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Archaeometallurgical residues from
Calstock Roman fort

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Abstract

The archaeometallurgical assemblage from Calstock Roman fort forms a slightly unusual collection. There is a very small assemblage of macroscopic slag – with approximately ten contexts yielding small pieces of slag, most of which can reasonably confidentially be assigned to iron-working (smithing), although some are of indeterminate origin. In contrast, there is good evidence for iron working from microresidues retrieved from fifty one samples taken right across the site. Most of these samples yielded rather small quantities of hammerscale, but six contexts produced very good assemblages and a further thirteen contexts contained moderately rich hammerscale assemblages. This pattern of poor macroresidue assemblages, but moderate to good microresidue assemblages is typical of sites that were kept clean in use. The collection of macroresidues and their disposal away from the active areas is common, but almost inevitably the microresidues are less easy to remove.

The interpretation of the distribution of microresidues is complicated by their potential for both being residual and intrusive. In this instance, the six rich (and therefore potentially the most reliable) assemblages were retrieved from: two pits in the 'workshop' area of Trench A3, a post slot at the rear of the rampart on Trench A2, a post slot in the building adjacent to the interval tower in Area A1, a later hearth over this building and medieval posthole outside the fort west of the interval tower in Area A1. The moderately rich microresidue assemblages are largely from similar areas: three further structural features in the area of the interval tower and five contexts within the fills of the fort ditches west of the interval tower, but also from two cut features and two contexts associated with the bonfire in Trench A4, and a second medieval posthole in Area A1.

Three potentially metallurgical features were recorded: the 'furnace' [514] in the 2008 evaluation, the hearth [2076] in area A1, the 'bonfire' in Trench A4 [2078]. Feature [514] yielded only a trace of hammerscale, but the morphology, with intense burning localised in one area, certainly resembles a floor-level smithing hearth. Hearth [2076] is probably identifiable as a smithing hearth, but is not closely dated. The 'bonfire' structure would be an unusual form for a metallurgical hearth. If the association with hammerscale is not coincidental, one possible, if unusual, interpretation might be that it is a hearth for heating a iron tyre for placing on a wooden wheel – a function usually undertaken in a large 'bonfire' outside a smithy. The location of feature [514] outside the known fort is interesting and may suggest it is associated with the possible larger enclosure. The residue assemblages from two medieval postholes west of the fort probably indicate a later, medieval, phase of smithing.

No evidence was identified for any smelting, nor of working of non-ferrous metals.

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Methods

This report was undertaken to provide a publication report, following on from an assessment report by Juleff (2010). All of the collected potential archaeometallurgical materials were re-examined visually, with a low powered binocular microscope where necessary, and have been logged to provide a summary catalogue (Table 1).

This project was undertaken for Dr Chris Smart, Exeter University.

Results

General description of material

Microresidues

The collections of magnetic microresidues are dominated by flake hammerscale, but the richer assemblages also contain spheroidal hammerscale, slag flats, slag blisters, slag droplets and comminuted macro-slugs.

When iron is heated, in order to hot-work it during smithing, it will quickly start to oxidise and form scale. When the oxide scale detaches from the workpiece, it forms small (typically up to a few hundred microns in thickness and up to a few millimetres in width) particles, usually referred-to in archaeometallurgy as flake hammerscale. Similar, but thicker and larger tabular particles may be formed from slag adhering to the outside of the workpiece; depending on the morphology these are known as slag flats or slag blisters when detached. These tabular particles are thus general indicators of iron-working.

High temperatures are required to forge weld iron,, leading to rapid surface oxidation of the workpiece. In order for the two weld surfaces to be brought together, the iron is heated to the point at which the oxide scale melts (or at least partially melts), so that when the weld is hammered closed, the oxide is expelled as a jet of liquid which coalesces and freezes in flight to form spheroidal hammerscale (Dungworth & Wilkes 2009; Young in press). This process is sometimes aided by the addition of a flux, such as sand, which promotes the formation of a silicate melt on the surface of the workpiece at a slightly lower –temperature than the oxide would melt on its own. Previous accounts of spheroidal hammerscale (e.g. Allen 1986) have emphasised a potential origin in primary smithing (bloomsmithing; the working of raw iron from bloom down to billet or bar), but a more general origin in forge welding is now accepted. These particles are also a general indicator of iron-working and not of a stage of iron production.

Slag droplets are morphological similar to spheroidal hammerscale, but whereas spheroidal hammerscale is typically less than 2mm in diameter, slag droplets range up to 10mm. They typically become less perfectly spheroidal in larger examples and commonly the larger particles are dimpled. These droplets derive from small droplets of liquid slag descending into, and cooling within, the fuel bed of the hearth.

Although commonly found together, these particles will be produced in slightly different places: the flake hammerscale (and also slag flats/blisters) mostly falls around the anvil, though some may detach in the

hearth, the spheroidal hammerscale will spray out several metres from the anvil and slag droplets are formed inside the hearth. Their co-occurrence in samples may be due to a common point of accumulation or deposition for sweepings from the smithy, as well as direct accumulation into the cracks and crevices of the smithy structure. If a floor-level hearth was employed, then all types of particle may find their way into the hearth, as a low-point on the smithy floor.

Macroresidues

In contrast to the widespread distribution of microresidues, there were just eighteen significant hand-picked pieces of slag were present in the collection.

The only fragments from well-formed smithing hearth cakes (SHCs) were from a medieval posthole [1836] and from the upper levels of the adjacent outer fort ditch [1682]. These materials were dense slugs, in well-formed cakes, with dimpled bases and charcoal inclusions. Neither of these occurrences is certainly Roman and both may be Medieval.

Several other occurrences of iron slugs showed contamination by quartz grains and other materials derived from the hearth wall (or possibly from the sides of the cut of a floor-level hearth). Such materials included unstratified material [1500] as well Roman contexts associated with the 'bonfire' [1584], gully [1637], a Roman ground surface [2075] and a Roman posthole [2226]. Some slag from the inner fort ditch ([1664] and [1665]) showed corroding inclusions of metallic iron and were possibly fragments of smithing hearth cakes.

Several slag pieces were of a dark glassy slag, probably from the wall of a hearth or furnace. These included examples from levelling deposit [2026] (which was closely associated with possible smithing hearth [2076]) and from posthole [2286] (in the same area).

Some samples of slag showed a higher degree of influence of the earth lining and/or fuel ash, and so are less certainly from iron working. These include examples from the pre-fort ground surface [2020] and from the possible early ditch [3009]. With such material it is not possible to exclude an origin in a hearth used, for instance, for working bronze in crucibles.

In summary, the macroscopic slugs were in general a very sparse and badly fragmented group. Most were probably iron-working slugs; all were possibly so.

Distribution of material

The interpretation of the distribution of microresidues is complicated by their potential for both being residual and intrusive. The overall spread of hammerscale-bearing samples was very wide – indeed some hammerscale was recovered from all areas of the site. Emphasis must therefore be placed on the richer assemblages.

The six richest (and therefore potentially the most reliable) microresidue assemblages were retrieved from: two pits in the 'workshop' area of Trench A3 ([1519], [1521]), a post slot at the rear of the rampart on Trench A2 ([1549]), a post slot in the building adjacent to the interval tower in Area A1 ([2328]), a later hearth over this building ([2027]) and a medieval posthole outside the fort west of the interval tower in Area A1 ([1837]).

The moderately rich microresidue assemblages are largely from similar areas: three further structural features in the area of the interval tower ([2286], [2224] and [2299]) and five contexts within the fills of the fort ditches west of the interval tower ([1664], [1671], [1672], [1682] and [1683]), but also from two cut features ([1508] and [1572]) and two contexts associated with the bonfire in Trench A4 ([1728] and [1730], and a medieval posthole in Area A1 ([2077]).

The macroscopic slag assemblage includes reasonably certain iron-working slags from the fort ditches ([1664], [1665] and [1682]), a medieval posthole immediately outside the ditches ([1837]), from a deposit associated with the 'bonfire' ([1584]), the fill of a post-trench to the west of the 'workshop' ([1637]), a Roman ground surface [2075] and a Roman posthole [2226]. All of these occurrences are close to areas or features with hammerscale.

Two pieces of possible hearth wall came from levelling deposit [2026] (which was closely associated with possible smithing hearth [2076]) and from posthole [2286] (in the same area).

The occurrence of macroresidues that were somewhat less certainly from ironworking in the same or similar locations to more identifiable iron-working slags and microresidues gives support to the inclusion of these residues with iron-working too.

The pieces that were indeterminate lining or fuel ash slags came from areas/contexts not directly associated with finds of hammerscale ([2020] and [3009]).

Interpretation

The evidence strongly indicates that ironworking was the dominant, and possibly the only, metallurgical activity undertaken within the excavated area.

There are several distinct areas of activity:

- In Trench A4 metallurgical residues occurred in ditch [1507], in a rubbish pit [1571] and associated with the 'bonfire' [1728]. Given the widespread distribution of hammerscale, the association with the 'bonfire' may be coincidental. If genuine, however, it is not possible to interpret such a large hearth as a conventional smithing hearth. Large hearths were sometimes built outside a smithy, even into the 20th century, for the purposes of heating iron tyres before shrinking them onto a wooden wheel. This process did not require a very high temperature, and could be done with cheap fuel (even wood or peat, depending on location). Because the required fire would be large, the hearth would often be constructed outside the smithy itself. None of this activity was certainly within the lifespan of the fort itself.

- In Trench A3 two pits ([1518] and [1520]) produced both microresidue assemblages and various ferrous fittings including ring-mail fragments. This suggests an association with a Roman military workshop, but again the location could not confirm with certainty that the activity was contemporary with the fort itself.

- In Trench A2 and Area A1 'dogleg' microresidue assemblages were associated with a variety of post-trenches and other features associated with the rear of the rampart and the building behind the rampart. Interpretation of these finds is complicated by hearth [2076] which is undated, but which postdates the building behind the rampart. This hearth yielded a

good microresidue assemblage and is therefore probably to be interpreted as a smithing hearth. It is possible that microresidues from this later phase are intrusive into earlier deposits in this area. However, it is equally likely that the microresidues in other features in this area might indicate disposal of sweepings from a smithy floor against the rear face of the rampart.

- A fourth area of significant deposition is in the fort ditches immediately west of the discussed above. Both micro- and macro-residues were recovered from the fill of both ditches. It is likely that much of this material is Roman, but the residues continue up into the tertiary fill of the outer ditch [1682], which contained medieval pottery. This area is very close (c. 8m) to the posthole in Area A1 [1836] which contained a very rich assemblage of smithing residues and which may be medieval (it contained a single sherd of medieval pottery). A further medieval pit/posthole [2072] containing moderately abundant microresidues lay a further 12m NW. There is thus tentative evidence for smithing associated with the medieval occupation west of the fort.

Three potentially metallurgical features were recorded: the 'furnace' [514] in the 2008 evaluation, the hearth [2076] in area A1, the 'bonfire' in Trench A4 [2078]:

- Feature [514] yielded only a trace of hammerscale, but the morphology, with intense burning localised in one area of the margin, certainly resembles a floor-level smithing hearth. This feature was located outside the fort to the south, but has given ¹⁴C dates centred on the early Roman period (cal. 34BC-AD127, Wk-23919; cal. 39BC-AD124, Wk-23923).

- Hearth [2076] is probably identifiable as a smithing hearth on the basis of the microresidues it contained, but is not closely dated. It may be Roman, but post-dated destruction of the building east of the interval tower.

- The 'bonfire' structure in Trench A4 would be an unusual form for a metallurgical hearth, but might just possibly have had a specialist use, as discussed above.

Summary

Several distinct areas of ironworking (smithing) were identified. These included two areas within the interior of the fort, one either side of the *via principalis*, one of which provided evidence for the repair of ring-mail. A third area with microresidues from smithing was along the interior of the western rampart, but the only structural evidence of smithing in this area was a hearth which post-dated destruction of the small building to the rear of the interval tower.

The fort ditches to the west of the interval tower also produced both macro- and microresidues from smithing. Although much of this evidence may relate to the activity within the fort described above, it is possible that residues from the upper fills of the ditches were produced during medieval smithing in the area west of the fort, where two medieval postholes produced good microresidue assemblages.

A somewhat enigmatic Roman hearth to the south of the fort produced no distinctive residues besides a tiny quantity of hammerscale. The cut feature does have a pattern of burning resembling that of a smithing hearth and this remains its most likely interpretation.

The small quantity of macro-residue recovered compared to the widespread occurrence of microresidues is typical of sites, including forts, which were maintained in a clean state during use. The macroscopic slag was relatively easy to collect and dispose outside the fort, whereas the microresidues would tend to accumulate in small quantities close to their source.

Smithing for the manufacture and repair of equipment and building materials would be integral part of the activity within most Roman forts. Although much of the metallurgical activity might be concentrated within a *fabrica*, occurrences of workshops in the buildings behind the ramparts (e.g. Chapman 2002) and in other locations apparently with the 'living space' (e.g. Zienkiewicz 1993) are common, leading to a dispersed distribution of metallurgical residues.

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Table 1: summary catalogue. Structured by context. Bulk = residue from sampling.

context	sample	context note	no	notes
508	1324	fill of Roman roadside ditch [506]	bulk	stone with tiny amount of flake hammerscale
516	2	Fill of hearth [514]	bulk	Stone, with some fired clay and minute amount of flake hammerscale
517	1344	layer of shillet and sandstone (2008 eval), basal fill of Roman pit [512]	bulk	stone, trace possible flake hammerscale
520	1345	Lower fill of Roman pit [519]	bulk	stone with trace flake hammerscale
532	1348	Lower fill of Roman pit [531]	bulk	stone with trace of flake hammerscale
1500		overburden	3	1 exploded fragment of weathered mineralised rock bearing pyrite and chalcopryrite 1 probable glazed pebble 1 piece of vesicular dense slag bearing quartz rains
1508	1300	fill of Roman ditch [1507]	bulk	stone with moderate flake hammerscale
1519	1303	fill of Roman pit/posthole [1518]	bulk	stone with abundant fragments flake hammerscale
1519			3	blebby fragments of probable slag, coated in secondary iron oxides and attached to gravel
1519	1343		17	tiny scraps of concretionary gravel. At least two show charcoal remnants and may be slag, but several others shows iron corrosion and may be iron scraps - cross section hints at nail shanks. Others show no real features
1521	1305	fill of Roman pit/posthole [1520]	bulk	very rich and abundant hammerscale assemblage
1521	1305		bulk	abundant flake hammerscale, slag and stone. Many flake hammerscale fragments are curved - suggesting formation on tool or round workpiece
1526	1301	fill of Roman ditch [1507]	bulk	stone with trace flake hammerscale
1545	1302	fill of ?tree throw	bulk	stone, tiny amount of flake hammerscale and one piece of spheroidal hammerscale
1549	1304	fill of Roman post-trench [1550]	bulk	abundant flake hammerscale, spheroidal hammerscale and slag with stone
1570	1306	fill of Roman pit [1569]	bulk	stone with very small quantity of flake hammerscale
1572	1307	fill of Roman pit [1571]	bulk	stone with moderate flake hammerscale
1574	1311	fill of Roman pit [1569]	bulk	stone, some tiny fragments of probable flake hammerscale

<i>context</i>	<i>sample</i>	<i>context note</i>	<i>no</i>	<i>notes</i>
1584	1317	Roman layer (assoc with bonfire) - charcoal deposit	bulk	rich collection of flake hammerscale and spheroidal hammerscale with some stone
1584			3	1 small fragment of low-density slag with maroon surface on one side, blebby ,rather like clinker but not 1 small sediment-rich prill 1 fragment of slag with charcoal inclusion and one charcoal-dimpled surface leading around to a slightly flowed, maroon face, has wall contact on third side - so presumably a sub-blowhole slag flange
			(1)	1 piece of iron-rich slag removed from collection for sampling
1589	1308	fill of Roman [1571]	bulk	stone, some flake hammerscale and spheroidal hammerscale
1593	1309	fill of pit 1592 (medieval?)	bulk	stone with small amount of flake hammerscale and spheroidal hammerscale
1614	1310	fill of Roman [1592]	bulk	stone flake hammerscale, spheroidal hammerscale, slag
1614			1	small fragment of concretion with charcoal and some vitrified material - probably a fuel ash slag.
1638		fill of Roman gully [1637]		iron-rich slag with vesicles and charcoal dimples, apparently gradational into dark glass with sand/gravel and bloated ceramic
1643		upper fill of medieval posthole [1642]	1	Large block of poor ferruginous vein rock
1664		upper fill of recut inner Roman military ditch [1663]	(5) 1	irregular broken fragment of charcoal-rich slag attached to fired clay. Piece has exploded to reveal rusty core with botryoidal secondary iron oxides, presumably marking forming location of an iron inclusion
1664			(1)	1 piece of slag removed from collection for sampling
1664	1312		bulk	stone with moderate flake hammerscale and spheroidal hammerscale
1665	1313	fill of recut inner Roman military ditch [1663]	bulk	stone with slag and small quantity of flake hammerscale
1665			1	biconvex nub of ferruginous charcoal-rich slag with patches of greenish fuel-ash slag. Piece shows some expansion cracking, suggesting it contains corroding iron. One surface shows more devitrified glass than the other - so possibly a small SHC
1671	1320	fill of inner ditch [1668]	bulk	moderately abundant flake hammerscale, some spheroidal hammerscale, stone
1672	1321	fill of inner ditch [1668]	bulk	moderately abundant flake hammerscale with some spheroidal hammerscale
1672	1321		bulk	moderate finely divided hammerscale debris, stone
1674	1315	fill of inner ditch [1668]	bulk	stone with small amount of flake hammerscale
1682	1325	upper fill of outer Roman military ditch [1681]	bulk	rich hammerscale assemblage, but quite small quantity

<i>context</i>	<i>sample</i>	<i>context note</i>	<i>no</i>	<i>notes</i>
1682			1 2 (1)	crescentic piece of dense slag, with finely dimpled base and charcoal-rich upper - probably an SHC fragment small sliver of dimpled base as above, bluish sheen probably indicates high Mn content Iron-rich slag removed from collection for sampling
1683	1329	middle fill of [1681]	bulk	moderately abundant flake hammerscale, some spheroidal hammerscale, stone
1728	1316	bonfire deposit Roman - constraining ring	bulk	stone with moderate flake hammerscale
1730	1318	Roman layer (under bonfire)	bulk	moderately abundant flake hammerscale, some spheroidal hammerscale, stone
1735	1319	pre-Roman soil	bulk	stone with trace flake hammerscale
1740	1323	fill of medieval pit, 12th-13th C, post- dates post-built building	bulk	stone with some flake hammerscale
1776 1776	1330	lower fill of Roman pit [1736]	bulk 1	stone, some flake hammerscale concretion around elongate iron object - probably a nail
1837 1837 1837 1837	1324 1324	fill of posthole [1836]	bulk bulk bulk many	very rich and abundant hammerscale assemblage (also large collection of material examined by Roger Taylor rather weathered fines - including slag blisters, larger flake hammerscale pieces, prills, droplets and some slag fragments tiny slag blebs, blisters probably anvil residues, plus one more glassy piece with some reddish areas that are probably sand/sandstone from the hearth wall pieces of ferruginous concretion with slag, slag flats and flake hammerscale, several pieces from small SHCs with dimpled basal crusts up to 15mm thick and charcoal-rich uppers. - none truly estimatable for original size, a few pieces of poorly developed blebby flow slags
2012	1333	occupation or destruction horizon, under 2026	bulk	stone, tiny amount of flake hammerscale and one particle of spheroidal hammerscale
2017 2017	1340 1340	Roman layer - destruction horizon?	bulk bulk	stone. Tiny amount of flake hammerscale tiny fragments of broken slags or slag blisters
2020		Roman ground surface, though which post trenches were cut	1	irregular lump of charcoal-dimpled gravelly lining slag
2025	1338	Roman layer - destruction horizon?	bulk	very small quantity of stone with flake hammerscale
2026 2026	1341	Roman layer, levelling destruction, cut by hearth [2076]	bulk 1	stone with slag spheroid, flake hammerscale and spheroidal hammerscale in small quantities dark glassy lining slag, highly vesicular, contains charcoal

<i>context</i>	<i>sample</i>	<i>context note</i>	<i>no</i>	<i>notes</i>
2027	1343	fill of Roman? hearth	bulk	abundant slag, flake hammerscale, slag flats and slag blisters, also stone
2027	1343		bulk	very rich and abundant hammerscale assemblage
2027	1343			1 fragment of vitrified face to bloated grey ceramic 1 concretion around iron remainder very badly weathered slag and Fe-concretion with charcoal
2075	1349	Roman ground surface?	bulk	moderately abundant flake hammerscale, some spheroidal hammerscale, stone
2075			1	highly vesicular grey slag ,mostly lining slag, has some included sediment grains, one face shows charcoal dimples - quite likely a smithing slag
2077	1326	fill of medieval posthole [2072]	bulk	stone with small quantity of flake hammerscale and spheroidal hammerscale
2077	1326		bulk	moderately abundant flake hammerscale, some spheroidal hammerscale, stone
2079	1328	lower fill of Roman pit [2078]	bulk	stone with trace flake hammerscale
2080	1327	upper fill of Roman pit [2078]	bulk	stone with trace flake hammerscale
2088	1331	lower fill of medieval posthole [2086]	bulk	flake hammerscale and stone in small quantity
2088	133		bulk	stone with minor flake hammerscale
2112	1337	fill of post [2011]	bulk	stone, some flake hammerscale
2141	1339	fill of linear [2140] - Roman drainage gully	bulk	grey vesicular slag grading into quartz rich material - coarse sandstone gravel?
2141	1339		bulk	stone with fine slag debris and some flake hammerscale
2224	1346	fill of Roman gully [2223]		stone with moderate flake hammerscale and spheroidal hammerscale
2226		fill of Roman posthole [2225] = 2296	4	small fragments of charcoal rich slag, some with adhering or included fragments of coarse sand
2281	1351	fill of pre-Roman? Post hole/pit	bulk	stone with trace flake hammerscale
2284	1352	fill of Roman posthole [2283]	bulk	stone with some flake hammerscale
2286	1353	fill of Roman posthole [2285]	bulk	stone with abundant slag fragments and hammerscale
2286				fragmented single (?) lump of dark glass slag with vesicles and abundant fragments of coarse sand and bloated ceramic. One piece seems to show contact with ceramic so probably a lining slag.
2299	1350	fill of Roman posthole [2267] (interval tower post)	bulk	stone and moderate flake hammerscale assemblage

<i>context</i>	<i>sample</i>	<i>context note</i>	<i>no</i>	<i>notes</i>
2319	1336	fill of Roman post-trench [2014]	bulk	stone with flake hammerscale
2323	1335	fill of Roman post-trench [2021]	bulk	stone with flake hammerscale
2328	1355	fill of Roman post-trench [2327]	bulk	rich collection of flake hammerscale and some spheroidal hammerscale with some stone
3009		a fill of large Punic ditch	1	broken block of low density frothy fuel ash slag with charcoal inclusions, no original surfaces. Probably low density Fe-slag but uncertain

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