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Evaluation of archaeometallurgical residues from Blonk Street, Sheffield

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Abstract

There was a total of 10.6kg of archaeometallurgical residues recovered from this site. Much of the material from the site is not diagnostic of process. Almost half the total material (4.62kg) comprises clinker (of which 4.1kg was a single block from Phase IIIB deposits), the partially melted residue from the burning of coal. Such material cannot be referred to a specific process, and might even relate to non-metallurgical use of coal in, for instance, a steam boiler.

Also rather undiagnostic are fragments of strongly heat effected, vitrified or clinker-coated stones from deposits in Phase V (and possibly to a lesser extent Phase IIIB). Such intense heating is likely, but not certainly, to be from a metallurgical process, but these fragments are not diagnostic. These pieces are therefore most likely to come from the demolition or refurbishment of a metallurgical hearth or furnace. Phase IIIB also produced an assemblage (1.1kg) of sherds of steel crucible in a levelling layer.

Clearer evidence of metallurgical activity is represented by material derived from iron-working (smithing), present mainly in deposits of Phase 1. These include dense slags, rich in iron, which are probably smithing hearth cakes from small-scale iron-working. Associated with the slags are a considerable quantity of lumps of deposit which have been cemented (concreted) through precipitation of secondary iron minerals following corrosion of pieces of iron metal. These concretionary lumps contain large quantities of hammerscale (both flake and spheroidal) as well as small coal particles. These concretions probably developed in-situ, which would suggest that their enclosing sediments (particularly the "clinker layer" c283/c263) were rich in smithing micro-residues. One concretion derived from a coal storage area and contained coal fines without archaeometallurgical micro-residues.

Context 251, an alluvial deposit, yields a single small piece of a brown glassy slag, which is probably not related to the other materials seen here. Glassy iron-working slags are not typically brown, although melted furnace/hearth ceramic may generate unusual colours. This material ,therefore, may be from a non-ferrous metallurgical activity, possibly lead working.

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Methods

All materials were examined visually, using a low-powered binocular microscope where necessary. All materials were weighed and recorded to a database (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. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional.

Results

Clinker

The dominant material in the assemblage is clinker (4.6kg). Clinker is the partially melted inorganic residue from the burning of coal. This material was typical clinker, with variably coloured, typically grey, melted

material, binding together fragments of shale with varying degrees of vitrification.

Material from c120 comprises a large block of clinker, weighing 4.1kg, with a moderately smooth top bearing slightly wrinkled flow lobes. Most other clinker specimens in the assemblage are very small.

Slag

Certain metallurgical slag rich in iron occurred in c207 (3 pieces, total weight 728g). A single example of a well-formed dense smithing hearth cake (SHC), of plano-convex shape, 120x90x47mm, and weight 444g, was accompanied by 2 small broken pieces of slag. The smithing hearth cake showed fragments of coked coal associated with its dimpled upper surface. Most surface details were, however, obscured by a superficial concretionary sandy layer, bearing clasts of coal, slag debris and hammerscale (both flake and spheroidal). The concretion also included mineralised plant remains.

A small fragment (50g) of well-flowed iron-rich slag was recovered from c116. The piece shows the development f well-formed flow lobes. Fluid, fayalitic slags may be generated in wide variety of processes, so a single small flow like this cannot be attributed to any particular activity.

A small piece of partially crystallised black glassy slag, with pale phenocrysts, of uncertain origin was recovered from c181. It may be associated iwth the crucible slags (see below).

Concretionary material

Several dense blocks of concretionary material were recovered from c213, c283 and c147 (total weight 2.8kg). These materials have been generated through the corrosion of iron debris or artefacts, releasing iron, which has then oxidised to form a cemented concretion around the original iron. In the material from c213 the concretion has formed around iron of uncertain form, with the concretion being sandy and rich in coal debris,

For the material from c283 and c147 the host sediment which has been cemented by the iron oxide is rich in not only coal debris, but also comminuted slag and hammerscale.

The iron debris is in variable form, dominantly sheet, but also including a short length of bar iron and a piece with a right-angle section.

The larger specimen from c213 also contains a sherd of glazed pottery.

Structural materials

Contexts c116, c220 and c295 all yielded material which showed the influence of extremely high temperatures on sandstones (total weight 914g). These materials showed smooth surfaces, with clinkery materials adhering to deeply vitrified sandstones.

Iron

C110 yielded a fragment of iron (358g) of rather uncertain origin. It appears to represent part of a dome-shaped object. If so, it would have had a basal external diameter of about 145mm, with walls 13mm thick, rising to about 45mm above the base. The walls are slightly oblique to the base giving an apparent thickness of the walls on the base of about 25mm.

The piece is extremely corroded and is fragmenting into irregular pieces. The angularity of the fragments suggests that the object may be cast iron rather than wrought iron (which normally shows its fibrous structure when corroded).

Non-ferrous slag?

A single fragment of a brown glassy slag was recovered from alluvial deposit c251. The piece is small (22g) and contains some inclusions (probably pale rock fragments). This slag piece does not resemble typical iron slags, and may be from a process involving non-ferrous metals, perhaps lead.

Crucible

Context 295 yielded 14 sherds (1.1 kg) of dark, graphitic crucible. All the material is deeply vitrified and shows variable slagging. The external surface is unaltered near the rim, with splashes and runs of adhering glassy slag. In the mid part of the crucible the external surface is variously dull and maroon or dark grey and vesicular. Towards the base there are local patches of thicker, greenish slag, with occasional coke inclusions.

The inner surfaces are mainly dull or vesicular, but some have dull grey, or glassy black and reddish-brown slags adhering.

The ceramic is very fine grained and dark grey, almost black, with abundant aligned irregularly tabular voids, picking out a strong fabric.

The single rim sherd shows a slightly inturned, but simple rounded rim, approximately 10mm thick. This single piece appears to show a vessel with an outwardly splay below the rim, atypical of steel crucibles, but the piece may be deformed.

These sherds are almost certainly steel crucibles, but the rim shape is atypical.

Stratigraphic distribution

The pattern of stratigraphic distribution of the various classes of residues recovered from the site appears to show some variation in activity (Table 2).

The single fragment of possible non-ferrous slag was retrieved from an alluvial deposit (c251) and may therefore be reworked onto the site from elsewhere.

Phase 1 deposits show an assemblage comprising slag (c207), including a good example of a smithing hearth cake, clinker (c138, c191, c218) and concretionary material (c213, c283).

The concretionary material from c213 includes coal dust, but not metallurgical micro-residues (and is recorded as being the surface of a coal-storage yard). In contrast c283 was described as a “clinker layer” and the concretionary material shows abundant hammerscale and comminuted slag. In both cases the concretions have grown within the sediment and are likely to be representative of the host; that in c213 was a sandy deposit rich in coal dust, whereas that in c283 was a deposit rich in smithy waste – hammerscale, slag, coal and iron fragments.

No archaeometallurgical residues were recovered from Phase 2 deposits.

Phase 3 produced a small number of pieces of residue of variable origin, including clinker, vitrified sandstone and a single piece of concretionary smithy material similar to that from c283 (perhaps derived?). It also (phase IIIB) contained a significant assemblage (1.1 kg, 14 sherds) of fragments of probable steel crucible.

No archaeometallurgical residues were recovered from Phase 4 deposits.

Residues from Phase 5 were represented by an assemblage from c116, which comprised 7 fragments of vitrified and clinker coated stone surfaces, 4 pieces of clinker and 1 tiny fragment of a denser slag flow.

Interpretation

The material from Phase 1 is indicative of iron working. The concretionary material from within the clinker layer (c283) contains iron-working micro-residues, so the layer is likely to represent fine debris or sweepings from a forge. The presence of both flake and spheroidal hammerscale in the assemblage would be typical of a forge (Starley 1995), but would not discriminate between small scale smithing activities and an industrial forge. The slags from c207, however, would appear to be from fairly small SHCs (the apparently complete cake weighs 444g), which would be compatible with the size of slag cake produced during blacksmithing, rather than during an industrial scale process (Crew 1996).

In general significant quantities of smithing fines tend to accumulate only very close to, or within, the forge itself, so these materials would indicate that the smithing activity was close to the area of deposition of C283.

The well-formed nature of the complete SHC from c207 is interesting, for 19th – 20th century coal-fired blacksmithing hearths typically produce rather poorly compacted slag/clinker cakes, not dense compact forms such as this. This is because the principal source of silicate for the slag formation is the coal residue. In earlier smithing hearths, the principle source would be the clay of the blowing wall or ceramic tuyère, but the introduction of the cast iron tuyère removed these sources. In this instance it would appear likely that a cast iron tuyère was not being used, allowing formation of a dense slag cake. Unfortunately the chronology of the development of the smithy hearth between the 16th century (when cast iron tuyères were yet unknown) and the mid 19th century (by which time the cast iron tuyère was ubiquitous in Britain) is essentially unknown.

From Phase 2 to Phase 5 there is little direct indication of metallurgical activity on the site. Most of the residues are not only of uncertain origin (clinkers and slagged stone), but they do not appear to be in primary contexts. The significant assemblage of steel crucible fragments from Phase IIB levelling, is indicative of process, but is likely to be derived. The large assemblage from c116 in Phase 5 is likely to come from demolition or refurbishment of a metallurgical hearth or furnace.

Evaluation of potential

The relatively small size of the assemblage, and lack of direct connection for most of the residues with other evidence for metallurgical activities means that there would only be limited value for further investigation of the material.

Possible avenues for investigation of the activities in Phase 1 would include characterisation of the iron being worked through metallography of the iron debris, and microscopic investigation of the micro-residues and slags. Such activities would probably only be worthwhile if the residues can be tied convincingly to a well-dated forge within the site. The value of analysis of dumped material without such control would be extremely limited.

The interest in the smithing residues is somewhat enhanced by the apparent use of hearth with a clay blowing wall or tuyère, rather than a cast iron tuyère. The adoption of cast iron tuyères is not well dated, nor are the exact blowing arrangements in smithy hearths of the earlier post-medieval period.

References

CREW, P. 1996. *Bloom refining and smithing, slags and other residues*. Historical Metallurgy Society, Archaeology Datasheet No. 6.

STARLEY, D. 1995. *Hammerscale.* Historical Metallurgy Society, Archaeological Datasheet no. 10.

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Context	Find	Weight (g)	Notes
110		358	fragment from domed piece of iron, highly corroded and actively "exploding". Form suggests a dome 145mm in diameter on base, curves in towards level 40mm above base then flares upwards again close to break. Iron 13mm thick, giving basal contact 25mm wide.
116		156	clinkery slag, moderately dense, vesicular, glassy
		62	smooth maroon vitrified surface cutting two stone slabs (now white) with red sandy material in gap between infiltrated by slaggy material
		198	heavily vitrified and ?blasted sandstone
		42	clinker with abundant shale fragments
		60	slightly flown clinker
		120	deeply vitrified and altered sandstone
		44	deeply vitrified and altered sandstone
		26	vitrified maroon slaggy material, similar to 62g piece above, but thicker, on stone
		6	clinker
		6	deeply vitrified and altered sandstone
		32	extremely deeply vitrified stone with maroon glassy surface
		50	dense lobes of fayalitic slag with maroon surface, probably associated with fuel contact, opposing surface has fine debris
120		4110	large block of coarse clinker, now fractured into several pieces, one surface of the piece is moderately smooth with some broad, slightly wrinkled flow lobes
138	1	4	Clinker
147		192	accretionary piece cemented through corrosion of iron fragments (mainly sheet visible), accretion includes coal, flake and spheroidal hammerscale as well as sand
181		26	smoothly vitrified low-density material, probably coal dirt?
		12	Black glassy slag, bearing small white/cream crystals. 1 surface slightly maroon, dull and ropey, opposing surface is orange/red glass, similar in colour to some of the slag in the crucibles in c 295. Somewhat similar to piece in c251.
191		22	6 pieces of variable clinker
207		444	SHC, lots of accreted material with organics, but also coal residue - probably a coal-fired slag, 120x90x47mm, details obscured by accretion
		226	vesicular iron slag in amorphous fragment - probably a smithing slag
		58	vesicular iron slag in amorphous fragment - probably a smithing slag
213		434	iron cemented debris including pebbles, coal and pottery - probably a substantial lump of iron inside to judge by weight
		4	small piece similar to above
218		102	5 pieces (largest broken in two) of rather variable clinker. Some highly vitrified material but others more iron-rich
220		560	slab of fine sandstone with clinkery reside on one end to a maximum of about 15mm thickness
251		22	dense piece of rich dark glass. Slightly brown but almost black. Some silicic rock inclusions and some brownish material - this could be metallurgical, perhaps a lead-working slag?
283		2175	large quantity of forge residue - fine sand, spheroidal and flake scale, slag, coke and coal cemented by corrosion around pieces of iron. The iron fragments have mainly sheet morphology, but there is one large right-angle piece and one bar (1x0.5 inch by 7cm long). One piece of accretion has an approximately 0.6mm diameter Cu alloy wire within it.
295		166	large slab of curved vitrified material. Resembles large crucible but formed of coarse quartz sand - so possible a curved sandstone face. 120x70x20
		96	clinker with highly vitrified surface
		1100	14 sherds of graphitic crucible.

Table 1. Summary catalogue of materials

	iron	accretion	slag	clinker	non-ferrous?	structural	*total*
alluvial					22		*22*
I		2613	728	128			*3469*
II							*0*
IIIA							*0*
IIIB		192		4206		166	*4564*
IIIC				26			*26*
IV							*0*
V			50	264		488	*802*
?	358					260	*618*
total	*358*	*2805*	*778*	*4624*	*22*	*914*	***9501***

Table 2. Summary of residue class by phase. All weights in gram.

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