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Roman crucibles, hearth lining and slag from Usk, Monmouthshire, South Wales

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Summary

1.6kg of Roman non-ferrous and ferrous metal working debris from excavations at Usk in South Wales were examined. This included the remains of hearth lining, iron smithing slag and copper alloy working crucibles. These were analysed qualitatively by energy dispersive X-ray fluorescence.

Keywords

Copper alloy,
Metal working Fe,
Metal working non-Fe,
Ceramic,
Technology,
Roman

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Archaeological background

Excavations in the late sixties and early seventies at Usk in South Wales produced a small quantity of Roman non-ferrous and ferrous metal working debris. This included the remains of copper alloy working crucibles, hearth lining and iron slag.

Examination and interpretation of the metalworking debris

All the material was visually examined and using the principles and systems set out by Bayley *et al* (2001). A breakdown of the visual assessment is listed in table 1 (see appendix 1 for full listing).

Table 1- Metallurgical debris from Usk

Interpretation	Weight (g)
Crucible fragments	308
Smithing Hearth Bottom	225
Possible smelting slag	215
Non diagnostic iron slag	235
Hearth lining	134
Daub	161
Vitrified stone	279
Pottery	95
Total	1652

Some types of slag are visually diagnostic, providing unambiguous evidence for a specific metallurgical process. Non-diagnostic slag and debris (such as the vitrified stone) is less distinctive; it is not possible to say from which metallurgical, or other high temperature process it derives.

Explanation of classification

Hearth lining is fired clay that has one partially or fully vitrified surface, and sometimes has slag adhering to this surface. It is the lining of hearths (or furnaces), often (as appears to be the case for Usk) from close to the blowing hole where the air entered the hearth as temperatures here are highest.

Smithing hearth bottoms have a distinctive shape, plano-convex to concavo-convex in section and circular or oval in plan. Sometimes the upper surface has a depression produced by the air blast from the blowing hole. They are the slag that collects in the base of the smith's hearth, are unlikely to be confused with the waste products of smelting, and are therefore considered to be diagnostic of iron smithing

The possible smelting slag is dense and dark-coloured but unfortunately it has no distinctive morphology. The classification (as possible smelting slag) is definite; it is the identification of the process that produced it which is uncertain. The non-diagnostic slag has the dark colour of iron slag, but has no distinctive surface morphology. Although it is indicative of iron working it cannot be used to differentiate between smithing and smelting activities.

Included in the assemblage were a number of items that do not appear to be directly related to metallurgical processes. These include the base of a pot (68 IEX∈) in which there are no signs of vitrification as would be expected if it had been used as a crucible. There were a small number of vitrified stones that appeared to have been heated to very high temperatures, but were not related to hearth or furnace structures. The daub does not appear to have been heated to a high enough temperature to be related to metallurgical processes.

Crucibles

Crucibles (see appendix 2) are the vessels in which metal is melted so it can then be poured into a mould. They are made of clay and a variety of forms have been identified (Bayley 1991). During the Roman period wheel-thrown crucibles became common and are found on many sites throughout Roman Britain. However the majority of the crucibles from Usk appear to be handmade.

The crucibles are of similar forms to those from Verulamium (Bayley 1991, Frere 1972 Fig 141), specifically matching two types. The first is a handmade globular vessel similar to Bayley's (1991) type B crucibles. Crucible 69AZ⑤ (figure 1, left) is of particular interest, having a handle on the outer surface with tong marks (similar to a Roman crucible from Ribchester [Bayley 1998, PL. 2]). The second type (figure 1, right) is similar to the type C crucibles from Verulamium. These are small handmade thumb pots, probably wider than they are deep. Only relatively small sherds of these survive so it is hard to make a firm classification. Both are made of a vegetable-tempered fabric, which is commonly found in Iron Age crucibles, which are also handmade.

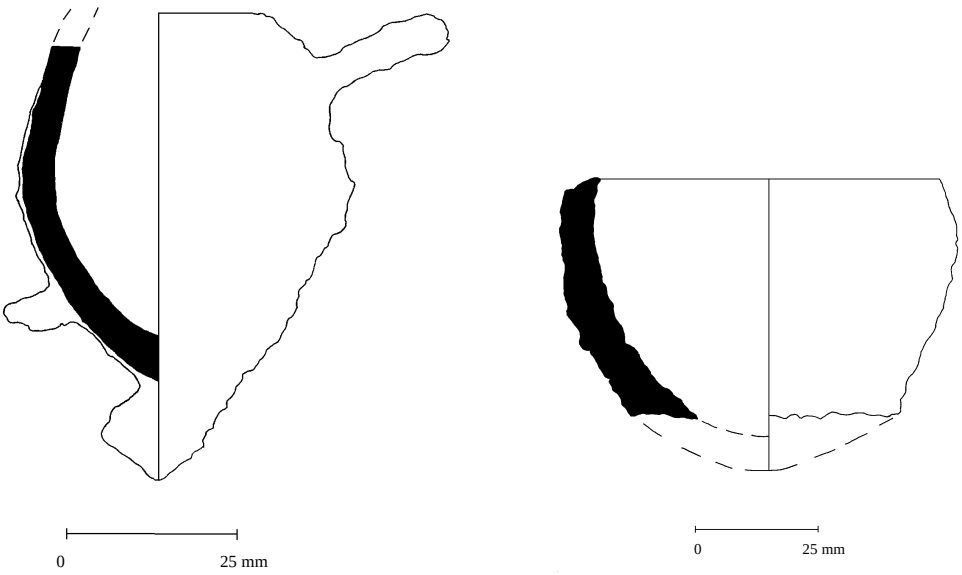

Figure 1 – Crucible 69AZ⑤ (left) and crucible 67AI extension∠ (right)

Sometimes an outer layer of clay can be added to crucibles (Bayley 1989, 249-5). This helped in maintaining a higher temperature within the crucible for a longer

period of time (Bayley 1984, 294), though it would have taken longer to heat the metal in the first instance. Extra layers of clay are normally only seen on wheel thrown crucibles. Four of the Usk crucibles may have had a second layer added. The addition of a second layer does not appear to be related to crucible type.

Analytical method

The crucible surfaces were analysed using energy dispersive X-ray fluorescence (EDXRF), providing a non-destructive qualitative method of identifying the types of metal that had been melted in them. As in Dungworth (2000a) and Dennis (1999) the interpretation of the EDXRF spectra was reliant on a visual assessment of the relative heights of the characteristic peaks. The peak heights are proportional to the abundance of the elements present in the sample, however they are dependent on a number of variables (such as absorption of secondary X-rays, the shape of the object and the effects of burial conditions) can affect them. Elements such as zinc are very volatile and so diffuse into the crucible wall (Bayley 1992, 817-8). Zinc is detected in crucibles even where zinc was only a minor component of the alloy melted in them (Barnes, no date). The proportions of metallic elements in crucibles are not the same as in the original melt (Dungworth 2000b).

Discussion of analytical results

(See appendix 2 for results)

The EDXRF analysis of the crucibles detected a number of elements related to the composition of the clay rather than specific metallurgical processes. Iron is most consistently detected, other elements include calcium, manganese, zirconium, titanium, and silicon. These have been omitted from the table of results in appendix 2.

On every crucible where a non-ferrous metal was detected the crucible had been used for melting copper alloys. Zinc is the metallic element most consistently present after copper in the inner vitrified layer of the crucibles. This is as to be expected due to zinc's high volatility, it has a boiling point of 907°C compared to copper's melting point of 1084°C. By the time copper has melted, zinc will be a gas. Zinc is also more readily oxidised than copper, tin or lead (Dungworth 2000b, table 2) and can act as glass-forming element, chemically binding it into the vitrified layer (Bayley *personal communication*). Therefore where no zinc is present the crucibles were used to melt copper alloys that did not contain zinc i.e. bronze (copper and tin) or leaded bronze (copper, tin and lead). In some cases it is not possible to say anymore than the crucible had been used, specifically those where only zinc and copper are detected, with zinc the greater.

One crucible fragment (67AI②) contained no copper, zinc, tin or lead. It is reduced fired and of a similar material to the other crucibles. It is very different from the pot base. It may have been from a crucible that failed when new, explaining the lack of metals on the fragment. Crucible fragment II⊕∀ contained copper on its inner and outer surfaces, yet is oxidised fired on the inner surface. It is handmade, produced of the same materials as the other crucibles and has a vegetable temper. Presumably this fragment has been heated up in an oxidising atmosphere after the crucible had failed.

Conclusion

The Usk crucibles had been used for melting copper alloys, possibly brasses or gunmetals. The slag is mainly related to the smithing of iron. Iron smelting is unlikely given the lack of tap slag and the small quantities, despite the identification of dense slag as possible smelting slag.

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Appendix 1: Metallurgical debris from Usk
(All weights in grams)

Key:

ND slag = non-diagnostic slag
SHB = smithing hearth bottom
Other = non-metallurgical debris

Year	Context	Crucibles	Hearth Lining	ND slag	SHB	Smelting slag	Other
67	67DI∇	14					
67	AI extension∠	41					
67	AI②	16					
67	DI∈		48				
68	⊕	32					
68	BB	14					
68	IAD∈			61			
68	IBA②	34					
68	IBG		12	72			
68	IBG∈	15	60	24			
68	IBL∈	12					
68	ICQ∈	3					
68	IEX			7			
68	IEX∈						95 (pot base)
68	IEX∈			6			172 (vitrified stone)
68	IFM∈			52	225		161 (daub)
68	IMS			13		215	
68	LD∈		14				
68	MS	5					
69	AZ⑤	66					
69	AZ∠	14					
69	CL⊕	6					
70	EC7∈						107 (natural geode)
73	⊕	19					
73	HBS②	2					
73	HII⊕	5					
	II⊕∀	10					

Appendix 2: Analysis of crucibles

Key:

All elements are listed in order of decreasing XRF signal strength. This does not directly relate to their original abundance.

(D) Indicates an extra layer of clay has possibly been added to the crucible.

Type refers to the types B and C Roman crucibles identified at Verulamium in Bayley (1991).

			Metals Detected		
ID	**Object**	**Type**	**Inside**	**Outside**	**Rim**
67AI extension∠	Crucible	C	Cu, Pb, Sn	Cu, Pb, Sn	Cu, Pb, Sn
67DI∇	Crucible		Zn, Cu	Zn	
68⊕	Crucible (D)	B	Zn	Cu	Zn
68BB	Crucible (D)	B	Cu, Zn	Pb, Cu	
68IBA②	Crucible	B	Cu		
68IBG	Crucible (D)	C	Zn, Cu, Pb, Sn	Zn, Pb	
68IBL∈	Crucible		Zn, Cu	Cu, Zn	
68IBL∈	Crucible		Zn, Cu	Cu, Zn	
68IBL∈	Crucible		Zn, Cu	Zn, Cu, Sn, Pb	
68MS	Crucible		Zn, Cu	Zn, Cu	Zn, Cu
69AZ⑤	Crucible (D)	B	Cu, Pb, Sn	Cu, Pb, Sn, Zn	Sn, Cu, Pb
69AZ∠	Crucible	C	Zn, Cu, Pb	Zn, Cu, Pb	
69AZ∠	Crucible		Zn, Cu	Zn, Cu, Pb	
73⊕	Crucible	C	Cu, Pb, Sn	Zn, Cu, Pb	Cu, Zn, Pb, Sn
73HBS②	Crucible		Cu, Pb	Cu, Pb	
73HII⊕	Crucible		Zn, Cu, Pb, Sn	Zn, Cu, Pb	
II⊕∀	Crucible		Cu	Cu	