CHAPTER 11

# THE METALWORKING

*By John R. L. Allen and Klare Tootell*

This chapter reports the evidence for non-ferrous metalworking from crucibles and for the making and working (forging) of iron. Further evidence for non-ferrous metalworking in Periods 3 and 4 can be found in Cook's report on the geochemistry (Ch. 3) and Crummy's report on the 'small finds' (Ch. 6). The latter also reports pieces of bar iron from Period 4 as evidence of blacksmithing.

## NON-FERROUS METALWORKING: THE CRUCIBLES

*By John R.L. Allen*

Four fragments were available and examined by hand-lens, in two cases also in thin-section. Three different crucibles are represented, two of which were found in third-century, Period 4 contexts (Object 700) (FIG. 106). The third was unstratified.

### 1. SF 1191 (1996) and SF 4962 (2610) (Object 700)

These are joining fragments from the lower parts of a flat-based crucible the size of probably a cup. The fabric, observed in hand-specimen and thin-section, is pale grey, hard, and slightly vitrified with very abundant quartz silt and scattered inclusions of fine- to medium-grained quartz sand and occasional grains of flint and feldspar, chiefly microcline and some plagioclase. Adhering to the outside of the joined fragments — the underside of the crucible — is a thick, uneven mass of greenish-black, highly vesicular, glassy material with scattered fine- to medium-grained quartz sand showing microfractures under the microscope. This mass reveals the moulds of several fragments of charcoal on which it rested. On the inner surface of one of the joined fragments (2610) is a small, blister-like body ranging in colour between off-white and pale green, probably corroded dross. X-ray fluorescence analysis by Dr Stuart Black using portable equipment revealed the presence in this dross of copper, zinc, lead and arsenic.

### 2. SF 2888 (Unstratified)

This doubly-curved fragment is 12mm thick and in a different, mid-grey, hard, slightly vitreous fabric with very abundant fine- to medium-grained quartz sand. The outer surface is pale grey but on the inner surface are a number of fused, smooth, glassy-looking, blister-like protuberances of off-white to pale green colour, probably corroded dross. This was also found by X-ray fluorescence analysis by Dr Black to contain copper, zinc, lead and arsenic. This fragment was found in a late Roman context.

### 3. SF 2297 (3412) (Object 700)

This context yielded three tiny fragments clearly different from those above. The fabric is pale grey and semi-vitreous, with abundant fine- to medium-grained quartz sand and many tiny vesicles.

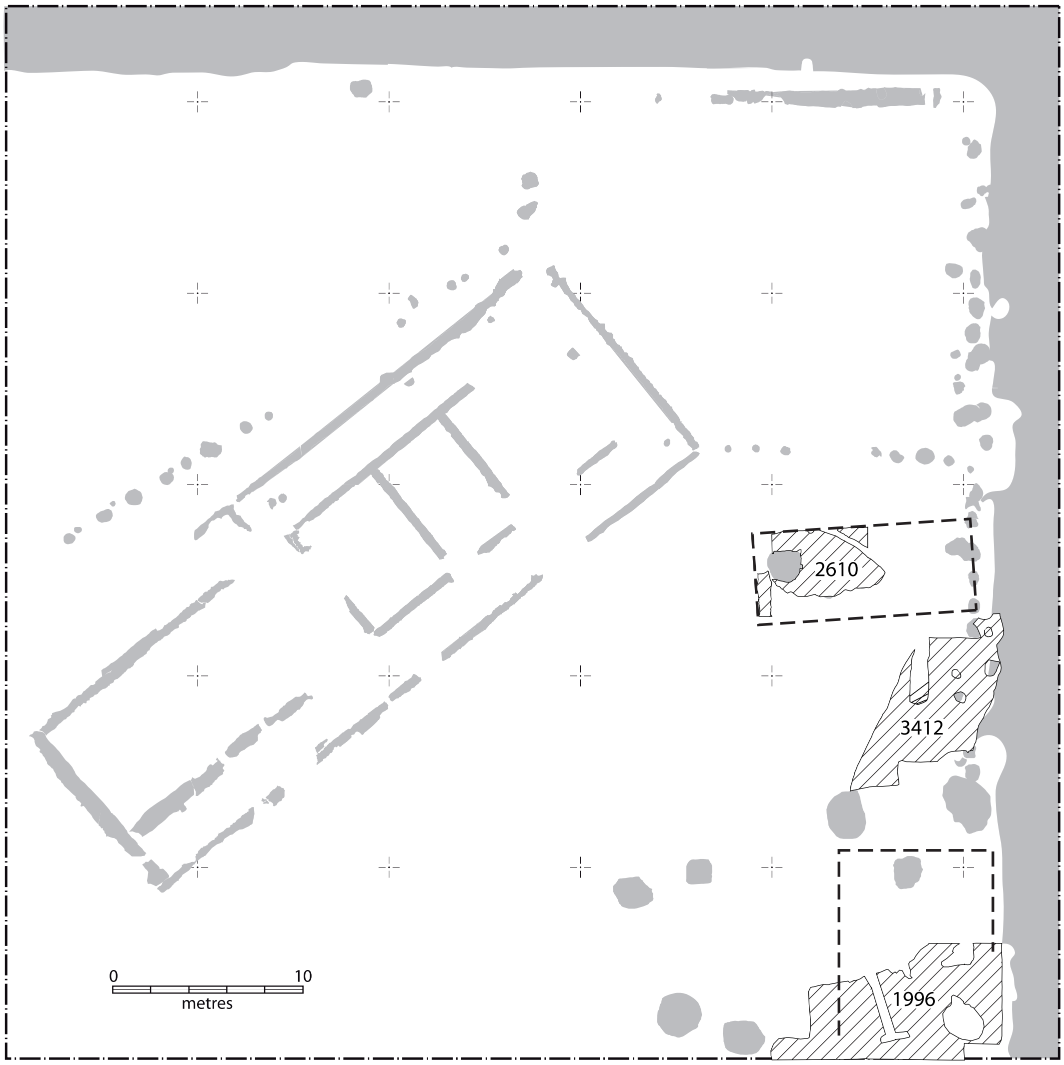


FIG. 106. Location of Period 4 contexts producing fragments of crucible.

## OVERALL INTERPRETATION

The vitreous but quartz-rich character of the fabrics, and the association in the case of No. 1 with a highly vesicular outer layer, perhaps added as an additional protection, points to a ceramic designed to withstand, and be operated at, high temperatures. The composition of the two joining fragments is consistent with manufacture from the local Tertiary sediments. There is evidence for charcoal as a fuel. The green-coloured, blister-like bodies found on the inner surfaces (SFs 2888 and 4962), probably corrosion products formed from dross, strongly suggest that the crucibles were last used for melting copper alloys, probably a brass for casting.

Very many crucible fragments have been described in considerable detail from the forum-basilica at Silchester, the great majority from first-century A.D. (pre-Flavian) contexts (Fulford and Timby 2000, 395–405). Bronze residues and corrosion products were recognised in two of these. In terms of fabric, the fragments described above most resemble the Roman-style, Form 4 crucible from the forum-basilica.

The remains of the two crucibles from Object 700 were found close together in contexts beneath late Roman Building 5. The sherd representing the third crucible is unstratified.

## IRONMAKING AND IRONWORKING: CONTEXT AND DISTRIBUTION

*By Klare Tootell*

A total of 8.88kg of slags derived from ironmaking and ironworking was recovered from Period 3 and Period 4 contexts. The great majority were found through hand-excavation, but hammerscale and other spheroidal spatter, the microscopic residues of ironworking, as characterised by Allen (1987) and Allen and Fulford (1987, 273), were also recovered as a product of flotation and the sorting of the associated residues. This sampling technique was applied selectively, primarily to contexts from pits and wells with the principal aim of recovering charred plant remains, but also to other layers which hand-excavation revealed to have significant charcoal or other charred remains. Wherever possible, samples up to 20 litres in volume were taken. There was no attempt to recover hammerscale and other microscopic residues of ironmaking through a systematic programme of wet-sieving across the excavation area. Nevertheless both the absolute quantities of microscopic slag in any sampled context and the proportion of sampled contexts yielding slag are indicators of the intensity of ironworking. Of the slag from Periods 3 and 4, 61 per cent was associated with the south-east layers, 38 per cent with MB 1–3 and MRTB 1/ERTB 1 (=ERTB 4), while 1 per cent derived from the pits and wells.

### PERIOD 3 (FIG. 107)

#### Masonry Buildings 1 and 2 and MRTB 1/ERTB 1 (=ERTB 4)

The incidence of slags associated with these buildings was very low. A total of 1.04kg of slag was excavated from 5 of 436 (1.1 per cent) contexts associated with the Period 3 buildings. Of the 26 contexts sampled by flotation, 8 (30 per cent) produced microscopic slags.

*MB 1*

Microscopic slags only were recovered from contexts associated with this building. Hammerscale flakes (24) and a single globule were identified from hearth context 3707. Very small quantities were found in samples from clay floor 3202 (3 flakes) and gravel wall foundation 3248 (1 globule).

*MB 2*

A small quantity of smithing slag was associated with clay layer 3396 (95g), while a charcoal rich context (3367) in a corner of the north-east Room 4 produced 70g including fuel-ash and smithing slags. Very small quantities of hammerscale were recovered from floor layer 5506 (5) and occupation layer 4449 (2).

*MRTB 1/ERTB 1*

A total of 0.88kg of slag was recovered from three contexts associated with this building, of which 56 per cent was associated with context 3732. This included a slag basin (340g). Fragments of smelting and processing slag (245g) were also found in context 3533, the remaining bulk slag (140g) occurring in context 3847. Only one context, 3532, produced a quantity of hammerscale flakes (56) and globules (8). Very small quantities of microscopic slag were produced from two other contexts.

#### Pits and wells

Northern pits: no slag was recovered from well 2234 and only a single, microscopic globule from cess-pit 4835.

South-eastern pits: no bulk slags were recovered from any of the south-eastern group of pits and wells. However, a significant quantity of microscopic slag was identified from pit 5039 with

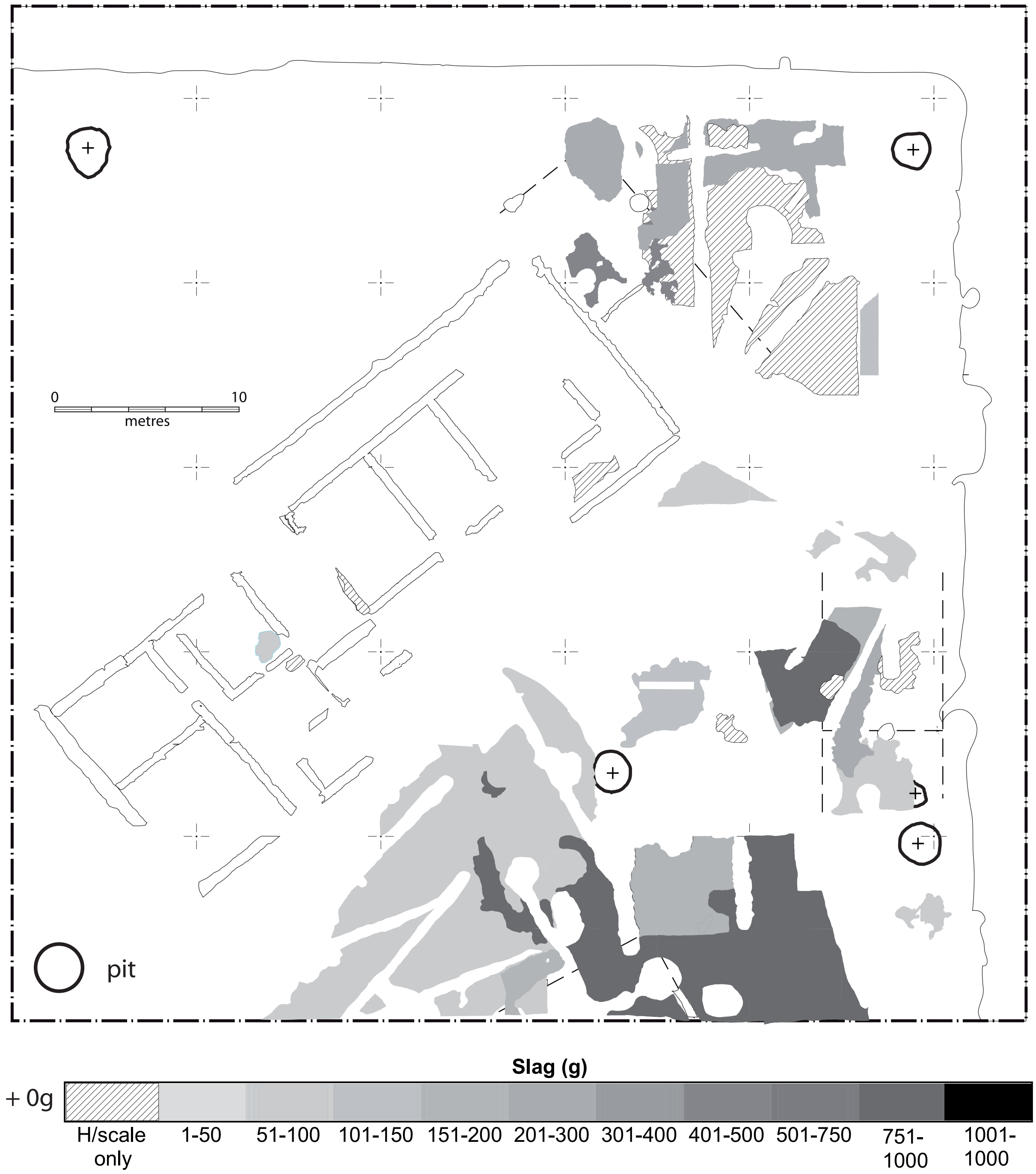


FIG. 107. The distribution of slags associated with ferrous metalworking in Period 3.

over 200 hammerscale flakes and 4 globules from contexts 6213 and 6228. A lesser quantity of hammerscale flakes (25) and globules (2) was associated with the slumps into 6290 and context 6284 in well 5693.

### South-east layers

In contrast to the south-east pits, a total of 2.15kg of slag was associated with the occupation spreads to the south and south-east of the Period 3 buildings. Out of the 156 contexts associated with this Object, only 12 (7.6 per cent) contained bulk slag. Of the 20 contexts sampled for charred plant remains, only 5 (25 per cent) produced microscopic slag.

Almost half of the slag derived from only two contexts, one of which (3833) produced a single slag basin (285g). The latter was the only certain evidence of ironmaking, the remaining slags from the south-east layers representing residues of ironworking. None of the sampled contexts produced significant quantities of microscopic slag. The largest amount (15 flakes and one globule) was associated with context 4273, while 11 flakes and 2 globules were associated with context 3833 and the larger slags described above.

## PERIOD 4 (FIG. 108)

### Masonry Building 3

A total of 2.33kg of slag was recovered from the contexts associated with MB 3. The great majority of this derived from only ten (4 per cent) of the excavated contexts, with microscopic slags associated with three (42 per cent) of the small number of only seven contexts sampled for charred plant remains. Just over half (54.5 per cent) derived from a single context, 1788, a make-up layer for Room 4, among which were two slag basins. Further possible evidence of iron smelting, in the form of dense pieces of slag, was identified from contexts 1397, 1410, 1796 and 3313, while the remaining iron-forging slags included fragments of furnace lining and fuel-ash slag. Small quantities of hammerscale, ranging from thirteen to four flakes and two globules, were recovered from three contexts, 1544, 3268 and 3276.

### South-east pits and wells

Only two (1.4 per cent) of the 135 contexts associated with all the south-eastern pits and wells of Periods 3 and 4 produced bulk ironworking slags. A small quantity was recorded from the adjacent pits or wells 3102 and 3406 of Period 4. The larger amount (105g) derived from 3102 and included fuel-ash and microscopic slags (<10 flakes and globules in total) from contexts 3144, 3182 and 3827. Pit or well 3406 produced only 4 flakes of hammerscale from context 4041.

### South-east layers

A total of 3.26kg of slag was recovered from the Period 4 layers to the south and south-east of MB 3. Of the 114 contexts associated with this Object only 14 (12 per cent) contained slag, while half of the small sample of 18 contexts processed for charred plant remains produced microscopic slags from their residues.

### Southern building (MRTB 4) and associated make-ups

A slag basin (210g) was recovered from clay surface 3911 associated with the putative building itself, while microscopic slag (19 hammerscale flakes; 3 globules) was recorded from 3467 and 3912, also in association with the building. Other processing slag, including 11 hammerscale flakes and 3 globules, was found in association with, respectively, dump deposit 4067 and make-up or possible occupation layer 3444.

Make-ups and occupation layers

A third (34 per cent) of the slag from Object 700 came from this group of contexts. It included a slag basin (250g) and a larger slag mass (575g) derived from smelting from make-up or possible occupation layer 3468.

Make-ups for Late Roman Buildings 1 and 5

Over half of the slag, accounting for 53 per cent of the total from the south-east layers of Period 4, came from the late third-century make-ups for Late Roman Building 1, in particular from deposit 2419 and levelling layer 3424. Slag basins, weighing respectively 420g and 300g, were found in these layers and in the gravel spread 2488 (190g). Two further probable slag basins (190g; 180g) were also recovered from 3424. A make-up layer (3412) for Late Roman Building

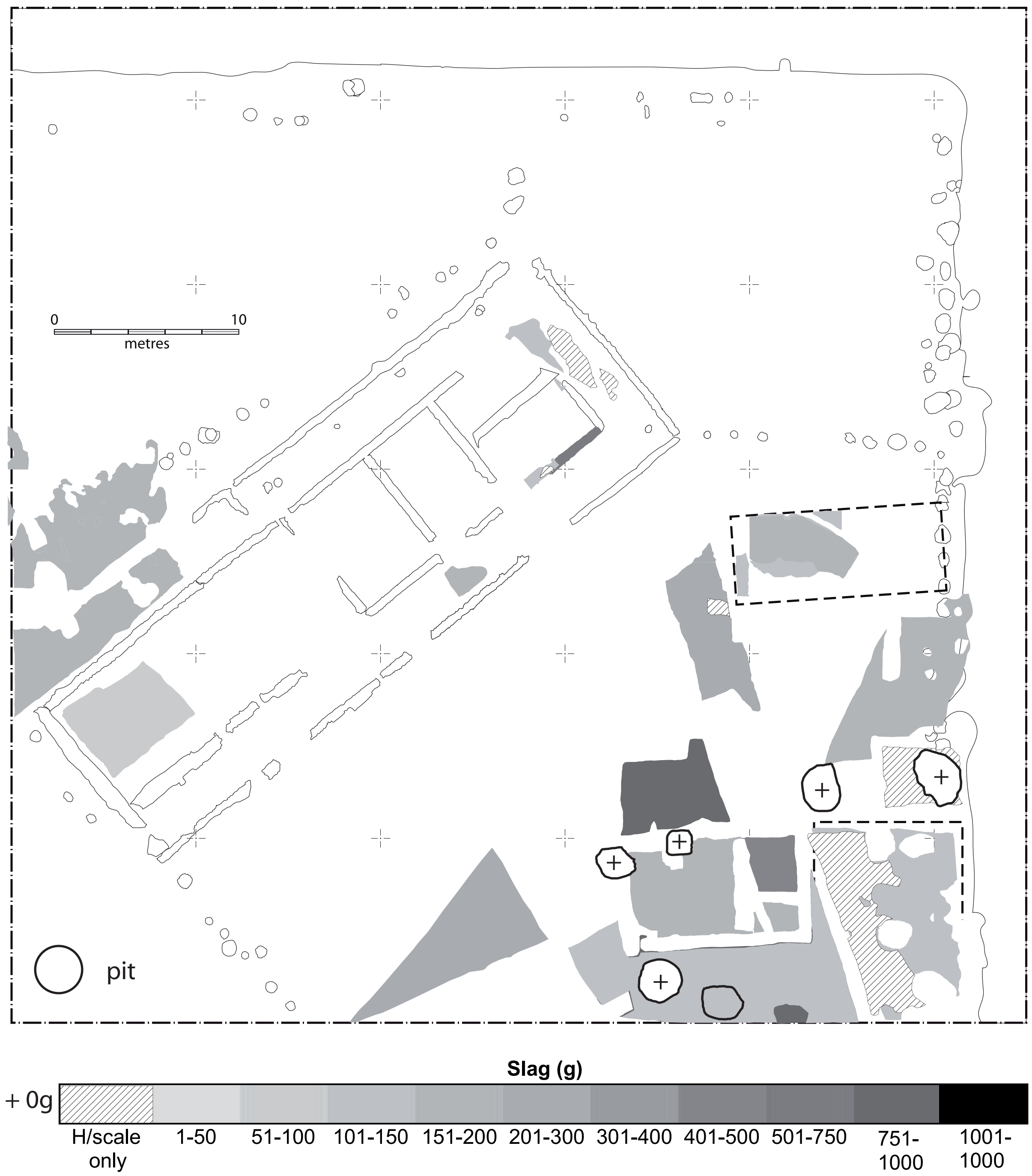


FIG. 108. The distribution of slags associated with ferrous metalworking in Period 4.

5 produced one piece of possible smelting slag and microscopic slags (22 flakes of hammerscale and 7 globules). Three further contexts produced microscopic slags but with a collective total of eleven hammerscale flakes and globules.

## DISCUSSION

The total quantity of slags, including microscopic material, from Periods 3 and 4 is small, a little over half the total amount recovered from the late Roman occupation (16.43kg) (Tootell 2006); two thirds (64 per cent) of the total derived from the third-century Period 4 contexts. With the exception of Period 3 pit 5039, which contained the largest quantities of microscopic slag (hammerscale) (>200 flakes) from any Period 3 or 4 context, the pits and wells of both periods produced almost no slag. The south-east layers of both periods were the most productive, together accounting for almost two thirds (62 per cent) of the total recovered from Periods 3 and 4. As with the total amount, the distribution between periods was also approximately one third:two thirds in favour of Period 4 (60 per cent). In both periods the greatest quantities were found towards the southern edge of the excavation trench, particularly in contexts pre-dating the construction of Late Roman Building 1. Among the buildings the greatest quantity was associated with Period 4 Masonry Building 3 and the distribution was again one third:two thirds in favour of Period 4 and MB 3 (62 per cent).

The quantities and character of slag recovered do not indicate any sustained ironmaking or ironworking and there is the possibility that all was imported from elsewhere in the town to Insula IX, for example in the context of preparing the ground for building work. Certainly the majority of the slag, including the slag basins indicative of smelting activity, is concentrated in the area later occupied by Late Roman Building 1. The same might also be true of the microscopic slag, a key indicator of iron-forging, that it was imported from elsewhere in *Calleva* in association with other materials. Indeed some flakes and globules may have been introduced casually, for example, on the soles of muddy hob-nail boots. However, there are concentrations, notably from Period 3 pit 5039 (>200 flakes) and MRTB 1/ERTB 1 (3532) (>50 flakes), which suggest some smithing activity nearby or within the latter building. Further concentrations (>20 flakes) were associated with two contexts in Period 3 (MB 1, 3707 and the slumps into well complex 6290). A third deposit of this size coincides with the concentration of bulk slags associated with the make-ups for Late Roman Building 1 and may indicate that, despite the absence of evidence from the adjacent pits and wells, some ironmaking and ironworking were taking place in association with the predecessor of Late Roman Building 1. In the case of Period 4 MB 3, where there is a small amount of evidence for both smelting and forging from the bulk slags, the significant contexts in question were not further sampled for microscopic slags.

Further interpretation of the microscopic residues is hindered by the lack of comparative, quantitative data and different approaches to the determination of the content of such residues in the soil. While there is clearly a higher incidence associated with the late Roman occupation, very few individual contexts produced quantities in excess of 100 flakes (Tootell 2006). By comparison a very large quantity was recovered from pre-Boudican Building 3 and also from the post-Boudican Period Structure 2, Borough High Street, Southwark (Drummond-Murray and Thompson 2002, 28; 612). With a total of over 60kg of microscopic slags recovered from these Borough High Street excavations, almost all of which derived from the above two structures, the interpretation of them as smithies seems unassailable (Keys 2002, 241). Elsewhere in Southwark a different approach was taken by Starley who used magnetic susceptibility to gauge the density of hammerscale (2003, 132–3). Sim's experimental work concentrated on the spatial distribution and morphology of microscopic residues in relation to a series of blacksmithing experiments (1998, 97–145). Although there is no directly comparable quantitative data, the experiments do reveal how concentrated the distribution of hammerscale and other spatter is around the anvil, and how steep the fall-off is away from it (Sim 1998, 97–145). Bearing in mind the sampling strategy which produced the Insula IX data, the larger quantities of microscopic residues (>20 flakes and spheroids) would not be inconsistent with smithing events (as opposed to the existence of a smithy) within the insula in Periods 3 and 4.

In conclusion, the total amount of slag is small and some may have been introduced from outside or elsewhere in the insula. In the case of Period 3 the evidence is such that it may only indicate limited and episodic ironworking, particularly in association with MRTB 1/ERTB 1 and pit 5039. A very small quantity of smelting slag is also associated with MRTB 1/ERTB 1. For Period 4 the concentration of bulk and microscopic slag in the area occupied by the predecessor to Late Roman Building 1 indicates a small amount of both ironmaking and ironworking, activities which continue in this location into the fourth century. In the absence of positive evidence of microscopic slags, we can be less certain of a similar interpretation for the slags from MB 3.

One important taphonomic observation arises from the study of the Period 3 and 4 slags. Microscopic slags were recovered as a product of a sampling strategy primarily designed to recover charcoal and charred plant remains. The largest quantity of microscopic slag was found in contexts within a pit which otherwise produced no bulk slag. The second largest quantity, from MRTB 1/ERTB 1, derived from contexts which did not themselves otherwise produce bulk slags, although the latter were found in adjacent, associated contexts. Given the aim of the environmental sampling strategy, we cannot extrapolate from its findings more generally about ironworking activity across the excavation trench in the second and third centuries, except in the case of the pits and wells which were subjected to intensive sampling for charred plant remains, etc. This suggests that a parallel sampling strategy, including magnetic susceptibility, ought to be developed for occupation layers with the principal purpose of recovering microscopic slags (as well as, of course, other surviving microscopic evidence).

## IRONMAKING: ANALYSIS OF SLAG BASINS

*By John R.L. Allen*

Each of the eight masses of slag interpreted as furnace bottoms (see below), was cleaned and sliced vertically along the longitudinal axis. The cut faces and other surfaces were subjected to hand-lens examination. In selected cases, the distribution, form and orientation of vesicles exposed on the cut faces was emphasised by rubbing these moistened surfaces with a bar of white, cold-cream soap, a simple process which infills these cavities with a material of contrasting colour.

### PERIOD 3

Two contexts each yielded a single furnace bottom. That from MRTB 1/ERTB 1 (context 3732) weighs 340g and is roughly oval in plan and weakly concavo-convex in profile. Many small scraps of charcoal are trapped on the underside and a little is captured on the uneven top. The almost black slag is dense and uniform, with evidence of crystallinity, and marked by frequent vesicles, the smaller spheroidal, the larger more irregular. There is no sign of internal stratification and the vesicles are fairly evenly distributed, but without any conspicuous radial orientation. The furnace bottom from the south-eastern layers (context 3833) weighs 285g and is roughly triangular in plan and deeply plano-convex. The underside, incorporating a few chips of charcoal, is irregular on a scale suggesting that the slag chilled against granular soil. One extensive face on this surface is flat and could be the mould of the tip of a spade with a V-shaped blade where it had dug into a substrate. The upper surface is very uneven. The slag is black, dense, uniform, partly crystalline, and with radially arranged vesicles near the lower and upper surfaces. Evidence of internal stratification is lacking.

### PERIOD 4

There are six furnace bottoms, two from MB 3 and four from the south-eastern layers. The slags from MB 3 come from a single context (1788). Two contexts represent the south-eastern layers.

One furnace bottom (410g) from MB 3 is oval in plan, deeply convex, and with a slightly concave top. The underside shows small-scale irregularities compatible with the slag having chilled against granular soil. Ochreous material occludes the top. The slag is black, uniform and partly crystalline, with small- to medium-sized spheroidal vesicles dispersed throughout. Signs of internal stratification are lacking.

The second mass of slag (335g) solidified at a level above that of the furnace bottom proper and is very irregular in plan and sliced section. The slag extends inward from a doubly-curved fragment of furnace lining which displays a short baking-sequence of dark red through grey to almost black glassy and vesicular sandy clay with scattered flint pebbles (<12mm). Beneath, the surface of the slag is uneven, with the moulds of fragments of charcoal. On the upper surface is a smooth, concave central area surrounded by an irregular zone. The slag is black, dense, uniform and partly crystalline, with numerous vesicles of very variable shape and size. Locally, these show a strong radial orientation. There is no internal stratification.

Context 3424 from the south-eastern layers gave three furnace bottoms. The smallest (175g) is oval with a shallow plano-convex profile, a few fragments of charcoal and chips of flint appearing on the base. Dispersed in the black, dense, uniform, partly crystalline slag are occasional spheroidal to elongated vesicles, those near the base having a strong radial orientation. The next largest furnace bottom (190g) is oval and plano-convex. The base and top are uneven, the former revealing entrapped charcoal, and the latter charcoal fragments and flint pebbles (<15mm). The slag is black, dense, uniform, partly crystalline and with very few vesicles. Signs of internal stratification are lacking. The third furnace bottom from this context (300g) has a shallow, concavo-convex profile. On the underside is a relatively smooth, flat face which could be the mould of a surface cut by some kind of digging tool. The almost black slag is dense, uniform and partly crystalline, with abundant, evenly dispersed, radially arranged spheroidal to elongated vesicles of small to medium size. Stratification is lacking. The furnace bottom (210g) from the only other context (3911) affording slag is oval and shallowly plano-convex. A few fragments of charcoal are trapped on the uneven base; just below the top occur a little quartz sand and a few chips of flint. The slag is black, dense, uniform and partly crystalline. A strong radial arrangement typifies the frequent small- to medium-sized vesicles. The sand and flint just below the top are the only indications of internal stratification.

## OVERALL INTERPRETATION

The main question is whether the described slags represent iron smelting (furnace bottoms) or iron smithing (hearth bottoms). Although bodies of slag of similar form result from the two processes, those from Insula IX can be assigned with some confidence to smelting, referring to Schrüfer-Kolb's (2004) and Allen's (2008) recent reviews. The main reasons are the high density, uniformity, absence of significant internal inclusions and lack of internal stratification displayed by the slags. The relatively small size and generally spheroidal form of their vesicles, and their frequent radial arrangement relative to the undersides of the slag bodies, together with the slag density, indicates that each mass represents a single cooling event from a silicate melt of comparatively low viscosity because of its high temperature. These are not the conditions associated with smithing, where the episodic operation of the hearth at a lesser temperature results in a layered mass replete with irregular vesicles and many different inclusions. As furnace bottoms go, however, those from Silchester are on the small side, suggesting small-scale operations of low efficiency. The form of the fragment of furnace lining to which one of the slags from MB 3 (Period 4) is attached, is consistent with the use of a non-tappable bowl furnace dug into the ground surface (Tylecote 1986). As no tap slags have so far been recovered from any part of the excavations, this simple technology seems likely to have been in more extensive use as, for example, reported in the context of the late Roman occupation of Insula IX (Allen 2006).