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Metalworking debris from Cripplegate Buildings (WFG 18), City of London

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Summary

Excavations of parts of the Roman fort at Cripplegate shortly after World War II also retrieved a well-dated assemblage of material from the early 17th century infilling of the city ditch. This included crucibles, distillation vessels, a bone ash cupel and other ceramic vessels and slags. A selection of these finds were analysed qualitatively by XRF to determine the metals being worked.

Keywords

Ceramic
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Technology

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Introduction

In the immediate post-World War II period, Prof Grimes excavated parts of the Roman fort at Cripplegate. Assessment in the 1990s of the archive by John Shepherd demonstrated it included a large and well-dated assemblage from the early 17th century infilling of the city ditch. This material is dated from the pottery it contains to the 16th and early 17th century and is believed to have come from adjacent properties. Included in the ditch fill are finds which are indicators of a variety of metalworking processes. The material was examined in the 1990s and a selection, including crucibles, distillation vessels, a bone ash cupel and other ceramic vessels and slags, was qualitatively analysed by X-ray fluorescence (XRF).

The crucibles

A number of different types of crucible were recognised (see Table 1). The distinguishing features were form, size, wall thickness and fabric. Forms were generally flat-bottomed with a rim diameter up to twice that of the base (see Figs 1 and 2). Most had a single pouring lip pulled out from the rim. The exceptions were those described as 'triangular' where the upper body and rim had been distorted to a triangular plan, providing three pouring lips. None of the 'large' crucibles analysed included rims so the presence/absence of lips could not be noted, though they are known on some variants of this type from other London sites (eg, Legge's Mount in the Tower of London). The 'small' and 'medium' crucibles were made from an earthenware type fabric and some appeared not to have been used as crucibles, as they were oxidised-fired and carried no trace of metals. The 'large' crucibles were thicker-walled and made of more refractory fabrics while the two fragments classified as 'stoneware' were intermediate between 'medium' and 'large' types. Most of the 'triangular' crucibles were made of a rather coarse fabric though they were still the thinnest-walled of all the types present.

Most of the crucibles that had surviving traces of metals showed some surface vitrification, caused by reaction of the crucible fabric with both ash from the fire and metal oxides from the melt. All were reduced-fired as metals must be melted under reducing conditions to avoid the formation of massive crucible slags. Analysis of the vitrified layers can give some indication of the composition of the metal being melted, though there is no direct relationship between metal and slag compositions. All the elements detected (noted in Table 1) would have been present in the metal being melted, but not necessarily as major or deliberate components. Zinc and, to a lesser extent, lead tend to be over-represented because of their chemical nature, while XRF (as used here) tends to under-estimate silver, tin and antimony.

On those small, medium and stoneware crucibles that have been used, there are mainly low levels of metals, suggesting the craftsmen's technique was good as they had reduced metal losses to a minimum. It is therefore difficult to identify the metals being melted, though most were probably copper alloys of some sort. The triangular crucibles also have low levels of metals detectable, but Nos 115 and 117 provide more evidence of the metal melted; the presence of detectable amounts of silver suggests that it was a major component of the melt.

The large crucibles were used to melt leaded copper alloys. Tin was detected on most of the analysed sherds and antimony on one of them, suggesting the alloy was probably similar to the heavily leaded bronzes containing arsenic and/or antimony that were used for large vessels such as cauldrons and skillets in the late and post medieval periods (Blades 1995, 136).

Table 1: The analysed crucibles and other vessels

Accn No	Context No	Crucible type	sherd type	ext diam of sherd (mm)	wall (mm)	Non-ferrous elements detected	Comments
118	19a	small	base	c.50	5	(Pb)	
119	141	small	base	50	6	-	not a crucible ?
120	25a=u/s	small	vertical half	rim c.20	3-4	-	oxidised fired; unused
121	128	small	base and body	c.40	7	-	oxidised fired; unused
128 *	210	small	vertical half with lip	rim 47, base 29	4	-	oxidised fired
109	217	medium	rim and lip		7	Cu (Pb Zn)	
116	47	medium	body		5-7	(Pb Zn Cu)	
122	128 or 239	medium	base and wall	c.70	4-6	-	? unused
123 *	217	medium	complete	rim 80, base 40	5	Pb (Cu)	some lead vitrification inside
127	201	medium	body and rim with lip		3-4	-	oxidised fired
107	31=u/s	'stoneware'	body	c.100	10	Cu Zn (Pb)	
111	217	'stoneware'	body		8	(Pb)	
105 *	86	large	base and lower body	base 75	12	Zn Cu Pb Sn Sb	
106 *	218	large	base and lower body	base 90	14	Cu Zn Pb Sn	
110	208	large	body		10	Pb Cu Zn (Sn)	
112	217	large	body	c.100	7-14	Cu Pb (Zn)	
114	217	triangular, fine	body and rim		3-4	(Zn Cu Pb)	
108	217	triangular, coarse	rim		3	nd	
113	217	triangular, ?coarse	body and rim	c.50 at 40 below rim	4	Pb (Cu Zn Sn)	vitrified crust at lip, ?remains of a lid
115 *	217	triangular, coarse	base and body	base 28	3-4	Cu Zn Pb Ag Sn	
117 *	217	triangular, coarse	nearly complete	base 42	5	Pb (Zn Cu) Ag Sb	
129	201	triangular, coarse	base	base 25	2-3	-	? unused

Table 1 (continued)

Accn No	Context No	Crucible type	sherd type	ext diam (mm)	wall (mm)	Non-ferrous elements detected	Comments
		cupel	complete	base , rim	-	Pb Ag	fabric is bone ash not ceramic
124 1	217	'saucer'		c.160		Pb Cu (Ag)	Parts of 3 vessels
2				c.>180		(Pb Cu Zn)	
* 3				) 140		Pb Cu (Zn)	
3				)		Cu Pb Sn Ag As Sb	
125	217	'saucer'			7-8	Pb Cu (Sn Pb)	
126	217	'saucer'		160	6-9	Pb (Cu Zn Sn)	

Key to Tables 1 and 2:

Cu = copper, Zn = zinc, Pb = lead, As = arsenic, Ag = silver, Sn = tin, Sb = antimony, Ca = calcium, Hg = mercury

Elements written within brackets only gave weak signals

* = see sketch drawing

nd = no metals detected

\- = not analysed

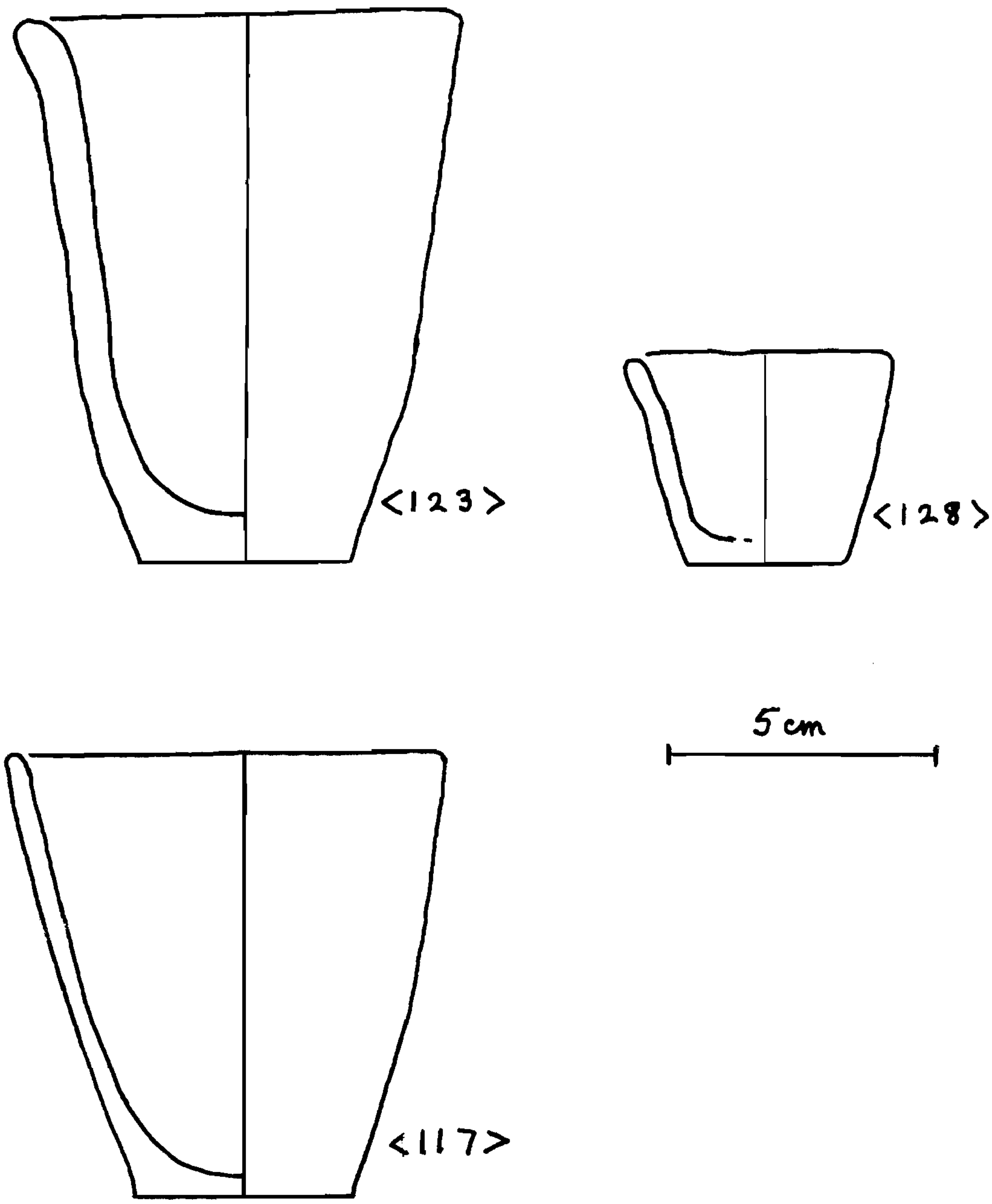

Fig 1: Small (No 128), medium (No 123) and triangular (No 117) crucibles.

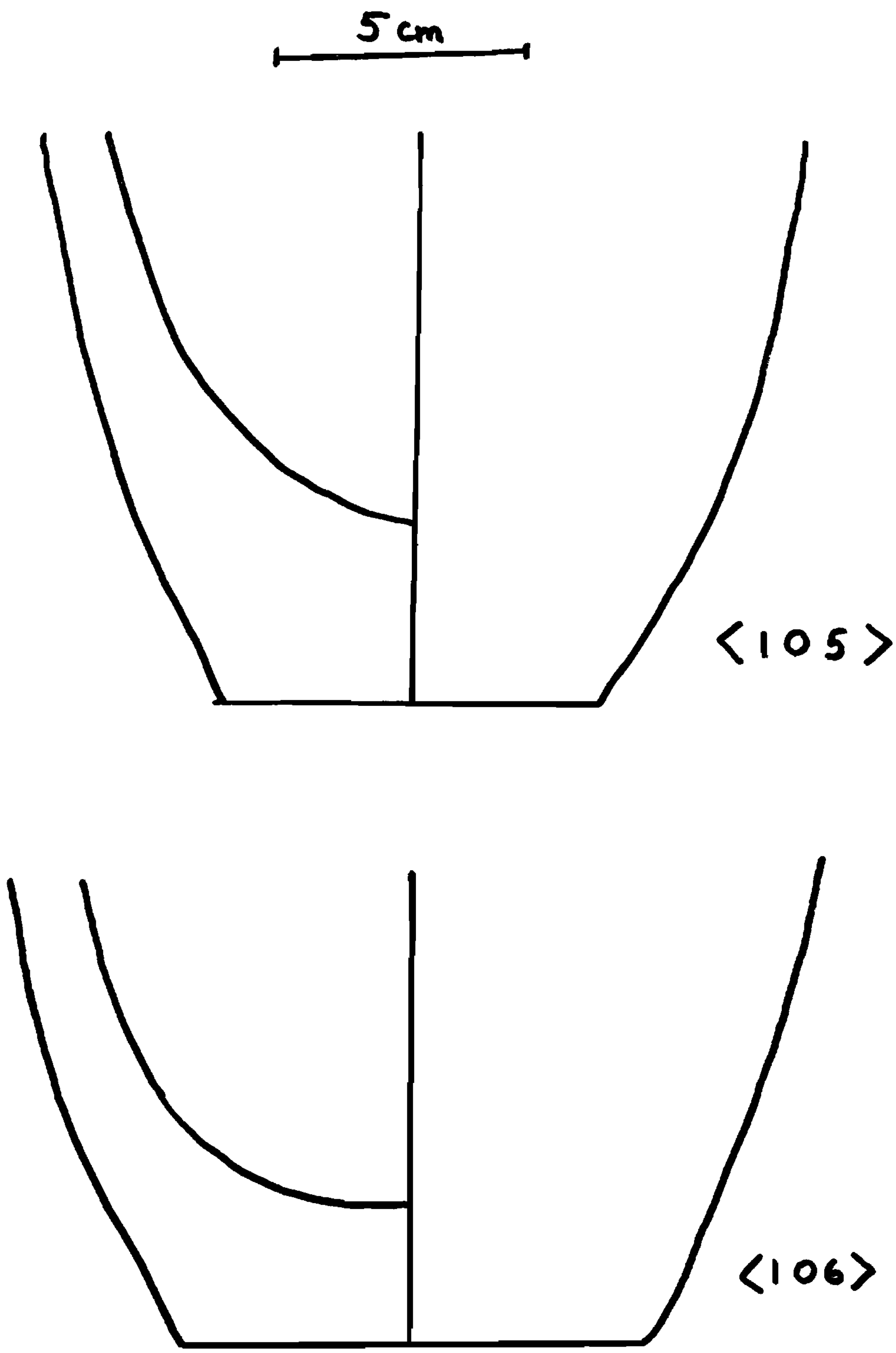

Fig 2: Large crucibles (Nos 105 and 106)

Flat-bottomed crucibles were introduced in the later medieval period when furnaces with firebars for them to sit on became common. Agricola (Hoover and Hoover 1950, 455) illustrates the sort of structure that would have been used and a surviving example is the brick-built furnace discovered in Legge's Mount at the Tower of London (Parnell 1993, Fig 40), associated with crucibles comparable to the small, medium and large types from Cripplegate Buildings.

Distillation vessels

A second major group of industrial ceramics were fragments of wheel-thrown, redware bottles, the long neck being made separately and luted onto the body of the vessel (Bayley 1996, Fig 8). Both body sherds and necks with a variety of rim forms are among the assemblage; they were found in contexts 19a, 22, 30, 40, 41, 47, 49a, 87, 122, 201, 208, 214, 217, 218, 228, 242 and 256. Many fragments have a red, powdery deposit, mostly on their inner surfaces, which X-ray diffraction (XRD) analysis has shown to be iron oxides (a mixture of haematite and magnetite). Similar vessels have also been recognised on a number of other sites in and around the Tower of London, in contexts dating to the 16th and 17th centuries; many have the red powdery deposits noted on the Cripplegate examples. They are therefore interpreted as curcurbits, the iron oxides being by-products of the distillation of nitric acid from a mixture of vitriol and saltpetre. Moorhouse (1972, Fig 24) reproduces a 16th century woodcut from Lazarus Ercker's *Treatise on ores and assaying*, showing vessels of this type in a workshop.

Other vessels

The majority of the other vessels are parts of shallow, saucer-shaped ceramic dishes with diameters around 150mm, most with vitreous deposits on their upper surfaces (Fig 3). These deposits are lead-rich and contain a variety of other metals, most notably silver. They appear to have been used to refine silver by the cupellation process (see below).

The final vessel type is a cupel, made of bone ash but now impregnated with lead oxide, and retaining an irregular lump of silver in its centre (Fig 4). Cupels were used for assaying (testing the purity) of precious metals. A sample of the metal was weighed and then melted on the cupel with a relatively large amount of lead. The melt had air blown over it to oxidise the lead to litharge (lead oxide) which in turn oxidised and dissolved any base metals mixed with the silver (or gold). The litharge was absorbed by the cupel and the silver that was left on its surface could be re-weighed, its original purity being calculated from the difference between the weights. The irregular surface of the silver is produced by dissolved oxygen being ejected from the metal as it solidifies; this only happens if the metal is very pure. Very similar 16th century bone ash cupels are known from Legge's Mount (Bayley 1996, Fig 7), in an area of the Tower of London used by the Mint at that time, and further contemporary examples are known from Germany (Rehren 1996), though none of the other cupels have silver present.

The advantage of using bone ash, rather than ceramic, for cupels is that the litharge is absorbed, giving good separation of the base and precious metals. Litharge reacts with the silica in ceramics forming a lead 'glaze' which tends to trap small metal droplets and so can lead to inaccuracies in determining purity. It is therefore likely that the saucer-shaped dishes were not being used for assaying but for some purification or extraction process where a fully quantified result was less important.

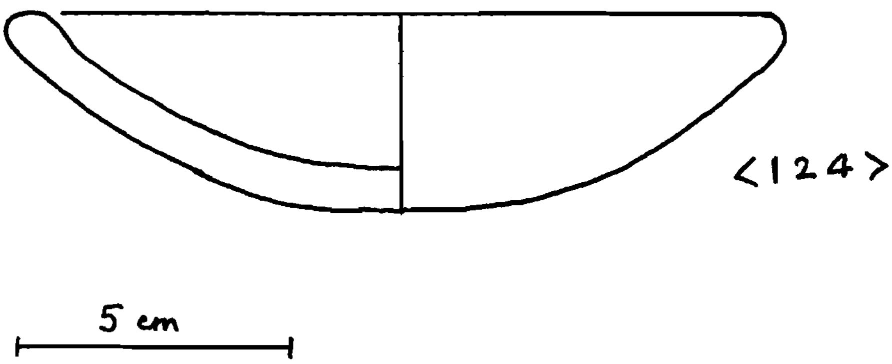

Fig 3: Saucer-shaped ceramic dish

Fig 4: The bone ash cupel with an irregular lump of silver on its surface (scale bar in mm)

The slags and other samples

The slags (see Table 2) contained a range of non-ferrous metals and are probably by-products of large-scale melting of lead-rich copper alloys. A brick with a vitrified surface (No 71) was probably part of a hearth or furnace in which this melting took place. The metal lump (No 73) is copper with minor amounts of lead.

An unexpected find was a lump of galena, a lead ore (No 140). The nearest British sources are the Mendips, Welsh Marches and Derbyshire so it must be a deliberate import to the site. As it came from the same context as much of the other metalworking debris, it is tempting to interpret it as evidence for a further metallurgical process, though it could have been used, for example, as a pigment.

The opaque yellow surface on vessel No 138 was a tin-opacified lead glaze or glassy deposit. Tin opacified glasses are normal in the early medieval period but yellow colours on later medieval pottery, eg maiolica, are usually produced by lead antimonate painted over a white, tin opacified glaze. The bright red pigment in pipkin No 139 contained both lead and mercury; it is a mixture of red lead (lead oxide) and cinnabar (mercury sulphide).

Table 2: Other analysed samples

Accn No	Context No	Type	Non-ferrous elements detected	Comments
68	218	slag	Pb Ca Cu Sn	
69	241	slag	-	similar to No 68
70	228	slag	-	similar to No 68
	255	slag	-	? similar to No 68
71	217	brick	Pb (Cu Sn)	surface vitrified
73	19a	metal lump	Cu (Pb)	
74	15=u/s	slag	Pb (Cu)	
140	217	galena	Pb	crumbly lead ore
141	174	slag	-	iron smithing slag
142	174	slag	-	iron smithing slag
143	15	slag	Pb Cu Ca Zn (Sn)	
138	256	vessel	Pb Sn (Cu)	opaque yellow glaze
139	141	pipkin	Pb Hg	bright red pigment

Key: Cu = copper, Zn = zinc, Pb = lead, Sn = tin, Ca = calcium, Hg = mercury
Elements written within brackets gave only weak signals
\- = not analysed

Discussion

The finds described above show that a range of metallurgical operations were carried out in the Cripplegate area in the late 16th and/or early 17th century. This is not surprising as it is in one of the areas of the City where diverse metalworkers operated in the medieval period (Keene 1996, Fig 1) and is not far from present day Goldsmiths Hall, which stands on land occupied by the Guild from the Middle Ages.

The finds show copper alloys were melted, and presumably cast, in both large and smaller quantities. As has been noted on other sites (eg Bayley 1992, 4), there appears to be a correlation of particular types of crucibles with specific alloys. This deliberate selection is partly due to the scale of use of metals; for example, only a large crucible would contain enough metal to cast a skillet. However, where size is not a factor, there is still selectivity. The 'triangular' crucibles, which have been identified as imports from Germany (Cotter 1992), have superior refractory properties to those of contemporary English crucibles of similar size which presumably explains their selection for melting silver. They would be less likely to fail in use that less refractory crucibles, so the valuable metal would have been safer.

There is evidence too for assaying and probably refining silver, and the distillation vessels for making nitric acid suggest that the parting (chemical separation) of silver from gold also took place near here. Keene (1996) identifies the area at the west end of Cheapside, just south of the Cripplegate area, as the main cluster of goldsmiths in the City in the medieval period, and there was a lesser group just outside Cripplegate, close to the excavated area that produced these finds. The archaeological evidence is reinforcing the location of craftsmen known from documentary evidence.

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