Ancient Monuments Laboratory
Report 54/2000

METAL WORKING EVIDENCE FROM NO 1 POULTRY, LONDON

D Dungworth
H S Bowstead Stallybrass

Ancient Monuments Laboratory Report 54/2000

METAL WORKING EVIDENCE FROM NO 1 POULTRY, LONDON

D Dungworth
H S Bowstead Stallybrass

Summary

The excavation of a large area in central London (Poultry), revealed early Roman through to medieval deposits. Over 300 kg of metal working waste was recovered although most of this comprises iron smithing slags. Three-quarters of the iron smithing debris comes from 10th and 11th century deposits. Unfortunately very little stratigraphy survives from the period (13th century) when there are documentary records detailing the different artisans at work in this part of medieval London. The small-scale working of copper alloys is indicated by the presence of crucibles, and the extraction of silver by litharge cakes.

Authors' addresses :-

D Dungworth
ENGLISH HERITAGE
Centre For Archaeology Fort Cumberland
Fort Cumberland Road Eastney
Portsmouth
HANTS
UK
PO4 9LD

H S Bowstead Stallybrass
Centre For Archaeology

Metal Working Evidence from No 1 Poultry, London

David Dungworth & Helen Bowstead Stallybrass

Introduction

Large-scale excavation at No 1 Poultry, London revealed Roman to medieval deposits. Over 300 kg of metal working waste was recovered. The iron working debris provides considerable evidence for iron smithing. Over three-quarters of the iron working debris comes from 10th and 11th century deposits. The working of copper alloys is indicated by the presence of crucibles, and the extraction of silver by litharge cakes.

Background to Site

The site lies in central London, at the eastern end of Cheapside (NGR TQ 3258 8110). The limits of the excavation were Poultry (to the north), Victoria Street (to the south and east) and Pancras Lane and Sise Lane (to the west). The excavated deposits ranged in date from before the Boudican revolt to the post-medieval period (see Table 1).

Period	Dating
1–4	c. AD 50 to c. AD 60
5–8	c. AD 60 to c. AD 130
9–17	c. AD 130 to c. AD 250/270
18–22	c. AD 250/270 to early fifth century
31–32	‘dark earth’ and post-Roman pitting
33–38	Late Saxon to Early Medieval, c. AD 900 to c. AD 1100
39	Construction of St. Benet Sherehog, c. AD 1050
40	Late Medieval
41-43	Post-Medieval to Modern

Table 1. Summary of No 1 Poultry Phasing.

The Roman remains included a series of terraces and the main east-west road through Roman London (the *via decumana*). During the 1st century clay and timber road-side buildings were constructed, these were destroyed by fire on several occasions (e.g. Boudican Fire and Hadrianic Fire) and some to the north of the *via decumana* were replaced in the late 2nd century by masonry buildings. The timber buildings were cleared and replaced by open yards in the 3rd and 4th centuries. The late Roman buildings were sealed by dumped ‘dark earth’ deposits that were cut by various pits (probably 9th century).

The earliest post-Roman evidence consists of dumping, open areas (a market?) and some sunken-featured buildings. Rows of narrow timber buildings facing onto Poultry were constructed in the mid 10th century (the excavation did not extend as far as the actual road surface). These buildings were particularly well preserved and included successive brickearth floor surfaces and hearths, although later wall foundations had destroyed the wall lines of the earlier buildings. In the second half of the 11th century, these individual buildings were replaced by a terrace of buildings that were partitioned into separate shops or workshops. Other buildings were also constructed facing on to Bucklersbury (which ran from Poultry to Victoria Road).

Archaeological evidence for later activity on the site is limited as later medieval layers were largely removed by the construction of deeply-basemented buildings in the 19th century. Nevertheless, there is considerable documentary evidence, especially from the 12th century onwards. Between the 12th and 14th centuries the area was characterised by the manufacture of high-quality iron goods. Professions recorded include ironmongers, spurriers, cutlers, lorimers and at least one armourer. A charcoal market was established in the vicinity in the 1170s to service the needs of the metal workers. The character of the area slowly changed over time and industrial activity declined in favour of financial activities.

Aims

The project design for No 1 Poultry identified the potential for studying the changing nature of trade and industry,

> Poultry developed between the Cheapside commercial district of the City and the Walbrook valley and was therefore influenced by both commercial and industrial activities. The size of the Poultry area, and the depth and complexity of the stratigraphy, will facilitate a thorough analysis of the changing pattern of craft and industrial activities in a central part of the City of London.
> . . . pivotal to this study will be a detailed comparison of the archaeological data with the wealth of documentary sources relating to trade and manufacture.
> Hill, Rowsome & Treveil 1997: 194

In addition, a number of specific aims were identified:

- The role of craft and industrial processes in Late Saxon/early medieval times.
- Relative importance of iron production and iron smithing.
- Chronological changes.
- Spatial patterns
- Comparisons with Cheapside 1990.
- Comparison of non-ferrous metal working debris from B17M (vicinity of church of St. Benet Sherehog) with documentary evidence for 12th century trade in precious metals.

Recovery of Metal working Debris

During excavation fragments of slag and other types of metal working debris were recovered and assigned to their particular archaeological contexts. Micro-residues (hammerscale) were also recovered from environmental samples and on occasion from soil samples taken specifically to recover micro-residues. The environmental samples were taken from a range of deposits but especially pits and occupation horizons. Multiple soil samples were not taken from single contexts in order to examine the spatial distribution of hammerscale within occupation/working horizons (cf. Burton Dassett, Mills & McDonnell 1992).

Types of Debris Recognised

Macro-slags

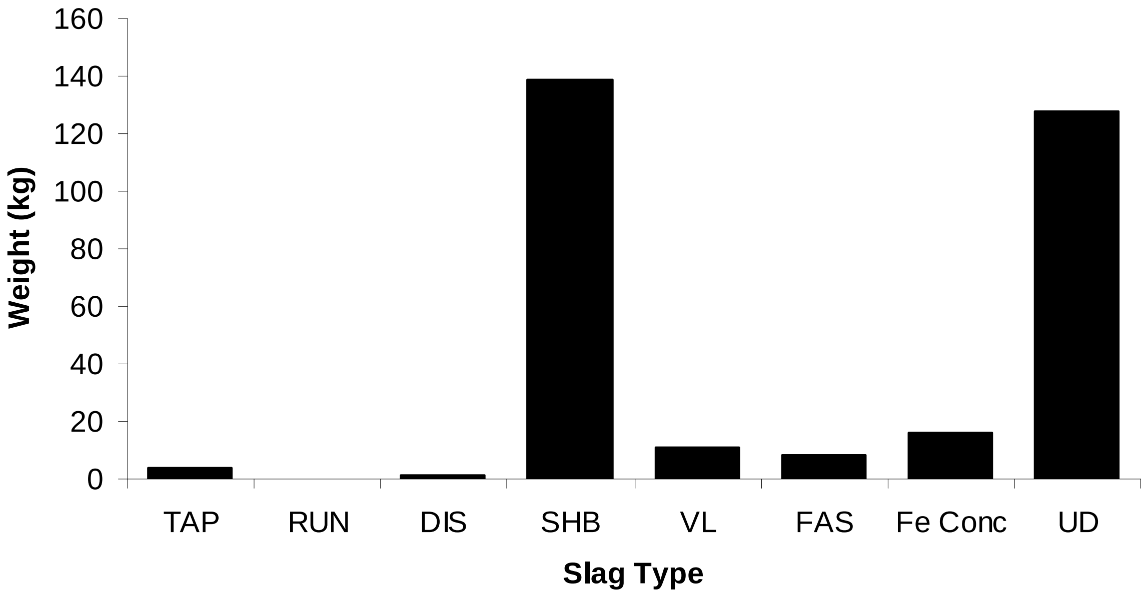

Figure 1. Breakdown of different types of metal working debris (by weight)
(TAP = Tap Slag, RUN = Run Slag, DIS = Dense Iron Silicate Slag,
SHB = Smithing Hearth Bottom, VL = Vitrified Lining, FAS = Fuel Ash Slag,
Fe Conc = Iron Concretion, UD = Undiagnostic Iron working Slag)

The assemblage of metal working debris recovered from No 1 Poultry included a number of different types classified according to their size, density, shape, porosity, colour, etc. The definitions and significance of the individual types are discussed below. The proportions, by weight, of the different types of debris are shown in Figure 1. Out of a total weight of just over 300 kg of metal working debris, approximately 42% are undiagnostic and do not indicate any particular iron working process. They are could be produced by iron smithing or smelting but are either too small or too fragmentary to allow positive identification. Out of the various diagnostic categories of iron working debris the most abundant is smithing hearth bottoms (45% by weight of the total assemblage). The remaining debris in total accounts for only 13% of the assemblage and includes fuel ash slag, vitrified hearth lining, tap slag, iron concretions (some of which may be blooms), run slag and dense iron silicate slag. The absence of large quantities of tap or run slag, the abundance of smithing hearth bottoms and the presence of hammerscale (see below) in many of the soil samples from No 1 Poultry indicates that iron smithing rather than iron smelting was the principal iron working activity.

Micro-slags

The assemblage of metal working debris submitted included 156 samples of hammerscale. These were recovered from soil samples taken as sub-samples from environmental samples. In addition 26 soil samples were provided. Magnetic susceptibility values were obtained on 50 g of these soil samples which were then sieved and the magnetic fractions separated (see Table 2). This showed that high magnetic susceptibility values were associated with hammerscale (cf. Mills & McDonnell 1992). Not all contexts (or even all contexts containing macro-slags) were sampled for the recovery of micro-slags.

Context number	Environmental sample number	Period	Building /Area	Weight of slag from this context (g)	Magnetic susceptibility (SI)	Hammerscale (g)
2510	200	36	B124	106	237	0
2548	204	35	B110	329	2839	6.97
2550	205	35	B110	479	1665	4.10
2694	218	36	OA124	6768	600	0
2697	217	36	B112	1872	821	0
2766	227	35	B113	12463	2235	8.44
2797	229	34	OA113	363	249	0
2843	236	35	B112	5849	1685	3.93
6010	661	34	OA142	19	19	0
12070	716	12	B70	0	31	0
12259	748	9	OA48	0	188	0
12812	845	5	OA22	0	26	0
15336	936	5	OA23	23	267	0
16737	645	36	OA135	5372	1034	2.31
16751	642	34	OA115	0	465	0
16797	665	35	B116	698	449	0
16800	666	35	B116	1352	471	0
16810	668	35	B116	258	388	0
16812	667	36	B168	1231	279	0
16866	673	35	B117	28	329	0
16870	677	35	B116	1255	2377	3.05
16883	678	35	B116	130	1710	1.05
16924	685	36	OA124	46	211	0
16991	697	35	B116	537	1522	0.96
17610	833	18	OA58	1058	170	0
17915	879	7	B44RD	0	36	0

Table 2. Details of soil samples taken for extraction of hammerscale

Those samples with magnetic susceptibility values below 1000 did not contain any hammerscale. In each case where hammerscale was detected the context also contained macro-slags. Nevertheless some contexts contained macro-slags but did not have any hammerscale.

Contexts with macro-slag but no hammerscale may be dumped rather than *in situ*. In those contexts with no hammerscale but with magnetic susceptibility values between 0 and 1000, fired ceramic material and/or iron corrosion products would have produced some enhancement of the magnetic susceptibility values.

Explanation of Terms Used

Macro-slags

The most distinctive type of iron working debris associated with iron smelting (i.e. primary extraction of metal from the ore) is **tap slag (TAP)**. This is a dense, fayalitic (iron silicate) material which shows a characteristic ‘ropy’, flowed, morphology on upper surfaces and low vesicularity at fracture surfaces. Tap slags are diagnostic of smelting of iron and are typical waste products of the tapped bloomery furnace from which the molten slag was run out rather than collecting within its interior.

Similarly, material described as **fayalitic runs (RUN)** most probably relate to smelting, being either small fragments of tap slag or small quantities of slag that have trickled down within a furnace but solidified before being incorporated into the more distinctive forms. However, care must be taken because, as experimental work has shown, small slag runs are occasionally formed in smithing hearths.

Dense ironworking slag (DIS) has a homogenous dense structure but not the distinctive morphology of tap or run slag. Much of this material was of a shattered blocky form and as such may be the broken up fragments of thick plates of tap slag. It can be assumed that at least the bulk of this material derives from iron smelting.

Evidence for iron smithing may be recognised in two forms, as bulk slag and as micro slags. Of the bulk slags produced during smithing only the **smithing hearth bottoms (SHB)** are unlikely to be confused with the waste products of smelting and are therefore considered to be diagnostic of smithing. Hearth bottoms are recognisable by their characteristic plano-convex form, typically having a rough convex base and a smoother, vitrified upper surface which is flat, or even slightly hollowed as a result of the downwards pressure of the air blast from the tuyère. Compositionally, smithing hearth bottoms are predominantly fayalitic (iron silicate) and form as a result of high temperature reactions between the iron, iron-scale and silica from either the clay hearth lining or sand used as a flux by the smith.

Most assemblages of slag include **undiagnostic iron working slag (UD)**, which has no distinctive morphology but is of fayalitic composition and can be formed during iron smelting or iron smithing. As most of the diagnostic slag from No 1 Poultry derives from iron smithing , it is likely that most of the undiagnostic slag is also from smithing.

Vitrified lining (VL) is produced by a high temperature reaction between the clay lining of a hearth or furnace, and the alkali fuel ashes or fayalitic slag. It can be formed by iron smelting, iron smithing, non-ferrous metal working or other pyrotechnical processes. This material usually shows a compositional gradient from un-modified fired clay on one side to a glazed surface or irregular cindery material on the other.

Fuel ash slag (FAS) is a very lightweight, light coloured (grey-brown), highly porous material which results from the reaction between alkaline fuel ash and silicates from soil, sand or clay at elevated temperatures. The reaction is shared by many pyrotechnological processes and the slag is not diagnostic. Energy-dispersive X-ray fluorescence analysis shows the presence of silicon and alkalis such as calcium, potassium and sodium with little or no iron.

Iron concretions (Fe conc) are amorphous orange-brown lumps that respond poorly to a magnet but do not have the typical vitrified surfaces of metal working debris. They are thought to have formed as a result of the re-deposition of iron hydroxides in a similar manner to the natural phenomenon of iron panning. The process may be enhanced by the nature of the surrounding archaeological deposits, particularly iron-rich waste. Iron concretions may also be severely corroded iron artefacts.

Micro slags

In addition to bulk slags, iron smithing also produces micro-slags of two types. **Flake hammerscale** consists of fish-scale like fragments of the oxide skin of the iron dislodged during working. **Spheroidal hammerscale** results from the solidification of small droplets of liquid slag expelled during working, particularly when two components are being fire welded together or when a slag-rich bloom of iron is first worked into a billet or bar. Hammerscale is considered important in interpreting a site because it is highly diagnostic of smithing. It often builds up in the immediate vicinity of the smithing hearth and anvil and may give a more precise location for smithing than the bulk slags that may be transported elsewhere for disposal (Mills & McDonnell 1992).

Examination of Iron Concretion (possible bloom fragment/waste)

One example of an iron concretion from No 1 Poultry (context 17529) was selected for further examination in order to determine if it was a ‘natural’ material or a fragment of a bloom. The specimen was large (~2.3 kg), clearly magnetic and composed of slag and iron corrosion products. A fragment was removed using a cut-off saw, embedded in resin, polished to a one micron finish. This showed that the material was approximately 30% metallic. The specimen was then examined using an optical microscope and a scanning electron microscope. Figure 2 shows a back-scattered electron image of the sample. This shows a number of distinctive phases; the brightest areas have the highest average atomic number, the darkest areas the lowest. The darkest areas are porosity (gas holes), the dark grey areas are a glassy matrix, the medium grey laths are fayalite ($2FeO.SiO_2$), the light grey areas are wüstite (FeO), and the white areas are droplets of metallic iron. The morphology of the metallic iron is typical of bloomery smelted iron, which has not been consolidated into a bloom (Blomgren & Tholander 1986).

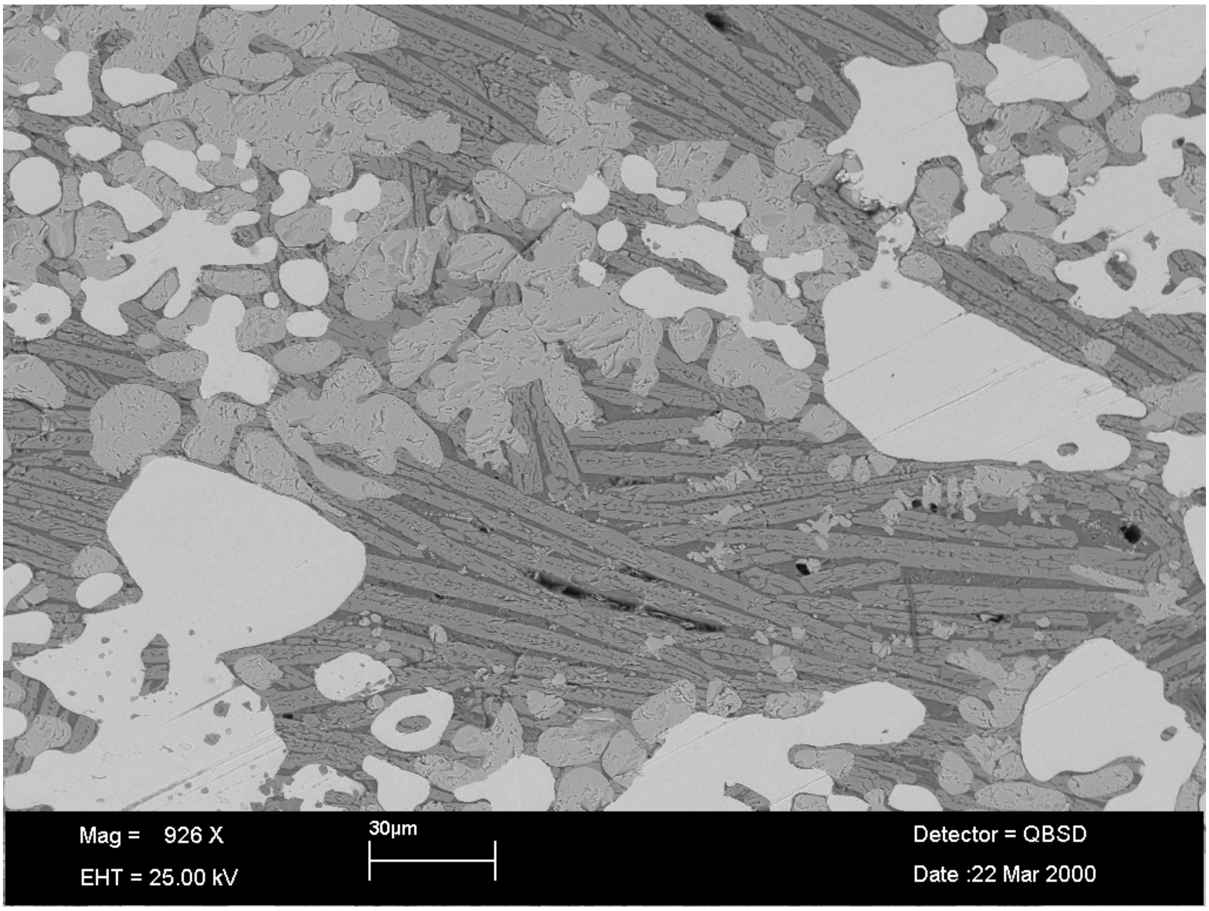

Figure 2. SEM microphotograph of iron concretion (from context 17529)

Chronological Distribution of Iron Working Debris

The range and weight of iron working debris from each phase is shown in Table 3. This shows that small amounts of debris were recovered from most periods but that large quantities were recovered from periods 35 and 36.

Roman Metal Working Residues

A total of 22 kg of metal working debris was recovered from Roman contexts. This includes a range of slags diagnostic of iron working, and iron smithing in particular. In addition ten of the Roman contexts also produced fragments of hammerscale. The total weight of smithing hearth bottoms is fairly modest given the total area excavated. Only a small quantity of tap slag (124 g by weight) was recovered from Roman contexts.

The Roman periods which produced the largest quantities of iron working debris were 5 (post-Boudican fire disruption, scattered robbing, dumping and re-deposition), 18 (late Roman road use and adjacent buildings and open areas) and 22 (very late Roman dumping, deposition, roadside gullies and ephemeral structures).

The Period 5 iron working debris was recovered principally from road surfaces (R1 and R2) and from Open Area 22. The Period 18 debris came exclusively from R1, R2 and Open Area

58. Most of the Period 22 debris was recovered from one of the buildings (B64RME) and Open Area 81.

Period	TAP	RUN	DIS	SHB	VL	FAS	Fe Conc	UD	TOTAL	Contexts with hammerscale
0	0	0	0	0.190	0	0.049	0.010	0.055	**0.304**	0
1	0	0	0	0	0	0	0	0	**0**	0
2	0	0	0	0	0.001	0.065	0.041	0.015	**0.122**	0
3	0	0	0	0.179	0.054	0.006	0.013	0.294	**0.546**	0
4	0	0	0	0	0	0	0	0	**0**	0
5	0	0	0	3.270	0.081	0.175	0.284	0.242	**4.052**	1
6	0	0	0	0	0.009	0.150	0.039	0.260	**0.458**	0
7	0.021	0	0	0	0.248	0.568	0.166	1.539	**2.542**	0
8	0	0	0	0	0.104	0.245	0.033	0.275	**0.657**	1
9	0	0	0	0	0.009	0	0	0.194	**0.203**	1
10	0	0	0	0	0	0.047	0	0.050	**0.097**	0
11	0	0	0.020	0	0	0.005	0	0.123	**0.148**	0
12	0	0	0	0	0.044	0	0.031	0.267	**0.342**	0
13	0	0	0	0	0	0	0	0	**0**	0
14	0	0	0	0	0	0	0	0	**0**	0
15	0	0	0	0	0	0	0	0	**0**	0
16	0	0	0	0	0	0	0	0.021	**0.021**	0
17	0	0	0	0	0	0	0	0	**0**	0
18	0.103	0	0.151	2.933	0.466	0.625	0.168	2.225	**6.671**	3
19	0	0	0	0	0	0	0	0	**0**	0
20	0	0	0	0	0	0.142	0	0.003	**0.145**	0
21	0	0	0	0	0	0.029	0	0.924	**0.953**	1
22	0	0	0	3.004	0.148	0.692	0.140	1.138	**5.122**	3
31	0	0	0	0	0	0	0	0	**0**	2
32	0	0	0	1.725	0.137	0.129	0.099	1.926	**4.016**	3
33	0	0	0	0.615	0.017	0.080	0.032	0.215	**0.959**	2
34	0	0	0	0.339	0.183	0.171	0.683	4.766	**6.142**	6
35	1.725	0.227	1.157	60.613	4.167	3.660	7.132	73.891	**152.572**	68
36	0.948	0.022	0.033	42.409	4.984	1.448	6.603	36.411	**92.858**	57
37	0.429	0	0	1.166	0	0.068	0	1.474	**3.137**	2
38	0	0	0	1.195	0.012	0.003	0	0.504	**1.714**	0
39	0	0	0	5.656	0.219	0.057	0.701	0.767	**7.400**	4
40	0.692	0	0	15.465	0.062	0.027	0	1.042	**17.288**	2
41	0	0	0	0	0	0.004	0	0	**0.004**	0
TOTAL	**3.918**	**0.249**	**1.361**	**138.759**	**10.945**	**8.445**	**16.175**	**128.621**	**308.473**	**156**

Table 3. Distribution of different types of iron working debris by period (in kg)
(TAP = Tap Slag, RUN = Run Slag, DIS = Dense Iron Silicate Slag,
SHB = Smithing Hearth Bottom, VL = Vitrified Lining, FAS = Fuel Ash Slag,
Fe Conc = Iron Concretion, UD = Undiagnostic Iron working Slag)

Post-Roman Metal Working Residues

Over 286 kg of metal working debris was recovered from post-Roman contexts, 85% of which came from periods 35 and 36. This includes a range of slags diagnostic of iron working, and iron smithing in particular. Again only a small quantity of tap slag (0.4% by weight) was recovered.

These small quantities are likely to be intrusive as smelting produces large quantities of slag.

The relatively large quantities of iron smithing debris recovered from Period 35 and 36 contexts imply that iron smithing played a significant role in the economy of the site at this time. The spatial distribution of this debris is explored further below.

Later and Post Medieval Metal Working Residues

From Periods 37 onwards relatively small quantities of iron working debris were recovered. This is probably in part due to the fact that much of the Period 37 onwards stratigraphy was truncated by the construction of 19th century cellars. A large proportion of the Period 37 onwards debris (62% by weight) derives from road surfaces and so does not necessarily relate to metal working activities in the immediate vicinity of Poultry.

Spatial Distribution of Iron Working Debris in Periods 35 and 36

Large quantities of iron working debris were recovered from contexts assigned to Periods 35 and 36 (80% by weight of all of the debris). The spatial distribution for each of these periods is explored in further detail below.

Period 35

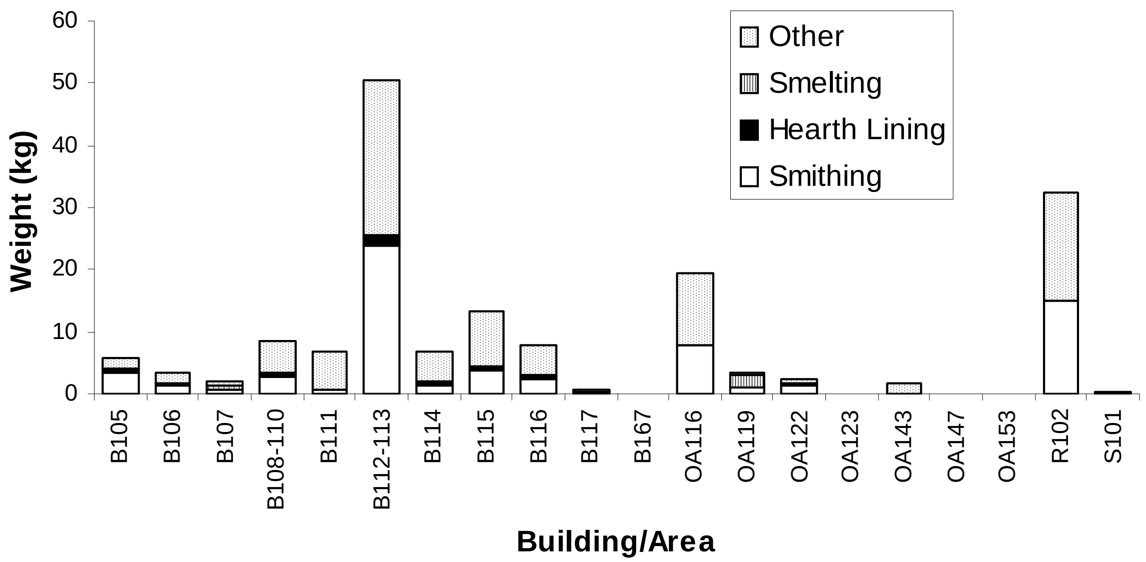

Figure 3. Distribution by weight of principal types of slag in Period 35

The spatial distribution of the principal types of slag for Period 35 is shown in Figure 3. For the purposes of this figure, the smithing slag is the total weight of smithing hearth bottoms, the hearth lining is the total weight of vitrified lining (as smithing is the main metal working activity it seems safe to assume that most of the vitrified linings are the remains of smithing hearths), the smelting slag is the total weight of tap slag, run slag and dense iron silicate slag, and other comprises the fuel ash slag, iron concretions and undiagnostic slag.

The spatial distribution in Figure 3 is organised by building (B) number, open area (OA) number, road (R) number or structure (S) number (those buildings and open areas with no slag have not been included). Buildings B105 to B114 face onto the southern side of Poultry. Buildings B120, B121 and B122 are situated in between Poultry and Bucklersbury near the junction with Cheapside. Open Areas OA116 and OA118 are situated immediately behind buildings B105 to B114. 7All of the debris from building B116 is included in Figure 3 even though it continued in occupation from Period 35 into Period 36 and has contexts dated to both periods. In addition some of the iron working debris from building B112 comes from Period 36 contexts but is dealt with here because it is associated with the period 35 building.

It can be seen that many of the buildings along the Poultry street frontage have large quantities of iron working debris associated with them; this is particularly true of building B112-113. Buildings B112-3 also produced two soil samples with high proportions of hammerscale (see Table 2). The relatively large quantity of iron working debris from open area OA116 almost certainly represents the dumping of debris from building B112-113 (OA116 is immediately behind B112-113). The debris from building B113 derives entirely from pitting near the street frontage; none of the debris was recovered from floor deposits (this includes the hammerscale). A relatively modest amount of slag was recovered from building B105 contexts but this included vitrified hearth lining. One fragment of this hearth lining had a 20–25 mm diameter perforation (tuyère) through which air would have been forced into the fire to maintain the temperatures needed for iron smithing.

In many of the buildings successive floor deposits were recognised but not all of these contained slag. Building B111 has no debris until its fourth phase of occupation, building B112 has debris from its second phase onwards, and building B114 has debris from fifth and sixth phases only. Most of the debris from building B115 is from the final phase of occupation, while most of the debris from building B116 is from its early phases. Building B116 also produced soil samples with high proportions of hammerscale (see Table 2). For the other buildings (except B113) iron working debris is found in most floor deposits.

In certain areas no debris (or only small quantities of debris) were recovered, e.g. the area at the junction of Poultry and Bucklersbury and open areas OA143 and OA153 to the south of Bucklersbury. Large quantities of iron working debris were recovered from the make-up of the Bucklersbury road surface and its associated roadside ditches. Some of this material may have been deliberately brought to the site from elsewhere in London (or even outside London) as road metalling. The range and proportions of different types of debris in the road make-up, however, are similar to those from the buildings and open areas. It is quite likely that this debris was obtained from the iron working areas along Poultry.

Period 36

The spatial distribution of the principal types of iron working debris for Period 36 is shown in Figure 4 (the categories used here are the same as for Figure 3). Some debris for Period 36 has been included in Figure 3 as discussed above. Buildings B123 to B126 face onto the southern side of Poultry and replace buildings B105 to B114 of Period 35. Buildings B119, B127 and B128 are situated in between Poultry and Bucklersbury near the junction with Cheapside. Open Areas OA124 to OA129 are situated immediately behind buildings B123 to B126 while

Open Areas OA129 to OA133 and OA144 are further south (with no associated buildings). Open Areas OA135 and OA136 are close to buildings B119, B127 and B128.

In Period 36 the largest quantity of iron working debris is found associated with building B126. This overlies buildings B112-113 and B114. It is possible that the building B126 debris relates to iron working in that building during Period 36. Alternatively, the debris may be residual and derive from the underlying Period 35 deposits. The debris from building B126 derives largely from features described by the excavators as ‘industrial pits’. The use of the word industrial here seems to be purely on the basis of the debris rather than any other evidence (e.g. signs of *in situ* burning).

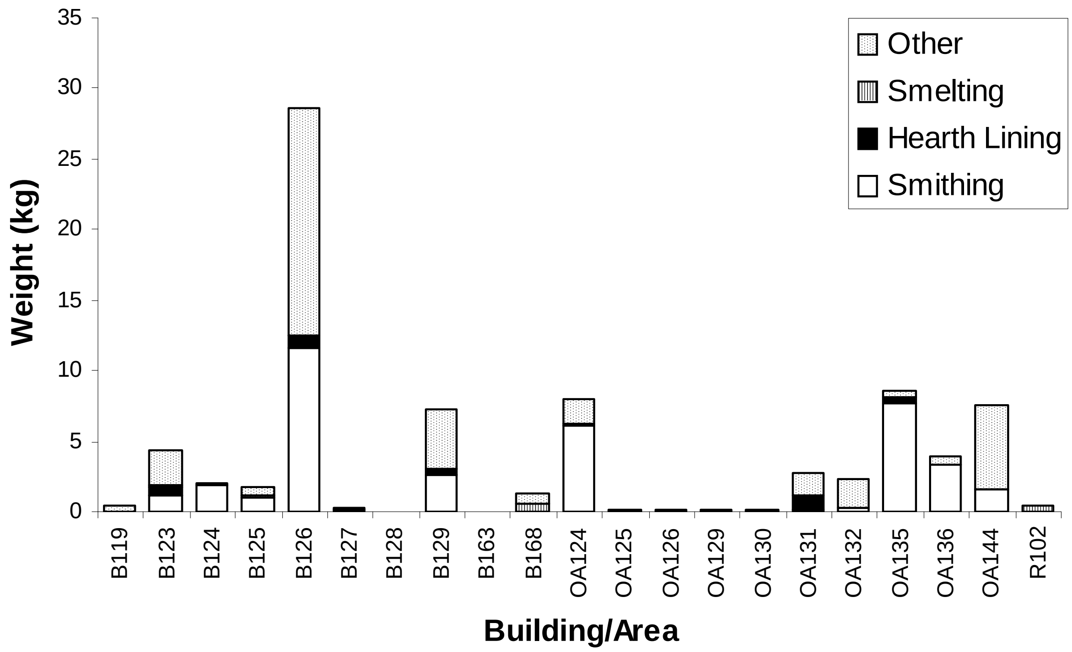

Figure 4. Distribution by weight of principal types of slag in Period 36

As with Period 35, many of the buildings had successive floor deposits: only some of which contained iron working debris. Building B119 had debris only from its first phase of occupation. Building B123 had debris only from make-up dumps of its first floor layer (and so this probably does not relate to any *in situ* iron working. Building B124 has debris only from the phase 2 floor level.

Non-ferrous Metalworking

Crucibles

Context	Area	Period	Fabric	Elements detected
12785	R1	8		Zn, Cu, Pb
17610	OA58	18		Zn, Pb
2947	OA106	32	CERA	Zn, Pb, Cu, Sn
11605	OA140	32	CERA	Zn
6028	OA142	34		Zn, Pb
2588	B105	35	CERA	Pb, Zn
2742	B105	35	CERA	Zn
2792	B105	35	LSS	None
16789	B116	35/36	CERA	Pb
2645	B123	36	EMSS	None
7240	OA131	36	CERA	Zn, Cu
7387	OA132	36	CERA	Ag, Pb, Cu, Zn
16103	OA136	36	CERA	Zn, Cu, Pb
16103	OA136	36	CERA	Zn, Cu, Pb
11503	OA144	36	CERA	None
11030	OA145	37	CERA	Cu, Zn, Pb
1769	B173	39	CERA	Cu, Zn, Pb
1786	B173	39	CERA	Zn, Cu
1833	B173	39	EMCR	Zn
1873	B173	39	CERA	Zn, Cu
1877	B173	39	CERA	Zn
1877	B173	39	CERA	Zn, Cu
1890	B173	39	CERA	Cu, Zn
1938	B173	39	CERA	None
1983	B173	39	EMCW	Zn
1851	B174	39	EMCW	None
1680	OA150	39	CERA	Cu, Zn, Pb
1792	OA150	39	CERA	Zn
1814	OA150	39	CERA	None
1842	OA150	39	CERA	None
1842	OA150	39	CERA	Zn, Cu
1879	OA150	39	CERA	Zn, Cu
893	B174	40	CERA	Zn, Cu, Pb
1586	B174	40	CERA	Zn, Cu
1647	B174	40	CERA	Zn, Cu, Pb
2298	R102	40	CERA	Zn

Table 4. Crucibles and the results of EDXRF analysis (Zn = zinc, Cu = copper, Sn = tin, Pb = lead, Ag = silver)

Fifty-one fragments of crucibles or possible crucibles were submitted for examination. During the examination of the iron working debris a further two crucible sherds were found. All of these were examined visually and analysed using EDXRF. The list of elements detected is given in peak-height order (note this does not necessarily equate with elemental abundance). These techniques were able to confirm that 36 were indeed crucibles (listed in Table 4). The remaining

17 do not have vitrified surfaces and no non-ferrous elements were detected during analysis. These ceramics also had clearly sooted surfaces and are tentatively identified as lamps (listed in Appendix 1).

Generally the crucible fragments are too small to be able to identify diagnostic characteristics of form, although they all appear to be wheel-thrown. The fabrics are usually grey to mauve (reduce-fired) and quartz tempered. Some of the crucibles have a heavily vitrified added layer of clay fused to their outer wall (Bayley 1988, 198–9).

The EDXRF analysis showed that the crucibles were largely used to melt copper alloys. It is not possible to re-construct the exact nature of the copper alloys that were melted. The extent to which metallic elements are deposited on and in a crucible depends on their varying thermochemical and physical properties as well as the temperature and redox conditions during melting (Barnes no date; Dungworth & Bayley 1999). One crucible contained silver and was therefore used at least once to melt silver (the other elements detected in this crucible were probably impurities in the silver).

Most of the crucibles were recovered from early medieval contexts (periods 35, 36 and 39) and from the southwestern sector of the site. The two crucibles from Roman contexts were from road surfaces or roadside drains rather than buildings. Three crucibles were recovered from Building B105 in Period 35 (and one from the Period 36 Building B123 which overlies B105 is probably residual) suggesting that some melting and casting of copper alloys took place in Building B105 in Period 35. Nineteen crucibles were recovered from the area around Sise Lane and the church of St Benet Sherehog (Buildings B173 and B174 and Open Area 150). Building B173, in particular, produced a number of crucible fragments from occupation horizons (rather than pits).

In addition to the crucibles a small amount of copper alloy slag was recovered from No 1 Poultry (Table 5). This slag is a green vitreous material. The green colour derives from the corrosion of droplets of copper in the slag. The slag is likely to have been formed accidentally during the melting and casting of copper alloys. The copper alloy slag derives exclusively from post-Roman contexts and like the crucibles is mostly concentrated in the area around Sise Lane and St Benet Sherehog.

Context	**Period**	**Building/Area**	**Weight**
3547	32	OA105	13
11035	35	OA143	2
1964	39	B173	5
1902	39	B173	39

Table 5. Copper alloy slag from No 1 Poultry

Litharge

Litharge cakes are a waste product characteristic of the purification of silver. A silver alloy may be purified by the removal of alloying elements (such as copper). The silver alloy would be placed in a small hearth lined with burnt and crushed bone and heated with excess lead. The lead would be easily oxidised and any impurities in the silver would then be oxidised and dissolved in the lead oxide (litharge). The litharge was absorbed by the burnt bone, leaving the pure silver in the hearth.

Context	**Period**	**Building /Area**	**Weight (g)**	**Size, mm (reconstructed)**	**Elements detected**
6104	12	R1	80	Too small	Pb, Ca, Si, P
17646	18	OA58	641	∅=100 mm, H=30–40 mm	Pb, Ca, Cu, Si, Al
6036	34	OA142	1775	∅=120–150 mm, H=25–45 mm	Pb, Cu, Fe, Sn, Ca
11372	35	OA143	374	Too small	Pb, Ca, Si, Cu, K, Al

Table 6. Details of litharge cake fragments

Several fragments of litharge cake (i.e. hearth lining impregnated with litharge) were recovered during the excavations. These were characteristically dense and usually grey to pink in colour. The examples from contexts 6036 and 17646 also had the diagnostic 'dish' in the upper surface where the separated silver collected as a pool of metal. Table 6 shows the elements detected in each litharge cake (using EDXRF). No attempt has been made to provide a quantitative analysis of the litharge given its inhomogenous nature. Examination of specimens of litharge using the scanning electron microscope indicated that some elements were present in the litharge cake variably as metals and as oxides. The list of elements detected is given in peak-height order (and this does not necessarily equate with elemental abundance). Calcium was detected in each of the litharge cakes (and in one case, context 6104, phosphorous was also detected) which suggests that bone ash was regularly used to absorb the lead oxide, assisting its separation from the purified silver.

The relatively small size of the litharge cakes from No 1 Poultry and the presence of copper indicate that these litharge cakes were formed during the purification of silver alloys.

Metal spillages

Amongst the assemblage of metal working debris submitted for analysis were a number of spillages of non-ferrous metals. This included a lead spillage (context 3137, B101, Period 33) and a pewter spillage (context 16797, B116, Period 35). These metals melt at relatively low temperatures and so could have been formed accidentally rather than during the deliberate melting and casting of these metals.

Interpretation

Smelting

Very small quantities of iron smelting debris were recovered from Roman and post-Roman contexts. The total quantities of tap slag, run slag and dense iron silicate were 295 g from Roman contexts and 5233 g from post Roman contexts. In addition at least some of the iron concretions appear to be fragments of partially consolidated blooms (cf. Crew 1991).

The 'bloomery' technology used to produce iron in Britain before the Industrial Revolution usually produced large quantities of smelting slag (100s of kg). It is possible that iron was being smelted in the Poultry area of London but the slag was removed. However, the most probable means of disposal would have been as road metalling, and only very small quantities of smelting slag were recovered from road contexts. The total weight of such smelting slags recovered from No 1 Poultry make it most unlikely that smelting was a significant activity at any time. It is possible that some of the slags identified here as smelting slags are simply smithing slags which were accidentally over-heated and so took on morphological characteristics of smelting slags.

Smithing

The vast majority of the iron working debris (of all dates) indicates that iron smithing took place in London. Approximately 22 kg of iron working debris was recovered from Roman contexts. The quantity and range of debris and the sorts of contexts it was recovered from, however, make it difficult to interpret this as evidence for significant Roman iron smithing within the area excavated. Much of the debris comes from scattered robbing, dumping and re-deposition; relatively little debris comes from buildings. Period 22, however, has debris (including hammerscale) from buildings and associated open areas.

The quantities of iron smithing debris from post Roman contexts (especially the 10th and 11th centuries) indicate that iron smithing was significant in the local economy. The earliest post-Roman evidence all comes from Open Areas and may be residual.

Copper alloy working

The two crucibles from Roman contexts cannot be taken as evidence for the working of non-ferrous metals in this part of Roman London as a few fragments of crucible are found during the excavation of most Roman urban sites.

Most of the post Roman copper alloy crucibles from No 1 Poultry were recovered from the vicinity of Sise Lane and St Benet Sherehog. No moulds or similar debris were found and so it is not possible to suggest what was manufactured. Analysis of the crucibles suggests copper alloys (and some silver) were being worked.

Silver working

The recovery of 4 litharge cakes and a crucible containing silver indicate that silver was being worked either on or close to the site. The evidence for silver working is somewhat limited, however, and so it is difficult to locate any particular focus for this activity.

Conclusions

The excavations at No 1 Poultry recovered substantial quantities of metalworking debris (in excess of 300 kg), although not too much significance should be read into this given the large area and the depth of stratigraphy excavated. The quantity of metal working debris from Roman contexts is quite small and much of this comes from ‘secondary’ contexts, such as dumping and make-up deposits. A range of metals was undoubtedly worked in Roman London but this does not seem to have been a major activity within the area excavated at No 1 Poultry. The vast majority of the metal working debris from No 1 Poultry derives from the smithing of iron in the early medieval period (Periods 35 and 36). The types of iron working debris from No 1 Poultry are broadly similar to those from earlier excavations at Cheapside (Bayley 1992; Hill & Woodger 1999). An examination of the spatial distribution of debris from period 35 and 36 contexts suggests that iron smithing took place in some buildings and not others. One of the most striking concentrations occurs in Building 112–113 and the associated Open Area 116. Some iron working debris characteristic of iron smelting was recovered but this does not provide evidence for iron smelting on site because of the relatively small quantities recovered.

References

Barnes, I. no date. The analysis and recreation of bronze and brass mould residues. In Bryce, T. and Tate, J. (Eds) *The Laboratories of the National Museum of Antiquities of Scotland* 2. National Museum of Antiquities of Scotland, Edinburgh, 40–46.

Bayley, J. 1988. Non-ferrous metal working: continuity and change. In Slater, E.A. and Tate, J.O. (Eds) *Science and Archaeology Glasgow 1987.* BAR British Series 196**.** Oxford: BAR, 193–208.

Bayley, J. 1992. Assessment of slag from Cheapside (site CID90), London. Ancient Monuments Laboratory Report 44/92.

Blomgren, S. & Tholander, E. 1986. Influence of the ore smelting course on the slag microstructures at early ironmaking, usable as identification basis for the furnace process employed. *Scandinavian Journal of Metallurgy* 15: 151–160.

Crew, P. 1991. The experimental production of prehistoric bar iron. *Historical Metallurgy* 25.1: 21–36.

Dungworth, D.B. & Bayley, J. 1999. Crucibles, moulds and tuyères from Mucking, Essex. Ancient Monuments Laboratory Report 72/99.

Hill, J., Rowsome, P. & Treveil, P. 1997. No 1 Poultry. Updated Project Design. London: Museum of London.

Hill, J. & Woodger, A. 1999. *Excavations at 72–75 Cheapside/83–93 Queen Street City of London*. London: Museum of London Archaeology Service.

Mills, A. & McDonnell, J.G. 1992. The identification and analysis of the hammerscale from Burton Dassett, Warwickshire. Ancient Monuments Laboratory Report 47/92.

Appendix

Some of the possible crucibles submitted for examination had soot marks on the surface, lacked vitrified surfaces, and contained no detectable amounts of non-ferrous metals. These are probably lamps. They are listed in the table below.

Context	Area	Period	Fabric	Soot marks	Elements detected
2617	B107	35	EMSS	Yes	None
17828	B127	36	CERA	Yes	None
1774	B173	39	EMCW	Yes	None
1776	OA150	39	EMCW	Yes	None
1877	B173	39	CERA	Yes	None
1877	B173	39	CERA	Yes	None
1890	B173	39	CERA	Yes	None
1907	B173	39	CERA	Yes	None
1907	B173	39	EMCW	Yes	None
1958	B173	39	EMCW	Yes	None
1983	B173	39	CERA	Yes	None
1983	B173	39	EMCW	Yes	None
2007	B173	39	CERA	Yes	None
2007	B173	39	EMCW	Yes	None
1772	OA152	40	CERA	Yes	None
1772	OA152	40	CERA	Yes	None
2390	R102	40	EMCW	Yes	None