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Evaluation of archaeometallurgical residues from Portwall Lane, Bristol (BSRMG 2006/17)

(revised version)

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Abstract

This site yielded a variety of both macroscopic and microscopic archaeometallurgical residues, indicating a protracted history of metalworking in the area.

Phase 1yielded a small amount of evidence for both ferrous and non-ferrous metalworking. Both phases 2A and 2B show strong microresidue evidence from the garden soils for iron working (smithing). Detailed site plans were not available, but it would be interesting to see whether these particular soils were associated with the property known to have been occupied by a smith in 1775. Material dumped on the site prior to glassworks construction yielded a significant quantity of large crucible fragments which had probably been employed in reheating brass for casting, although this activity may not have been local to the site. Phase 3 levelling deposits yielded further macroscopic slags from iron working.

An interesting facet of the site is the ubiquitous use of coal as fuel, with no slags producing evidence for charcoal use in either the non-ferrous or the ferrous metalworking.

This report is a revised version of GeoArch Report 2007/10 of March 2007, which inadvertently incorporated description of material actually from the Victoria Street site.

Contents

Methods

All the material from the collection was inspected visually (and with a low-powered stereo-microscope where necessary) and recorded to a spreadsheet (the content of which is presented as Table 1).

As an evaluation, the materials were not subjected to any high-magnification optical inspection, nor to any other form of instrumental analysis (with the exception of representative examples of the crucible sherds). The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional.

Two representative crucible sherds were investigated using the Eagle II ED-XRF system at English Heritage's laboratories at Fort Cumberland, Portsmouth, England, in order to examine the elemental composition of the metal contamination. The results of this analysis are only qualitative, having been taken from a rough surface in a normal atmosphere.

Terminology used in this report employs the term "slag" for a material which has been fully molten, particularly one originating in a metallurgical process, "clinker" for the material deriving from the melting of the inorganic impurities in coal and its admixed host shale (and which often contains some unmelted material), and "coke" for unburnt organic coal residues (sometimes termed cinders).

Results

Description of materials

Microresidues

The sieved residues included two broad suites of material: those attributable to iron-working with a high degree of confidence, and those which certainly involved the burning of coal, but for which a metallurgical origin is not proved.

Metallurgical particles include both flake and spheroidal hammerscale, together with blister-like slag films, slag flats (thin sheets of slag with a metal contact surface on one face, but showing an irregular and convex form on the other). Slag fragments also occur, but certain discrimination of iron-working slag and simple clinker is often difficult at this size. Good assemblages of this kind were recorded from contexts 1365, 1432, 1453, 1454, 1455, 1516, 1643, 1718, and 1735.

The coal-burning residues include fragments of coke (a highly vesicular, black, shiny material, largely carbon, generated during the incomplete burning of coal), clinker (a glassy slag material, typically with a maroon surface, formed from the melting of the impurities of the coal, and often including partially-melted shale fragments), burnt shale and highly magnetic burnt stone particles (iron-rich inclusions, probably originally either of pyrite or siderite, from with the coal seam or coal shale). Assemblages with significant quantities of fines from the burning of coal include those from contexts 1516, 1523, 1547 and 1627.

One interesting observation is the occurrence of slag spheroids, strongly resembling spheroidal hammerscale, within assemblages which otherwise have no evidence for metallurgical input. Spheroidal particles appear to be generated in several settings other than conventional spheroidal hammerscale from forge welding. In this instance it may be that spheroidal droplets of slag (clinker) formed within the coal-burning hearth. It is also possible, since some of these assemblages derive from contexts closely related to those with iron-working residues, that some sorting process has concentrated the spheroidal particles in these contexts without concentrating the flake hammerscale.

Another interesting form of microresidue is of uncertain origin, but many of the assemblages contain magnetic (presumably magnetite) rods, roughly circular in cross section, with diameters ranging from approximately 0.7mm up to 2.5mm, and occurring in lengths of up to about 8mm. These might represent oxidised wire fragments, but are most likely precipitates of iron oxides around plant roots or worm burrows.

Macroscopic residues

Ferrous metalworking

Smithing hearth cakes (SHCs), the normal dominant slag type produced in early smithing hearths, are not well represented in the assemblages. Two reasonably well-formed examples, indicative of original SHC weights of over 800g were recovered from Phase 3c context 1037. This provenance means they are not closely tied to on-site activity. Both showed evidence for the fuel employed being coal. A fragment from a much smaller SHC was found in Phase 1b context 1696. This piece had some adhering charcoal, and might just have been from a charcoal-fuelled hearth although the charcoal was not certainly originally attached to the slag (some charcoal is also sometimes found in coal-fired hearths from the remains of fire-lighting).

Small fragments of probable smithing slags were recovered from contexts 1453 and 1548, both showing evidence for coal use.

A crescentic block of coal-fired smithing slag from context 1365 was not a conventional SHC, but may have formed attached to the tuyère or blowhole area.

Non-ferrous metalworking

The working of copper alloys was demonstrated by material from two contexts. In Phase 1b contest 1734 produced several fragments from copper-alloy working: a dense disk of material probably representing metal spilled in the hearth, a piece of crucible slag, a piece of hearth slag, and a piece of vitrified hearth lining.
In Phase 2b context 1131 yielded a larger assemblage of residues including crucible sherds, hearth slags and clinker. The crucibles are represented by 38 sherds, many bearing indications of failure during use. There are relatively few joins between sherds and no complete profile has yet been reconstructed. The crucibles show variable, but typically thick bases (up to 35mm) with an external diameter of about 125mm. The internal diameter at the base is about 90mm. The sides of the vessels are straight and slightly splayed, thickening from 25mm near the base to about 10mm at the simple rim. The external diameter at the rim is approximately 150-170mm. One sherd shows a small simple out-turned spout. The original height of the crucibles has not yet been reconstructed, but the minimum height indicated is about 150mm, which would give the crucibles a minimum volume of 1400cm^3.

Crucibles with only a slight use have a smooth exterior and a white to buff coloured hard fabric. In use the fabric turns dark towards the outside, particularly on the base. Very well used fragments show the fabric becoming pale grey, with a hint of lilac, with a bleached pale layer below the inner surface.

The inner surfaces of some basal sherds show accumulations of thick, dense residues rich in secondary copper minerals, whereas the sherds from near the rim show a thin inner smooth slag coating, becoming rougher with included dross material in the area below the spout.

The exterior surfaces show a deep, rich, dark brownish glaze on the upper parts and a thicker slag accumulation near the base. These basal accumulations typically have included burnt shale fragments from the coal fuel.

Two sherds were examined using an ED-XRF (Table 3). Although the results were obtained under analytical conditions which mean they must only be taken as qualitative, they suggest (from the analyses of corroded metal) that the alloy was high in zinc and lower in lead, with very little tin. The analysis of the body of one of the sherds showing a grey/lilac colour indicates substantial zinc accumulation within the ceramic. The metal being handled is therefore suggested to have been brass.

Coal-burning residues

The assemblages also include some larger pieces deriving from the burning of coal which cannot be linked, with any certainty, to a metallurgical process. These pieces include low density clinker (context 1354) and coke (context 1436).

Stratigraphic distribution

None of the metallurgical residues comes from a metallurgical feature. Several of the productive contexts are dumps of one sort or another (e.g. contexts 1696, 1718, 1734, 1744, 1131,1627, 1037) and the metallurgical materials from those contexts may well have originated off-site.

More significant perhaps is the persistent recovery of iron-working microresidues from garden soils in phases 2a and 2b (contexts 1523, 1643, 1662, 1365, 1453, 1548), and also from other cut features (contexts 1518, 1718).

Interpretation

The site produced no unequivocal evidence for metalworking within its limits. Much of the assemblage was probably derived from activities elsewhere.

The Archaeological Desktop Study (BARAS report 809/2001) showed that a smith, Thomas Palmer, was recorded at no. 66 Saint Thomas Street in 1775, although that property may have been a sugar house earlier in that century. The microresidues from the Phase 2a and 2b garden soils provide a hint that a smith was active in this area over a considerable period of time prior to this.

Evaluation of potential

The material has some potential to enhance understanding of the variety of metalworking being undertaken in southern Bristol. Further analysis of the non-ferrous metal residues would clarify what metal(s) were being worked; however, the context of the finds means that the material was probably not produced on this site, and thus the potential value of this information would be slightly limited.

The likelihood of on-site blacksmithing in phases 2a and 2b also has some potential for further work. In particular the detailed nature of the slag spheroids is of considerable current research interest, and analyses of those from both iron-working and apparently non-metalworking assemblages would potentially aid understanding of this important class of microresidue. A limited programme of analysis (chemical and textural) on the spheroids would therefore be recommended.

context	*sample*	*label*	*description*
Microresidues			
1365	21	hammerscale	large assemblage with good flake and spheroidal hammerscale, miscellaneous iron rich particles, magnetite rods, rusty concretions, shale, occasional coal
1432	22	hammerscale	good assemblage rich in flake and spheroidal hammerscale, along with slag fragments, shale and ashy white concretionary material
1453	25	hammerscale	dusty assemblage with abundant spheroids, some flake scale, lots of various coal residues
1454	23	hammerscale	abundant flake and spheroidal scale, also other slags films and lumps, fired clay, magnetite rods,
1455	24	hammerscale	abundant flake and spheroidal scale, also other slags films and lumps, fired clay, magnetite rods, charcoal, shale, coke
1516	32	magnetic residue	mainly fired stone and slaggy material, a few shiny flakes almost like hammerscale, but probably not
1516	32	slag	very shiny vesicular fragments - clinker?, also probable piece of coal
1516	32	hammerscale	burnt stone ,shale, clinker, cokes, slag, some flake scale rare spheroids
1518	31	clinker	large bag of coal residue, mainly coke
1518	31	hammerscale	very iron rich residue - lots of burnt stone, iron crusts, thin magnetite rods, possible flake hammerscale, occasional spheroid, some shale, a few angular slag fragments
1523	38	hammerscale	mainly burnt stone, but also abundant spheroids, some possible flake, shale, some rust particles
1547	34	hammerscale	lots of clinkery residue, white residue fragments, some spheres, some shiny flakes - at least some of which may be true flake scale
1548	35	hammerscale	some hammerscale but mainly shale, stone and glassy slag. Some elongate concretions, possible nail head
1627	42	slag	dark vesicular glass with maroon surface, 2 piece: clinker
1627	42	hammerscale	clinker droplets. Burnt stone, shale, probable flake hammerscale, abundant spheroids, crude magnetite rods,
1643	44	slag	red and black glassy clinkers
1643	44	hammerscale	mainly burnt stone and pale material (fired clay or ashy concretions - some rod like), has some flake scale and spheroids, some clinkery blebs
1662	41	hammerscale	some flake and spheroidal scale, clinker, slag, some very thin rods, stone
1718	49	hammerscale	mainly burnt stone and pale material (fired clay or ashy concretions - some rod like), has some flake scale and spheroids
1718	49	slag	small piece of greyish dimpled slag, small fragment, worn, of haematite ore, possible concretionary piece
1735	48	hammerscale	iron-rich coal fragments , possible rare flake and spheroidal scale, possible crucible slag fragment or clinker, magnetite rods, burnt stones
1744	47	hammerscale	mainly burnt stone, but some is slagged, also shale, some slag droplets
1744	47	slag	red and black glassy pieces with white grains - presumably clinker, other lumps may be concretionary
1751	50	clinker	coke (single small fragment)
Macroresidues			
1037	1556	slag	748g curving ferruginous block probable SHC fragment 155x110x60mm; 798g SHC (140)x105x65, both show evidence of coke and first has adhering ash and coal
1354	132	slag	large clinker block - now in several pieces
1354	32	slag	low density clinker in curved sheet
1365	108	slag	rusty crescent of dense clinkery slag. Probably from near tuyère in smithing hearth using coal
1436	76	slag	large block of shale-bearing coke
1453	22	slag	grey vesicular slag with shale fragments, rusted surface
1548	36	slag	dense slag with brownish surface and probable coke inclusions - coal fuelled smithing slag
1696	50	slag	small piece from small SHC, smooth maroon top, ?folded, base smooth with possible charcoal fragment, slightly concreted with freshwater? mussels
1734	130	Cu al slag	10g coke, 20g maroon crucible slag bearing corroded Cu-alloy droplets, 32g dense green glassy slag with Cu-alloy corrosion dimpled around coke fragments, 16 cu corrosion attached to piece of hearth wall - organic temper oxidised fired, 46g extremely dense probable Cu-alloy disk in slag
1754	16	slag	reduced fired vitrified lining
Crucible Assemblage			
1131	96	vitrified ceramic	2 pieces of slagged refractory material - possibly failed crucible fragments
1131	6880	crucibles	38 sherds of large crucibles
1131	790	Cu-alloy slag	11 pieces of slag. At least 4 pieces are effectively clinker, with large shale fragments, 1 is a piece of slagged crucible debris, 1 is a very dense block of iron-rich slag, the others are lower density slags with extensive development of secondary copper minerals.
1131	86	burnt stone	lightly vitrified shale with some Cu-alloy slag
1131	290	vitrified ceramic	2 blocks of vitrified shale strongly coated in slag including Cu-alloy material

Table 1: Summary catalogue by context

Context	Description	Phase	Assemblage
1735	fill of feature 1736	1a	coal burning residue, possible smithing
1751	fill of linear 1752	1a	coal-burning residue
1754	disturbed surface of alluvium	1a	hearth lining
1696	redeposited alluvium	1b	smithing
1718	redeposited alluvium	1b	indeterminate metalworking
1734	redeposited alluvium	1b	copper-alloy working, coal-burning residues
1744	redeposited alluvium	1b	coal-burning residues
1454	deposit	2a	smithing, coal-burning residues
1523	garden soil	2a	smithing, coal-burning residues
1643	garden soil	2a	smithing, coal-burning residues
1662	garden soil	2a	smithing, coal-burning residues
1718	fill of pit 1717	2a	smithing, coal-burning residues
1131	deposit	2b	brass working (casting), coal residues
1354	fill of shallow pit cut by old cone	2b	coal-burning residue
1365	garden soil	2b	smithing, coal-burning residues
1436	depost	2b	coal-burning residue
1453	garden soil	2b	smithing, coal-burning residues
1518	fill of linear 1519	2b	smithing, coal-burning residues
1548	garden soil	2b	smithing, coal-burning residues
1627	dumped deposits	2b	smithing, coal-burning residues
1037	levelling over new cone	3c	smithing
1432	?	?	smithing, coal-burning residues
1455	?	?	smithing, coal-burning residues
1516	?	?	smithing, coal-burning residues
1547	?	?	smithing, coal-burning residues

Table 2: Summary of interpretation of assemblages organised by phase and context.
Records of coal-burning residue do not necessarily exclude a metallurgical origin for the residues.
Stratigraphic and phasing details were not available for four contexts (1432, 1455, 1516 & 1547)

	Portwall 1 brown residue	Portwall 1 green residue	Portwall 2 green corrosion on outside	Portwall 2 inner pale fabric
Oxide:	At%	At%	At%	At%
CaO	1.43	1.66	4.44	25.19
MnO	0.26	0.15	0.01	0.13
Fe_2O_3	72.15	48.54	2.66	8.18
CuO	17.04	36.96	83.32	2.11
ZnO	6.76	10.27	8.38	62.64
PbO_2	1.85	2.18	0.83	0.52
SrO	0.08	0.11	0.09	0.31
ZrO_2	0.35	0.03	0.15	0.74
SnO_2	0.08	0.09	0.13	0.16
Oxide:	Wt%	Wt%	Wt%	Wt%
CaO	0.57	0.766	3.024	17.091
MnO	0.129	0.088	0.011	0.115
Fe_2O_3	82.11	63.629	5.168	15.799
CuO	9.659	24.134	80.531	2.029
ZnO	3.917	6.861	8.283	61.659
PbO_2	3.155	4.283	2.416	1.511
SrO	0.063	0.093	0.115	0.388
ZrO_2	0.31	0.03	0.22	1.11
SnO_2	0.088	0.117	0.233	0.297

Table 3: Raw ED-XRF analyses (qualitative) from crucible sherds from context 1131.

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