Ancient Monuments Laboratory
Report 26/91

EVIDENCE FOR ANGLIAN METALWORKING FROM WHARRAM PERCY, YORKSHIRE (SITES 94 AND 95)

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Summary

The finds include crucibles, moulds, tuyere blocks and vitrified clay hearth lining as well as a small quantity of slag. Parts of at least five crucibles are represented. They were probably all lidded and were used to melt copper alloys containing tin, lead and zinc. A total of 15 fragments of piece moulds were found, and the decoration on some of them suggests an 8th century AD date for the assemblage.

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EVIDENCE FOR ANGLIAN METALWORKING FROM WHARRAM PERCY, YORKSHIRE (SITES 94 AND 95).

The finds which provide evidence for metalworking include crucibles, clay moulds, slag, vitrified clay hearth lining and tuyeres. The total weight of slag is under 1 kg so though both smithing and smelting slags are represented, there is nothing to suggest that iron was either smelted or smithed within the area excavated; the iron-working slags are almost certainly residual in the contexts in which they were found (see appendix for listing of slag). The concentration of moulds and crucibles, on the other hand, does suggest that copper alloys were being melted and cast - the hearth (2436) found in the sunken building cut into the Romano-British ditch may have been a focus for this activity. The tuyeres and hearth lining are probably part of the metal casting debris though the only evidence for this is their association with the crucibles and moulds.

All the finds were carefully examined and many of the crucible and tuyere fragments with traces of metal-rich vitreous deposits were analysed qualitatively by energy dispersive X-ray fluorescence (XRF), as were some of the mould fragments. The elements detected which were not an intrinsic part of the ceramic fabrics were copper (Cu), zinc (Zn), tin (Sn), and lead (Pb). These symbols appear in the catalogue entries in order of decreasing XRF signal strengths and where they are written within brackets only a very weak signal was detected. There is no simple relationship between the composition of a metal alloy and that of the slaggy residue left on the crucible in which it was melted because the chemical nature and volatility of the component metals is very varied. A further complication in interpreting the XRF data is the fact that equal amounts of each metal do not produce the same XRF signal strengths. The combined effect of these factors is that zinc and lead (to a lesser extent) tend to be over-represented and tin under-represented.

The numbers at the end of each catalogue entry are site/context/finds no, phase [AM Lab No].

<u>The crucibles</u>

1 Joining rim sherds with a sharp angle, probably the pouring lip, at one end and slight traces of an added outer clay layer. Thickness 9-11 mm. XRF detected Zn Cu Pb Sn. 95A/2402/44, Ph 4.5 [902098] and 95/2420/125, Ph 4.2 [902301]

2 Rim sherd with slight traces of an added outer clay layer. Thickness c.9 mm. XRF detected Zn Cu (Pb). 95A/2403/70, Ph 4.3 [902099]

3 Rim sherd with an added outer layer of clay continuing above the rim. Thickness 6-8 mm; added layer up to 4 mm. XRF detected Zn Cu Pb Sn. 95A/2409/81, Ph 4.3 [902260]

4 Rim sherd with an added outer layer of clay; possibly from near a pouring lip. Thickness 6 mm; added clay layer up to

5 mm and coloured red in parts on its outer surface. XRF detected Zn Cu Pb Sn. 94/2302/56, Ph 4 [903448]

5 Rim sherd with an added outer layer of clay continuing above the rim. Outer surface coloured red in places. Total thickness 5-6 mm. XRF detected Cu Pb Sn Zn. 94/2302/27, Ph 4 [893155]

6 Rim sherd with traces of an added outer layer surviving, though this has broken away in a band 10-15 mm wide below the rim. The crucible slag on the inner surface is more massive than on the other crucibles. Thickness 4 mm; added layer very thin where it survives. XRF detected Cu Pb Sn (Zn). 94/2302/57, Ph 4 [903449]

7 Joining rim and body sherd with an added outer layer of clay, probably once extending above the rim. Thickness 9 mm; added layer up to 3 mm. XRF detected Zn Cu Pb Sn. 94/2302/55, Ph 4 [903447]

8 Body sherd, ? from crucible. Thickness 6-7 mm. 95/2401/129, Ph 5 [902975]

9 Body sherd, ? from crucible. Thickness 6-7 mm. 95/2405/135, Ph 4.3 [903182]

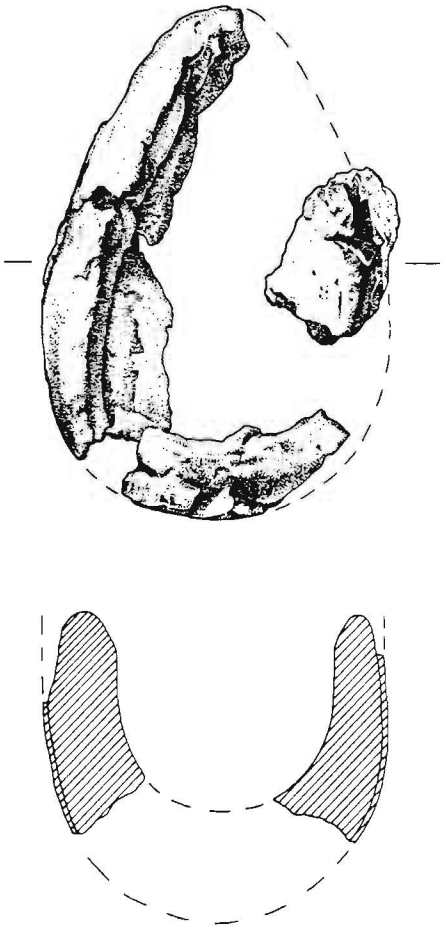
10 Body sherd, ? from crucible. Thickness 4-7 mm. 95/2409/131, Ph 4.3 [902976]

11 Body sherd, ? from crucible. Thickness c.13 mm. 95A/2411/106, Ph 4.4 [902283]

12 Body sherd, ? from crucible. Thickness 7-8 mm. 95/2416/130, Ph 4.4 [902977]

The crucible sherds are all reduced fired and most are deeply vitrified on their outer surfaces. There is considerable variation in fabric, colour, and wall thickness which suggests a minimum of five vessels are represented. Nos 1-3 are probably from a single vessel as the fabric and colouration of both the slag deposit on the inner surface and the vitrified added clay on the outside are similar on all three pieces. The curvature of the rims are varied, suggesting the crucible was not circular but of a half pear shape, ovoid with one more pointed end. The position of the slag 'tide-mark' within the crucible suggests the molten metal was poured out of the pointed end which acted as a lip. The clay applied to the outside of the crucible obviously once continued above the rim level, presumably forming a lid of some sort. There are traces of this lid all the way round the surviving pieces except near to the lip, suggesting a small gap was left here so the molten metal could be poured out.

The other definite crucible sherds, nos 4-7, all appear to be from separate vessels and all have more or less distinct traces of an added outer clay layer which either definitely or probably once continued above the rim. It is likely that they were all of forms similar to that suggested for the crucible represented by sherds nos 1-3 though the small size of most of the pieces makes it impossible to be sure of this. Small



Crucibles: Reconstruction of Nos 1-3 (above) and No 5 (below) (scale 1:1)

amounts of copper, chemically bound in the outer vitrified surface, give the red colour noted on nos 4 and 5.

The XRF analyses of the metal-rich deposits on nos 1-7 suggest all the crucibles were used to melt copper alloys containing some tin, zinc and lead. No accurate metal composition can be suggested as none of the metal itself survives. As has been noted above, zinc tends to be over-represented and this effect would be magnified in a crucible with a lid as the zinc-rich vapour produced by the molten metal would be trapped in the crucible fabric as it could not readily escape. It is likely therefore that the metals being melted were bronzes or lightly leaded bronzes, though some may have contained sufficient zinc to re-classify the alloy as a gunmetal (Bayley 1991).

The sherds catalogued as nos 8-12 are very different from those discussed above as they have only very slight traces of vitrification on their outer surfaces though they are all reduced fired. They also lack added outer clay layers and slaggy deposits on their inner surfaces which are undulating, unlike those on the crucibles which are smooth. XRF analysis of the inner surfaces detected only zinc which confirms an association with metalworking while at the same time indicating that these sherds are not from ordinary metal melting crucibles. It may be that they are fragments of clay moulds, but they lack any of the usual diagnostic features. A further possibility is that they are from crucibles used to make brass by the cementation process as was done in Roman times (Bayley 1984). Though the analytical results are consistent with this, it is not a likely explanation as the existing evidence on alloy usage does not suggest that brass is being made during the Anglian period (Bayley 1988B).

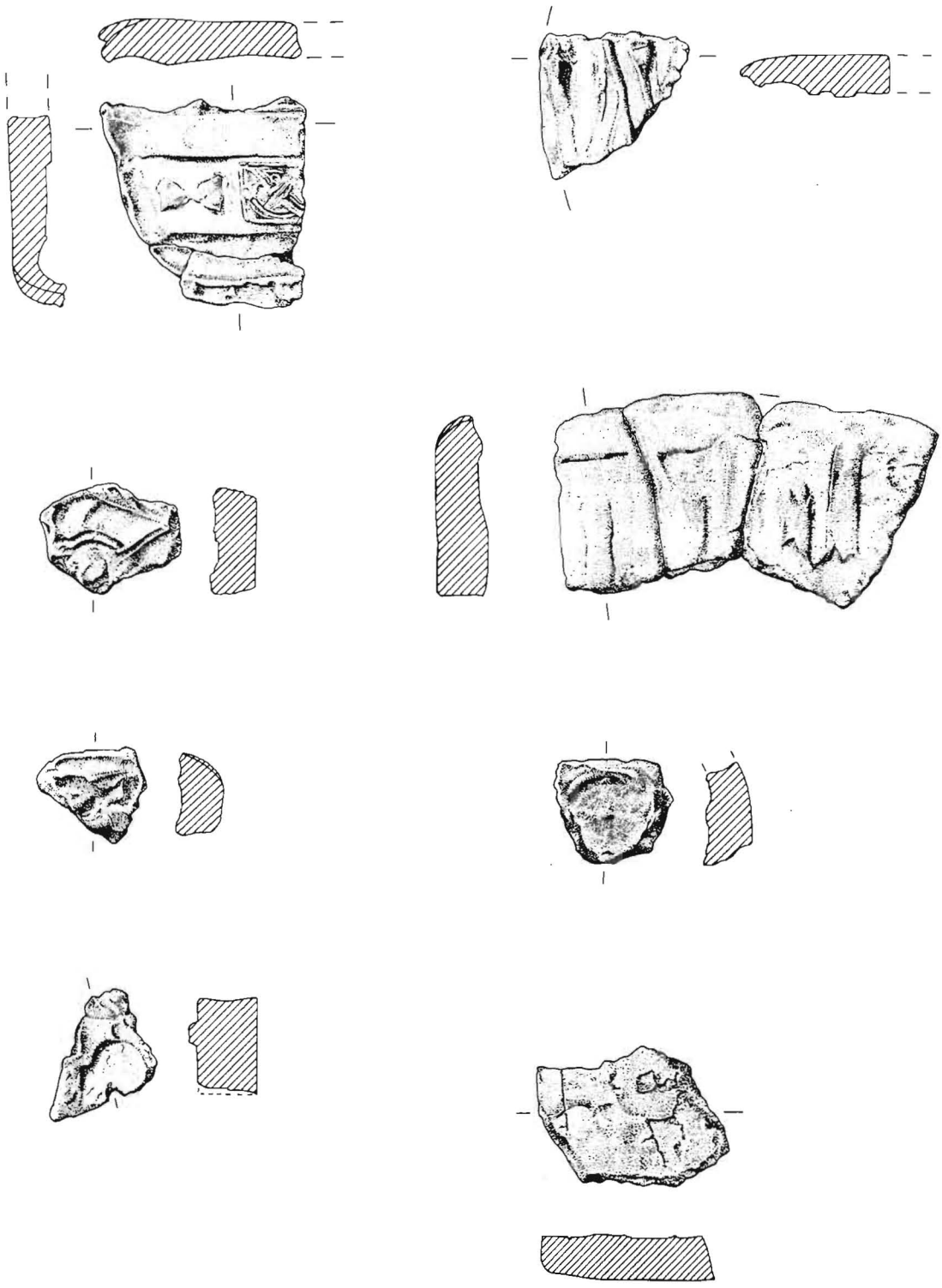
The moulds

13 Corner of upper valve with traces of luting clay along both original edges. The end of a ?rectangular panel of interlace decoration survives as well as an apparent continuation of it with two triangular knobs between the parallel edges. This continuation may be an undecorated part of the object being cast or the knobs may be part of a series of locating marks to aid the re-assembly of the mould with the two valves correctly registered. Oxidised fired except on the modelled area which is pale grey. 6 mm thick. XRF detected Zn Pb (Cu). 94/2302/20, Ph 4 [894537]

14 Triangular fragment from upper valve of mould with one edge an original one. Away from this edge irregular stripes can be seen. Fabric dark grey (reduced) except the outermost surface layer. 6 mm thick. XRF detected Zn (Pb Cu). 94/2302/48, Ph 4 [894536]

15 Abraded interlace/knot design on a fragment with no original edges. Oxidised fired. 6.5 mm thick. Possibly from same mould as sf 54 (see below). XRF detected (Cu). 94/2302/50, Ph 4 [894967]

16 Fragment from the edge of an upper valve with the suggestion of a similar pattern to that on sf 50 (see above). Oxidised



Moulds: Nos 13, 15, 16 and 21 (left side from the top)
Nos 14, 18, 20 and 25 (right side from the top)
(scale 1:1)

fired. 94/2302/54, Ph 4 [903389]

17 Two joining fragments from the edge of an upper valve 13 mm thick. The inner surface is a plain mating surface, without shapes or decoration. Fabric oxidised fired throughout. No trace of luting clay. 94/2302/60, Ph 4 [903451]

18 Three joining pieces 7 mm thick. Rather abraded outlines of repeating shapes can be seen though no decoration. From the lower valve of a mould of sandy clay with traces of the luting clay surviving. Fabric reduced fired all through. XRF detected Zn. 94/2302/52, Ph 4 [894969] and 94/2301/53, Ph 5 [903388]

19 Edge fragment from upper valve in a sandy clay with two offset rows of irregular depressions. Mainly oxidised fired but with a reduced zone around and between the rows of depressions. 13 mm thick. XRF detected Zn Pb (Cu). 94/2301/49, Ph 5 [894535]

20 Fragment, probably from upper valve, with no original edges; 7 mm thick. Faint traces of an abraded design survive on the concave (inner) side. Dark grey (reduced) all through. XRF detected no metals. 94/2302/51, Ph 4 [894968]

21 Fragment with no original edges 10.5 mm thick. Relatively deep relief survives but no decoration. A narrow pit penetrates 5 mm into the mould. Oxidised fired all through. 94/2302/64, Ph 4 [903452]

22 Fragment 12 mm thick with no original edges but two flat surfaces meeting at an angle on the inner face which is reduced (grey), unlike the rest of the piece. 94/2301/59, Ph 5 [893154]

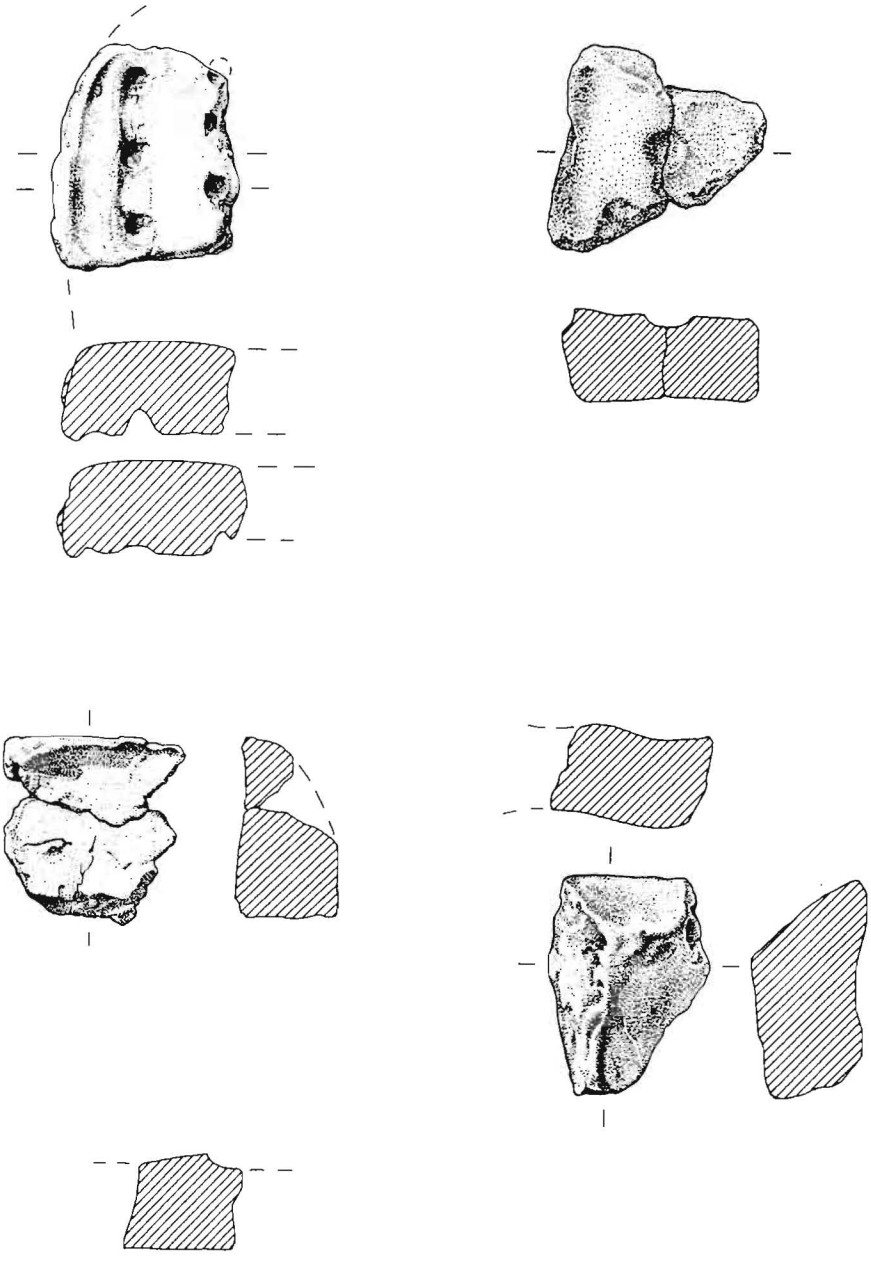
23 Two joining fragments from edge of mould 10.5 mm thick in very sandy clay. A small hemispherical depression and a trace of a second survive in the reduced fired inner surface. Similar to sf 49. 95/2403/133, Ph 4.3 [903390]

24 Fragment from in-gate of piece mould. Possibly from upper valve. Oxidised fired except close to metal contact zone. 12 mm thick. 95/2502/134, Ph 4 [903391]

25 Fragment from near the edge of an upper valve 6 mm thick. The mating surface is somewhat abraded but carries the remains of a design. Most of the outer surface is oxidised fired. 94/2303/69, Ph 1 [910224]

26 Two joining pieces 6 mm thick. The inner surface is not smooth, suggesting it originally carried a design though it is now much abraded. Reduced fired all through. 94/2303/70, Ph 1 [910225]

27 Fired clay fragment 18 mm long with a small area of flat oxidised fired surface at one end; the rest is reduced fired. Probably a fragment from a mould. 95/2502/140, Ph 4 [910226]



Moulds: Nos 19, 17 and 22 (left side from the top)
Nos 23 and 24 (right side from the top) (scale 1:1)

The form of the mould fragments indicates that most if not all of them come from piece moulds, most probably with two valves, though on some fragments no specifically diagnostic features survive. Piece moulds were made by taking a lump of clay of suitable size, roughly flattening it and pressing into its upper surface a pattern of the object to be cast. A second piece of clay was then pressed down on top of the pattern, forming the upper valve of the mould. The mould valves were then taken apart, the pattern removed, and the pieces re-assembled and luted together with a small amount of extra clay. Lower valves are usually thicker than upper ones. The specific features which permit the recognition of piece moulds are the concavo-convex section of the upper valve, the plain mating surfaces (from around the pattern) and the added luting clay.

Many objects have a definite front and back, the front being more highly decorated. The lower valve of the mould normally carried the shape of the back of the object so it is often only the upper valves which have any detailed decoration. The pattern from which the mould was made was either an existing object or a model, perhaps of wood or lead which were relatively easy to carve to shape. The advantage of piece moulds is not that they could be re-used to produce multiple castings (which is unlikely as the fine surface detail would probably not survive well enough) but that the model from which they were made could be re-used to produce many moulds.

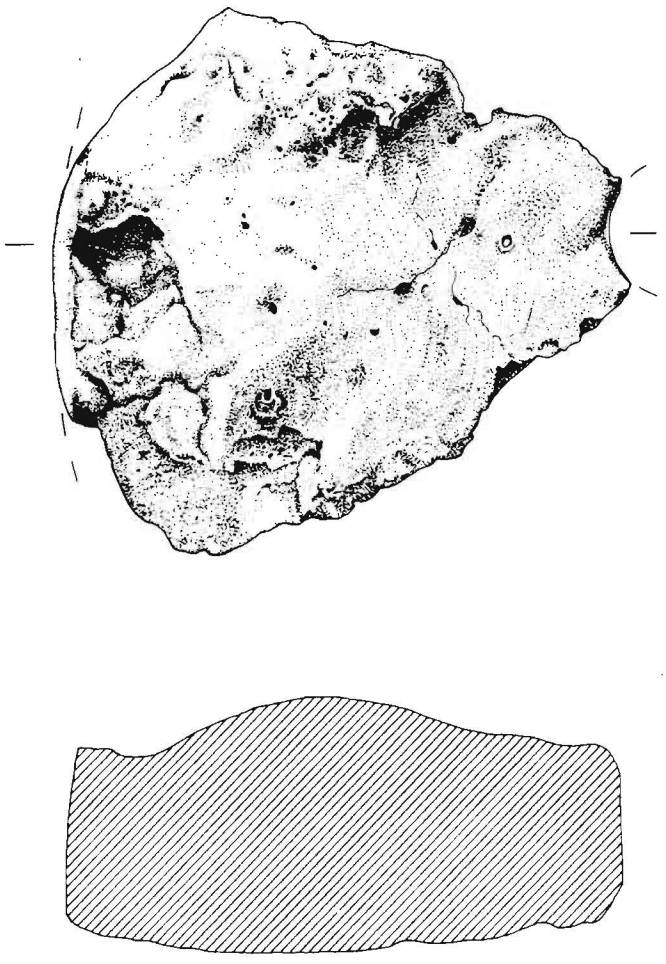
Most of the moulds are made from a sufficiently fine fabric to allow detailed decoration to be reproduced. The exceptions are Nos 19, 23 and 24 which are made of a rather sandier fabric. Nos 19 and 23 have modelled surfaces but no decorative patterns while No 24 is an in-gate. Most are oxidised fired except in or near to the areas that were in contact with molten metal which are reduced fired, as is normal with clay moulds. Three pieces, nos 18, 20 and 26, are reduced fired all through.

The traces of metals on those moulds that were analysed are much weaker than those on the crucibles because the molten metal was only in contact with the mould for a short time. It is the most volatile metals that are most strongly represented so the XRF results only indicate that the moulds had been used, and give no useful information about the composition of the metal cast in them. The results are consistent with the use of alloys of similar composition to those melted in crucibles nos 1-7. Nos 15 and 16 may not have been used.

The imbalance between numbers of upper and lower valves is probably mainly due to the small sample size but may also have been affected by a 'recognition factor' as the concavo-convex form and decorated surfaces of upper valve fragments are more distinctive. The finds identified on site as fired clay, daub or pottery have been carefully examined and several mould fragments retrieved and added to the catalogue.

The tuyeres

28 Fragment from the edge of a tuyere block with vitrified front surface; part of the tuyere hole (diam just under 20 mm) survives. 95A/2403/68, Ph 4.3 [902898]



Tuyere block fragment: No 28 with original edge at the left and part of the perforation surviving to the right (scale 1:1)

29 Fragment from the edge of a tuyere block with vitrified front surface. May possibly be from the same block as sf 68 though the pieces do not join. 95A/2409/78, Ph 4.3 [902257]

30 Joining fragments from the edge of a tuyere block with vitrified front surface; part of the tuyere hole survives (diam just under 20 mm). 95A/2403/69, Ph 4.3 [902258] and 95A/2409/79, Ph 4.3 [902259]

31 Small fragment, with lightly vitrified surface, probably from the edge of a tuyere block. 95A/2403/69, Ph 4.3 [902258]

32 Small fragment from the edge of a tuyere block with vitrified front surface. 94/2302/61, Ph 4 [903453]

33 Small fragment from the edge of a tuyere block with vitrified front surface. 95A/2409/83, Ph 4.3 [902261]

34 Six fragments of fired clay, vitrified on one surface. These may come from tuyere blocks or may be pieces of hearth lining. 94/2302/62, Ph 4 [903454]; 94/2302/63, Ph 4 [903455]; 95A/2409/85, Ph 4.3 [902263]; 95A/2410/97, Ph 4.2 [902270]; 95/2410/136, Ph 4.2 [903179]; and 95/2409/137, Ph 4.3 [903174]

A tuyere is an opening through which the blast of air from a bellows is introduced into a fire. This forced draught is necessary to produce the high temperatures needed for metalworking. The hottest part of the fire is in the area immediately in front of the tuyere, so the clay hearth lining in this region is likely to undergo extensive vitrification as it reacts with the ash from the fuel in the fire (Bayley 1985A). A pre-fabricated clay tuyere block, like the ones found here, can simplify the repair of the hearth. When the vitrification reaches the stage that the tuyere is no longer functioning efficiently, the failed block can be relatively easily replaced by a new one.

All the tuyere blocks are far from complete so it is difficult to suggest exact sizes or shapes. Nos 25, 26 and 30 all appear to have a rounded corner and in No 25 the edge running up to the corner is straight, suggesting a square or rectangular shape. The distance from the centre of the tuyere hole to the edge of this block is about 80 mm, so the width of the block was probably about twice this. The surviving thickness of these pieces is 20-30 mm though poorly fired clay has been lost from the back of them so the blocks would originally have been thicker than this. In No 27 the distance from the centre of the tuyere hole to the edge of the block is about 65 mm and the back is flat, suggesting it is the original surface; this block was 15-25 mm thick. In both cases where part of the tuyere hole survives, it is not exactly perpendicular to the surface of the tuyere; it was probably angled downwards so the air blast was fed towards the bottom of the hearth. XRF analysis failed to detect any non-ferrous metals on the vitrified surfaces of the tuyere blocks.

The hearth (2436) found in the sunken building may have had a clay superstructure built on it which included a tuyere block, as a well-defined boundary makes a bellows-blown fire easier to control and use.

Discussion, parallels and dating

The crucibles, moulds and tuyere blocks described above add Wharram Percy to a short list of English sites which have produced evidence for non-ferrous metalworking dating to the 5th to early 9th centuries (Bayley 1991B). Scotland and Ireland have far more metalworking sites of this period; some are listed by Alcock (1987, 112) and a selection of finds from them is illustrated by Youngs (1989, 174ff). The English sites are of a mixture of types including monastic centres (eg Jarrow and Hartlepool), 'urban' settlements (eg Southampton, London and York) as well as rural ones (eg Mucking and Wharram Percy); it is only from the late 9th or 10th century onwards that evidence for metalworking is almost exclusively found in towns.

The tuyere blocks are perhaps the least exciting of the metalworking finds but, surprisingly, they are the most difficult to find parallels for. They are not common finds although thin sheets of vitrified clay hearth lining, some with traces of tuyere holes, are regularly found on sites of all periods - together with other evidence for both ferrous and non-ferrous metalworking. The only other sites with tuyere blocks known to me are Mucking, which has produced many tuyeres of the common type too, and the Coppergate site in York (Bayley forthcoming). The dating of the Mucking tuyere blocks is not yet clear as there is prehistoric, Roman and early Saxon activity on the site; those from York come from late 9th or 10th century contexts. A further form of tuyere which may be related to the tuyere blocks is recorded in Viking-Age Scandinavia where free-standing perforated 'furnace-stones' are known (eg Graham-Campbell and Kidd 1980, 89) although there is no evidence that they were built-in to hearth or furnace structures.

More can be said about the crucibles as the form suggested above is not uncommon on sites such as Dinas Powys, where they date to the 5th-7th centuries (Alcock 1963), and Dunadd (Craw 1929-30, Fig 8.5), where more recent excavations suggest the metalworking probably dates to the 7th century (Youngs 1989, 191), though it may continue later.

Lidded crucibles have not been recognised on English sites apart from that at Church Close, Hartlepool (Bayley 1988A) where they are dated to around 700 AD from their association with clay moulds whose decoration can be parallelled on objects of this period (Cramp and Daniels 1987). Other English crucibles, even those from Anglian sites such as Yeavering and York (Eoforwic), all appear to be unlidded though their exact form cannot often be identified as only small fragments survive.

On the basis of the parallels quoted it seems reasonable to suggest the Wharram crucibles are most likely to be 7th or 8th century, though there is no good reason why they could not be earlier or possibly later.

The moulds provide the best opportunity for dating the assemblage of metalworking debris. Clay piece moulds were the normal form of mould for small objects from Roman times onwards (Bayley 1988B) so the mould technology itself is no help in suggesting a date. However, the decoration visible on some of the moulds can be compared with that on metal and other objects, which themselves are sometimes more securely dated. The dates suggested for the more highly decorated moulds are 8th century (J Lang and L Webster, pers comm).

English sites where clay piece moulds of Saxon date have been found are Mucking (Jones 1975) and possibly West Heslerton for the early Saxon period; Church Close, Hartlepool (Cramp and Daniels 1987, Bayley 1988), Cook Street, Southampton (M Garner, pers comm), Barrow on Humber (Bayley 1983) and probably Canterbury (Bayley 1985B) for the Middle Saxon period; and The Lanes, Carlisle (Taylor and Webster 1984), Netherton (Tite et al 1985) the Buttermarket site in Ipswich and the Flaxengate site in Lincoln for the 9th century and later.

Even the comparatively short list of Middle Saxon English sites is misleadingly large when parallels for the Wharram moulds are sought. The Canterbury moulds are so fragmentary and abraded that the only thing that can be said of them with any confidence is that they are moulds. Those from Barrow are only slightly better preserved - ring-shapes can be seen on some of them - while those from Southampton are recent finds and have not yet been studied. The Hartlepool moulds were made in a non-standard way as the objects being cast were decorated on one side only and so do not bear comparison with those from Wharram on technological grounds. The Wharram moulds are thus our best preserved English examples of Middle Saxon piece moulds of the standard type.

Acknowledgement

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Slag from sites 94 and 95

	Fe slag	FAS/HL	Vit clay	Other
94/2300				burnt clay ?
94/2301	+			
94/2302	+	+		
94/2302/2	+			
94/2302/6	+			
94/2302/8	+			
94/2302/9	+			
94/2302/10		+		
94/2302/14	+			
94/2302/15	+			
94/2302/16	+			
94/2302/18	+			
94/2302/21				ferruginous concretion
94/2302/24	+			
94/2302/25	+			
94/2302/31	+			
94/2302/39	+	+		
94/2305/45	+			
95/2400				lava
95/2400/4	+			
95/2400/5		+		
95/2400/6				ironstone
95/2401			+	
95/2401/10	+			
95/2401/86			+	
95/2402/24		+		
95/2402/40		+	+	
95/2402/45		+		
95/2402/47		+		
95/2403/65	+			
95/2403/67	+			
95/2405/71				ironstone
95/2409/84				vitrified stone
95/2409/87		+		
95/2409/91			+	
95/2410/96		+	+	
95/2410/97			+	
95/2410/98	+			
95/2410/99	+			
95/2411/106				clay
95/2420/115				ore
95/2420/126				stone
95/2432/128				bone?
95/2500/2	+			
95/2501/13				lava
95/2502/37	+			
95/2502/46	+			
95/2503	+			
95/2503/61				?soil from sf 63
95/2503/62	+			
95/2503/63				ferruginous concretion
95/2504	+			

Fe slag = iron-rich slags
FAS/HL = fuel ash slag and/or hearth lining
Vit clay = vitrified clay