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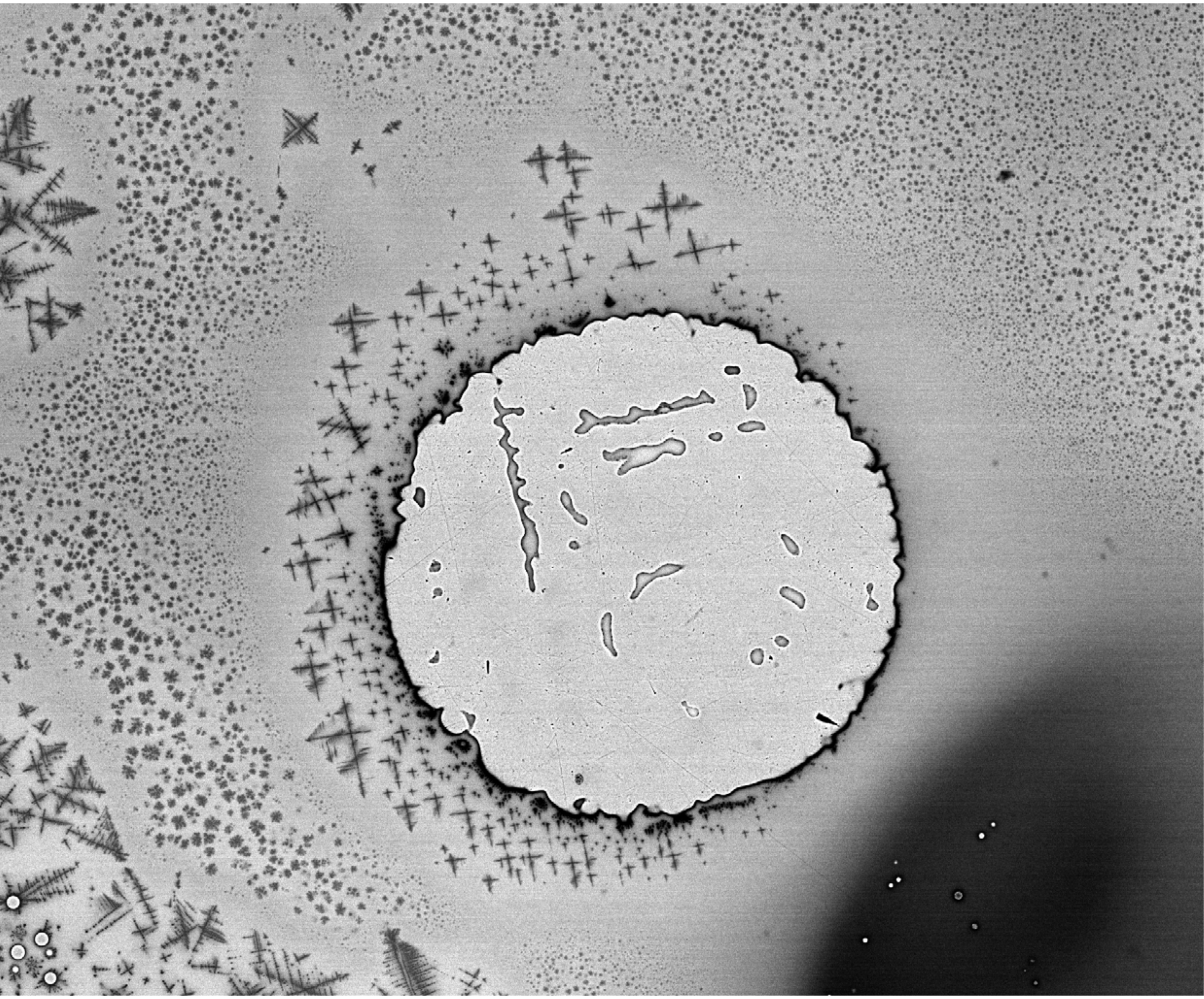
THE ROMAN FORT AT BROUGH, BAINBRIDGE
THE EXAMINATION OF METAL WORKING DEBRIS

TECHNOLOGY REPORT

Carlotta Gardner



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The Roman Fort at Brough by Bainbridge

The Examination of Metal Working Debris

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SUMMARY

An assemblage of metal working debris from excavations in the 1950s to the 1970s, by Brian Hartley, of the Roman fort at Bainbridge has been assessed using visual observations and XRF analysis. From the assessment it has been possible to identify three different metal working processes; iron smithing, assaying of precious metals and casting of copper alloys. The metal working has been dated to the late phase of the fort, 4th century AD, and located in the central area.

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ARCHIVE LOCATION

Yorkshire Museum, Museum Gardens, York, YO1 7FR

DATE OF Research

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INTRODUCTION

The Roman fort at Brough by Bainbridge (SD 9383 9013), named *Virosidvm,* 'The settlement of true men', has been excavated on four separate occasions. The site was first excavated by Kirk and Collingwood in 1925 to 1926, secondly by Droop for Liverpool University in 1928 to 1929, thirdly by Wade in 1950 to 1953 and lastly by Hartley who excavated annually between 1956 and 1969. The fort is slightly irregular in shape measuring 99m north-south by 73m east-west at its greatest and encloses an area of 1.06ha. Very little stonework is visible within the fort although the fort platform still survives to a maximum height of 3.90m. The fort annexe is not as well preserved as the fort but is still clearly visible. Surrounding the north, east and south sides of the fort is a single ditch and on the west side there are five irregularly-spaced ditches.

The fort appears to be occupied episodically between the 2nd century AD and the late 4th century AD. It is thought that at the end of the 2nd century the fort was burnt (Wilson and Wright 1969) and rebuilding took place in the early 3rd century by the VI Cohort of Nervi (*Cohors Sextae Nerviorum*) who continued to occupy the fort into the late 4th century. Evidence for the rebuild by this cohort comes from a number of inscriptions on stones that are associated with the fort, for example:

'…the centuries of the Sixth Cohort of Nervians made this [a stone revetment] under the command of Lucius Vinicius Pius, designated prefect of the same cohort.' (Wilson and Wright 1969, 246)

'…the ramparts and its branches were faced in stone by the Sixth Cohort of Nervians under the administration of Lucius Alfenus Senecio…' (Wright 1961, 192)

It is thought that during this refurbishment the, assumed, timber structures within the fort were replaced by stone buildings by the same cohort. Further information on the different phases of the fort can be found in Wilson and Wright's (1969, 207) report on Roman Britain in 1968.

The material studied in this report is from the last set of excavations by Hartley (1956-1969). A number of trenches were excavated; these were named using a letter followed by a Roman numeral, for example H XI. The majority of the material has been labelled with a layer number which in many (but perhaps not all) cases corresponds to what would now be called a context. This report will look at the metal working debris found during these excavations, aiming to describe the processes taking place, where in the fort they were based and finally to which phase or phases of the fort they belong.

METHODS

After it had been cleaned the metal working debris was examined visually. A number of different materials were identified in the assemblage the most abundant materials were: undiagnostic slag (US), smithing hearth bottoms (SHB), fuel ash slag (FAS), vitrified stone

(VS) and hearth lining (HL); these materials are discussed in detail in the archaeometallurgy guidelines (Bayley *et al* 2001). Once identified the material was weighed and recorded in a spreadsheet along with a reference number, context description where provided, context number, year of excavation and the trench where the material came from (Appendix 1).

Where their identification was unclear, samples were qualitatively analysed using X-ray fluorescence (XRF) to determine their composition. This was particularly important for identifying the function of some of the small finds; for example, the heating tray. The heating tray required further examination using scanning electron microscopy with energy dispersive spectrometry (SEM-EDS) to identify elements, such as silver and lead, which helped to confirm its function.

A thin slice of the tray (approximately 5mm in depth) was set in epoxy resin, ground flat and polished using diamond paste down to a 1µm grade. It was then placed under vacuum and carbon coated. The sample was then ready to be placed in the FEI inspect F SEM which can produce two different images. The secondary electron (SE) image shows the surface topography of the sample as the SE are generated at the surface. The second type of image is produced by back scattered electrons (BSE) which have a higher energy than the SE and are the result of interactions between the electron beam and the nuclei of the atoms at the surface. The intensity of the BSE is proportional to the atomic weight of the element (Pollard *et al* 2007, 109). The differences of intensity are shown on a grey-scale image where lighter tones represent higher average atomic weights and darker tones represent lower average atomic weights. The BSE image thus contains useful information about the chemical composition of the sample. The heating tray was analysed using EDS at 25kV.

RESULTS

The metal working debris consisted of a wide range of materials; three metal working processes are evident. The majority of the material shows evidence for ferrous metal working, in particular smithing. The second, and less obvious, process is assaying of silver and finally the third process: casting of copper alloys.

Iron smithing

Iron smithing produces a wide range of different residues; the characteristic ones are smithing hearth bottoms (SHB), smithing pan (SP) and hammer scale (HS). Other residues associated with smithing, but that are also produced by other processes, are undiagnostic slag (US), fuel ash slag (FAS), vitrified stone (VS) and hearth lining (HL) (McDonnell 1991). Iron smelting also produces characteristic residues but none were present at Bainbridge. Hartley's excavations at Bainbridge produced just over 20kg of debris, excluding small finds, and Table 1 is a summary of the amounts of different residues found. The process that can be positively identified from these quantities of residues is smithing. The fuel used was coal, evident from the individual pieces recovered (small find numbers 189, 220 and 248) and from the presence of small pieces in some of the smithing hearth bottoms. Tylecote (1986, 225) states that coal is further evidence for iron smithing taking place on a site as it was not a fuel that could be used for smelting. The hearths used during this process were most likely made of clay; evidence for this is the numerous pieces of fired clay attached to the FAS, US and SHB, some of these pieces show where the air would have entered the hearth through a blowing hole.

It is clear from Table 2 that much of the debris is from contexts that have not been phased. Nevertheless, it is likely that the majority of metal working was taking place in the 4th century as nearly two-thirds of the dated debris is from this period. This also supports the discussion by Wilson and Wright (1969, 207) who state that evidence for iron and bronze working in the late 4th century is strong. The debris could be residual from previous phases however; this is unlikely due to the lack of material found from these earlier phases.

The spatial distribution of the smithing debris is difficult to assess due to a lack of information about contexts. The majority of the finds come from trenches in the centre of the fort: HX, HVI, HXI and HII. This area of the fort is where Hartley identified the presence of a forge area dating to the late 4th century (Wilson and Wright 1969) and evidence of hearth-like areas, stone- and clay-lined circular features, prior to the building of the forge.

A similar assemblage of material, although less in quantity (7.744kg), was found at Bowes Roman fort, Durham (Hall 2007). This material shows a peak in activity during the 3rd century. Metal working debris is found at most Roman forts and settlements (Bayley *et al* 2001, 3).

Table 1: Quantities of different materials identified from Bainbridge.

Material	Weight (kg)
Undiagnostic slag (US)	10.19
Smithing hearth bottom (SHB)	5.23
Fuel ash slag (FAS)	1.66
Vitrified stone (VS)	0.94
Hearth lining (HL)	1.49
Vitrified limestone (VLS)	0.78
Iron ore (O)	0.06
Smithing pan	0.05
Cu slag (CuS)	0.04
Lead-tin alloy (PbSn)	0.03
Coal (C)	0.05
Total	20.52

Table 2: Chronological distribution of metalworking debris (weight in kg).

Material	Severan	3rd century	4th century	Late Roman	Post Roman	Unphased	Total
SHB	-	0.12	0.84	-	-	4.20	5.23
HL	-	-	0.20	-	-	1.30	1.49
FAS	-	0.11	0.06	0.01	-	1.48	1.66
US	0.68	0.41	1.50	0.04	0.06	7.51	10.19
VS	-	0.15	0.15	-	-	0.65	0.94
VLS	-	-	-	-	-	0.78	0.78
O	-	-	-	-	-	0.06	0.06
CuS	-	-	-	-	-	0.04	0.04
SP	-	-	-	-	-	0.05	0.05
PbSn	-	-	-	-	-	0.03	0.03
C	-	-	-	-	-	0.05	0.05
Total weight	0.68	0.79	2.75	0.05	0.06	16.15	20.52

Cupellation

Cupellation is the process by which precious metals, i.e. gold (Au) and silver (Ag), are separated from base metals. In order to refine the metal it would have been melted with an excess of lead under a blast of air which caused the lead to oxidise, forming litharge (PbO). The litharge oxidises other base metals like copper and tin under these conditions and they dissolve in the litharge (Bayley 1992a, 748) which is then raked off or absorbed by the dish or hearth leaving a prill of precious metal (Bayley *et al* 2001). During the Roman period ceramic dishes were used for small scale cupellation and the reaction between them and the litharge normally caused a glassy surface, often red in colour from the presence of copper (Bayley 1985), on the inner side of the dish (Bayley *et al* 2001). Assaying, testing the purity of a precious metal, used the same method but on a smaller scale and often potsherds or purpose-made ceramic discs usually called heating trays were used.

Ceramic dishes used for cupellation and assaying during the Roman period are found in the archaeological record and are often identified by the lead-rich glassy inner surface and by the central depression caused by the prill. At Bainbridge one fragment of a ceramic heating tray has been identified. The tray is made of a fine clay fabric and has little visible temper (cf Bayley1989). The inner surface has a thick layer of glassy material ranging between dark grey, green and red in colour and has a clear depression where the prill solidified. The XRF identified high levels of lead and copper in the glassy material and a very small silver peak which confirms that cupellation was taking place. The rim of the tray was affected by the heating, a cracked surface, which might suggest that the tray was heated from above (Bayley 1989). From the size of the heating tray (approximately 60mm in diameter) it is possible to infer that assaying or small scale cupellation of silver was taking place at Bainbridge. Unfortunately, due to a lack of stratigraphic information, it is not possible to say in which phase and where on the site this process was taking place.

To confirm the identification of the heating tray SEM-EDS was used. Using the backscattered electron (BSE) detector it was possible to identify metallic droplets of silver and copper in varying proportions, within the lead rich glass (Figure 1 and 2).

In Table 3 the normalised average results of the area analysis of the glassy material and ceramic fabric are shown. These results confirm that the glassy material is a lead-rich silicate with small quantities of copper and smaller quantities of silver. These are the expected results for a heating tray and show that the process represented by the tray was successful as only a small amount of silver was trapped in the glassy material.

Table 3: Normalised results of SEM-EDS analysis of heating tray (average of eleven analyses of the lead-rich glass and three analyses of the ceramic).

Material	Glass	Ceramic
Na2O	0.15	0.61
MgO	0.40	1.25
Al2O3	5.35	20.08
SiO2	18.99	62.75
P2O5	<0.12	0.46
SO3	<0.15	0.25
Cl	<0.10	0.20
K2O	1.03	3.42
CaO	2.05	1.26
TiO2	0.33	1.00
MnO	<0.05	<0.05
Fe2O3	1.79	6.91
CuO	8.15	<0.20
Ag2O	0.42	0.08
BaO	0.48	<0.10
PbO	60.52	1.31

A number of metallic droplets were located within the glassy material (Figures 1). Table 4 shows three different metallic droplets analysed. The three droplets have varying concentrations of silver and copper; one is very rich in silver (2.1), one in copper (5.1) and the third has almost equal amounts of silver and copper (4.1). The differing appearance, seen in Figure 2, is because of the varying compositions of the droplets and the way that they have solidified (Scott 1991, 12). As the metal in the silver-rich droplet (2.1-90.2% Ag) cools, pure silver solidifies, leaving a melt that becomes progressively more copper-rich until the eutectic composition (71.5% Ag) is reached at which point the whole droplet is solid. The matrix in which the pure silver sits thus has the eutectic composition. For 5.1, which is copper-rich (80.19% Cu), the first phase to solidify is pure copper (dark in Figure 2) the melt becomes progressively more rich in silver until the eutectic composition is reached (28.5% Cu) and the droplet is solid. The different structures seen in Figure 2 are thus the product of the different compositions.

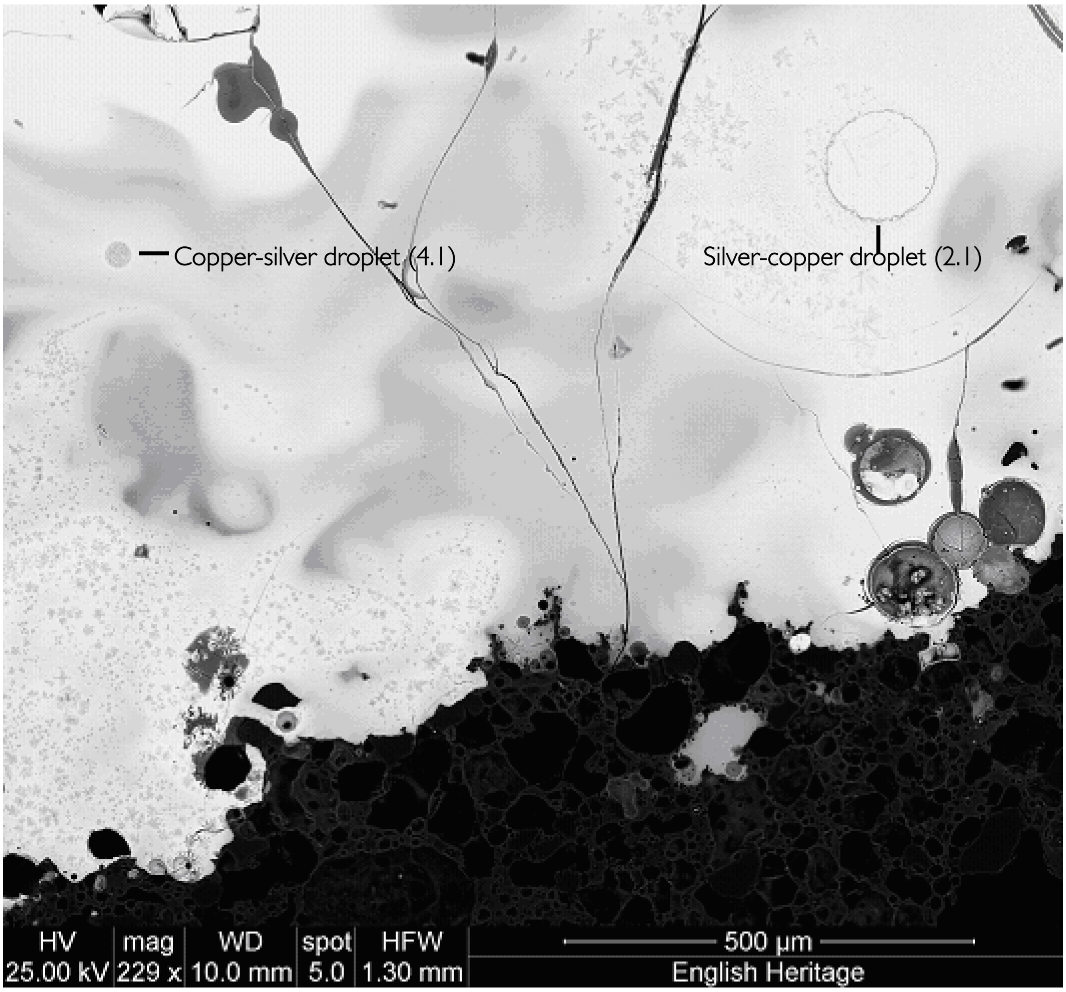

Figure 1: BSE image showing the ceramic tray (dark material at the bottom of the image), lead-rich glassy material (light coloured material in the upper part of the image) containing metallic droplets 4.1 and 2.1(labelled). The circular features, close to the ceramic on the right hand side of the image, are bubbles within the lead-rich glass and the lines running from the ceramic through the lead-rich glass are cracks in the glass.

Table 4: Results from SEM-EDS analysis of metallic droplets found in heating tray.

Material	Area	Fe	Cu	Zn	Ag	Sn	Pb	Total
Metallic droplet	2.1	<0.10	3.39	<0.10	90.20	<0.10	3.73	97.71
Metallic droplet	4.1	<0.10	49.65	<0.10	45.79	<0.10	3.44	99.20
Metallic droplet	5.1	0.21	80.19	<0.10	6.68	<0.10	5.52	92.90
Eutectic composition			28.5		71.5			100

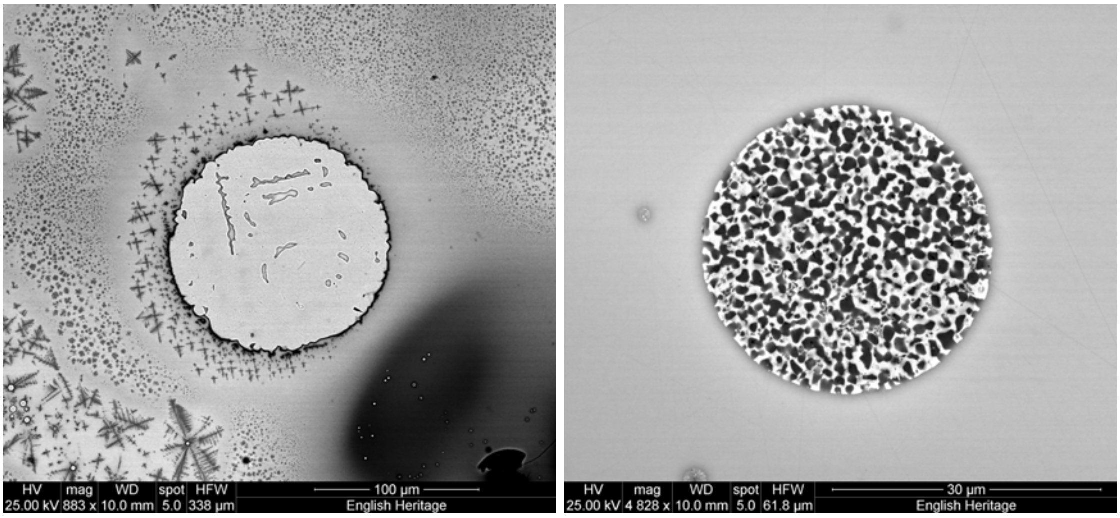

Figure 2: Two BSE images of metallic droplets 2.1 (left) and 4.1 (right).

Evidence for cupellation is most commonly found on late Saxon and Anglo-Scandinavian sites in England but there are examples found on Roman sites across Britain. This process, but on a larger scale, has been identified at Silchester, Wroxeter and Hengistbury Head (Tylecote 1986, 60) by the presence of cupellation hearths and litharge cakes. Evidence for small-scale silver refining has been found at Verulamium (Bayley 1992b, 50) but the closest parallel to the Bainbridge heating tray is one from Piercebridge (Bayley 2002).

Casting

Two types of moulds have been found at Bainbridge; numerous fragments of clay piece moulds and one ingot mould. Two pieces (spillages) of copper alloy have also been found (small find numbers 2 and 239).

These alloys were qualitatively analysed using XRF and both contained small quantities of lead and tin and in one, small find number 2, zinc. There is no information on which trenches they were from. The composition of these alloys fits well with that of Roman copper alloys (Dungworth 1995) and it is likely that these pieces were waste from metal casting.

Clay piece moulds

Clay piece moulds were commonly used in Roman Britain. They are less labour intensive and provided the technology to produce more castings than investment moulds (Bayley 1989). The fragments of clay piece moulds found at Bainbridge are from at least three different moulds. The inner parts of the moulds were made using fine clay; this was so that the details of the pattern would transfer when pressed into the clay. These moulds have an outer layer of clay added to them made of a slightly coarser fabric, seen in Figure 3a; the purpose of this layer would have been to hold the two sections of the mould together. During casting the inner surfaces of the moulds would have been exposed to reducing conditions causing the dark appearance seen in Figure 3b, the outer surface would have been exposed to oxidising conditions causing the mould to appear reddish as seen in Figure 3c.

Figure 3: a) fragment from a clay piece mould showing the coarser, oxidised clay used to hold the two sections of a mould together (maximum width35mm), b) The inner fine clay surface showing part of the impression from the pattern (top left) and the colour after exposure to reducing conditions during casting(maximum width 30mm), c) The coarser outer surface of the same fragment as seen in Figure 3b showing the colour after exposure to oxidising conditions (maximum width 30mm).

From the mould fragments that are large enough, it is possible to identify the object being cast: a concave, three armed object ending in circular plates. This is similar in size and the degree to which it curves to an object found at Bays Meadow Villa, Droitwich, which has been identified as a spur (Lloyd-Morgan 2006). Other examples of comparable objects include those found at *Clausentum* (Southampton), Woodeaton and Corbridge (Lloyd-

Morgan 2006). Shortt (1959, 69) suggests that these date to the end of the 3rd or 4th century and he classifies them as a 'distinctive Romano-British Group'. The mould fragments were found in late 4th century contexts (Wilson and Wright 1969), i.e. during the occupation of the fort by the VI Cohort of Nervi in the 3rd and 4th centuries. XRF analysis of a mould fragment showed the presence of a small copper peak indicating that the spurs would have been made of a copper alloy. The absence of zinc in the XRF spectra obtained from the moulds suggests that the alloy contained little or no zinc (cf Dungworth 2000). The analysis of a similar spur from Piercebridge showed it was made of a leaded bronze with low levels of zinc (Dungworth 1995) perhaps similar to the alloy used at Bainbridge. It is rare for clay piece moulds to survive this well in the archaeological record due to their friable nature (Bayley 1990) and it is more common to find small fragments, like those mentioned below. There are a number of very small fragments that also appear to be parts of clay piece moulds. Their fabric is very similar to the larger fragments and so it is likely they were parts of the moulds discussed above.

Ingot moulds

Ingot moulds are most commonly found on late-Saxon or Anglo-Scandinavian sites but are not unknown in other periods and occasionally are found on Roman sites in Britain, for example; Tower Knowe and Studland (Bidwell and Welfare 1985, 152). They are usually made from one piece of stone, occasionally brick or tile, and have simple shapes carved into them like bars or discs (Bayley 1989). Like the clay piece moulds it is not possible to tell which metal was cast in the ingot moulds (however, it is known that bar ingots from other sites are made from a range of metals including precious metals).

The ingot mould found at Bainbridge (small find number 260) is made of coarse red sandstone and has two bar-shapes carved into it (Figure 4). The complete bar matrix measures 118mm by 17mm across and 136m of the broken one survives; it is 25mm wide and 15mm deep. Where the mould has been broken it is possible to see that the sandstone has been reddened from the surface to a depth of c.10mm due to the heat of the metal being poured into it. The very upper surface, in areas, is blackened; this is not uncommon (Bayley 1990).

Figure 4: A photograph of the ingot mould found at Bainbridge (maximum width 220mm).

The mould was found in the same phase of the site as the clay piece moulds, according to trench drawings from 1969, which date it to the late 4th century. Due to the rarity of these moulds in the Roman period, and examples such as the moulds found at Vindolanda which came from a Post-Roman phase (Bidwell 1985, 152), it is necessary to question the date assigned to the ingot mould. Within the same area as the ingot mould there are two inhumations that have been dated to the 9th century (Wilson and Wright 1969) and therefore it is possible that the mould may be post-Roman.

CONCLUSION

The analysis of the material found at Bainbridge by Hartley has provided evidence for three different metal working processes within the fort; iron smithing, cupelling silver and casting copper alloys. From the quantity of material found on the site associated with smithing it is possible to infer that it was taking place within the fort. The evidence for casting is strong with at least three clay piece moulds and one ingot mould, all showing signs of use. The friable nature of the clay moulds must be considered when drawing conclusions about the scale of the casting taking place at Bainbridge; however the small amount of associated material indicates a small scale industry. The clay piece moulds are thought to represent the production of spurs on site, supporting Bishop and Coulston's (1993) thoughts that the army produced their own equipment. Cupellation is represented by one fragment of a heating tray, so assaying is more likely than silver refining because of the size of the fragment. The metal working appears to be taking place during the 4th century and is located in the central area of the fort, though the heating tray is unstratified and it is possible that the ingot mould may have been post-Roman.

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APPENDIX 1: METAL WORKING DEBRIS

Ref Number	Year	Trench	Date	Layer	Layer Description	Material Description	Number of pieces	Weight (kg)
41.77	63	A I		5		Fuel ash slag	1	<0.01
47.18	63	D I		25		Undiagnostic slag	1	<0.01
33.00	64	E I	Pot= 360+	8	Second Surface of Via Principalis	Undiagnostic slag	5	0.30
32.95	64	E I	Pot= late C.3rd	12	Under layer 8	Undiagnostic slag	1	0.16
32.93	64	E T		13		Fuel ash slag	1	0.02
32.72	64	G I		3	Wall robber trench, cross hall/rear range office	Fuel ash slag	5	0.05
32.72	64	G I		3	Wall robber trench, cross hall/rear range office	Hearth lining	1	0.01
32.72	64	G I		3	Wall robber trench, cross hall/rear range office	Smithing hearth bottom	1	0.12
32.83	64	G II		9		Fuel ash slag	1	0.05
21.51	64	G II		20	Material associated with lime kiln	Fuel ash slag	2	0.01
	64	G II	Post Roman	12	Bowl of lime kiln (post Roman)	Undiagnostic slag	2	0.06
21.97	64	G II	Severan	19	Under upper floor, S room of rear range	Undiagnostic slag	1	0.02
32.83	64	G II		9		Vitrified stone	1	0.02
26.71	66	G IV		10		Undiagnostic slag	1	0.02
32.73	64	G T		2		Fuel ash slag	1	0.06
29.61	66	G V	Pot = C.3rd	17	Building debris	Fuel ash slag	1	0.11
38.17	66	G V	Late Roman	46	In cross hall. Stone filled trench	Fuel ash slag	1	0.01
50.03	66	G V		58	Grey clay cut by C.4th contexts	Fuel ash slag	1	0.02
32.17	66	G V		3		Undiagnostic slag	1	0.05
29.61	66	G V	Pot = C.3rd	17	Building debris	Undiagnostic slag	2	0.13
38.18	66	G V	Late Roman	42	Post pit in post trench	Undiagnostic slag	1	0.04
34.60	66	G V	Pot = C.3rd	44	Under lower floor of rear range office.	Vitrified stone	1	0.13
36.99	67	G VII		8	Robber trench	Smithing hearth bottom	1	0.03
37.09	67	G VII	Pot = 370+	6	Debris in building on Via Decumana.	Undiagnostic slag	2	0.01

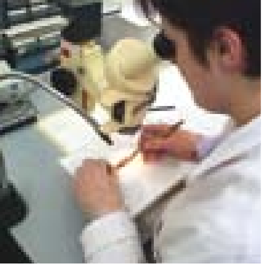
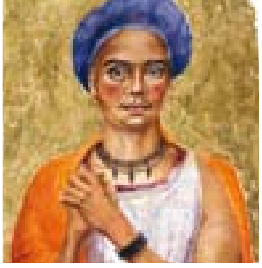
Ref Number	Year	Trench	Date	Layer	Layer Description	Material Description	Number of pieces	Weight (kg)
37.03	67	G VII	Pot = C.3rd	13	Stone floor in Via Decumana building.	Vitrified stone	1	0.01
21.06	66	H I		9	Pebbly clay in cross hall under layer 7	Fuel ash slag	1	0.28
21.06	66	H I		9	Pebbly clay in cross hall under layer 8	Hearth lining	1	0.02
21.03	66	H I	Pot = 270+	7	Cross hall. Building debris	Undiagnostic slag	1	0.11
34.73	66	H III		4	Building debris, under layer 3	Copper slag	2	0.04
29.43	66	H III	Pot = 360+	3	Large stone filled pit.	Hearth lining	1	0.08
29.31	66	H III		7	Fill of pit, earlier than layer 5	Hearth lining	2	0.06
29.34	66	H III	Pot = 360+	3	Large stone filled pit.	Hearth lining	4	0.12
26.64	66	H III				Iron ore	1	0.06
29.42	66	H III	Pot = 360+	3	Large stone filled pit.	Smithing hearth bottom	1	0.17
29.42	66	H III	Pot = 360+	3	Large stone filled pit.	Smithing hearth bottom	1	0.24
29.42	66	H III	Pot = 360+	3	Large stone filled pit.	Smithing hearth bottom	1	0.44
29.42	66	H III	Pot = 360+	3	Large stone filled pit.	Undiagnostic slag	5	0.31
29.34	66	H III	Pot = 360+	3	Large stone filled pit.	Undiagnostic slag	8	0.60
34.55	66	H III	Pot = 360+	3	Large stone filled pit.	Undiagnostic slag	1	0.07
34.55	66	H III	Pot = 360+	3	Large stone filled pit.	Undiagnostic slag	1	0.10
34.75	66	H III	Pot = C.4th	5	Fill of pit.	Undiagnostic slag	1	0.02
34.75	66	H III	Pot = C.4th	5	Fill of pit.	Undiagnostic slag	1	0.07
34.75	66	H III	Pot = C.4th	5	Fill of pit.	Undiagnostic slag	1	0.02
29.31	66	H III		7	Fill of pit, earlier than layer 6	Undiagnostic slag	3	0.06
26.64	66	H III			?	Undiagnostic slag	1	0.01
29.34	66	H III	Pot = 360+	3	Large stone filled pit.	Fuel ash slag	2	0.04
36.67	66	H IV	Pot = C.4th	3	Rubble.	Fuel ash slag	1	0.02
21.74	66	H IV		1	Topsoil	Hearth lining	3	0.18
21.74	66	H IV		1	Topsoil	Undiagnostic slag	2	0.06
36.63	66	H IV		1	Topsoil	Undiagnostic slag	1	0.18

Ref Number	Year	Trench	Date	Layer	Layer Description	Material Description	Number of pieces	Weight (kg)
36.69	66	H IV		1	Topsoil	Undiagnostic slag	1	0.01
36.69	66	H IV		1	Topsoil	Undiagnostic slag	1	0.05
36.69	66	H IV		1	Topsoil	Undiagnostic slag	1	0.05
34.61	66	H IV		7	Top of beam trench (veranda?)	Undiagnostic slag	1	0.03
34.19	67	H V	Pot = C.3rd	22	Loose brown earth	Smithing hearth bottom	1	0.20
37.99	67	H V		1	Topsoil	Undiagnostic slag	1	0.02
33.96	67	H V		2	Brown orange earth, below layer 1	Undiagnostic slag	1	0.02
33.96	67	H V		2	Brown orange earth, below layer 2	Undiagnostic slag	2	0.14
33.96	67	H V		2	Brown orange earth, below layer 3	Undiagnostic slag	1	0.02
43.92	67	H V	Severan or later	4	Blocking wall (Between veranda piers?)	Undiagnostic slag	7	0.67
33.96	67	H V		2	Brown orange earth, below layer 4	Vitrified stone	1	0.09
26.12	67	H VI		9		Smithing hearth bottom	1	0.30
26.12	67	H VI		9		Smithing hearth bottom	1	0.23
26.12	67	H VI		9		Smithing hearth bottom	1	0.53
32.34	67	H VI		5	Stone floor below layer 2	Undiagnostic slag	1	0.36
26.12	67	H VI		9		Undiagnostic slag	10	0.91
32.36	67	H VI		23	Foundation of east wall of cross	Undiagnostic slag	1	0.02
34.43	67	H VI		20		Vitrified stone	1	0.02
32.39	67	H VI	Pot = C.4th	2	Gravel debris	Vitrified stone	2	0.15
33.90	68	H VII		10	Foundation of Severan fort wall	Hearth lining	1	0.03
33.90	68	H VII		10	Foundation of Severan fort wall	Smithing hearth bottom	1	0.94
33.90	68	H VII		10	Foundation of Severan fort wall	Undiagnostic slag	1	0.14
35.84	68	H VIII		29	Beam slot (of first, timber, principa?)	Undiagnostic slag	1	0.01
50.09	68	H VIII		1		Undiagnostic slag	1	0.01
35.82	68	H VIII		29	Beam slot (of first, timber, principa?)	Undiagnostic slag	1	0.06
30.21	68	H VIII		28	Coal layer sealed by Antonine paving (layer over first, timber…)	Vitrified limestone	1	0.78

Ref Number	Year	Trench	Date	Layer	Layer Description	Material Description	Number of pieces	Weight (kg)
33.32	68	H VIII		2	Rubble under topsoil	Vitrified stone	1	0.35
33.19	68	H X		3	Debris below topsoil	Undiagnostic slag	1	0.03
49.90	68	H XI		9	Earth filled channel	Undiagnostic slag	1	0.01
30.24	68	H XI		30	Linear diagonal hole east of forge base with mould fragment	Undiagnostic slag	1	0.10
49.84	68	H XI		2	Debris below topsoil	Fuel ash slag	12	0.32
49.96	68	H XI		2	Debris below topsoil	Fuel ash slag	16	0.33
33.86	68	H XI		11	Hard lump of slag north of forge base	Fuel ash slag	1	0.14
49.84	68	H XI		2	Debris below topsoil	Hearth lining	1	0.01
30.24	68	H XI		30	Linear diagonal hole east of forge base with mould fragment	Hearth lining	1	0.05
49.96	68	H XI		2	Debris below topsoil	Hearth lining	6	0.18
50.02	68	H XI		2	Debris below topsoil	Smithing hearth bottom	1	0.41
49.84	68	H XI		2	Debris below topsoil	Undiagnostic slag	13	0.84
49.96	68	H XI		2	Debris below topsoil	Undiagnostic slag	18	0.93
33.85	68	H XI		3	Pit over paving, post Roman burial, rubble	Undiagnostic slag	6	0.15
33.89	68	H XI		5	Intrusion of metal working pit	Undiagnostic slag	3	0.25
49.90	68	H XI		9	Earth filled channel	Undiagnostic slag	1	0.10
49.90	68	H XI		9	Earth filled channel	Undiagnostic slag	1	0.08
49.90	68	H XI		9	Earth filled channel	Undiagnostic slag	1	0.07
33.86	68	H XI		11	Hard lump of slag north of forge base	Undiagnostic slag	4	0.26
33.86	68	H XI		11	Hard lump of slag north of forge base	Undiagnostic slag	3	0.31
33.86	68	H XI		11	Hard lump of slag north of forge base	Undiagnostic slag	1	0.28
	68	H XI		2	Debris below topsoil	Vitrified stone	1	0.05
33.85	68	H XI		3	Pit over paving, post Roman burial, rubble	Vitrified stone	1	0.06
42.72	69	I		1		Fuel ash slag	1	0.01
42.92	69	I		1		Fuel ash slag	1	0.01
40.41	69	I		13		Fuel ash slag	1	0.07

Ref Number	Year	Trench	Date	Layer	Layer Description	Material Description	Number of pieces	Weight (kg)
43.47	69	I		9		Hearth lining	2	0.25
43.51	69	I		6		Smithing hearth bottom	1	0.23
42.72	69	I		1		Undiagnostic slag	3	0.10
42.92	69	I		1		Undiagnostic slag	1	0.11
42.99	69	I		4		Undiagnostic slag	3	0.14
43.08	69	I		6		Undiagnostic slag	1	0.09
42.53	69	I		6		Undiagnostic slag	1	0.04
42.80	69	I		6		Undiagnostic slag	1	0.12
40.41	69	I		13		Undiagnostic slag	1	0.05
42.70	69	I		4		Vitrified stone	1	0.02
22.14	69	II		30		Hearth lining	2	0.20
44.20	69	II		1		Undiagnostic slag	1	0.01
21.53	69	II		7		Undiagnostic slag	1	0.02
43.92	69	II		7		Vitrified stone	1	0.07
28.75	52	T I		31		Hearth lining	1	0.03
28.67	52	T I		32		Undiagnostic slag	1	0.05
	71	X II		36		Hearth lining	1	0.14
	71	X II		18		Undiagnostic slag	1	0.20
34.02	71	X II		36		Undiagnostic slag	4	0.45
	71	X III		9		Undiagnostic slag	1	0.04
	71	XIV		10		Undiagnostic slag	1	0.02
33.73	72	XVI		8		Undiagnostic slag	1	0.08
33.73	72	XVI		8		Fuel ash slag	1	0.02
33.73	72	XVI		8		Fuel ash slag	1	0.02
33.73	72	XVI		8		Fuel ash slag	1	0.02
	71	XVI		8		Hearth lining	1	0.03

Ref Number	Year	Trench	Date	Layer	Layer Description	Material Description	Number of pieces	Weight (kg)
	72	XVI		1		Iron slag	1	0.04
	71	XVI		8		Smithing hearth bottom	1	0.50
33.73	72	XVI		8		Undiagnostic slag	1	0.02
22.11	72	XVI		13		Undiagnostic slag	1	0.03
	74	XXI		3		Hearth lining	1	0.12
50.02	74	XXI		3		Lead-tin alloy	1	0.03
	74	XXI		1		Smithing hearth bottom	1	0.20
	74	XXI		7		Undiagnostic slag	1	0.11
49.02						Fuel ash slag	2	0.05
49.02						Smithing hearth bottom	1	0.56
49.02						Smithing hearth bottom	1	0.14
49.02						Smithing pan	1	0.05
35.65	50					Undiagnostic slag	1	0.06
21.36	64					Undiagnostic slag	2	0.13
49.02						Undiagnostic slag	1	0.08
						Total Weight (kg)		20.58



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- *Archaeological Science*
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- *Architectural Investigation*
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