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Evaluation of archaeometallurgical residues from Caerleon Junior School (CA/JS/07)

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Abstract

This small assemblage (c. 7.2kg) of material was largely composed of residues derived from the working of iron (smithing) with smithing hearth cakes (2.2kg), smithing slag lumps (0.7kg), clinker (0.2kg) and associated hearth lining/lining slags (1.1kg). There was also a smaller component identifiable as deriving from iron smelting with 0.8kg of tapped bloomery smelting slags. Indeterminate slag, which might have derived from either process made up 1.3kg of the collection. Both coal and charcoal were employed as fuel for smithing.

Non-ferrous metalworking is indicated by a single crucible sherd, although it is possible this failed before use.

The small size of the smithing hearth cakes (SHCs) would suggest that the work being undertaken was blacksmithing (rather than bloomsmithing). However, if the smelting slags were relatively in-situ (i.e. not brought in from outside the area as hardcore for instance)then that might imply that bloomsmithing would be a likely activity in the area – and might possibly give one reason why both coal and charcoal appear to have been employed for smithing (with charcoal being preferred for bloomsmithing).

The residues mainly occurred in association with a row of "tabernae*" within the eastern range of the* fabrica *previously identified by geophysics.*

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Methods

All materials were examined visually and with a low powered binocular microscope where necessary. All samples were weighted, described and recorded to a database (Table 1). No chemical analysis or high-powered microscope work is attempted during an evaluation and therefore the identifications of materials in this report are necessarily limited and must be regarded as provisional.

Results

Materials from Caerleon Junior School were recovered during the excavation of a series of test pits with little or no lateral continuity. Discussion is therefore limited by the available contextual information.

Description of residues

Iron smelting residues
The assemblage included 836g of dense flowed slags, interpretable as tapped bloomery slags (i.e. slags allowed to flow from the base of a bloomery iron smelting furnace during its operation and which cooled outside the furnace). In addition to these slags, some of the indeterminate iron slags might possibly be slags which cooled inside the furnace (i.e. furnace slags).

Smithing hearth cakes
Smithing hearth cakes (SHCs) comprised approximately 2.2kg of the assemblage. Much of this material was in present as fragments however at least

six were either certainly more-or-less complete or probably so. Identification of the degree of completeness of small, poorly consolidated SHCs is always problematic, particularly in cases where they have been deformed on extraction from the hearth, as appears to have been the case in at least one example (TP 41, c74). It is likely therefore that the original weights would actually have been slightly higher than those recorded here.

Of those almost complete (or almost complete) examples the mean weight was 172g (range 58g – 284g). Many of the SHC fragments contained small charcoal inclusions and moulds indicating the use of a charcoal fuelled hearth, including five of the six 'complete' examples.

Smithing hearth slags/lumps
This category includes slags which texturally resemble the SHCs (for instance with features like dimpled surfaces from fuel contact), but which did not have the overall morphology of SHCs. A high proportion of these materials were formed from coalesced small slag prills, and in the majority of these, coal was identifiable as the fuel.

Clinker
The term clinker is reserved in this report for black glassy slags, usually bearing small, often partially melted, clasts of shale, with a low overall density and typically a maroon surface.

In some instances the amount of melt may be very small and the recorded particles may be pieces of shale or siltstone that were mixed with the coal, and have become partly melted and slagged.

These glassy materials grade into the smithing hearth slags described above, but usage in this category is intended for materials with a low iron content, i.e. materials which are largely or wholly derived from the melting of the inorganic component of coal. Such materials can form in other places where coal is burnt at high temperatures (and unstratified material might derive, for instance, from agricultural steam engine boilers), but in the context of the assemblage most are probably just iron-poor slags from the coal-fuelled smithing hearths. Just 0.2kg of the assemblage was classifiable as clinker.

Indeterminate iron slags
Approximately 1.3kg of the Caerleon assemblage has been labelled as indeterminate slag meaning that their technological origin is not certain. In many cases this was because the pieces were too small to reveal any characteristic morphology or there was not certain morphological evidence of being part of a SHC.

Included here are some slags with blebby or flowed texture which may have formed in a smithing hearth, but for which an origin in a smelting furnace cannot be excluded.

Lining slags and hearth lining
Approximately 1.1kg of material has been assigned to these two categories. The lining slags are those slags formed mainly, or entirely of melted hearth (or furnace) ceramic. They are mainly dark glasses bearing abundant grains of unmelted material derived from the ceramic. In most cases these grains are of sand-grade, but the hearth lining here appears to be full of pebbles, and clasts, mainly of sandstone, of up to about 40mm are seen.

Slags derived from the lining are a major contributor ot the overall composition of the hearth slags – so these materials grade into the hearth slags and the SHCs, often with a rather arbitrary distinction based upon the amount of visible glass.

One particularly important piece in this category is the large block of lining from TP28, c5. This piece appears to derive from the wall below the smithing hearth's blowhole. Interestingly, although the blowhole is not itself preserved, the piece suggests that the blowhole was on a slightly bulbous convex projection from the hearth wall. Below the blowhole the degree of vitrification decreases rapidly, and the overhang of the wall causes the slags of the blowhole region to hang into the hearth away from the wall. Although this form mimics, to some extent, the shape (and function) of a protruding tuyère, there is no evidence that it did form a tuyère, in the sense of a distinct physical entity - a block of clay set into the hearth wall. The overhanging form would reduce wall damage below the blowhole, and thereby decrease the need for repair.

Corroded iron and concretions
The assemblage also included approximately 819g of corroded iron and concretions believed to contain iron, including several fragments of nails, and several pieces of sheet iron.

Crucible
A single small sherd of thick-walled rounded crucible was recovered from TP40, c59. The external surface of crucible was vitrified, and the fabric was deeply altered with developing vesicularity, but the internal surface showed crisp, fresh moulds of the organic temper (grass or chaff?) employed. Such features would be expected to degrade rapidly with use, and it would appear likely that this crucible failed either during initial manufacture or during its being brought up to working temperature prior to use (tempering).

Distribution of residues

Because of the small quantities of material involved, and the lack of stratigraphic control, little can be said about the distribution.

However, there was a notable concentration of iron working residue in the pits 21, 28, 30, 33, 34, 37, 41 and 42, with the crucible sherd deriving from pit 40. This suggests a clear clustering in specific areas.

The rich contexts were 7, 43, 58, 66, 70, 73, 74 and 80.

Beyond the general observation that most of the residues derive from the area of the *fabrica* (Guest & Young in press; Figure 1), there is no particular association of residue type with context or fence pit location. There is possibly an association with the identified fuels – all identified examples of charcoal as fuel derived from the area of the "*tabernae*" in the east range of the *fabrica,* but identified examples of coal fuel came from a wider area. It is unfortunate that samples were not taken for micro-residue investigation, but note was taken during this assessment of instances where microresidues were found to be adhering to material, or included within concretions. Interestingly the clearest example of this is from TP21 c43, which tentatively appears to be outside the building footprint suggested by the geophysics (Figure 1).

Interpretation

The general style of the recognisable fragments of SHCs is compatible with their origin during light blacksmithing work. Such work might include light fabrication and repair tasks, but would probably exclude extended periods of forge (fire) welding (including bloom refining), which would tend to cause more loss of iron to the hearth and hence larger SHCs.

The size of the SHC assemblage here is too small for meaningful comparison with the statistics from other sites. A general comparison can be drawn, however, with sites such as the rural Roman ironworking at Marsh Leys Farm, Bedfordshire (with an average SHC weight of 333g; Young 2005) and the urban smithy at Carmarthen (with an average SHC weight of 227g; Crew 2003).

Rather more local to the current site, there is iron-working known from several sites in Caerwent, although only the *Forum-Basilica* assemblage has been studied in detail (Young 2006). The iron working here was in two phases; an early phase dominated by iron production (perhaps associated with the construction of the *Forum-Basilica*) and a later phase of large scale blacksmithing (Young 2006). This later phase entailed the use of both charcoal and coal as fuel, and the function of the *basilica* at this period has been compared with that of the Caerleon *fabrica* (Young in press).

Residues from a Roman smithy at Bulmore (2km NE of the present site) produced evidence of the use of coal, and included SHCs with a weight range of 125 - 470g , with outliers at 570g and 770g, with an overall mean of 270g. A fragment representing approximately 25% of a large SHC weighed 310g. These larger cakes may possibly be indicative of bloomsmithing.

Smaller scale ironworking is known from a rural site at Trowbridge 14km SW of Caerleon (Young 2009), where most if not all, of the smithing was undertaken using coal. Only a very small number of SHCs were found on this site, but they had a weight range of 144-290g, comparable with that of the present material.

The occurrence of iron smelting residues within the fortress in apparently stratified contexts is unexpected. Although much of the smelting debris in and around Caerleon is probably of medieval date, smelting evidence was recorded outside the fortress to the east (Evans 2000, pp. 154-158). Smelting slags were recovered from excavations of the south-western defences (Young & Thomas 1997), although a medieval age was suspected for these specimens. At other sites where iron smelting was undertaken around military establishments in the area, the smelting has, so far, proved to have been undertaken outside any active defences (Young, in press). Smelting slag is a durable material, capable of being used for metalling and hardcore, but the occurrence in these assemblages appears to parallel that of other slags, and production in a local process would appear much more likely.

The chemical signature of the slag from the SW defences was that of the Forest of Dean ores. Forest of Dean ore was also represented amongst material found upon the Roman road surface in Bulmore (Young 1999). There is no ore in the present collection, but it is anticipated that a Forest of Dean source would be very likely.

Evaluation of potential

The detailed analysis of the materials in the assemblage would be unlikely to have great potential for providing significant further information. The only exception to that would be the iron smelting slag. Chemical evidence for the ore source being employed would be very useful for the construction of economic relationships of the fortress with the hinterland. However, since the smelting activity cannot currently be demonstrated to have been within the fortress with any certainty, then pursuing that analysis is not of the highest priority.

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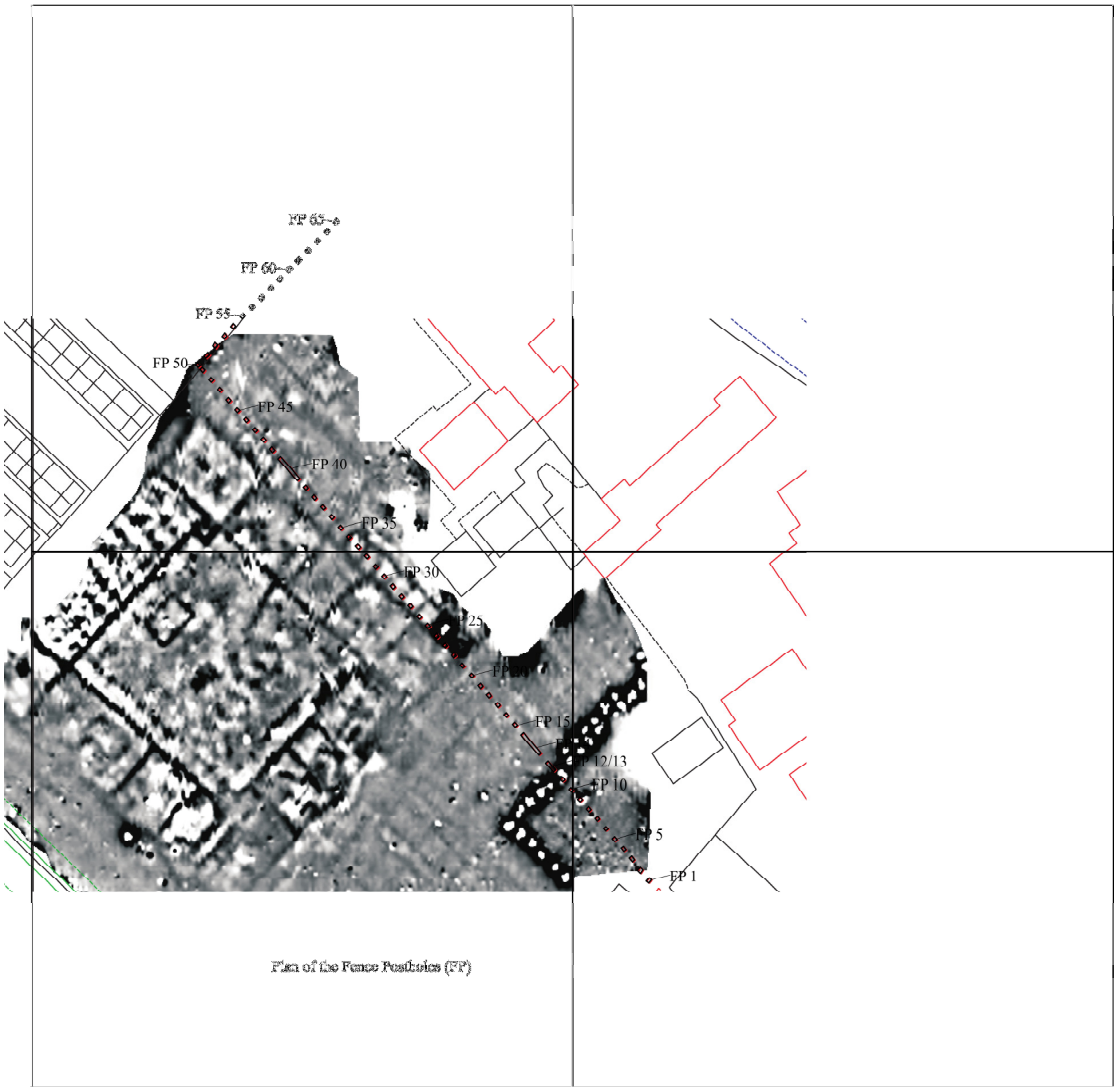

Figure 1. Geophysical survey of School Field, showing the Fence Post locations referred to in the text.

Table 1: catalogue of material from Caerleon Junior School

Post pit	***context***	***weight (g)***	***Description***
TP04	11	10	1 small fragment black glassy slag with maroon surface - clinker
TP14	33	72	24g piece of rounded lining slag, possibly a failed wall fragment; a 22g fragment of rather clinkery looking, but dense slag attached to, or with a clast of, reduced-fired ceramic; 26g piece grading from dense iron-rich slag in to a fuel ash slag of pale glass binding charcoal debris.
TP19	31	16	2 small fragments of flowed slag, probably tapped smelting slag
TP20	38	220	3 pieces of concretion (168g) presumably containing iron, in gravelly sediment; 2 pieces (60g) of prilly/lobate lining influenced slags – one with charcoal inclusions one with coal residues.
TP21	43	526	182g, irregular charcoal rich slag, probably a small SHC or major part thereof, has charcoal in dimples and adhering coal; 232g 4 rounded nubs of dimpled hearth slags (2 with coal shale clasts, 2 with possible coal and charcoal); 32g smithing floor concretion with hammerscale and coal; 48g fragment of reduced-fired lining, with adhering clinkery, purple-surfaced lining slag, slag contains shale chips so probably coal fuelled, but dimples mainly contain debris from lining; 22g low density clinker (note: all slag specimens from this context have adhering particles of coal and flake hammerscale, with rarer spheroidal hammerscale)
TP21	47	18	2 very small fragments of dense flowed slag, at least one of which may be tapped slag (8g); 2 concretions around iron (10g)
TP26	50	225	182g, 4 pieces of smithing floor concretion, contain corroded iron, one is large (10x4cm, 130.5g), they containing charcoal, and hammerscale and coal residues; 1 prill-like blebby piece of clinkery slag with coal residues in dimples; 1 rounded nub of lining slag.
TP28	5	392	Convex-surfaced hearth lining (392g), borderline oxidised fired becoming more strongly oxidised towards one margin. Area with oxidised lining is covered in thick irregular mass of mixed lining slag and iron-rich slag. Less oxidised zones are not slagged and show no vitrification. The geometry suggests this is below the blowhole in a situation where the blowhole is situated on a bulbous zone of wall or a large tuyère.
TP28	5	14	2 small fragments of dense slag (8g); 1 piece of concretion on iron (6g)
TP29	6	17	1 small piece of slagged lining, with charcoal clasts and dense slag mixed with lining slag
TP30	7	310	5 fragments of probable SHC: 140g, small SHC broken in 2 with part missing, extremely dense and rusty, crudely plano-convex, contains charcoal; 86g tiny SHC, slightly prilly base enclose charcoal, biconvex, irregularly smooth top; 2 pieces (58g and 26g) of substantial parts of small SHCs, both contain charcoal.
TP31	58	90	2 fragments of indeterminate slag, one quite blebby, internally prilly piece with charcoal in dimples (60g), 1 vitrified lump of ceramic, probably a failed wall fragment. (30g)
TP32	62	54	1 fragment of rusty indeterminate slag (10g); 1 fragment of slag with internal prills and charcoal inclusions, probably a hearth slag, possibly contorted (44g)
TP32	64	8	2 small fragments of concretion on iron (4g); 1 piece (4g) of a glassy slag bleb, lining slag or clinker

Post pit	*context*	*weight (g)*	*Description*
TP33	2	55	1 piece concretion in coal-rich ashy sediment (6g); 2 pieces of dense irregular internally prilly slag nub, enclosing coal residue fragments (26g & 12g);
TP33	66	634	1 corroded nail fragment (4g); 5 pieces of sheet iron in "smithing floor" concretions (82g); 1 smithing floor concretion cored on unknown iron fragment (24g); 52g, 2 pieces of slagged and vitrified shale; 3 pieces of slagged lining (102g), with largest suggesting slagging on a convex face; one fragment of low density slag attached to oxidised fired lining and bent, or draped, through 90 degree angle (72g); 2 pieces (92g) of amorphous blebby lumps of clinkery low density slag (one with coal residue, one with charcoal); 64g rounded bleb of dimpled dense slag, with coal residue in dimples; 136g piece of dense slag probably derived from a SHC, shows interaction with wall at one side, top has raised lobes with maroon surface, base probably finely dimpled, but mainly rusted, no clear fuel residue.
TP33	70	186	1 small fragment of vitrified lining (12g); 1 fragment (106g) of indeterminate slag, with strong ridges on one surface of dense, gently dimpled slag, whereas opposing surface shows some glass, probably a small SHC with tool-marks on the base, but ridges might just be deformational; 1 fragment (52g) of slag with one surface rich in pale glass and gently lobate, the opposite face is a fracture exposing a cavity with large crystals exposed, probably part of an SHC; 1 small fragment of flowed slag, probably tapped smelting slag (16g)
TP34	67	95	1 fragment of indeterminate slag in a sheet like form, basal surface is prilly, no visible fuel residue, margin has some maroon surface smooth area, top is a fracture surface revealing grey vesicular iron slag. Probably the lower part of an SHC.
TP34	73	500	178g of corroded iron in concretions with smithing floor material which is rich in charcoal, hammerscale and coal relatively sparse.; 1 corroded nail fragments (2 g); 2 fragments of dense flowed slag (146g), one shows bright non-wetted basal surface, the other is a runner, with a rough basal surface and dimpled top; 38g fragment of oxidised-fired vitrified wall, attached slag contains shale and coked coal debris; 56g of low density clinker with vitrified and slagged shale, in 7 pieces; 70g, 5 pieces of dense slag in small prilly masses. Moulds between prills contain coal residues; 10g small prill of lining slag.
TP36	76	250	1 probable fragment of SHC (150g); 1 fragment of flowed slag, probably tap slag with large vesicles (100g)
TP37	80	636	9 pieces of slag, all showing aspects of slag interaction with a hearth ceramic which bears large pebbles (up to 30mm). 3 pieces (140g) are conjoining fragments of pebbly, sandy hearth ceramic with a deep vitrification and a very smooth, maroon-surface, black glassy slag coating. The underlying ceramic shows a high surface topography – possibly due to proximity to blowhole, but it is also possible this was a detached fragment; 2 small fragments (8g) of slagged hearth ceramic; 2 pieces of denser nubs of lining slag containing pebble clasts (146g) ; 1 piece with interaction between a dense slag and hearth ceramic – showing variously either reaction or non-wetted intrusive contacts (62g); 1 large block (90x90x40mm) of maroon-surfaced clinkery slag, mixed with variously melted/vitrified ceramic (282g), upper surface contains much dispersed sand, lower face is more prilly and dimpled. This piece is arguably an SHC.
TP37	80	1.5	I small sheet (20x15 by up to 2mm thick) of dense slag. One face is a non-wetted contact surface with a lightly lobate slag, dark and with a metallic lustre, opposite side shows variously a maroon metallic lustre, or khaki silicate slag. The piece is broken on one narrow side. This appears to be a "slag flat", probably due to slag chilling on the workpiece or on the smith's tools.
TP40	59 [47]	7.6	Sherd of thick walled crucible. Outside is vitrified. Inside shows well-reserved grass/chaff tempering of quartz-rich fabric, with no remains of metallurgical residues. Wall is thick (10mm) and shape suggests a large rounded crucible.
TP41	74	600	3 fragments of SHC: 1 essentially complete SHC has flowed upper surface and is deformed - probably manipulated while hot, was 115x105mm, but rather concertinaed making the original thin slab have a folded thickness of 50mm (284g), lining attached to one end; one block (198g) is almost a conglomerate of sandstone pebbles to 45mm, bound by slag; third is a small slag mass , triangular in shape, protruding 60mm forward of oxidised-fired lining (130g); all three pieces show abundant charcoal debris.
TP42	2	203	3 fragments of dense flow lobed slag (54g), probably tap slags; 78g fragment of dense vesicular slag with a flat maroon upper surface, probably a tap slag, must might just be a smooth-blown SHC fragment; 26g piece of lining slag, comprising several pebbles fused by slag films; 48g slag piece, one surface has maroon-surfaced zone ,but this passes into material with lobes of both dense slag and sandy black glass lining slag, probably an SHC fragment or related material.

Post pit	*context*	*weight (g)*	*Description*
TP42	85	444	50x75x25mm, probable small SHC with charcoal rich top and slightly prilly base (58g); 380g curious large flow lobe with smooth convex base (?) and flat charcoal rich top, this could be an aberrant SHC, or could be a lobe of furnace slag from a smelting furnace. Extremely dense; 6g lobate flowed clinkery slag.
TP44	88	46	1 piece of slagged lining (14g); 2 small pieces of flowed slag with smooth surface, probably tapped smelting slag (32g)
TP45	89	102	2 pieces of flowed and lobed slag (36g) with maroon surfaces, probably tapped smelting slag; 1 indeterminate fragment of slag possibly also with lobes, but covered in accretion (66g).
TP45	92	57	Probable fragment of SHC, details obscured by accretion on surface
TP50	100	86	Concretion with small charcoal inclusions – core not seen, but probably iron metal
TP50	100	23	small fragment of pale grey lining, with attached lining slag
TP52	104	110	Burr-like fragment of SHC with dimpled base (with coal residue in hollows) and small amount of lining and sandstone clasts at one end. Very dense rusting so presumably carried an iron inclusion.
TP53	107	22.8	fragment of indeterminate dimpled, rounded slag, probably a hearth slag lump
TP54	106	288	1 large fragment of very dense slag, with abundant large rounded vesicles. Lower part massive, but upper part shows flow lobes on surface associated with internal chilled surfaces. Tapped smelting slag.
TP60	2	17	1 small fragment of vitrified grey clay, 2 rounded blebs of clinker
TP62	2	6	Fragment of glassy clinker with very coarse coal, shale and sandstone clasts
TP65	109	39	1 piece of slagged oxidised fired lining, rather clinkery appearing slag, includes a clast of grey shale
TP66	109	6.1	corroded top half of nail, shank c. 7mm square, head squareish, 13mm across
TP67	109	28.5	corroded iron in concretion 50x22x13mm, has irregularly rounded outline and may actually be two pieces
TP68	109	410	large block (410g) of irregularly lobed slag, associated with much admixed vitrified lining. Top has large lobes, but the base is much more finely-structured. Lots of charcoal inclusions
TP69	109	266	dense flow-lobed slag mixed with much debris of oxidised fired hearth ceramic (266g)
TP70	109	136	6 fragments (136g) of variably prilly/lobed slag with lining inclusions.

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