GeoArch

Report 2011/36

Evaluation of archaeometallurgical residues from St Loyes College, Exeter EA6846

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12th November 2011

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Abstract

Assessment of the small assemblage from the St Loyes College site (EA6846) shows widespread microresidue evidence for ironworking (smithing) associated with the Roman military phase. Only a very limited amount of macro-residues were recovered, probably indicating that the facilities were maintained in a clean state, with off-site disposal of macro-residues. The microresidues were associated both with the fabrica *(Building 1212), but perhaps more particularly with Building 1060 to its NW. The residues are indicative of the end-use of iron (blacksmithing) in clay-built hearths with charcoal fuel.*

Ironworking microresidues also occurred both in Iron Age contexts, where they are interpreted as intrusive given the lack of macroscopic residues from Iron Age deposits and their occurrence in deposits below the later fabrica*, and sporadically in later Roman civilian contexts, where they are interpreted as residual.*

A low level of finds of lead on the site may indicate some general use of lead in the civilian settlement, but the particular presence of thin lead sheet in military contexts may suggest the use, production or recycling of 'baggage tags'.

The archaeometallurgical materials have little potential for the acquisition of useful data through additional analysis, so no further analysis of these materials is recommended.

Contents

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, 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 macroscopic material is given in Table 1 and a summary of the archaeometallurgical microresidue content of the magnetic fraction of the processed samples in Table 2.

This project was undertaken for Exeter Archaeology.

Results

General nature of the residues
The assemblage comprised material from two distinct processes: firstly both macro- and microresidues from ironworking (smithing) and secondly a small quantity of lead waste (including both sheet fragments and probable casting waste) of which the implication is uncertain.

Smithing residues
The residues from ironworking (smithing) include microresidues (mainly hammerscale) and macro-residues (slag and hearth lining).

The microresidues are dominated by flake hammerscale. This material is formed by the surficial

oxidation of hot iron in air (Young *in press*). 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). The flake hammerscale from St Loyes is generally very fine, indicating formation during fairly short periods of heating – such as those during blacksmithing. Flake hammerscale has planar surfaces, one of which is typically very smooth and reflective, the other only slightly less so.

The residues include other tabular microresidues, slag flats and slag blisters. Slag flats are formed from an accumulation of slag on the surface of the workpiece (or sometimes on the surface of the smith's tools). 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 blisters are strongly raised areas of slag or oxide accumulation on the surface of the workpiece. They typically have a similar thickness to the co-occurring flake hammerscale, but a much more irregular appearance. Slag blisters are presumably formed when volatiles escaping from the hot iron cannot traverse the impervious oxide layer.

The microresidues also include two forms of spherical or sub-spheroidal particles. Most of the small particles of this sort are spheroidal hammerscale (Dungworth & Wilkes 2009; Young *in press*). These are formed when, mainly during forge welding, the iron is heated sufficiently for the oxide layer to melt; when the two sides of the weld are closed, the molten oxide is expelled. This coalesces into droplets and chills in flight to form spheroidal hammerscale. Most of these small particles can be recognised as spheroidal hammerscale from their shiny surface with a metallic lustre and a close to perfectly spherical shape (unless deformed by impact).

Larger sub-spheroidal particles are rounded, dull in lustre, and less perfectly spherical. These are mainly slag droplets formed by the dripping of slag within the fuel bed of the hearth.

The microresidue assemblages also include other irregular fragments of broken slag and small pieces of vitrified ceramic from the hearth wall. There are also small particles of corroded iron.

All of these metallurgical components are subordinate, in all but one or two samples, to a lithic component formed of burnt rock particles. These are probably mainly from the subsoil of the hearths, but may also include detritus from the ceramic hearth walls. An abundance of such material is not necessarily indicative of metallurgical activity and for samples rich in such particles but lacking in hammerscale, then an origin in domestic hearths or other pyrotechnological processes is possible.

The 'richness' of such assemblages has been categorised in Table 2 as a number from 0 (absent) to 3 (abundant). Such an indicator is, of course, relative and there were no large samples dominated by hammerscale such as are commonly recovered from within metallurgical features themselves. All of the present samples were more likely to be indicative of low levels of residue entering essentially non-metallurgical features. All of the microresidues assemblages were indicative of iron working – and more specifically secondary smithing (blacksmithing). There were no assemblages that were indicative of either iron smelting or primary smithing (bloomsmithing).

The macro-residues that can be attributed to ironworking including one certain and possible example of a smithing hearth cake (SHC; the typical large concavo- or plano-convex mass of slag formed below the blow hole in a smithing hearth), together with a variety of blebby lining slags and hearth lining fragments. Such an assemblage would be typical of residues from iron working in a clay-walled forge hearth with charcoal fuel.

The single certain SHC (c1281) weighed 378g, but was very porous and low density, so has probably experienced some weathering. The SHC showed a lower ferruginous section with some moderately large charcoal moulds and an upper more glassy section strongly influenced by the loss of ceramic from the hearth wall. The smaller, possible, SHC (c1281) resembled the lower ferruginous section of the larger example and weighed only 68g.

The SHCs were accompanied by a large number (at least 15) of slag lumps, similar in composition and, to some extent, texture to the upper layer of the larger SHC. These represent ceramic materials from the failure of the hearth wall that have not reacted with sufficient iron oxide (lost from the workpiece) to form denser slags or an SHC.

A few small pieces of blebby dense slag represent more fluid iron-rich slags that have developed with the fuel bed of the hearth, but which have not become incorporated within an SHC.

The hearth wall itself was presented by almost 30 pieces of vitrified, oxidised-fired ceramic. These pieces are likely to derive from the area close to the blow hole of the hearth, which requires frequent repair. Such pieces are likely to represent pieces broken from the wall during the course the course of repair, rather than destruction of a hearth.

Iron

The submitted assemblage included two fragments (c1353 & c1649) of iron and three concretions (c1281) that were probably cored on corroding iron. It is not known whether these concreted pieces were debris from smithing or were actually artefacts. It is recommended that these pieces are examined by X-Radiography to resolve this.

Lead

Some 45 fragments of lead were recovered. Most of these were in a highly oxidised, fragile, weathered state (*NOTE: care should be taken in the handling and repackaging of these items as the degraded lead oxide powders represent a health risk*).

Some of these lead fragments (#239, #240) clearly displayed a flowed morphology suggesting that they were spills. Some pieces (c1844, c2061) showed curved contact surfaces suggestive of charcoal fuel – and these may have been lost into the fuel bed of the hearth being used for melting.

However, by far the majority of the lead pieces were in the form of thin sheet, mostly 1-2mm thick, but with a few thicker examples at 3-4mm. Poor preservation

prevented certain discrimination between corroded remnants of larger objects (e.g. the nineteen thin sheet fragments from c1852) and smaller items. None of the pieces showed evidence for being a clipping (e.g. from the trimming of a larger sheet), although poor preservation would have made it difficult to recognise cut edges).

Distribution of the residues
The macroscopic smithing residues had a very restricted distribution, with all the material having been recovered from the Roman fills of the Iron Age ditch c1217 (c1246 and c1281) apart from one single fragment of lining slag from c1279.

In contrast the microresidues were very widely distributed across the site. The richest assemblages were recovered from the Roman fills (c1246, c2181) of the Iron Age ditch c1217 (i.e. the same deposits as yielded the macroscopic smithing residues) and from one of the postholes of Building 1060.

Slightly more modest assemblages were obtained from:

Iron Age features:
- from the Iron Age roundhouse gully (1566),
- from fills of linear features 1018 and 1022

From Roman 'military' deposits:
- from the other postholes of Building 1060,
- from a few of the postholes of the Building 2012,
- other upper fills (1282, 1292) of ditch 1217

From Roman 'civilian' features:
- from some of the postholes of Building 1481
- from one of the fills of feature 2105,

Low levels of microresidues were a wide range of contexts.

The lead fragments included 24 fragments from the Roman fill of IA ditch 1351 (the SE side of the later Iron Age enclosure; the iron working residues were recovered from fills on the NW side of the enclosure).

The other lead fragments were recovered from Roman civilian contexts: fifteen lead fragments were recovered from pit 2105, a Roman 'civilian' feature, two pieces from well 1975, one piece from a post trench in Building 1479 and two pieces from isolated features.

Interpretation

The interpretation of the ironworking residues is straightforward in terms of process (they can be referred to smithing, as described above), but their context is more problematical.

The macro-residues from the upper levels of ditch 1217 are very few in quantity compared with the widespread evidence from the microresidues. This probably suggests that the smiths dumped their slag waste in general away from the settled area. In contrast, the microresidues may have become more widespread through treading, or through sweeping of floors. Although the features of the *fabrica* show modest amounts of hammerscale, the postholes of Building 1060 show more consistently elevated levels.

Such a pattern may suggest that Building 1060 functioned as a smithy – but might conceivably also have been developed if the area of Building 1060 was used as a dumping area for floor sweepings from the *fabrica*, either before or after its use. In the absence of firm evidence for hearths, then the microresidue evidence must be balanced with that from other lines of archaeological evidence.

The presence of significant amounts of microresidues in some of the smaller Iron Age features (for instance the roundhouse gully) might be evidence for Iron Age ironworking, but if this were to have been the case, then disposal of the corresponding macro-slags into the Iron Age enclosure ditches might have been expected. Since there is no evidence for this, contamination of these features from overlying Roman activity is perhaps more likely.

The rather sporadic occurrence of ironworking microresidues in the Roman civilian deposits might be evidence for ironworking having been undertaken somewhere in the area, but it is perhaps more likely that this material represents material residual from earlier activity. If there had been significant later Roman ironworking then at least some macroscopic residues might have been expected from the cut features of this period.

In summary therefore, it seems most likely that all the ironworking activity is associated with the military phase of the site, but some ironworking at other periods cannot be ruled out with certainty.

The lead from the site is also not easy to interpret. Finds of lead scrap may be either material lost from a fabrication process, or material collected for recycling. The small quantity of material does not suggest a major industrial process. The rather variable material from the Roman civilian phase is compatible with that seen on sites elsewhere, where lead was employed in a wide variety of uses (for plumbing, as weights . Small scale fabrication of artefacts from lead is simple and may be undertaken, at relatively low temperature, by 'end-users'. The present material is not indicative of what use(s) might have been made of lead here.

In contrast, the lead from the Roman fill of ditch 1351 includes many fragments of rather similar form – sheet of 1-2mm thickness. The total amount is very small, so conclusions are difficult to draw. It might be noted however, that thin sheet is most commonly associated in a Roman context as a writing medium – either as 'curses' on religious sites or, perhaps more commonly, as the 'baggage tags' which are found on Roman military and commercial sites.

Evaluation of potential

The materials described above have little potential to reveal additional useful information through further analysis. No additional analysis is therefore recommended.

References

DUNGWORTH, D & WILKES, R. 2009. Understanding hammerscale: the use of high speed film and electron microscopy. *Historical Metallurgy,* **43**, 33-46.

YOUNG, T.P. in press. Some preliminary observations on hammerscale: implications for its genesis, interpretational potential and the understanding of welding. *Historical Metallurgy,* **45** (forthcoming).

Table 1. Summary catalogue of macro-residues and associated materials

Context	*SF#*	*Feature*	*weight*	*number*	*Notes*
1246		Roman fill of IA enclosure ditch 1217	25.2	7	vitrified oxidised hearth lining
1246		Roman fill of IA enclosure ditch 1217	32.4	5	rounded blebs of lining slag
1246		Roman fill of IA enclosure ditch 1217	7.2	2	blebs of denser iron slag , with indications of penetration between charcoal particles
1246		Roman fill of IA enclosure ditch 1217	7	9	tiny slag scraps
1246		Roman fill of IA enclosure ditch 1217	20	1	accreted piece - probably cored on iron-bearing lining slag, but also has abundant charcoal and sediment
1281		Roman fill of IA enclosure ditch 1217	418	22	vitrified oxidised fired lining, one piece shows possible straightedge - somewhat like margin of block tuyère, another shows a curved impression to rear , possibly stone or wicker.
1281		Roman fill of IA enclosure ditch 1217	378	1	low density SHC, lower part ferruginous and rich on moulds of moderately large charcoal fragments, upper part dominantly glassy, distal side appears particularly FAS-like. Distal side also overgrown by accretion - suggesting former inclusion of iron particles. 105x100x60mm. Crudely plano-convex , but top rather irregular.
1281		Roman fill of IA enclosure ditch 1217	282	10	irregular rounded blebby masses of lining slag, mainly pale grey vitrified material.
1281		Roman fill of IA enclosure ditch 1217	198	3	concretions, presumably cored on iron artefacts or debris
1281		Roman fill of IA enclosure ditch 1217	68	1	75x50x25mm, small plano-convex , ferruginous mass with abundant charcoal moulds. Possibly a small SHC.
1353		fill of 1352 post-trench (*fabrica* area)	58	1	corroded and accreted iron fragment - probably short length of bar c. 18x50x10mm
1279		fill of feature 1256 (*fabrica* area)	7	1	bleb of bloated lining slag, locally with dark surface glass suggesting origin in iron working.
1579	298	fill of post-trench in building 1479	26.6	1	4-6mm thick lead sheet fragment
1649			8.8	1	corroded iron (only part of original piece)
1519	131	fill in Roman civil industrial feature 2105	4.8	1	angular lump of lead waste
1696		fill in Roman civil industrial feature 2105	12.9	6	1 rounded bleb and five small fragments of c. 3mm lead sheet
1696	132	fill in Roman civil industrial feature 2105	9.9	1	curved thick lead sheet fragment
1696	140	fill in Roman civil industrial feature 2105	4	2	2 small fragments of oxidised lead, both very irregular - possibly formed within fuel bed?
1696	158	fill in Roman civil industrial feature 2105	3.4	1	small fragment of c. 2mm lead sheet
1696	172	fill in Roman civil industrial feature 2105	2	1	tiny rounded oxidised lead fragment
1696	228	fill in Roman civil industrial feature 2105	4.8	1	fragment of lead sheet, <2mm
1696	239	fill in Roman civil industrial feature 2105	7.6	2	lead fragments, both very heavily corroded, but appear as blebby flow lobes?
1696	240	fill in Roman civil industrial feature 2105	6.2	1	blebby piece of flowed lead waste
1844		Roman fill in IA enclosure ditch 1351	29.6	1	irregular lead piece, probably delimited by sandy hearth base and by fuel clasts?
1852		Roman fill in IA enclosure ditch 1351	100	23	lead fragments. 19 fragments of thin (c. 1mm) sheet and 4 thicker fragments, together with some ashy? sediment with lead oxides.
2061		fill of p/h 2062	66	1	irregular piece of lead with flow lobes one end and other delimited by curved surfaces - probably indicative of lead lost into fuel. Lead much fresher than other pieces

Context	*SF#*		*weight*	*number*	*Notes*
2157	220	fill in well 1975	16	1	folded irregular lead sheet fragment
2159	2	fill in well 1975	18	1	folded piece of c. 3mm rounded lead sheet

Table 2: summary catalogue of microresidues and associated materials. Residue abundance: 0 = absent, 1 = sparse, 2 = moderate, 3 = abundant.

Sample	*Context*	*Feature*	*Notes*	*residue abundance*
1	1008	fill of p/h 1007 Building 1060	abundant comminuted FHS and some SHS	3
2	1014	fill of p/h 1013 Building 1060	moderate FHS, some SHS and few pieces of irregular slag bleb	2
4	1009	fill of p/h 1010 Building 1060	moderate FHS, some SHS and a few pieces of blister	2
5	1011	fill of p/h 1012 Building 1060	moderate comminuted FHS, some SHS, slag spheroids and slag flats	2
6	1019	fill of p/h 1020 Building 1060	moderate fine FHS and some SHS	2
8	1032	fill of p/h 1033 Building 1060	moderate amount of comminuted FHS and some slag blebs	2
3	1018	fill of probable IA linear	moderate FHS, some SHS and few pieces of irregular slag bleb	2
		(ditto, second bag)	moderate FHS, some SHS and a few pieces of blebby slag	2
7	1022	fill of linear 1024	moderate fine FHS and some SHS, together with irregular slag blebs and angular slag fragments	2
9	1246	upper fill in IA enc ditch 1217	exceptionally rich sample - FHS and some SHS in sand	3
10	1281	upper fill in IA enc ditch 1217	good sample dominated by FHS, some SHS, rare thin blisters	3
11	1282	upper fill in IA enc ditch 1217	modest amount of FHS, SHS and slag blisters	2
12	1291	upper fill in IA enc ditch 1217	sparse FHS	1
13	1292	upper fill in IA enc ditch 1217	some FHS and blisters	1
		(ditto, second bag)	moderate FHS and trace of SHS and slag blebs	2
14	1259	fill of p/h 1258 Building 1212 (*fabrica*)	some slag blebs (sub-spheroidal) and blisters	1
15	1263	fill of p/h 1262 Building 1212 (*fabrica*)	trace of FHS and small slag spheroids, together with some angular slag fragments	1
16	1267	fill of p/h 1266 Building 1212 (*fabrica*)	some FHS, SHS. FHS in very small fragments	1
		(ditto, second bag)	slag blebs, slag flat and some degraded FHS	1
17	1269	fill of p/h 1268 Building 1212 (*fabrica*)	several SHS, some FHS and few pieces of possible slag	1
21	1308	fill of p/h 1307 Building 1212 (*fabrica*)	moderate amount of FHS	2
22	1329	fill of p/h 1258 Building 1212 (*fabrica*)	some irregular slag blebs	1
23	1337	fill of p/h 1258 Building 1212 (*fabrica*)	minor slag, slag flats and FHS	2
24	1389	fill of p/h? 1388, Building 1212 (*fabrica*) area	slag fragments, some comminuted FHS	1
25	1391	fill of p/h 1390, Building 1212 (*fabrica*) area	irregular slag blebs, SHS, FHS	2
26	1567	deposit within R/H ring gulley 1566	low levels of SHS, spheroids, FHS, blisters and other slag debris	2
27	1568	deposit within R/H ring gulley 1566	minor FHS, SHS, spheroids, slag flats, blisters and slag fragments	2
28	1532	fill of p/h 1533 Building 1481	trace FHS and SHS	1
29	1530	fill of p/h 1531 Building 1481	moderate FHS and some SHS	2

Sample	*Context*	*Feature*	*Notes*	*residue abundance*
30	1528	fill of p/h 1529 Building 1481	minor degraded FHS and a couple of pieces of SHS	1
31	1526	fill of p/h 1527 Building 1481	moderate FHS	2
32	1524	fill of p/h 1525 Building 1481	sparse comminuted FHS and one droplet or SHS	1
33	1519	fill in Roman civil industrial feature 2105	some FHS/flats and one droplet or SHS	1
34	1696	fill in Roman civil industrial feature 2105	poorly washed sample (fine pale clay cf. 33) but no certain HS or slag	0
44	1564	fill in Roman civil industrial feature 2105	quite rich in FHS, presence of other residue classes not confirmed	2
52	1812	fill in Roman civil industrial feature 2105	minor FHS and slag particles	1
65	1708	fill in Roman civil industrial feature 2105	fine silty sample with a trace of FHS	1
35	1733	fill of p/h 1734 Building 1482	some angular slag fragments, but only trace of FHS	1
36	1833	base charcoal-rich fill in civilian kiln/oven 1387	pale silty stone assemblage no Fe residues - but has platy vesicular pale hard material	0
37	1840	fill in IA enc ditch 1351	trace levels of FHS	1
38	1629	fill in IA enc ditch 1351	some FHS, SHS and flats/blisters	1
39	1844	fill in IA enc ditch 1351	trace FHS, but mainly fired mudstone	1
40	1852	fill in IA enc ditch 1351	one fragment of vitrified ceramic	0
42	1892	fill in IA enc ditch 1842	no scale	0
43	1911	fill in hearth 1882 (Roman civilian)	no residues	0
45	1709	fill in Roman civil industrial feature 2104	very rare FHS and slag grains	1
51	1862	fill in Roman civil industrial feature 2104	no scale	0
46	1881	fill of pit 1880 (in *fabrica* courtyard)	some comminuted FHS	1
57	1924	fill of pit 1880 (in *fabrica* courtyard)	some possible highly fragmented FHS	1
?	1774	fill of pit 1880 (in *fabrica* courtyard)	probably fired clay sample, a few irregular slag blebs, no HS	0
47	2022	fill in Grave 2021	rare SHS and trace FHS. Occasional slag bleb	1
		(ditto, second bag)	traces of FHS	1
49	2098	fill in well 1120	single FHS piece	1
50	2099	fill in well 1120	probably fired clay sample, some very comminuted FHS	1
53	2083	fill of ditch 2080 (IA?)	no metallurgical materials	0

Sample	*Context*	*Feature*	*Notes*	*residue abundance*
58	2161	fill of well 1208	mainly stone, trace FHS, clumping is on possible bog ore or oxidised pyrite?	1
		(ditto, second bag)	no scale	0
59	2163	fill of p/h 2162	trace of FHS, blisters and SHS	1
60	2265	fill of 2264 ?p/h (IA)	modest amount of degraded FHS, an irregular bleb and a few pieces of slag debris	2
61	2269	fill of 2268p/h	trace of FHS	1
62	2297	fill of pit 2296 (undated)	single spheroid, some slaggy material some possible FHS	1
63	2330		moderate FHS, SHS, slag spheroids, slag flats and other slag fragments	2
64	2334	post hole 2333	moderately abundant small slag fragments, spheroids, sheets and some FHS	2

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