan,
4076		clay	1	1	bag of crushed oxidised fired clay
4077		fired clay	38	5	5 pieces of fired clay, oxidised, larger ones with deep vitrification layer becoming vesicular and flowed outwards,
4080		slag	16	1	appears to be a 'bog iron ore' that is overgrowing a charcoal-rich sediment (i.e. grown within the context)
4512	1	stage 2 hand sieve, magnetic residue, 1000micron		assm	stones, large pieces of vesicular lining slag (some with very large vesicles), good large FHS, slag flats, slag droplet, rust and concretion fragments, dimpled slag blebs, some with slightly maroon surfaces
4520	7	slag sieving finds	1085g bag		
			148	1	large block of slag concealed by accretion - has flow lobes on one margin- probably a dense SHC fragment from shape - in which case the smaller pieces below may be from similar margins
			42	6	small slag pieces - some well flowed with large rounded voids
			remainder	c.45	smithing floor

C	S	label	wt	no	description
4520		industrial waste	1740g bag		
			112	1	accreted SHC fragment
			326	1	accreted SHC fragment - possibly c40-60% - 30mm thick dense bowl with 5mm thick glassy top pealing up at broken centre
			186	1	accreted SHC fragment
			80	1	accreted SHC fragment
			118	1	accreted SHC fragment
			92	1	accreted SHC fragment
			72	1	accreted SHC fragment
			50	1	accreted SHC fragment
			48	1	slag fragment with curved (bent?) flowed top and dimpled base
			142	3	accreted slag fragments indet.
			remainder	many	smithing floor concretion fragments

Table 2: brief summary of assemblages by context for material from Trenches C and D

Context	Assemblage	Nature of context
Trench C		
4010	assemblage dominated by hearth wall fragments. Some concretions around iron. A few prilly dense slag fragments, probably amalgamated prills from SHCs	fill of ditch [4009]
4011	assemblage includes fragments of wall and a probable lining-dominated small SHC (76g)	
4014	mixed macroscopic assemblage with ceramic fragments, concretions. Moderately rich microresidue assemblage with scale and flats. Concretions probably include both small nails and hobnails.	fill of ditch [4009]
4016	non metallurgical	fill of pit [4015]
4032	mainly fine grained residues - vitrified pebbles, droplets and scale	fill of ditch [4009]
4033	fired clay, one small SHC (74g+) and part of another	fill of ditch [4009]
4048	daub, fine residues including blebs, FAS, scale and a possible nail	fill of ditch [4009]
4049	fired clay	
4052	fired clay	fill of ditch [4009]
4069	lining slag or FAS	fill of ditch [4009]
4074	non metallurgical	fill of ditch [4009]
4076	fired clay	
4077	fired/vitrified clay	
4080	concretion	
Trench D		
4512	fines including scale, flats, droplets and lining slag	fill of [4511]
4520	abundant smithy 'floor' material and dense SHC fragments - largest probably originally 550-800g	fill of [4511]

Table 3. Weight distribution of selected comparative SHC assemblages from Roman (Marsh Leys Farm, Carmarthen) and medieval (various locations in Worcester) sites.

Marsh Leys Farm from Young 2005 & 2011b; Carmarthen from Crew 2003; 35 Mill Street assemblage from Young2009; Willow Street from Young 2007; Worcester Deansway from McDonnell & Swiss 2004; Burton Dassett from McDonnell 1992.

	Marsh Leys Farm Roman	Carmarthen Roman	Worcester, 35 Mill Street	Worcester, Willow Street	Worcester Deansway (period 8) 11th – 13th	Worcester Deansway (period 9) 13th-15th	Burton Dassett 14th- 15th
No. of SHCs	30	136	23	28	61	32	60
Min weight	60	100	74	86	168	144	130
Max weight	824	820	782	770	1490	1800	1670
Average weight	333	227	233	327	492	499	550
% of SHCs with weight							
<500g	77%	94%	91%	82%			
<1000g	100%	100%	100%	100%			
>1000g	0%	0%	0%	0%			
>3000g	0%	0%	0%	0%			

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