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Assessment of residues from Ipplepen

Dr Tim Young

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Dr T.P. Young

Abstract

The submitted samples totalled approximately 22.9kg, of which 17.5kg were certain archaeometallurgical residues, 1.58 kg were pieces of iron or concretions formed around iron, 350g were fragments of fuel ash slag, not all of which probably derived from metallurgical processes and 3.3kg natural materials. The overall size of the assemblage is small, particularly compared with the area excavated. This is often the case in intensively settled areas, with the preferential deposition of waste, particularly the macroscopic waste, outside the occupied areas. The total quantity of waste may therefore be a poor indicator of the scale or importance of the activity.

Almost all the residues were derived from iron smithing, with just a single slag piece likely to have been produced during iron smelting, with four crucible sherds, a mould fragment and a fragment of a block tuyère (totalling under 200g) probably deriving from non-ferrous metalworking.

Contexts of Iron Age date produced approximately 3% of the iron slags, and 4% of the fuel ash slags, but 23% of the metallic iron fragments and associated concretions present in the submitted collection. Contexts of early Roman age produced 27% of the iron slag, 35% of the iron/concretions and 91% of the fuel ash slag. For late Roman contexts the equivalent figures are 64%, 42% and 5%. Younger contexts produced very little archaeometallurgical residues, all of which is likely to be residual.

The earliest evidence for ironworking is from Iron Age deposits examined in 2013/14. Context (1125) of Phase 3c produced a particularly large quantity of microresidues (hammerscale) and iron fragments typical of smithy floor deposit; this assemblage is likely to be very close to, or at, its original source. The macro-residues from this phase of smithing were probably dumped elsewhere.

Early Roman smithing residues were dominantly recovered in 2012/13 (65% of the early Roman assemblage), but with significant evidence also from trenches 10, 13 and 14 (9%, 11% and 12% of the early Roman assemblage respectively). Although the nature of the evidence was different, this may indicate that a focus of ironworking remained in the same area as during the Iron Age, although new areas of activity (or dumping) developed. The early Roman pyrotechnological assemblage also includes a significant proportion of fuel ash slag (FAS).

The late Roman smithing evidence almost entirely derives (>95%) from Trench 14. This assemblage lacks the low-density residues seen here from the early Roman period but does contain a high proportion (about 7% of the assemblage) of slagged, oxidised fired hearth lining.

Later periods produced only a very small, probably residual, proportion of the assemblage.

Most of the residues (65%) comprise intact (49 examples, total weight 7.8kg) or partial (3.8kg) smithing hearth cakes (SHCs) or closely related slag masses. These have a weight range of 46g to 640g, with a mean of 159g. These statistics compare very closely with other assemblages from rural sites in Roman Britain. It has been proposed previously that such assemblages reflect the waste from smithies with an intermittent, task controlled, workload as opposed to those from urban settings where works may have been more continuous.

Iron smelting slags are represented by a single small probable fragment of a type most commonly associated with Iron Age technology, but from a late Roman context in the 'horseshoe-shaped enclosure'.

Evidence for non-ferrous metalworking is sparse. A single mould fragment indicates bronze-casting probably in the Bronze Age. Early to middle Roman work is indicated by residues present on two fragments of domestic vessels (from trench 10), presumably employed as large crucibles, but just possibly used for support within the hearth. One fragment had dross derived from the working of bronze, the other from the working of a zinc-bearing alloy. Trench 16 produced a small casting jet, probably from the casting of leaded bronze alloy. Trench 18 yielded several items including a dubious crucible sherd (from early Roman context (18081)), a sherd of a crucible probably used for melting a zinc-rich alloy (leaded brass or gunmetal; from (18242)) and a substantial section from the front face of a rectangular block tuyère (from (18106)) that may, perhaps, have also been employed in the work of zinc-bearing alloys.

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Methods

This assemblage derives from work at Ipplepen, Devon, conducted by Exeter University and their partners between 2012 and 2019. The work was commissioned by Dr Chris Smart.

The initial assessment was conducted and reported upon in August 2022. All materials were examined visually, using a low-powered binocular microscope where required. The catalogues of submitted material are presented in tables 1 to 7.

Following this, two further batches of materials were submitted and the catalogued updated. This additional material included much of the evidence for non-ferrous metalworking. The non-destructive analysis by handheld pXRF of elements of the non-ferrous metalworking evidence was undertaken to clarify the nature of the metals being worked.

The pXRF analysis was undertaken with a Bruker Tracer IIISD portable X-Ray fluorescence spectrometer (instrument belonging to the Department of Archaeology, Cardiff University, and the National Museum Wales). The instrument was operated with the Bruker 'yellow' filter (300µm Al + 25µm Ti), at 40kV and 9.60 µA, with a filament current of 189 µA, for 100s. The instrument was controlled by a PC running Bruker's S1PXRF software. Data were exported as text files for further imaging and processing in Bruker's Artax software. Data are presented here (Table 13) as the net peak area for the principal peaks as reported by Artax.

Description of the assemblage

General

The submitted samples (tables 1 to 7) totalled approximately 22.8kg, of which 17.4kg were certain archaeometallurgical residue, 1.58 kg were pieces of iron or concretions formed around iron, and 350g were fragments of fuel ash slag, not all of which probably derived from metallurgical processes. Almost all of the residues were derived from iron smithing, with just a single piece likely to have been produced during iron smelting.

The overall size of the assemblage is small, particularly compared with the area excavated. This often seems to be case in intensively settled areas, with the preferential deposition of waste, particularly the macroscopic waste, outside the occupied areas. The total quantity of waste may therefore be a poor indicator of the scale or importance of the activity.

Contexts of Iron Age date (Table 8) produced approximately 3% of the iron slags, and 4% of the fuel ash slags, but 23% of the metallic iron fragments and associated concretions present in the submitted collection. Contexts of early Roman age produced 27% of the iron slag, 35% of the iron/concretions and 91% of the fuel ash slag. For late Roman contexts the equivalent figures are 64%, 42% and 5%. Younger contexts produced very little archaeometallurgical residues, all of which is likely to be residual.

The earliest evidence for ironworking is from Iron Age deposits examined in 2013/14. In particular, context (1125) of Phase 3c produce a large quantity of microresidues (hammerscale) and iron fragments typical of smithy floor deposit; this assemblage is likely to be very close to, or at, its original source. There was very little evidence for smithing hearth cakes (SHCs) in these Iron Age contexts, so the macro-residues may have been dumped elsewhere.

Early Roman smithing residues were dominantly recovered in 2012/13 (65% of the early Roman assemblage), but significant evidence also derived from trenches 10, 13 and 14 (9%, 11% and 12% of the early Roman assemblage respectively). Although the nature of the evidence was different, this may indicate that a focus of ironworking remained in the same area as during the Iron Age, although new areas of activity (or dumping) developed. The early Roman pyrotechnological assemblage also includes a significant proportion of fuel ash slag (FAS).

The late Roman smithing evidence almost entirely derives (>95%) from Trench 14. This assemblage largely lacks the low-density residues from the early Roman period at Ipplepen but does contain a high proportion (about 7% of the assemblage) of slagged, oxidised fired hearth lining.

Later periods produced only a very small, probably residual, proportion of the assemblage.

Iron smelting residues

A single fragment (72g) of slag from context (18303) comprising amalgamated flow slag prills with slight impressions of, probably, wood on the surfaces is suggestive of a slag formed in the basal pit of a non slag tapping iron smelting furnace. Such furnaces formed the dominant technology of iron smelting in the British Iron Age (for examples in SW England see Young 2016b, 2022) and, locally, also in the early medieval period (for examples in SW England see Rainbird & Young 2015, Reed *et al*. 2006, Young *et al*. forthcoming).

Slags from iron smithing

The smithing slags were dominantly in the form of smithing hearth cakes (SHCs) of various forms.

The smaller cakes (those of less than about 80g) are typically sub-circular in plan, ranging from 45mm up to 60mm in diameter and from 20mm to 30mm in thickness. Where these small masses have approximately planar upper and lower surfaces, then the term 'puck' has been employed informally in the catalogue, rather than the more general term 'proto-SHC'. Some of these small masses can be seen to be composed of amalgamated prills, others appear more homogeneous. Most show impressions of fuel particles on their surfaces.

Above a weight of approximately 80g, the smithing hearth cakes tend to become more conventional in form, with a rounded lower surface. This surface may be composed of rounded prills (which if less than approximately 2mm across have been described here as microprills) and may have fuel impressions. The upper surfaces of the SHCs are typically smooth, sometimes with slightly raised lobes, sometimes with broad, shallow fuel impressions. In a few cases the tops have been impinged upon by the air blast quite strongly, and have developed a matte, maroon-coloured oxide veneer on a very smooth upper surface. Some examples of these cakes show a double layer structure, suggest of a cake that has dropped in the hearth (or been pushed down) and a new SHC has generated above and adjoining, the first. For almost all these cakes, where the internal structure is visible, the slag is strongly vesicular and may contain small charcoal particles.

46 of the 49 SHCs have weights less than 340g, but three are larger- at 560g, 604g and 640g. These three are all different from each other in morphology, so it is not possible to generalise about the larger cakes, except to say that they show a similar range of features to the small ones. None of the three shows signs of a two-stage evolution; each is a single cake.

Some of the SHCs showed some evidence for their means of extraction. Most of small the SHCs in this assemblage have no hard attachment to the hearth wall. Many SHCs in the assemblage show fracture of the proximal side, suggesting they were removed cold. A few examples show some deformation, with tears and rolling suggestive of removal hot. One example (a 640g SHC from late Roman context (14035)) shows a cut in the upper surface apparently made by an axe or similarly bladed tool, presumably during an attempt at its extraction from the hearth.

Most of the smaller pieces of dense iron slag are fragments from SHCs but approximately 30% could not be positively identified as having been part of an SHC. Some of these will have formed either as slags within the hearth bed or attached to the hearth wall, but not incorporated within the main mass.

The assemblage included a large proportion of low-density, iron-poor slags, most, but not all of which were probably from smithing. These were divided in Table 8 into four categories.

Where there was no evidence for iron-enrichment and the slags were intensely vesicular (they resemble a froth) then they have been recorded as a fuel ash slag (FAS). FAS typically results from the partial melting (usually under the fluxing influence of the one or more of the alkali or alkaline earth elements) of a substrate rich in a volatile-containing material (often calcium carbonate) which generates a melt so viscous that the large amount of gas (typically CO_2 or water vapour) generated during heating cannot escape. Many examples of FAS were generated from the heating of a calcareous substrate in a process that need not be metallurgical (examples are known from settings such as lime kilns, corn drying kilns and even continuously burning domestic hearths). In this case the calcium carbonate both provides the flux and a source of volatiles. These slags are dominantly glassy.

Where iron enters the hearth (as it does during the smithing of iron) then it will provide another fluxing agent for the generation of slags from the hearth wall. The slags generated tend to be darker-surfaced, denser and slightly less vesicular than the simple FAS described above. Certain identification of the role of iron in the generation of the slag may require analysis. Slags of this type in a smithing hearth may show a gradation in properties with the dense iron slags in one direction and with the slagged coat on the cermaic wall fragments in the other. Imperfect mixing of slags with varying degrees of influence of the melting of the hearth wall and of iron/iron oxides from the workpiece commonly results in a surface of variable composition, particularly in the upper part, of SHCs. In some cases, strongly lining-influenced slags may accumulate around the hearth blowhole and may form a pad on top of SHCs. This group of slags as a whole is labelled low-density slag on Table 8, but this term is here synonymous with 'lining slag'.

In the working of ground level (cut) hearths, it is quite common to find that small pebbles enter the hearth from its walls. These may react, often bloating in a process similar to the FAS formation described above and become incorporated into a slag. The gravelly slags here are probably all from ironworking on the basis of the colour and density of the slag phase between the stones, but that isn't always necessarily the case.

The final group of iron-poor slags is a very small of pieces that were formed of non-vesicular glass. Some of these contained isolated relict pale grains of quartz or feldspar. This group is probably just a variant of the lining slags with a moderate iron content that were sufficiently fluid to degas, but sufficiently siliceous to form a translucent glass rather than crystallise.

Hearth lining

Fragments of vitrified, oxidised-fired lining were recovered in very small quantities from Iron Age contexts (1125) and (1149), but in much larger quantities from late Roman contexts in Trench 14. The material included an example bearing a partial

blowhole margin, slightly angular, but with an approximate effective diameter of 30mm.

Tuyère

Part of the vitrified front face of a sub-rectangular block tuyère (sf041) was recovered from context (18106). Viewed in the direction of blast, the piece represents the upper right corner, approximately one quarter of the face of the tuyère. The restored fragment is 80mm x 90mm and the material has an overall weight of 140g. The front face has eroded back substantially, with the partial preservation of the blowhole on a slight protrusion, lateral to which the face is slightly dished and leaving the lower right margin protruding forwards a relic of the original form. The front has an overall inclination at approximately 30° to the vertical, eroded preferentially towards the top. The vitrified face shows a slightly glassy surface, with fine dimples (possibly from contact with the fuel particles). The rear face as preserved is probably the limit of firing of the cermaic and the unfired rear of the tuyere has been lost entirely. The bore is preserved over a very small area, so estimation of the diameter is imprecise, but appears to be approximately 20mm. The centre of the bore lies 54mm below the upper margin and 75mm from the lateral margin. Other examples of block tuyères show a central blowhole, so this example might reasonably be reconstructed as having been 150mm wide by 108mm tall. However, the lateral faces of the block appear to have been curved, so the font face of the tuyère would have been narrow before its erosion. It is conceivable that the whole front of the tuyère might have been roundedly pointed prior to use.

Qualitative analysis by pXRF of representative areas of both the vitrified front and unaltered rear of the fragment showed slight enrichment of strontium in areas of the front, indicative of the role of the fuel ash in fluxing the melting of the ceramic. One area of the front also showed enrichment by zinc, hinting that the tuyère might have been employed in the working of a zinc-bearing copper alloy, but as this was only in one area, a natural origin (from a zinc-rich particle in the ceramic) cannot entirely be excluded.

The fabric of the tuyère is coarse and poorly sorted, bright red in colour and with fragments of slate up to 12mm across. The material is poorly fused, leading to its current highly friable state.

The surviving parts of the lateral and top faces appear well-formed and smoothed. The upper surface appears to have some partially melted clay resting on top of the surface, possibly suggesting that a small amount of clay had been employed to bond the tuyère into a broader wall structure.

Tuyères are a rather poorly known component of early British metallurgy. For much early ironworking the preferred technique in Britain appears to have been the use of a hearth with a wall with a simple perforation for a blowhole. The use of a specially pre-fabricated block to contain the blowhole is less commonly encountered. The published record for tuyères is complicated by the misidentification of pieces of vitrified hearth wall surrounding a blowhole as a tuyère, and by confusion with other forms of perforated ceramic artefact (such as loom weights).

There appear to be two distinct traditions in ceramic tuyère design in Europe in the first millennium AD: firstly, the so-called block tuyères, with a variable but typically rectangular cross section, seen widely in the pre-Roman Iron Age of central and western Europe and secondly, the 'tubular' tuyères (including the 'clay discs') with a sub-circular section (although commonly with a flat base), which are associated with the early medieval and medieval periods, prior to the introduction of iron tuyères.

In Pleiner's review (2006, 132) he described the brick-shaped block tuyères as being characteristic finds from the Iron Age oppida of Europe. They are rare in Britain, but Iron Age rectangular block tuyères are represented in Britain by examples from the Middle Iron Age for copper smelting at Four Crosses (Young 2006, 2010; Havard *et al*. 2016, illus. 17), apparently for iron working at Gussage All Saints (Spratling 1979, 129), probably for ironworking at Mucking (Dungworth & Bayley 1999) and by a late Iron Age or early Roman assemblage from Axminster (Young 2015a).

Although Tylecote (1999) claimed that block tuyères are 'typical of the Roman period', he provided no British comparative examples; at best they are extremely rare in Britain but do occur in Europe in the Roman period in the same area as their occurrence in the late Iron Age. They have been recorded at Autun in the Roman period (e.g. Chardron-Picault & Pernot 1999, Figure 169), where their occurrence, rather than the use of simple blowhole, was regarded as unusual (Picault & Pernot 1999, 208). Orengo & Bonnon (2000) documented block tuyères from a number of sites in southern France (Feurs, Roanne-Radumna, Toulon-sur-Allier). An example 100mm square from Carpow in Scotland (Tylecote 1986,1999) has commonly been described as Roman but it occurred in a dump of smithing waste in the upper fills of the legionary fortress ditch and is therefore likely to post-date the abandonment of the site and be 3rd century or later (and thus probably not culturally Roman).

Early medieval block tuyères were recorded in abundance (1500 sherds) at Helgö, Sweden, particularly from Building Group 3, the main metalworking area of the Vendel period in the 5th-6th centuries AD (Madsen 1981, dating after Clarke & Lamm 2017). Madsen (1981, 98) suggests that although at Helgö the distribution of the tuyères parallels closely that of the non-ferrous casting debris, this form of tuyère was probably employed for both ferrous and non-ferrous work.

Tuyères of a circular or 'D' cross-section are recognised from Merovingian Europe where they were particularly employed in iron smelting (e.g. Les Boulies, Eschenlohr & Serneels 1991). In Britain, similar large tuyères have been reported only very rarely - including at Rook Hall and Mucking in Essex. Hamerow (1993, 17) suggested that most of the ferrous metalworking at Mucking was of late 6th to 7th century and the Rook Hall furnace has a single ^{14}C determination calibrating to between the mid-6th and late 8th century. These sites produced Frankish artefacts and close connections with Merovingian Europe are suggested. No sites of the early post-Roman Period in SW England are known to have yielded tuyères.

Tuyères of these forms, most likely employed solely for smithing (and possibly remelting) reached Ireland probably around the middle of the 7th century and are very common artefacts from then until the early post-medieval period there.

Ceramic coatings

Two examples of slaggy material with a metal contact surface (a planar, but irregular, surface to the material with a thin veneer of very fine-grained dark slag with a highly glossy lustre) were recovered from Trench 10.

Context (10141) produced a piece (40mm x 25mm and up to 15mm thick; 6.78g) with a morphology suggestive of it having been highly molten. The metal contact surface is lobate and maroon-surfaced slag. The contact is planar except from close to one edge, so might possibly have been attached to a blade. The high degree of melting may suggest this piece formed from slag that became attached to a tool, rather than a deliberate ceramic coat.

The second piece, from context (10142) was an angled fragment of coating formed of bloated clay, with an iron contact on its internal side and irregularly glazed and cracked externally. The internal sides were 8mm and 17mm long, separated by a filleted angle of radius c. 8mm. The internal face is curved, with a possible radius of c30mm, so the coating could have been applied to disc or ring-shaped object. Coatings of this type may be applied to iron to facilitate brazing, or to control oxidation and/or carbon content during welding or heat-treatment of a steel.

Smithing microresidues

A single sample (from Context 1125, Middle/Late Iron Age) produced a significant assemblage of smithing microresidues. The assemblage included hammerscale, as well as comminuted slag debris and fragments of hearth ceramic. Such an assemblage would be likely to derive from within the hearth, or more likely the smithy floor.

Hammerscale was recorded from processed samples from several other contexts, but at very low levels, not necessarily indicating proximity to source.

Fuel

Four pieces of coal were recovered: a 44g piece from the spoil-heap of Trench 16 together with a second 4.98g unstratified piece from the same trench, a 20g fragment from topsoil (1004) and a less than 1g piece from IA context (1117), where it was probably intrusive.

All the evidence from the slags pointed to the use of charcoal as fuel. It would appear likely that the finds of coal were all associated with the post-medieval (potentially from use in hearths or steam boilers).

Iron

Fragments of iron were abundant in the assemblage. The iron was typical highly weathered, commonly coated in rust and accretion. This material weighed a total of 1.58kg, a figure that exaggerates the amount of iron actually present because it includes the accreted matrix. Fragmentation of the material (mostly since excavation) means that the count of 74 pieces may also be an over-estimate.

Some of the iron present in the collection was in the form of artefacts (typically where the accretion hid their form during the initial post-excavation sorting, but subsequent spalling of the iron corrosion products has revealed the form of the iron). This includes probable nails (or fragments of nails) from (13017), (13065) and (14042). The pieces from (1281) and (14073) may also be artefact fragments.

More relevant to the discussion of the archaeometallurgy are fragments from (1125), (10142), (13022) and (14046), all of which may possibly be very small fragments from stock iron bars. These fragments show cross-sections of approximately 7mm in thickness by 20mm to 30mm in width. Bars of this section were commonly employed for the distribution of raw iron in the Iron Age, the so-called ‘currency bars’. Such a size would be appropriate and convenient for the iron stock held by Roman smiths too, even if long distance trade in the Roman period was in the form of larger bars (e.g. the bars reported by Pagès *et al.* 2011, Paynter 2007, and Frere & Wilkes 1989). Some of the iron is represented solely by cavities bounded by secondary oxide crusts, other pieces, including several of the possible bar fragments are still solid items, but it is unclear whether any iron metal remains.

Copper alloys casting materials

Evidence for the working of copper alloy was extremely limited, comprising one mould fragment, four crucible sherds and a casting sprue, with possibly also the block tuyère described above.

Mould fragment SF <710> (1103)
The mould fragment is potentially of Bronze Age date. SF <710> from context (1103) is a 7.42g fragment of ceramic mould measuring 35x22x9mm. The external curvature suggests this is part of a small mould, or more probably a small inner valve from a bivalved mould that would have been coated with an outer clay wrap (see Needham 1980, Figure 3, for illustration of this technique). The fragment is oxidised fired externally and reduced internally. The matrix suggests the casting of an object with a thin margin, at least 3mm thick and at least 20mm in width, with a slightly arcuate margin. The general form is compatible with the tip of a small tool, perhaps a chisel, but the preserved area is too small for any certainty. Analysis of the interior of the mould by XRF shows slight enrichment in copper, lead and tin, consistent with the casting of lead-bearing bronze.

Crucible sherd (10297)
The two items from trench 10 are of early to mid-Roman date and have almost identical fabrics, well gritted, with lithic grains and mica. They appear to derive from similar vessels (if not the same vessel), although they bear residues of differing compositions.

The larger crucible fragment from Trench 10 (from context (10297)) is a substantial section (21.03g) from the upper part of a decorated open jar or bowl with an upright rim (drawn vessel #30). The decoration includes a cordon on the shoulder and an arcaded zigzag (or hatched) incised decoration below). The interior shows intense bloating in a zone from the lip down to the height of the external cordon. The glass in the bloated zone is locally reddened (probably from copper oxide) and contains blebs of copper corrosion products (probably after metal prills). The bloated material has partially sloughed from the neck region down towards the body, which shows much less alteration. There is a partial-thickness crack around the neck just above the cordon, probably another indication of the failure of the vessel at high temperature. A 0.68g fragment of the bloated interior material has spalled from the main piece. These features suggest that the vessel was employed as a crucible in its conventional orientation, rather than the

slagging being associated use of sherds within a hearth (to stabilise a mould ready for pouring, for instance), although this possibility cannot entirely be excluded. Analysis of the bloated material in the area of the copper weathering products by pXRF shows elevated levels of copper and tin, consistent with the working of bronze.

Crucible sherd (10008)
The second sherd from Trench 10 (from Context (10008)) is smaller (7.42g) and has a curvature suggesting an inclined orientation either from the shoulder or just above the base of the vessel. The interior is strongly bloated and contains blebs of copper weathering products, probably after metal prills. In this case, analysis by pXRF showed very strongly elevated levels of zinc in addition to copper, tin and lead, so the metal being worked was probably a brass or gunmetal.

The pattern of distribution of the bloating and slagging of the sherds suggests heating from above in both instances. The smaller sherd would be compatible with the lower section of a truncated jar being re-used as an open crucible or scorifer. The larger sherd suggests that a complete jar was being used for the melting of copper alloy. This makes it possible that the smaller sherd represents the lower part of a vessel used in the same manner, indeed it is possible that it derives from same vessel although the differing analyses make that unlikely. If the smaller fragment is indeed from the lower part of a similar vessel, then it demonstrates that the slagging could extend much further into the vessel than illustrated by the larger sherd.

Crucible sherd? (18081)
A sherd from early Roman context (18081) is apparently from a substantial crucible, showing an internal diameter of 75mm and varying from 8mm at the top of the sherd to 12mm at the bottom (63mm height difference). Neither rim nor base is preserved and the vessel appears internally cylindrical over the preserved height. The fabric is dark grey, paler on the surfaces, bloated (increasingly so towards the external surface) and very coarsely tempered with angular chert(?) lithic grains to 5mm, quartz and some biotite. Fabrics this coarse are unusual in crucibles and no examples were noted, for instance, in crucibles described from Exeter (Gardner 2018, Appendix IV). The form is not able to be compared closely with known vessels because of the lack of both the rim and base, but also appears slightly unusual in being relatively tall and parallel-sided. Neither internal not external faces show indications of adhering resides. The internal surface does not show the microstructure typical of an applied clay coating used during brazing but does show broad ridges suggestive of a coil construction. Analyses of internal and external surfaces by pXRF were consistent and showed no elevated metal contents.

The provisional identification of this sherd as crucible is based largely on its bloated microstructure. Given its dissimilarity to known crucibles in the region in terms of both morphology and fabric, as well as its lack of metal contamination, it seems likely that its over-fired nature may be due to reasons other than the use of this vessel in metallurgy, during either manufacture or disposal.

Crucible sherd (18242)
A sherd (from context (18242)) is the rim of small, thick-rimmed crucible. The fabric is quartz rich (up to coarse sand grade), cream coloured in the rim, but mid-grey where bloated below the rim. This is suggestive of one of the white firing clays (such as that used for the Oxfordshire whiteware) commonly employed for Roman wheel turned crucibles. There is an external dark sandy glassy slag (mostly dark green but with some red patches) thickening upwards from 1mm at the base of the sherd to 2mm at 12mm below the rim, above which it is fractured off leaving a clean surface to the underlying vessel. It is unclear if this suggests the vessel had an extra outer layer of clay (EOL; *sensu* Bayley 1992), whether the external glass was simply a poorly adhering spill or whether clay had been employed to connect this vessel to another component.

The rim is 35mm diameter at its top, with the internal diameter reducing to 25mm at 10mm below the rim, at which height the external diameter is 45mm. The lack of a profile for the lower part of the vessel makes interpretation uncertain, but the vessel seems most likely to have had a very small cupel- or scorifer-like form. Scorifers of this general form are known from the Roman period but become particularly important with the rise of a bullion economy in the early medieval period. Typical usage was in the recovery of silver and gold from a mixed metal assemblage (e.g. the recycling of debased coinage) or as part of the process of assaying, usually by dissolving the material to be tested in lead and oxidising the lead so that it formed a slag with the ceramic that also incorporated the base metals, leaving a noble metal button.

Analysis by pXRF showed some enrichment in copper (particularly on the rim and externally, rather than internally), possibly in tin and lead (both externally only), but very strong enrichment in zinc (particularly on the rim and internally). The metal contamination was not dominated by lead as it would be in a typical cupel or scorifer.

Bayley (1992, Figure 4.5.4) illustrates a cupel-like vessel with a break in an EOL in the same place as the present example being used as the basal part of a vessel for parting (the separation of silver and gold). The analysis of the present material is not compatible with this process.

This analytical pattern would instead be consistent with a very low level of contamination from a copper alloy metal, but strong contamination from zinc vapour – suggesting the working of brass. Taken in combination with the presence of the fractured EOL, it is suggested that the vessel was employed together with another component to form a sealed vessel (or at least a vessel with restricted opening. The small size of the vessel and the lack of internal contaminated by the bulk metal, may indicate that it was employed as a lid, but it cannot be excluded that this is a sherd from a vessel that was itself lidded.

It is not possible to determine the actual zinc content of the metal being worked, but the apparently very high degree of enrichment in the body of the crucible is taken to suggest a high zinc content rather than the low levels present in many gunmetals.

The use of very small crucibles capped by a ‘lid’ formed by an EOL for the manufacture of brass by cementation (the heating of a mixture of finely divided copper, calamine and charcoal in a sealed vessel) has been described by Rehren (1999). Bayley (1984a; 1992, Figure 4.7) described and illustrated small Roman vessels for cementation from Canterbury and Colchester. These vessels for cementation are, however, characterised by a very thin wall and a

porous fabric with little mineral temper, quite unlike this piece.

The present example could potentially represent use of an atypical vessel for the making of brass by cementation but is perhaps more likely to have been employed for the melting of brass; the lid being used to reduce the loss of zinc from the alloy to vapour.

Given the uncertainty of the dating of this context, it is worth noting that because of the effects of mixing and recycling of Roman materials, brass is relatively rare in the 5th to 7th centuries of Britain; only later does the advent of new sources of fresh metal produce any return to significant amounts of high-zinc metal (see, for instance, Pollard *et al.* 2015, Blakelock *et al.* 2022).

Small lidded crucibles are common in the early medieval and were fashioned in a variety of forms. Small examples, most closely resembling the form of the present sherd, are often stated to have been used mainly for the melting of silver (e.g. those from Dunadd; Bayley 1984b). Those from Dinas Powys (Alcock 1963, Figs 30, 31; Bayley 1992 Type 11: Figure 5.9; Bayley & Rehren 2007, Fig 3a) have. However, been described as having been used for melting copper alloy. There does not appear to have been any modern analysis to determine the level of zinc in the Dinas Powis materials.

The piece from context (18242) is therefore very likely to be of Roman date, although an early medieval age cannot entirely be excluded. The small size of the fragment leaves uncertainty over whether it is a cupel-like vessel repurposed as a lid, or lidded vessel with a somewhat cupel-like profile.

Casting jet (16005)
This piece derives from the upper fill of a well and is probably of late Roman age. It is a bilobed object, with a 10mm diameter inlet, from which arise two sprues, one 6mm x 6mm and the other 4mm x 6mm, with an overall height of 13mm. The top of the inlet is slightly oblique to the sprue direction.

Analysis by pXRF of the corroded material suggests a composition dominated by tin, with abundant copper and lead. This composition would be compatible with an oxidised metal or dross, in which tin has become enriched through oxidation. The material also bears a lesser, but significant, quantity (up to 1%) of silver. Zinc was not detected above background levels.

Other materials

Two fragments of oxidised lead were recovered as surface finds. One piece shows a fragmented outer layer that might be a carapace of slag, the other appears to be just simple oxidised lead. Both show fuel debris and may be melted fragments of lead lost into the hearth.

Alongside a large amount of stone of various lithologies, the collections particularly included fragments of various goethite- and haematite- bearing iron ores. Most of these showed a degree of rounding consistent with them simply being sedimentary grains; no material showed fracture in such a way as to imply It might have been a piece of an exploited iron ore. It is likely that these ores are present simply as parts of the natural background sediments.

Interpretation

There are two strands to the interpretation of the smithing residues from Ipplepen: the overall character of the assemblages from different periods and the size-frequency statistics of the SHCs.

The character of the early assemblages (principally those identified as early Roman, but also possibly the Iron Age examples) differs from the late Roman assemblages, in including a high proportion of low-density materials, including both simple FAS as well as the lining slags (both fine and gravelly). In contrast the late assemblage shows less of these materials, but more hearth ceramic (tables 9 and 10).

With relatively small assemblages, such as this, it is difficult to discriminate between taphonomy and technological change as being the cause in minor variations in the character of the assemblage. In this instance technological change might involve a switch from the use of a cut hearth to a more constructed one. A taphonomical explanation of the change might be that the assemblages switch from the local deposition of general smithy waste to remote deposition of selected lump waste – including smithing hearth cakes and the ceramic debris produced during hearth reconstruction.

If the early and late Roman assemblages differ on their composition, the assemblages show remarkably similar weight-frequency statistics for their SHCs (Table 11). The number of SHCs involved is too few to be statistically meaningful, but there is no apparent indication that the size of SHCs changed over time.

The weight of a SHC is dependent upon the amount of iron lost from the workpiece during a work period (a typical SHC will be approximately 50% iron). It will thus vary with the length of the work period (typically a day – but the smith might clean out the hearth more frequently) and the rate of iron loss (higher for high temperature processes involving welding, a high degree of shape change from that of the stock and large pieces; lower for small pieces in work entailing only simple forging with a low degree of shape change and little or no welding). The statistics for the total assemblage of SHCs from the site bears very close comparison with those of assemblages from other rural sites of Roman age (Table 12). The assemblages of SHCs from a wide range of site-types commence with small SHCs of approximately 40-50g weight. These cakes would be the result of a relatively minor piece of work. Those sites undertaking blacksmithing in a rural context tend to show averages SHC weights of 120-180g, whereas in more urban sites the mean is 200-300g; for sites involved in the working of iron as part of iron production (bloomsmithing or bloom refining), then the average weight is well over 400g.

The difference between the rural and urban sites might be associated with the smithies in the rural sites undertaking various tasks, as and when those tasks needed to be done. In contrast, the urban smithies may have had a more regular supply of work, so the work periods were defined by the length of the working day, rather than by the size of an individual task.

Such a rural smithy might be a regular part of a large agricultural estate, but the provision and repair of tools would also underpin many other crafts and activities.

For the present assemblage, the majority of SHCs are small, 40g – 160g, which would be of a size appropriate for the waste deriving from conventional

blacksmithing tasks. The significance of the largest SHCs is uncertain, but they probably represent the waste from whole days of intensive smithing, although it is also possible that they represent work for which the stock iron was not fully refined.

The small fragment of ceramic coating from context (10142) hints at a slightly more complex technique rather than simple forging, but the small size of this fragment precludes identification of either the particular process or the nature of artefact being worked upon. Indeed, the area of Trench 10 has also produced the two fragments of jar used as a crucible for the melting of copper alloy, suggesting a greater diversity of metalworking practice here than elsewhere on the site.

The single piece of probable iron smelting slag hints that smelting may have been undertaken in the general area, outside the excavated zones. The date of that activity is unknown, with the slag type being equally likely to be attributable to the Iron Age and early medieval periods.

A single fragment of a mould from a possibly Bronze Age context is interesting; such finds are not common but do occur sporadically on sites of the period in the southwest. The moulds from Banwell (Young 2013b) bear close comparison with the present fragment. The nearest major assemblage, however, is that from Dainton, just 1500m from the present site (Needham 1980). Although the present fragment does not appear to be from a mould for one of the martial artefact types present at Dainton, this presents an intriguing context for the Ipplepen find.

Unlike many Roman sites, there was relatively little evidence recovered for the working of copper alloy, but what there was slightly unusual. The use of a decorated jar, with no external sacrificial clay coat is remarkable, if indeed it was used intact, rather than as isolated sherds for supporting a crucible or mould. Most rural copper alloy working involved the use of small hand-made crucibles, whereas urban centres tend to employ wheel-thrown whiteware crucibles (of various origins), typically with a sacrificial external coating. The use of a domestic jar might perhaps suggest an ad-hoc solution to a particular problem (such as the melting together of scrap materials). Equally unusual was the apparent use of a lidded vessel for the melting of a zinc-rich copper alloy (brass or gunmetal). This indicates great care being taken to maintain the zinc content of the alloy. Finally, the use of a rectangular block tuyère is unusual, although by no means unknown. Analysis provides a hint that this too may have been used in the working of a zinc-bearing alloy.

The presence of two fragments of lead is not likely to be associated with metallurgical activity.

Overall, the assemblage indicates that a wide variety of metallurgical activities were conducted at Ipplepen on occasion. However, only the iron smithing appears to have been conducted on a persistent basis.

Further work

The assemblage spans a wide range of time and was recovered from over a moderately wide area of the site. There is only a single context with microresidues to supplement the evidence from the macroscopic residues. These factors mean that it would be difficult to assemble an analytical programme to produce significant additional data of archaeological value.

One key area for which it would be useful to learn more would be the source and composition of the iron being employed. Two potential routes could be used to examine these factors – analysis of the potential fragments of the stock iron and analysis of the smithing microresidues. For the former, it is unclear whether the surviving iron fragments would contain enough metallic iron to provide useful information and for the latter, there is only a single assemblage which would only provide data for a snapshot within the long history of the site. In either case, it is doubtful whether appropriate analysis would manage to generate archaeologically-useful information.

Notwithstanding the potential strands of possible analytical work mentioned above, the archaeometallurgical residues from Ipplepen form an important assemblage that should be deposited in its entirety in a suitable institution as part of the physical archive from the site.

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Table 1: summary catalogue of materials, IPP12/13. Weights in g. Dimensions of SHCs expressed as L x W x D(depth of bowl).

tr	sample	fraction	context	wt	no	notes
	632	slag	none	560	assm/1	roughly circular SHC, now fragmented, 90mm diameter by 60mm thick, basal section vesicular, then dense planar sheet without vesicles of 25mm, then upper part with some lobes, charcoal and vesicles overlain by corrosion
		slag	unstrat	150	1	very porous SHC, base well formed, lots of similar slag above bowl limits, both ends missing
		slag	1004	130	1	small fragmented compact SHC, 70x55x27mm, plano-convex, internally vesicular
				20	2	coal
				16	3	fired clay
				14	3	low density vesicular slags with deep fuel imprints
				78	1	large block from the bowl of an SHC
	042	unknown	1004	2	1	dense droplet fallen onto fuel, with upper tail, dense iron slag
	044	slag	1004	6	1	somewhat lobate porous lining slag
				8	1	fragment of thick dark pottery
	045	slag	1004	28	1	central section of a very small SHC
	502	slag	1004	30	1	dense, finely prilly iron slag, intimately mixed with bright red fired clay
	524	slag	1004	0.3	2	dark friable fragments, pieces parallel side to original interpretation of pottery probably correct. Not slag
	017	slag	1010	24	1	angular fragment of porous slag - probably central part of a small SHC
	183	slag	1010	36	3	vesicular iron slag in contact with very strongly oxidised ceramic
	195	slag	1010	94	1	vesicular green rock
	197	slag	1010	90	46	fragments (from one piece?) of FAS, although some pieces become moderately dense
	115	slag	1035	4.93	2	small blebs or fragments of fuel dimpled dense iron slag
	224	slag	1035	4.98	1	vesicular black glassy slag, slightly lobed with sandstone clast
	264	slag	1038	2.61	1	blebby FAS

364	slag	1038	9.43	1	rounded worn pebble of botryoidal mineral, very dense, probably iron ore
598	slag	1077	9.15	1	dimpled and slightly lobate vesicular iron slag fragment
118	slag	1096	12	1	weathered dolerite
110	coke	1101	1	1	weathered igneous rock
755	slag	1103	0.35	1	centimetre scale rounded grain of FAS/bloated stone
SF<710>	pot	1103	4.15	1	Fragment of ceramic mould; 35x22x9mm; oxidised fired externally, reduced internally; matrix suggests the casting of a thin object, at least 20mm in width, with a curved tip at least 3mm thick. The external curvature suggests this is part of a small mould.
087	slag	1113	156	1	60x80x35(25)mm small SHC, slightly lobate, but well-formed oval bowl with biconvex section
			98	assm	porous iron slag - may be a fragmented SHC or attachment area, unclear if all from same original piece
059	charcoal	1117	<1	1	charcoal
084	slag	1117	1	1	coal
309		1118	0.62	1	slag in concretion with charcoal
001	hammer scale	1125	552	assm	hammerscale with some slag fragments and fired clay - a very rich assemblage
162	slag	1125	110	7	fragments of four concretions with sheet/thin bar iron in concretionary material
			16	assm	debris
			6	2	stones
			10	3	fired clay
			26	3	low density slags in rounded lumps with very deep fuel dimples
			52	1	fragment of dense, but vesicular slag in rounded mass - probably a piece of SHC
162	slag	1125	126	1	30x6x80mm piece of bar iron in exploded concretion
			112	1	stone
			10	1	iron 30x8x6mm
			94	assm	debris - mostly fragments of iron in concretion
			16	4	stones?
441	slag	1127	26	2	highly vesicular low density iron slag
458	slag	1127	236	assm	multiple fragments - probably, but not certainly a single vesicular SHC

463	slag	1127	56	1	fragmented lump of FAS/low density iron slag
539	slag	1127	14.3	2	highly vesicular pale slag - FAS/clinker
385	slag	1130	5.11	1	fragment of vesicular grey slag or rock
516	slag	1130	0.52	2	highly vesicular lining influenced slag or FAS
534	slag	1130	1.63	1	vesicular iron slag fragment
536	slag	1130	9.36	2	fragments of moderately dense vesicular iron slag
548	slag	1130	1.38	4	fragments of piece of highly vesicular FAS or low-density iron slag
551	slag	1130	42	4	fragmented piece (or pieces) of vesicular FAS type slag
555	slag	1130	62	6	rounded pieces of vesicular slag ranging from definite iron slag to things closer to FAS
559	slag	1130	50	1	central section from a small SHC, contains charcoal
560	slag	1130	204	4	fragmented dense but vesicular SHC
			70	3	deeply dimpled lobes of low-density slag - within hearth/foot of wall accumulation - unclear if directly associated with above SHC
561	slag	1130	70	1	rounded nub of dense vesicular iron slag, possibly an entire proto SHC
563	slag	1130	1.82	2	tiny fragments of vesicular iron slag
564	slag	1130	4.44	1	vesicular iron slag fragment
566	slag	1130	60	2	fragments of very small, moderately dense vesicular SHCs
567	slag	1130	74	1	slab-like fragment of vesicular iron slag with associated charcoal
568	slag	1130	6.62	1	blebby slightly flowed FAS
626	slag	1130	78	19	fragmented highly vesicular FAS? Has some bloated lithic clasts
627	slag	1130	208	1	90x65x25mm, slab like oval SHC, dense, top smoothly lobate, base obscure but dimpled?

669	slag	1130	14.82	1	vesicular iron slag fragment
096	slag	1140	154	12	fragmented slag (probably originally an SHC or part of) - vesicular and rich in charcoal
			28	4	fired clay
500	slag	1140	0.69	1	thin sheet of vesicular grey slag, probably iron slag
504	slag	1140	3.29	1	low density vesicular FAS-like material with smooth blown metallic lustre surface - clinker?
506	slag	1140	3.52	1	small fragment from sheet with lobate maroon top and darker base, internally pale grey and highly vesicular slag with quartz/feldspar grains and shale clasts. Clinker like
511	slag	1140	6.01	1	iron object in concretion
512	slag	1140	16	5	fragmented piece of highly vesicular lining-influenced slag
515	slag	1140	26	17	small fragments of pale highly vesicular FAS type slag in association with some oxidised hearth ceramic
			14	1	concretion on iron
155	possible iron ore	1147	12	2	reddened stone
186	slag	1149	1.85	1	fired clay ranging from oxidised fired into grey bloated reduced fired to dark face
199	slag	1147	0.44	1	probably rotten stone
215	slag?	1147	2.69	1	stone
117	iron slag	1159	6	1	spikey coarse grained in hearth slag fragment
256	slag	1162	1.01	1	highly blown small, rounded grain - clinker? Grey surface
102	possible iron ore	1170	198	1	rock
129	slag	1170	46	7	fragmented blebs of iron slag, variable but mostly dimpled lining influenced material
145		1177	128	1	stone
154	slag	1173	56	3	dark grey ceramic with quartz grains, probably pottery, but just possibly a natural sheared rock
314	slag	1177	330	1	slightly irregular thick concavo-convex SHC, 80x85x50mm, internally vesicular

331	slag	1177	23.21	1	stone
351		1177	0.34	1	dark pottery
378	slag	1177	46	1	fragment of dense iron slag, fuel dimpled base to this lobe, top is flatter with some impressed fuel particles, dark granular slag, distinction of fuel particles and worn slag lobes difficult - but if these inclusions in the dimples are fuel, then they are coke
586	slag	1177	22	8	single fragmented lump of highly vesicular FAS
619	slag	1177	3.61	2	highly vesicular slag fragments
633	ore	1177	134	1	weathered igneous rock
659	slag	1177	4.32	1	vesicular iron slag fragment
663	slag	1177	7.25	1	vesicular iron slag broken in 2
667	slag	1177	1.11	1	small fragment of glassy iron slag
683	slag	1177	5.12	1	vesicular iron slag fragment (broken in 3)
701	slag	1177	128	1	dense small nub-like SHC, lower crust thin and wraps around an upper lump
713	slag	1177	632	2	probably a single piece of slag - rich in very fine charcoal, has microprilly/microdimpled base, top appears locally smooth but poorly preserved, fragment of large hearth cake?
721	slag	1177	5.77	1	charcoal and vesicle rich iron slag
205	slag	1188	1.46	1	vesicular iron slag fragment
252	slag	1263	8.64	1	small piece of crudely lobate dense slag, accretion contains charcoal and FHS
267	slag	1263	2.55	1	dimpled contorted bleb of lining slag
269	slag	1263	3.08	1	fragment of lining -influenced iron slag
358	slag	1281	8.88	1	fragment of vesicular iron slag
370	slag	1281	1.63	1	FAS fractured into 3

374	slag	1281	8.7	assm	exploded iron fragment, square shank with flattened end or ends
387	slag	1281	3.81	1	vesicular iron slag fragment
335	slag	1293	1.51	1	highly vesicular - lining influenced iron slag rather than FAS probably
393	slag	1303	122	1	very irregular slag lump, probably entire SHC, 70x45x35mm, contains charcoal, dense, rusty
6	??	1341	2.03	13	small in hearth slag particles, 7 or so show high sphericity, others more irregular few are proper coffee-bean shapes, some are slightly reddened.
6	?	1341	1.28	8	spheroids and other particles of pale FAS
673	slag	1341	17.59	1	dimpled slag sheet, probably from base of SHC, internally vesicular with probable charcoal
			4.68	1	rounded irregular slag bleb in charcoal rich accretion
649	slag	1342	1.25	1	thin fragment of plate of black vesicular glassy slag
655		1342	10	2	small concretions on iron
			<1	1	charcoal

Table 2: summary catalogue of materials, IPP14. Weights in g. Dimensions of SHCs expressed as L x W x D(depth of bowl).

tr	*sample*	*fraction*	*context*	*wt*	*no*	*notes*
	2098	grid sq d	7005	214	5	stone
		pottery fragment		8	1	stone
	002	sk17 sk1? Nail? Magnetic stone	7018	4.24	assm	stone with trace of FHS
	002	spheroidal slag	7018	<.01	2	3 tiny blebs, 2 joined, of highly vesicular FAS
	6187	slag sk10	7049	70	1	very dense fragment of a single flow lobe of dense iron slag, base smooth and shiny but slightly dimpled, top rough (not preserved?), internally some vesicles
		hammerscale from excavation	7050	1.49	assm	stone
	017	sk13 fe ore?	7066	24	1	fractured rounded pebble of layered haematite
				4	2	darker mineralised rocks
	016	slag sk12	7082	6.87	1	concretion on iron object, slightly fragmented
				3.32	1	stone

Table 3: summary catalogue of materials, IPP15. Weights in g. Dimensions of SHCs expressed as L x W x D(depth of bowl).

tr	sample	fraction	context	wt	no	notes
7		10250 slag	7055	10	1	dimpled flowed slag, may be part of 292g item from (7225), certainly very similar
7	117	residue slag? Sk22	7097	0.64	3	largest piece soil, medium piece is bone, small piece stone or slag
7	131	sk22 residue slag?	7097	0.19	1	complex double within-hearth droplet - just possibly clinker
				14.31	1	stone
7	122	sk16 slag	7204	0.96	2	stone
7		10443 slag SK29	7225	292	6	single fragmented block of slag. Dimpled surfaces and flowed top, 2 parallel gouge marks on base suggest this is from hearth clearance and slag flow may mean it has lost its SHC form (glued together to allow examination)
7		10486 slag sk29	7225	83	1	fragmented slightly prilly small SHC, 65x45x25mm
7	133	residue: tap slag? Sk29	7225	1.39	4	3 small blebs of highly vesicular lining influenced material, the larger bleb is a flow slag with large voids, not a tapslag
7	137	residue iron ore? SK30	7232	1	1	weathering crust from iron rich sandstone
7	137	residue iron? Sk30	7232	18	2	stones
7	137	residue slag ore? Sk30	7232	12	9	stones, 4 of which goethite iron ores, plus single probable FHS flake
7	137	residue slag, sk30	7232	0.32	1	micro-botryoidal iron ore, black shiny with slightly red core
7	141	iron ore?	7237	4	2	slate
7	141	sk32 residue slag	7237	0.3	1	tiny worn iron ore fragment
7	141	residue slag, SK32	7237	0.39	1	worn fragment of goethite ore around red soft core
7		10949 slag?	7247	1	1	granules bound by tar - probably modern 'tarmac' asphalt surfacing
8	136	residue, mineral blobs, ?spheroidal slag, sk28	8030	1.1	assm	dark granular spheroids. Possibly oxidised pyrite granules?
9		tr9 cleaning west end slag?		158	4	porous rocks with rounded voids
				32	4	vesicular iron slag (SHC debris?) - possibly all part of a fractured lump

9		mid east cleaning slag		6	1	dense amalgamated flow slag with impressions/dimples of fuel
9		cleaning slag?	9002	0.59	1	angular fragment of vesicular slag, probably from SHC
9		spoil slag?	9002	0.78	2	weathered rock
9		west edn spool slag	9002	92	1	large part of small SHC, well worn and rounded
				4	1	small fragment of vesicular iron slag (probably SHC fragment)
9		west slag?	9002	28	1	fragment of small dense SHC, internally lobate, fuel impressions on base, some maroon surfaces, could perhaps be coal-fuelled but no hard evidence
9s	124	flot slag?	9041	0.32	assm	small fragments of FAS, burnt clay and possibly other BOM

Table 4: summary catalogue of materials, IPP16. Weights in g. Dimensions of SHCs expressed as L x W x D(depth of bowl).

tr	sample	fraction	context	wt	no	notes
10		slag	10006	64	1	discoidal dense, biconvex slag lump, probably a proto-SHC; 50x50x24mm
10		Crucible?	10008	7.42	1	Sherd of pottery, with intense internal bloating. The bloated material contains blebs of copper weathering products, probably after metal prills. The fabric is similar to that of the 21.03g piece below. The curvature suggests this could either be the shoulder of a vessel or it is from just above the base. If the latter it is possible a trimmed or broken vessel has been used to substitute for a bowl-shaped crucible or scorifer.
10		slag	10099	36	1	highly vesicular smithing slag (SHC?) fragment
10		slag	10099	200	assm	probably a single fragmented SHC, possibly complete and possibly two layered
10	539	?slag	10099	0.27	1	stone
10		slag	10101	22	4	low density slags and bloated clasts - gravelly smithing slag
				44	3	dense, blebby, rusty, hearth slag lumps with deep fuel dimples
				16	1	burnt stone
10		slag	10141	6.78	1	lobate and maroon surfaced slag with metal contact surface, 40mm x 25mm up to 15mm thick. Contact is planar until close to one edge, so could be blade section? Slag is well melted so maybe adhesion to a tool rather than a workpiece coating
10		slag	10142	54	assm	lumps and debris of low-density blebby slags
				78	1	sub-discoidal SHC with marginal flow lobes/protrusions, 50x57x23mm well-formed concavo-convex disc, with up to 15mm protrusions.
				1.66	1	bloated clay coating, iron contact on internal side, irregularly glazed and cracked externally, sides 8mm and 17mm, separated by filleted angle of radius c. 8mm, internal side is curved suggesting radius of c30mm, so could be from a ring. Brazing or welding residue
				5.37	1	iron fragment, 22x7x 16mm, suggests end of bar?
				0.8	3	rust spalls from above
10		Sherd with Cu traces, drawn vessel #30	10297	21.03	1	Large section from the upper part of a decorated open jar or bowl with an upright rim, the interior of which shows intense bloating in a zone from the lip down to the height of the external cordon. The glass in the bloated zone is locally reddened (probably from copper oxide) and contains blebs of copper corrosion products (probably after metal prills). The bloated material has partially sloughed from the neck region down towards the body, which shows much less alteration. The fabric is well gritted, largely with lithic grains and mica.
				0.68	1	Small spall of bloated material from the piece above, with copper weathering products.
11	535	?slag	11042	4.28	assm	stone, with probable fired clay and possible trace of slag

12	slag?	12041	6	2	rock fragments
			108	6	1 very large fragment and 5 tiny pieces probably from the same SHC; 50x57x30mm, base microprilly, dimpled, top probably crudely lobed, but somewhat accreted; internally highly vesicular and has inclusions of charcoal, base has lot of grey ceramic inclusions.

Table 5: summary catalogue of materials, IPP17. Weights in g. Dimensions of SHCs expressed as L x W x D(depth of bowl).

tr	sample	fraction	context	wt	no	notes
u/s		residue ? Hammerscale		2.1	assm	stone with low levels of slag and FHS, trace of SHS
13		slag	u/s 13001	108	1	exploded mass of iron
13	625	slag	13003	0.6	assm	stone with rare slag fragments
13	625	clinker/hearth lining?	13003	0.53	2	coarsely vesicular, pale FAS
				0.28	1	buff coloured lining passing into finely vesicular partial melt
				<.1	1	double spheroid of finely vesicular FAS
13	625	clinker	13003	4.51	38	pale FAS, mainly in small fragments and blebs just a few mm across
13	604	slag	13017	1.81	1	concretion - appears to contain the head of a small nail
				0.32	1	concretion - narrow square sectioned shaft
				0.28	1	iron rich stone
				0.51	1	small chip of vesicular slag
				0.5	1	concretion, probably on narrow square sectioned iron
				1.07	1	exploded concretion in many pieces, iron
				0.08	1	stone
13		slag	13022	38	1	55x25x5mm exploding iron bar fragment with green minerals on explosion crack
13		slag and burnt stone	13023	12	1	stone
				22	1	angular fragment of SHC
13		slag and burnt clay/stone	13045	244	6	45mm thick highly vesicular highly weathered iron slag, has charcoal inclusions, fragmented.
				34	1	stone
				6	2	pottery
				78	1	SHC fragment
13		slag and burnt stone	13056	80	4	stone - some red but not certainly burnt
				82	1	small irregular plano-convex proto SHC
				304	1	this appears to be a sub semi-circular SHC, but contains iron and is starting to explode; the surface has a layer of accretion so no real details are visible
				38	8	low density slag fragments (plus some debris)
13	627	slag	13056	0.22	1	red coarse sandstone

				0.22	1	clay pellet from sieving process
13	615	slag	13056	4.91	1	concretion, probably on iron. Rich in small stones and charcoal
13		slag and burnt stone	13059	76	1	stone
				4	1	grey fired clay
				16	1	small fragment of prilly SHC
13		slag	13065	8	1	square cross section mineralised iron - nail shank?
13	647	slag	13065	1.58	1	fine grained iron slag, locally preserving a maroon surface, in a tightly lobed or folded morphology abutting intensely oxidised ceramic
13	667?	slag	13065	0.37	assm	stone with a single fragment with possible slag fragment
13	623	?	13065	0.68	1	square cross -sectioned mineralised iron (nail?)
13	648	magnetic material from residue	13099	1.56	assm	stone, single scale-like fragment probably outer skin of slag, not FHS
14		slag	u/s 14001	68	1	thick lobes of vesicular lining slag, mostly dark surface
14		slag	14002	1	1	tiny rusty slag particle
14		slag	14013	152	9	fragmented dense SHC with planar base
14		slag	14015	60	4	maroon-surface thick lobed slag mass of vesicular lining slag
				18	2	small fragments of SHCs
				1	1	vitrified oxidised fired lining
				16	assm	debris
14		slag	14023	250	18	concretions on iron and fragments of
				4	1	stone
				62	1	very dense irregular microprilly lump, possibly a deformed proto SHC
				50	16	low density blebs of lining-influenced material
				22	14	minor slag debris
14		slag and burnt clay	14024	66	1	45x50x25mm, small puck like proto SHC, deep fuel impressions on top, some charcoal on base, highly vesicular internally despite high density
				20	5	blebs and fragments of low-density vesicular iron slag
				20	1	mineralised material spalled from iron artefact

				20	1	rounded fragment of iron slag
				42	8	conventional oxidised fired lining, passing through grey to vitrified dark front
				8	4	variably coloured fired clay
				15	assm	debris
14	610	spheroidal slag	14024	<.01	1	single dull-surfaced slag spheroid, probably, but not certainly an in-hearth droplet rather than SHS
14		slag	14033	66	5	fragments of dense slag
14		slag & burnt clay	14034	120	1	highly irregularly shaped small but deep proto SHC, 45x60x45mm, maroon blown top, flow lobe on one side, rough round base
				68	13	vitrified oxidised fired lining
				2	1	stone
				10	3	low density vesicular lining slag in flow lobes
				12	1	medium density slag fragment
14	641	?slag (spheroidal)	14034	2.19	assm	mostly stone, with a few slag fragments. Has a small number of FHS, but no SHS
14		slag	14035	640	1	well-formed almost discoidal SHC, 120x135x40(25)mm, well formed, plano-convex, some dribbles on base on proximal margin , otherwise fairly smooth, top originally rather planar, but cut (by axe?) in centre, cut 20mm deep x 15mm maximum width and slightly arcuate.
				14	2	vitrified oxidised lining
				60	2	small angular fragment of iron slag, probably SHC fragments
				48	2	highly porous gravelly lining slag
14		slag	14037	160	1	80x95x35(25)mm, slightly worn SHC with very friable surface, slightly biconvex, top with shallow fuel dimples, base rounded
				166	1	75x85x30(20)mm, base in several rounded lobes, top deeply fuel impressed
				240	4	substantial fragments of SHCs, possibly rounded
				18	1	stone
				42	3	flowed dense slags
				6	1	lobe of low-density slag
				70	assm	small slag fragments and debris
14	sf<317>	hearth lining	14037	94	1	Dished section of oxidised fired hearth wall, with dark, almost black, slagged face.
14		slag	14039	4	1	dense slag bleb
14		slag	14042	102	30	vitrified oxidised fired clay
				62	1	angular fragment of large dense SHC
				214	6	stones
				126	1	concavo-convex SHC, 65x80x27(23)mm, fuel impressions on top, together with droplets of vesicular lining slag

				90	14	blebby lobate highly vesicular lining slag with dark grey or reddish surfaces
				118	1	65x70x30mm, slightly biconvex SHC, vesicular, prilly lower part smooth top,
				194	7	concretions on iron
				66	4	moderately dense flowed slags in various forms
14	602	slag	14042	3.27	1	lobate/dimpled small bleb of dense iron slag
				1.72	1	mineralised iron (?nail shank)
				7.21	1	botryoidal goethite ore (possibly ex-sulphide?)
				1.33	1	small lobe of slag with maroon surface
				3.69	1	dark green vesicular glassy slag - lots of indications of very viscous flow
				12.53	6	dense slaggy material, granular with inclusions of clay, stone and charcoal - almost appears like sinter, but probably slag
				0.95	2	conventional slagged oxidised fired lining, lining rich in shale pellets
				9.27	6	highly vesicular glass slag, some bloating shales, slightly rusty in areas, very variable in colour
14		slag	14046	272	1	rather worn looking irregular SHC, dimpled base, vesicular, surface poorly preserved 55x80x35m, plano-convex
				98	1	part of a medium sized SHC
				94	13	low density slag fragments and debris
				40	1	down-wall flow and two lobes extending onto base with poor non-wetted bases, otherwise rough surface and apparently vesicular internally
				42	2	concretions on iron - larger piece appears to be bar fragment of 50x20x7mm approximately
				18	1	slag lobe binding gravel
				44	1	rather equant mass of low-density slag, smooth and gey surfaced above, dimpled with stone inclusions on base
14		slag	14049	40	1	vitrified oxidised fired clay with a partial blowhole margin. It is slightly angular but approximately equivalent to 30mm
				604	1	95x125x45mm large SHC - forms more of a wall coating with amalgamated flow slags than a typical SHC, fuel dimples on upper surface are large
				130	18	vitrified oxidised fired clay
				130	9	low density, often slightly maroon surfaced, lining slags with signs of flow
				342	9	denser slags with signs of flow
				118	2	angular fragments from cores of SHCs
				246	6	fragments of slag that are internally microprilly - presumably all SHC fragments
				262	assm	tiny slag fragments and debris
				210	1	95x115x50mm, dimpled and prilly base, lobate top with fuel impression,
				148	1	60x95x35mm, parallel base and top semi-circular SHC, dimpled base with charcoal
				158	1	100x70x55mm, plano-convex SHC, microdimpled and slightly microprilly base
				114	1	80x55x50mm, smooth top, microprilly on base, red surfaced flow lobe near to contact surface
				88	1	55x95x40(25)mm plano-convex cake with smooth top, microprilly and microdimpled base
				70	1	slab of dense slag, with microprilly base, top smooth surface but irregular
				48	1	65x55x25mm, approximately square small puck formed of merged flows, many with a maroon surface, charcoal moulds
14		slag	14055	24	1	dense slag nub with fuel dimples

			1	1	low density lining slag
14	slag and burnt clay	14064	34	3	vitrified oxidised lining
			114	7	dense iron slag fragments
14	slag and burnt stone	14072	48	1	40x45x20mm small fuel-dimpled puck
			66	1	fragment of SHC with concave smooth haematised top and dimpled base
			90	1	55x45x25mm crude probable proto SHC, surfaces obscured by minor accretion
			106	1	65x75x30mm irregular somewhat slab-like SHC with smooth but not planar top and dimpled base
			110	1	55x65x35mm triangular SHC with smooth haematised top, fuel-dimpled base with charcoal
			258	1	70x80x50mm rather irregular hot deformed SHC, unclear if this is close to the whole of if a significant part is missing
			44	1	45x50x25mm, small fuel-dimpled puck
			668	28	dense slag - in various forms of flow, blebs fragments of SHCs etc
			390	89	low density slag down to FAS in blebs sheet fragments etc
			10	1	stone
			16	1	slag binding gravel
			222	14	pieces of iron and concretions containing iron
			24	1	piece of iron-containing concretion that shows green rust on its fracture
			32	6	oxidised fired slagged lining
			200	assm	debris
14	slag	14073	18	2	low density iron slag
			12	1	concretion on iron
14	slag	14074	20	5	stone
			82	26	low density highly vesicular blebby lining slag
			52	5	gravelly lining slag
			200	70	vitrified oxidised lining
			66	1	40x60x30mm, semi-circular proto SHC, rough base with charcoal, smooth top with fuel dimples
			46	1	35x50x30(20)mm, flat topped proto SHC with some extra slag on margin, base fuel-dimpled
			56	1	40x50x20mm rough and irregular probable proto SHC
			54	1	40x45x25mm small rounded slightly prilly slag lump, probably proto SHC
			38	1	runnels of slag from hearth floor, contains clasts of charcoal
			270	19	denser iron slags, mostly vesicular, some rich in charcoal some blebby
			74	assm	debris
14	slag	14078	18	2	low density iron slag, one very gravelly
14	slag	14084	50	1	angular fragment from core of medium sized SHC

14		slag	14087	54	1	stone
				70	5	concretions on iron - 1 piece curved through 180 degrees
				86	2	stone
				6	1	vitrified oxidised lining
				8	1	bleb of low-density lining slag
				78	assm	fragments of dense slag and debris
14		slag	14088	108	1	60x55x55(45)mm, very smooth maroon top, dimpled slightly by fuel, microdimpled irregular base
				98	1	large mass of low-density lining slag, grey surface locally maroon
				26	1	rusty dense slag fragment
14		slag	14091	202	1	very irregular subconical SHC, 70x80x55mm, microdimpled base, upper section is slightly layered, maroon, irregular
				74	3	dense SHC fragments
				28	2	stones
				16	2	lobate low-density slags
15	637	2 of 7	15032	0.15	1	sandstone
				0.8	1	twisted nub of glassy slag with some quartz/feldspar inclusions and a maroon surface
15	637	residue hammerscale	15032	0.21	assm	stone with a trace of possible slag
15?	?	?hammerscale	?15032	3.38	assm	stone with a trace of FHS, SHS and slag

Table 6: summary catalogue of materials, IPP18. Weights in g. Dimensions of SHCs expressed as L x W x D(depth of bowl).

tr	sample	fraction	context	wt	no	notes
16		slag	u/s spoil	234	1	concretion on iron
16		slag	cleaning	426	14	igneous rock ?basalt
				1	1	pottery sherd
16		slag	u/s spoil	424	1	breccia cemented by dense iron oxides
				44	1	coal
				60	1	strangely twisted flow lobe of slag, base finely dimpled, top has coarse fuel impression, probably, but not certainly, a hearth slag
				20	1	iron object
16	none	slag	u/s	4.72	1	viscous flow slag, green below maroon above, grey interior, white shale clast
		slag	u/s	46	1	variegated glassy to granular crystalline slag, locally maroon exterior - could be coal fuelled smithing slag or just possibly a simple clinker
16		residue from glass making?	u/s	4.98	1	coal
				16.23	1	black glass, lime coated, partly devitrified
16	Sf<0033>	Casting jet	16005	5.14	1	bilobed casting et in Cu-alloy
16		lag/clinker	16033	<.1	1	coke
16		slag	16037	15.02	1	vesicular iron slag fragment
		slag	16039	0.57	1	variegated highly vesicular glassy, clinkery iron slag
		possible iron ore	16055	200	1	fragment from rounded pebble(?) of coarse haematite with ruddle zones
16		slag	16057	2.48	2	FAS, grey/green internally, locally maroon on surface - possible clinker
16		metal/slag	16111	30.39	1	iron, starting to explode
16		slag	16114	56	1	iron-rich rock
16		slag	16130	14.27	1	igneous rock

16	possible iron ore	16278	198	1	fragment from 60mm thick botryoidal haematite, soapy texture, but is smooth and only just marks paper

Table 7: summary catalogue of materials, IPP19. Weights in g. Dimensions of SHCs expressed as L x W x D(depth of bowl).

tr	sample	fraction	context	wt	no	notes
18		slag (cleaning layer)	18001	52	1	flow slag puck, lobate margins, charcoal impressions on both faces, 60x45x12mm
18	Sf<028>	Industrial waste?	18081	16.58	1	Fragment of dark, quartz rich pottery, of rather cylindrical form, highly bloated, possibly just over-fired pottery rather than metallurgical.
18		industrial waste/slag	18093	2.05	1	white porous material - probably rock, but just possibly a mortar
18	sf<041>	fired clay	18106	140	1	Fragmented (and partially restored) section of a rectangular block tuyère
18		slag	18159	12.1	1	fragment of very dense but porous iron slag - probably SHC fragment
18		slag	18195	2.96	1	bleb of dense but vesicular iron slag
18		industrial waste/slag	18211	72	11	fragmented dense vesicular iron slag with small charcoal clasts - part of a fragmented SHC (although may not all be from one piece)
				16	2	stones
18		crucible frag?	18242	8.89	1	Stout, but small diameter crucible rim, pale fabric, very quartz-rich. External green glaze broken away well below rim, probably suggestive of luting.
18		slag	18303	72	1	very dense piece of amalgamated flow slags with hints of wood contacts. FB fragment
18		industrial waste	18427	4.1	3	grey pumiceous FAS, very highly vesicular
18		slag	18471	2.56	1	bloated partial melted local stone
18	024	>2mm picked	18474	1.48	5	well gritted fired clay - grits appear to be pellets of grey siltstone
		industrial residue		1.04	1	red sandstone with large cavities
				0.94	3	bluish glassy slag overlying vesicular partial melt, pale
				0.57	2	blue glassy slag
				0.17	1	greenish glassy stalactite, possible lining fragment at core.
18		industrial waste/slag	18474	134	assm.	one or two large attachments of glassy slag with wall below blowhole. Wall ceramic is finely gravelly, slag contains larger lumps of stone - unclear if from wall or as a flux, slag is atypically glassy for a smithing slag
				106	1	glassy, slightly double-layered SHC, 70x65x35mm, top convex, simple smooth greenish glass, base is very porous with dep dimples and small prills, internally has sandstone fragments.
surface		lead slag	unstrat	70	2	2 fragments, one may have carapace of fragmented slag, the other appears just simple oxidised lead. Both show fuel debris and may be fragments of melted lead lost into hearth

Table 8. distribution of residue facies by period and context. All weights in g. Contexts yielding only stone excluded.

context		*SHC*	*dense ss*	*low density ss*	*gravelly ss*	*droplets*	*glassy*	*FB*	*coating*	*FAS*	*lead*	*ceramic*	*fired clay*	*iron*	*pottery*	*rock*	*charcoal*	*coal*	*crucible/ mould/ Cu-alloy*	*scale*	*debris*
Neolithic/BA																					
1103	2A									0.35									4.15		
										0.35									*4.15*		
Iron Age																					
1117	3A																<1	1			
1170	3A			46												198					
1035	3B		4.93				4.98														
1038	3B									2.61						9.43					
1149	3B											1.86									
1162	3B									1.01											
1188	3B		1.46																		
1125	3C			26									10	246		134				552	110
1263	3C		8.64	5.63																	
1341	3?	17.59	4.68			3.31															
1342	3?						1.25							10			<1				
1140	3+	154	0.69	42						6.81			28	20.01							
		171.59	*20.4*	*119.63*		*3.31*	*6.23*			*10.43*		*1.86*	*38*	*276*	*0*	*341.43*	*<1*	*1*		*552*	*110*
Early Roman																					
18427	3D/4Ai									4.1											
1118	4Aii	0.62																			
1010	4Aii	24	36							90						94					
1113	4Aii	254																			
1127	4Aii	236		82						14.3											
1159	4Ai		6																		
1177	4Aii	1090	68.46	3.61			1.11			22					0.34	285.21					
1303	4Ai	122																			
1130	4A+	592	181.18	62						128.52											

13023	3/4A	22													12					
13003	3/4A									5.04		0.28								
13022	4A													38						
13059	4A	16											4	8	76					
13065	4A		1.58											0.68						
13099	4A																		tr	
10099	4Avii	236													0.27					
10141	4Avii								6.78											
10142	4Avii	78		54					1.66					6.57						
14023	4A	62		50										250	4					22
14087	4A		78	8										70	140					
14088	4A	108	26	98																
14073	4A			18										12						
14055	4A		24	1																
14039	4A		4																	
12041	4Aviii	108													6					
16039	4Aii			0.57																
16057	4Aiii									2.48										
16111	4Aiii													30.39						
16033	4Avii																			
18081																		16.58		
18471	4A									2.56										
18195	4Av		2.96																	
		2948.6	*428.18*	*377.18*	*0*	*0*	*1.11*	*0*	*8.44*	*269.00*	*0*	*0.28*	*4*	*415.7*	*0.34*	*687.75*	*0*	*0*	*16.58*	*tr*	*22*
Roman																				
13045	4	322													34					
13017	4		0.51											3.7	0.36					
13056	4	386		38										4.51	80					
14015	4	18		60								1								16
		726	*0.51*	*98*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*8.21*	*0*	*114.36*	*0*	*0*		*0*	*16*
Late Roman																				
9041	4B									0.32										
10101	4B			44	22										16					
14013	4B	152																		

14024	4B	66	20	20							42	8	20							15
14033	4B		66																	
14034	4B	120	12	10							68				2				low level	
14035	4B	700			48						14									
14037	4B	566	42	6							94				18					70
14042	4B	306	70.6	90	12.53				12.96		102.95		195.7		221.21					
14046	4B	370	40	138	18								42							
14049	4B	1804	342	130							170									262
14064	4B		114								34									
14072	4B	1390		390	16						32		246		10					200
14074	4B	222	308	82	52						200				20					74
14078	4B				18															
14084	4B	50																		
14091	4B	276		16											28					
15032	4B			0.8											0.15				trace	
16005																		5.14		
18106											140									
18159	4B/5	12.1																		
18211	4B/5	72													16					
18242	4B?																	8.89		
18303	4B/5							72												
18474	4B/5	106		134			0.74			0.94			1.48							
		6212.1	*1014.6*	*1060.8*	*186.53*	*0*	*0.74*	*72*	*0*	*14.22*	*0*	*896.95*	*9.48*	*503.7*	*0*	*530.40*	*0*	*0*	*14.03*	*0*	*621*
Early medieval																				
7018	5x									<.1									tr	
7049	5x		70																	
7082	5x													6.87		3.32				
7055	5x		10																	
7097	5x					0.19														
7225	5x	375		1.39																
7232	5x															31.32			tr	
		375	*80*	*1.39*	*0*	*0.19*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*6.87*	*0*	*69.39*	*0*	*0*		*0*	*0*
Late/post-medieval																				

1077	6		9.15																		
10006	6	64																			
		64	*9.15*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Uncertain																					
none		560																			
1096																	12				
Unstratified																					
u/s 14001	U/S			68																	
14002	U/S		1																		
16055	6 (ie U/S)																200				
16037	U/S		15.02																		
u/s spoil	U/S			60			16.23			50.72				254	1	850			48.98		
1004	topsoil	236	30	20		2							16		8.3				20		
1281	topsoil		12.69							1.63				8.7							
1293	topsoil			1.51																	
unstrat		150																			
18001	topsoil		52																		
9002	topsoil & u/s	156	6.59													158.78					
u/s 13001	U/S													108							
																				low levels	
unstrat	topsoil										70										
		1102	*117.81*	*150.31*	*0*	*2*	*16.23*	*0*	*0*	*57.39*	*70*	*0.28*	*16*	*374.4*	*9.3*	*1499.3*	*0*	*68.98*	*0*	*0*	

Table 9. Proportion of specified classes of material recovered from each time-period, showing the variation in composition of the residue assemblages over time.

	Residues (excl. FAS)	Iron & concretions	FAS
Iron Age	3.0%	22.98%	3.6%
Early Roman	26.8%	34.8%	91.3%
Roman undiff	2.7%	0.0%	0.0%
Late Roman	64.1%	41.7%	4.9%
all Roman	*93.6%*	*76.6%*	*96.3%*
Early Medieval	2.9%	0.6%	0.0%
Late or post-Medieval	0.5%	0.0%	0.0%

Table 10. Distribution of low-density, ceramic influenced facies by period and context. The early periods show high levels of low-density material (including FAS, lining lags, gravelly slags, glassy slags and hearth ceramic), with later Roman contexts producing less low-density material overall – and what there is contains much vitrified hearth lining and little FAS. The absence of the low-density varieties of residue in the later periods probably reflects the residuality of materials in those periods.

	All low-density material	FAS	Vitrified hearth ceramic
Iron Age	28%	2%	0%
Early Roman	15%	6%	0%
Late Roman	13%	0%	7%
Early Medieval	0%	0%	0%
Late /post-medieval	0%	0%	0%

Table 11. Comparison of the SHC weight-frequency distribution of different periods.

	Iron Age or later	***Early Roman***	***Roman undiffd***	***Late Roman***	***Early Medieval***	***u/s***	***All***
Count	1	9	5	28	2	4	*49*
Total weight (g)	154	1292	868	4294	375	806	*7789*
Minimum weight (g)	154	62	70	44	83	52	*44*
Maximum weight (g)	154	330	304	640	292	560	*640*
Average weight (g)	154	144	174	153	188	202	*159*

Table 12: Comparison of the overall SHC weight-frequency distribution with that of other selected Romano-British assemblages from southern Britain, ordered by mean weight. Weights in gram.

Site:	**Cleevelands**	**Exminster**	**Uffington**	**Ipplepen**	**Ebrington**	**Neath**	**Ware**	**Newyears Green**	**Mantles Green**	**Kingstone**	**Dymock**
Source:	Young 2016a	Young 2014b	Young 2015b	This report	Young 2016c	Young 2013a, 2014a	Young 2014c	Young 2021	McDonnell 1985	Young 2012	Young & Kearns 2010
Site type	Rural	Rural	Rural		Rural	*Vicus*	Small town	Iron making	Iron making	Iron making	Iron making
count	176	107	57	49	37	47	70	93	29	15	10
min. wt	44	32	36	44	53	74	36	46	200	230	112
max. wt	530	482	614	640	628	630	952	1975	1700	1035	3885
mean wt	125	127	137	159	180	244	246	472	550	565	1032
% <150g	73%	77%	72%	63%	46%	32%	44%	17%	-	-	20%
% <500g	99%	100%	98%	94%	97%	89%	82%	65%	59%	47%	60%
% >1000g	-	-	-	-	-	-	-	9%	7%	7%	20%
% >3000g	-	-	-	-	-	-	-	-	-	-	10%

Table 13: net peak heights for selected peaks from the pXRF analysis of materials from Ipplepen. Grey tone indicates values of low significance.

Element:	Fe	Cu	Zn	Ag	Sn	Pb
Line:	K12	K12	K12	K12	K12	L1
Energy/keV:	6.405	8.046	8.637	22.163	25.271	10.551
pot used as crucible, internal dross (10008)	96202	88348	34979	1116	180130	9681
pot used as crucible, internal dross (10297)	141883	192608	1328	1077	262431	3267
cupel/crucible (18242), external	98688	12724	41429	3525	1434	2280
ditto , internal and part of section	122652	6465	236541	1882	962	1552
ditto , rim	102398	9575	548026	1556	869	1621
sf <710> mould, internal (1103)	152899	3674	2171	2795	995	2396
crucible? Sf<28>, external (18081)	92659	1780	1100	1851	499	1028
ditto , internal	91266	1985	1249	2162	576	1037
sf <041>, block tuyère, face #1 (18106)	213935	2369	3888	2157	467	1264
ditto , face #2	212470	1803	2009	2042	731	1680
ditto , rear fracture surface	167446	1957	1779	2635	553	1069
casting jet sf<0033>, (16005)	84340	572612	2392	6658	315187	78274

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geoarchaeological, archaeometallurgical & geophysical investigations

Unit 6, Block C,
Western Industrial Estate,
Caerphilly,
CF83 1BQ

Office: 029 20881431
Mobile: 07802 413704

E-Mail: Tim.Young@GeoArch.co.uk
Web: www.GeoArch.co.uk