

# GeoArch

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Assessment of archaeometallurgical  
residues from the  
Wormington-Sapperton pipeline

# Assessment of archaeometallurgical residues from the Wormington-Sapperton pipeline

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## Abstract

*The project produced evidence for metalworking from ten sites out of the thirteen sites submitted for investigation. This wide distribution of evidence indicates just how ironworking was widely integrated into rural communities at all periods since the introduction of iron until the early 20<sup>th</sup> century.*

*Most of the metalworking sites are indicated by a very low level of metalworking waste and in most instances this requires no further investigation.*

*Two sites stand out as indicating particularly significant activities:*

*Plot 07.09 : this site had evidence for early Iron Age ironworking and bronze casting. The objects being cast in the four significant mould fragments from the site were all indeterminate, but deserving of further study. The age of the metalworking would be important to ascertain. The smithing hearth cake fragments from the site are very dense and may contain metallic iron. Examination of this might be significant, since the movement of iron metal within the earlier Iron Age is not well understood.*

*Plot 20.02: this 1<sup>st</sup> century AD site produced a very small amount of highly vitrified clay which resembles the clay coatings used during the process of brazing (coating or joining iron components by copper alloy). Further analysis would be required to confirm that this interpretation is correct and further work is required on attempting to identify the artefacts being made. Provisional examination of the key fragment suggests that the work may have been to join together the iron components of an unusual style of bridle bit. If this is correct, then this may be a significant site (it lies close to the headwaters of a valley flowing 10km south to Bagendon, itself known for its unusual production of composite bronze-iron brooches in the mid-1<sup>st</sup> century AD.*

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## Methods

All investigated materials were examined visually using a low-powered binocular microscope where necessary. All materials were summarily described and recorded to a database (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.

This project was undertaken for Cotswold Archaeology.

## Results

### *Plot 07.02*

The sole stratified metallurgical find was a small fragment of a charcoal-fuelled smithing hearth cake (SHC). This type is not indicative of a particular age – and is entirely compatible with the medieval age ascribed to this fill. It presumably indicates smithing was undertaken somewhere in the vicinity.

An unstratified fragment from Plot 07.02e was probably a fragment of a coal-fuelled smithing slag. Coal was employed locally for smithing during the Roman period and again from the medieval period onwards, becoming more widespread until most late 19<sup>th</sup>-20<sup>th</sup> century rural smithies would have been fuelled by coal.

### *Plot 07.09*

[079115] is a deposit rich in metallurgical debris – including smithing fines (hammerscale, slag flats, slag droplets...) and smithing hearth cake fragments. In addition to the ferrous metalworking evidence the material also include four fragments of moulds from the casting of small objects in a non-ferrous metal – presumably a copper alloy. A further possible mould fragment occurred in a posthole fill [079123], but this was not certain and another possible tiny fragment was recovered from a pit fill [079259].

It was not possible to determine what was being cast in the moulds, although the largest piece appears to have been for an object with a dished circular face about 20mm across. Although the material is not particularly well preserved, the gates appear quite broad.

Small quantities of hammerscale were recovered from deposits [079248] and [079259]. Although this suggests these fills are Iron Age rather than Bronze Age, the quantities involved are very small and it would be possible for the material to be intrusive.

Several other contexts yielded macroscopic or microscopic examples of fuel ash slags. Although these may be generated in metallurgical hearths, particularly when non-ferrous metals are being worked, it is more likely that these slags are the products of domestic fires or other technologies, such as cereal drying kilns. Larger pieces of fuel ash slag are particularly common on Middle Iron Age sites, perhaps associated with the use of outdoor cooking hearths.

### *Plot 12.05*

The fills of Roman pit [121168] shows burnt material in association with some piece of ironwork, but not conclusive evidence for ironworking. Pit fills [121191], [121260] and [121318] have tiny amounts of slag debris, indicative of ironworking in the general area.

A fill of a sub-circular ditch feature [121427] has a smithing fines assemblage with flake hammerscale, slag flats and some slag fragments. The coarse tabular particles are slag flats rather than flake hammerscale, although true flake hammerscale is also present. Flake hammerscale results from the surface oxidation of hot iron in air. Slag flats result from the formation of a thin film of slag, either on the workpiece or on the smith's tools. Such materials tend to accumulate around the anvil and often become deposit fairly close to or within the smithy, often within the hearth itself if a floor-level, rather than elevated hearth. This deposit is likely to be close to or within an area of smithing activity.

### *Plot 12.06*

This site yielded one indeterminate piece of burnt organic material, possibly coke.

### *Plot 19.06*

A tiny quantity of possible slag or hammerscale was recovered from a Roman pit fill [192092]. Material from a presumably Bronze Age barrow ditch was a lining slag or clinker droplet – mainly formed from melted clay – and not necessarily of metallurgical origin.

### *Plot 20.02*

Fill [209538] of pit [90536] yielded an important assemblage with hammerscale (both spheroidal and flake), together with some pieces of highly fired clay, which had been pressed onto (presumably iron) artefacts. Although finds of clay with right-angled re-entrant impressions may be explained as the smithing removing fallen clay debris from the hearth with his tongs, the piece with the arcuate impressions cannot be explained away in this manner. It is much more likely that the three examples of fired clay with impressions here are all due to a deliberate metallurgical activity.

Two groups of processes employ clay in this way:

- firstly, a smith may employ clay coatings to control carbon, typically when steeling an object by soaking in charcoal for a considerable time any areas of metal that should not take up the carbon may be covered with clay (e.g. a smith might cover the back of a knife with clay, whilst steeling the blade edge)

- secondly, a clay coat may be employed when coating an iron object in a different metal, typically a copper alloy. This process, brazing, may be used for either simple coating (e.g. Young in press), or as a joining technique (Theophilus, Book 3, Chapter 92).

Fill [209527] of pit [209526] yielded a further piece of the clay shrouding, together with some blebs, possibly derived from the melting of similar clay. This pit fill is dated as mid- to late C1 – so may provide a date for the activity.

The three key pieces include two where the presumed iron in the clay had a flat surface with a right-angled edge and a third where the clay contains two abutting arcuate objects – possibly rings (one probably c. 100 mm outside diameter, the other possibly c. 50 mm), but only a short section was preserved. If the coatings are brazing shroud, then it is not clear whether the process was intended to join the two rings directly. It is just conceivable they were to be joined by brazing closed a third, hypothetical, link. If joined together directly, the most likely possibility, if these segments represent complete rings, is that the object was part of a horse harness – just possibly a side ring forming an equivalent in iron to the normally cast bronze 'derivative three-link bridle bits'. Other interpretations are possible and the material requires further investigation.

Another C1 pit fill [209505] produced some small fragments of probable iron working slag, one of which had inclusions of burnt bone. This is unusual and may not necessarily represent a deliberate metallurgical action.

A small amount of flake hammerscale in grave fill [209554] of cut [209540] for skeleton [209553] is quite likely to be residual in view of the context.

#### *Plot 20.05*

This site produced some clinker or slag blebs from [201007] and a piece of coal-fuelled smithing slag from [201065], together with a minute slag fragment from [201081]. This finds are indicative of smithing employing coal as fuel somewhere adjacent, but probably not within the excavated area.

The use of coal as fuel for smithing in the Roman period was common, but the precise periods and contexts when it was employed, and why it was chosen instead of charcoal in areas far from coalfields, remain uncertain.

#### *Plot 21.04*

This site produced a single fragment of slag from a hearth lining, from a medieval context. This is a single isolated piece of residue.

#### *Plot 30.04*

This site yielded a single worn, residual, piece of dense iron slag, probably from smithing using charcoal as fuel, within a Roman ditch fill.

#### *Plot 31.01*

This material was probably natural.

#### *Plot 31.02*

Most of the samples from this contained natural (if perhaps burnt) materials. Fills of pits [311139], [311182] and [311302], all possibly of Iron Age date, all contained very small quantities of fuel ash slag. This material is probably not of metallurgical origin and may result from a domestic hearth or from crop processing.

#### *Plot 33.06*

The majority of samples from this site contained no metallurgical residues. A low level of waste (both macro- and microscopic) from ironworking was however recorded from across the site: posthole fill [331207], silt [331181], fill [331097], fill of tree throw [331088], fill of posthole [331075] and pit fill [331032]. There is so little material it is probably unlikely that smithing was a major occupation within the medieval farmstead, but rather may have been an intermittent or occasional activity.

#### *Plot 35.10*

This site yielded sparse microscopic remains (slag fragments, clinker, hammerscale and burnt organic matter, probably coke). Inclusion within this assemblage of clinker and coke raise the likelihood that this material is residual evidence for Roman smithing in the area. Saxon use of coal for smithing in this area is not documented.

## Interpretation & Potential

The project produced evidence for metalworking from ten sites out of the thirteen sites submitted for investigation. This wide distribution of evidence indicates just how ironworking was widely integrated into rural communities at all periods since the introduction of iron until the early 20<sup>th</sup> century. The dominant metalworking being undertaken was ironworking. At different sites and periods this was undertaken using coal (which would need to have imported to the area) and charcoal.

Sites identified as being of Iron Age date appear particularly to have produced non-metallurgical fuel ash slags from waste pits and other features. This production of fuel ash slag may be indicative of some aspect of Iron Age life, perhaps the use of outdoor domestic cooking hearths.

Most of the metalworking sites are indicated by a very low level of metalworking waste and in most instances this requires no further investigation.

Two sites stand out as having produced evidence for particularly significant activities:

**Plot 07.09**: this site had evidence for early Iron Age ironworking and bronze casting. The objects being cast in the four significant mould fragments from the site were all indeterminate, but **deserving of further study**. The **age** of the metalworking would be **important to ascertain**. The smithing hearth cake fragments from the site are very dense and may contain **metallic iron, examination of which might be significant**, since the movement of iron metal within the earlier Iron Age is not well understood.

**Plot 20.02**: this 1<sup>st</sup> century AD site produced a very small amount of highly vitrified clay which resembles the clay coatings used during the process of brazing (coating or joining iron components by copper alloy). **Further analysis would be required to confirm that this interpretation is correct and further work is required on attempting to identify the artefacts being made**. Provisional examination of the key fragment suggests that the work may have been to join together the iron components of an unusual style of bridle bit. If this is correct, then this may be a

significant site (it lies close to the headwaters of a valley flowing 10km south to Bagendon, itself known for its unusual production of composite bronze-iron brooches in the mid-1<sup>st</sup> century AD (Ruddock 1961).

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Table 1: summary catalogue. FAS = fuel ash slag, FHS = flake hammersale, SHS = spheroidal hammerscale, BOM = burnt organic matter

c	s	bag label	wt	no	description
<b>plot 7.02</b>					
71188		slag	47.67	1	probable fragment of lining-rich SHC with abundant charcoal, small piece, vesicular, concreted
<b>plt 07.02e</b>					
u/s		slag	25.2	1	dense flow-lobed slag with maroon surface to upper lobe, deeply dimpled base with indeterminate fuel remnants. Some clasts appear foliated, so are probably shales and this is probably a well-flowed smithing slag from a coal-fuelled hearth rather than a smelting slag
<b>plot 7.09</b>					
79006	6	magnetic material	3.2	bulk	mainly stone, some reduced fired shelly clay (pottery?)
79046		slag	3.43	1	fragment of black vesicular material - BOM - probably coke
79057	8	magnetic material	5.1	bulk	mainly fired clay, stone and fuel ash droplets, but a few pieces of dense slag
79082	4	slag?	1.8	bulk	FAS
79082	4	magnetic residue	17	bulk	mainly stone, some fired clay, lots of fuel ash slag including droplets, rare fragments of possible dense slag
79115	1	metalworking waste	116	bulk	rich assemblage with FHS, slag flats, slag droplets, FAS, and at least one concretion on iron
79115	4	tuyère	3.57	2	2 mould fragments, reduced fired ceramic, buff exterior, grey interior, porous, one rather wide gate, other shows narrow zone of interior surface
79115		slag	44.59	2	fragments of grey vesicular slag with rusted surfaces, very dense: SHC fragments with iron metal inclusions
		"	11.99	1	a low-density, twisted, complex lobe of fuel ash type slag with a dense maroon surface - could be a clinker lump pulled off workpiece perhaps?
		"	1.28	2	fragments of oxidised, finely vesicular FAS, with local denser surfaces
		"	6.89	3	grey conventional, coarsely vesicular FAS
		"	3.93	1	pale weathering grey vesicular smithing slag
79115		slag	222	2	2 large pieces from small but very dense SHC - must have contained metallic iron (may relate to 3 SHC fragments listed above)
79115		tuyère	8.92	1	reduced fired porous ceramic - a mould. Interior cavity is poorly preserved but suggests it was to cast a dished circular object
79115		mould	5.72	1	mould fragment similar fabric to above, object possibly had triangular projection to one side
79123		fired clay	2.59	1	nub of low density fired clay, reduced inner oxidised outer (possible mould fragment)
79123		slag	11.64	4	largest piece is curiously twisted bloated oxidised ceramic with localised red slag (cf Brawdy), 1 small piece bloated grey ceramic, 1 slag bleb adhering to grey coarse ceramic, small piece frothy fuel ash slag
79124		slag	9.24	3	variably vitrified granular friable material - probably fired and vitrified soil
79134	2	possible metalwork	<	3	fragments of dark grey material, probably stone not slag
79134	2	magnetic material	12.7	bulk	stone with FAS droplets, rare FHS
79198		vitrified clay	3.09	1	extremely coarsely vesicular fuel ash slag
79210		ash fuel?	1.32	1	finely and evenly vesicular fuel ash slag
79215		slag	1.77	1	frothy coarse fuel ash slag
79219	3	vitrified clay	3.8	bulk	FAS

<i>c</i>	<i>s</i>	<i>bag label</i>	<i>wt</i>	<i>no</i>	<i>description</i>
79219	3	magnetic material	34	bulk	small fuel blebs, fired clay and stone
79220		vitriified clay	3.21	1	rounded nub of oxidised bloated ceramic with local red/purple melted zones (cf. Brawdy)
79226		slag	7.3	1	broken nub of finely vesicular FAS with maroon vitrified crust ( cf. Brawdy but reduced fired)
79248	5	magnetic material	3	bulk	mainly fired clay stone and fuel ash slags, but trace of both FHS and SHS
79259	7	magnetic material	50.5	bulk	mainly reddened burnt stone, some FAS, one possible mould fragment, some FHS and occasional slag fragments
79259	7	vitriified clay	0.7	1	FAS
79262	9	magnetic material	4.4	bulk	mainly stone, FAS blebs, some bone and rare grey slags
79270		fired clay	7.87	4	3 very fine-grained pale pieces may be altered natural clay/stone, the largest piece is a burnt clay with very coarse organic temper - daub?
79271	10	metalworking waste	2.3	10	fuel ash slags plus 1 stone
79271	10	magnetic residue	6.3	bulk	stone with a little FAS
79276		vitriified clay/slag	0.83	1	coarse, frothy, fuel ash slag with dark surface lobes
<b>plot 12.05</b>					
121168		slag	14.2	1	concretion on iron object, circular c.23mm, possible protrusion suggests inclined shank with large head
121168	7	slag	8.04	bulk	2 pieces of bloated reduced ceramic with dark slag- probably burnt stone, 6 tiny concretions on iron in charcoal-rich soil, 1 vitrified stone, 2 small clinkery slag fragments, 1 charcoal
121168	32	metalwork/industrial residue	25.1	1	exploded iron object
121168	32	vitriified/burnt clay	1.71	7	1 piece probably burnt stone, others variably vitrified lining - from bloated grey to black glass with sand
121190	6	metalwork residue	1.3	3	small scraps of irregular slag or clinker
121190	6	vitriified clay	0.2	2	vesicular fuel ash slag
121191	8	metal residue	1.83	11	small slag fragments, some containing coarse equant crystals, some more lining influenced
121260	16	metal residue	0.44	bulk	most iron corrosion, but some slag and fired clay
121276	39	metal residue - slag	6.51	2	1 reduced fired bloated and slagged grey ceramic - hearth lining? 1 dimpled and vesicular fine dark grey slag - possibly clinker?
121318	23	slag	0.3	1	vesicular grey slag fragment
121347	31	metal residue	1.03	bulk	slag flats, slag fragments and a few iron rich rock particles
121427	36	metal residue	14	bulk	FHS, coarse slag flats (including angles), fired clay, slag debris
<b>plot 12.06</b>					
1013	1	magnetic material	<	1	BOM/coke fragment
<b>plot 19.06</b>					
192092	18	hammerscale	<	2	2 particles of SHS (1 just possibly a clinker droplet)
192032	10	slag sphere	<	1	lining slag or clinker droplet

<i>c</i>	<i>s</i>	<i>bag label</i>	<i>wt</i>	<i>no</i>	<i>description</i>
<b>plot 20.02</b>					
209505		slag	30.8	4	1 low density FAS, 3 irregular dense slag pieces, one containing burnt bone
209527		slag	7.7	2	large piece shows area of about 25x30mm of vitrified clay coating margin of sheet(?) with right angle coated in - rather irregular- inner face slagged like rings below (the other similar 12.9g piece is not slagged), small piece is bleb of flowed FAS
209527		slag	12.2	1	irregular lobes of vesicular lining-influenced slag, moderately dense
209535	1	ind. Residue	3.4	bulk	stone with some dark slag fragments, FHS and some SHS
209538		slag	15.3	1	bloated grey vitrified clay, very irregular, dark thin slag veneer, internally shows two abutting rings; 45mm chord of larger seen, 85mm internal diameter?, c 10mm diameter section, small curved part more angular in section possibly and maybe more tightly curved (possibly 45-50mm external diameter? – but irregularity of the clay makes this uncertain).
209538	5	vitrified material	12.9	8	1 large piece of vitrified clay with right angle re-entrant at least 15x20mm and 45mm long - either a clay coat/shroud, or lump removed with tongs?, 2 other sheets of vitrified clay, 4 small low-density dark slag blebs, 1 larger dark slag fragment, but still essentially a FAS
209538	5	metalwork	0.6	bulk	small scraps of hammerscale and slag - slag is dense, locally with maroon surface, slag flats, rust
209538	5	magnetic material	4.5	bulk	stone with moderately abundant FHS and some SHS
209554	3	ind. Residue	<	5	FHS
209565	9	flake	<	4	stone with one possible slag flat
209573	4	ind. Residues	<	4	iron-rich crust/rust fragments
<b>plot 20.05</b>					
201007	2	metalworking residue	0.91	7	4 probable dense clinker/slag blebs, 2 pieces of bone, 1 iron rich rock
201065		slag	54	1	dense slag, irregular sandy? dimpled lower surface, top with slightly contorted, deflated, wrinkled lobes. Internally vesicular, with probable shale clasts: coal-fuelled smithing slag
201081	7	metalwork	<	1	possible slag fragment
201093	10	metalwork	0.77	1	small iron concretion - possibly hobnail
<b>plot 21.04</b>					
211004		vitrified clay	23.97	1	extremely sandy lining slag sheet - perhaps originally still attached to wall and not an independent slag lump
<b>plot 30.04</b>					
309004	1	slag	17.33	1	worn fragment of vesicular charcoal-bearing coarse dense slag
<b>plot 31.01</b>					
319004	2	hammerscale	<	1	spheroid, probably not SHS

<i>c</i>	<i>s</i>	<i>bag label</i>	<i>wt</i>	<i>no</i>	<i>description</i>
<b>plot 31.02</b>					
311008	6	mag material	<	bulk	mostly Fe-rich stone, some rust fragments and 1 or 2 possible, but not certain, slag fragments
311016	8	ind. Residues	<	3	Fe-rich crusts and stone
311016	8	metal residue	<	1	probably iron oxide after pyrite - complex piece, but tiny
311017	9	ind. Residues	<	5	stone plus at least 1 tiny slag fragment
311023	3	ind. Residues	<	3	stone
311075	23	ind. Residues	<	5	stone
311076	22	ind. Residues	<	5	Fe-rich crusts and stone
311086	14	ind. Residues	<	5	natural Fe-rich stone
311129	25	ind. Residues	<	2	spheroids, not SHS probably
311139	16	ind. Residues	<	9	tiny friable slag fragments
311182	19	vitrified/fired clay	0.3	2	smaller stone, larger vitrified, bloated clay or FAS
311230	26	ind. Residues	<	8	Fe-rich crusts and stone
311302	27	ind. Residues	<	7	tiny FAS fragments
311302	27	vitrified clay	3.6	bulk	FAS with two pieces of bone
<b>plot 33.06</b>					
331029	1	flake hammerscale	3.1	bulk	mainly stone, bone, some possible slag, no certain HS
331032	7	slag	0.09	1	maroon curved slag with glassy droplets adhering - clinker?
331032	7	fe flake	<	bulk	several rusty flakes and two spheroids that are not SHS
331058	3	hammerscale?	<	3	spheroids, not SHS
331075	4	magnetic material	1.26	bulk	mainly burnt stone and fired clay, some slag, rare hammerscale, one Cu corrosion film
331088		Fe slag	22.2	1	small slightly pale, smithing slag fragment with lots of evidence for lining mixing
331097	6	fe flake	<	bulk	small amount of FHS, iron-rich flakes and slag fragments
331145	10	fe flake	<	3	3 flakes as in 331170 - Fe-rich but not FHS
331159	1	hammerscale?	<	5	spheroids not SHS (Mn nodules?)
331169	12	fe flake	<	bulk	iron rich flakes and pointed object - all possibly iron corrosion
331170	13	magnetic residue	0.6	bulk	mainly burnt stone, many dark flakes but only very sparse true FHS. Spheres are not SHS
331181		slag	222	1	piece from the margin of a large dense SHC, dimpled/lobate base, very dense ,corroded, plenty of charcoal
331185	15	hammerscale?	<	2	2 dark spheroids, not SHS
331185	15	fe flake	<	21	flakes as in 331170 - iron-rich but not FHS
331207	16	flake	<	16	about half of these are the rough iron-rich flakes and half true FHS
331265	21	magnetic residue	1.03	bulk	stone, lots of iron-rich-crust fragments, one possible FHS fragment, 1 green ?Cu alloy piece
<b>plot 35.01</b>					
359006	1	Fe	<	2	tiny probable slag fragments

<i>c</i>	<i>s</i>	<i>bag label</i>	<i>wt</i>	<i>no</i>	<i>description</i>
359006	2	ind residue	<	12	2 possible coke fragments, 2 dense spheroids (slag spheres/SHS), 1 brown/white clinker droplet, rest stone
359006	3	Fe	0.53	2	broken small abraded fragment of vesicular iron slag
359006	3	hammerscale	<	15	3 possible slag spheres/SHS, 2 small FHS, rest ferruginous stone
359006	4	ind residue	<	17	1 rust fragment, 2 clinker droplets, 1 slag fragment, rest stone
359006	5	flake?	<	13	3 possible coke fragments, remainder dense grey - but probably stone not slag
359006	7	ind residue	<	12	2 fragments of probable coke, 1 probable SHS, remainder iron-rich spheroids probably not SHS, plus 3 slag fragments

# GeoArch



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